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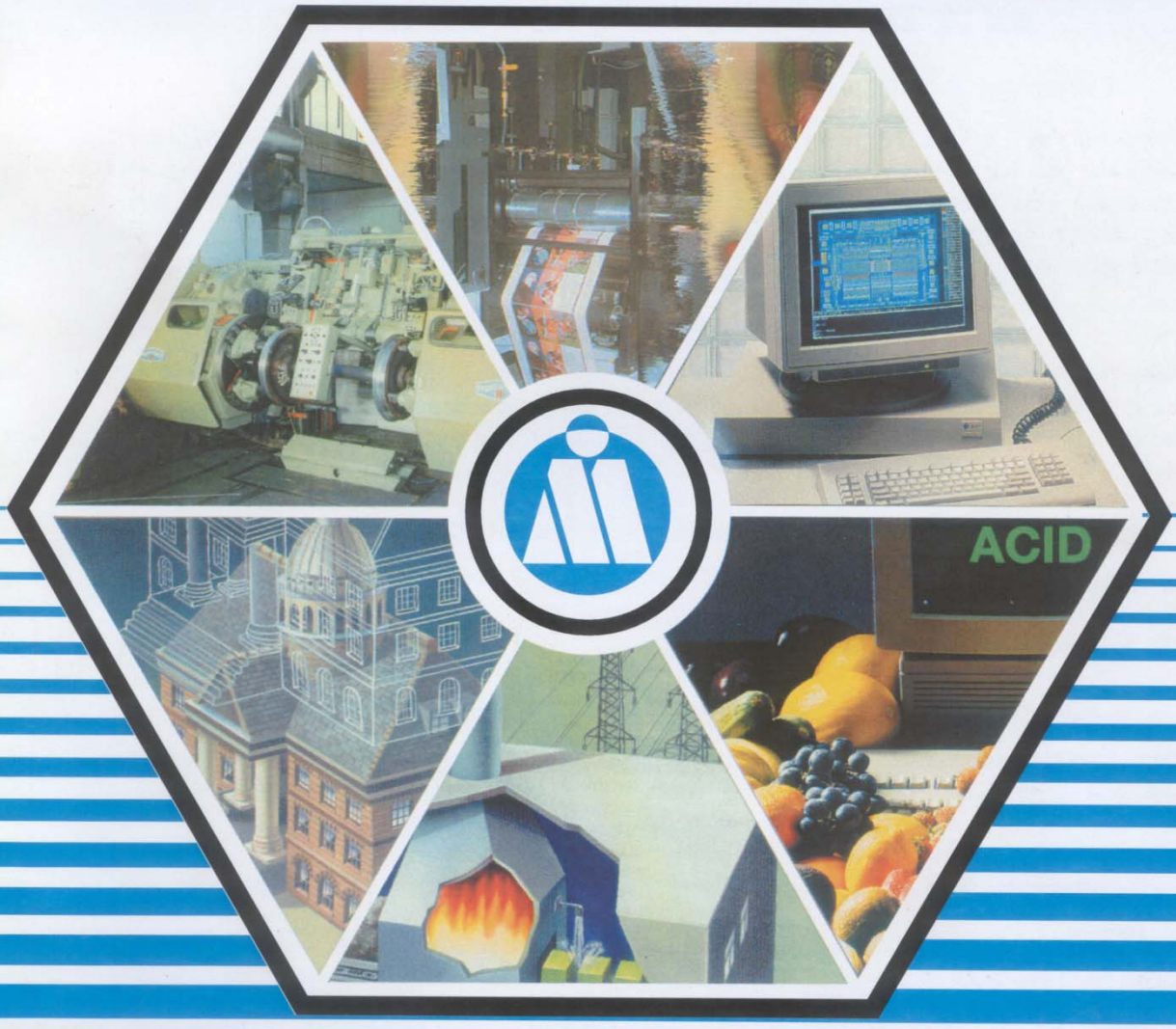

CALENDAR – ANNIVERSARIES

5 April, 1929 - Ivar Giaever is a physicist who shared the Nobel Prize in Physics in 1973 with Leo Esaki and Brian Josephson „*for their discoveries regarding tunnelling phenomena in solids”.*

6 April, 1949 - Horst Ludwig Störmer is a German physicist. He was awarded the 1998 Nobel Prize in Physics jointly with Daniel Tsui and Robert Laughlin "*for their discovery of a new form of quantum fluid with fractionally charged excitations*".

19 April 1854 - Anghel Saligny (19 April 1854 – 17 June 1925) was a Romanian engineer, most famous for designing the Feteşti-Cernavodă railway bridge (1895) over the Danube, the longest bridge in Europe at that time. He also designed the storage facilities in Constanţa seaport.

20 April 1809 - James David Forbes (20 April 1809 – 31 December 1868) was a Scottish physicist and glaciologist who worked extensively on the conduction of heat and seismology. He invented the seismometer in 1842.

22 April, 1904 - Julius Robert Oppenheimer (22 April, 1904 – 18 February, 1967) was an American theoretical physicist. He is among the persons who are often called the „*father of the atomic bomb*” for their role in the Manhattan Project, the World War II project that developed the first nuclear weapons.

25 April 1874 - Guglielmo Marconi (25 April 1874 – 20 July 1937) was an Italian inventor. He shared the 1909 Nobel Prize in Physics with Karl Ferdinand Braun „*in recognition of their contributions to the development of wireless telegraphy”.*

29 April 1854 - Jules Henri Poincaré (29 April 1854 – 17 July 1912) was a French mathematician, theoretical physicist, engineer, and a philosopher of science. He is often described as a polymath, and in mathematics as *The Last Universalist* by Eric Temple Bell.

15 May 1859 - Pierre Curie (15 May 1859 – 19 April 1906) was a French physicist, a pioneer in crystallography, magnetism, piezoelectricity and radioactivity. In 1903 he received the Nobel Prize in Physics with his wife, Marie Skłodowska Curie, and Henri Becquerel.

21 May 1964 - James Franck (26 August 1882 – 21 May 1964) was a German physicist and Nobel laureate. In 1925, Franck received the Nobel Prize in Physics.

31 May, 1954 - Dragomir M. Hurmuzescu (13March, 1865 – 31 May, 1954), Romanian physicist, inventor, professor, member of the Romanian Academy. He had contributions in the fields of electricity and the physics of the X - Rays.

25 June 1894 - Hermann Julius Oberth (25 June 1894 – 28 December 1989) was an Romanian physicist and engineer born to a Transylvanian Saxon family in Sibiu. He is considered one of the founding fathers of rocketry and astronautics.

26 June 1824 - William Thomson, 1st Baron Kelvin (26 June 1824 – 17 December 1907), was an Irish and British mathematical physicist and engineer. At the University of Glasgow he formulated the first and second laws of thermodynamics.

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C O N T E N T

REZUMATE

Băjenescu, T.-M. I. **Câteva elemente-cheie pentru o fiabilitate îmbunătăţită a dispozitivelor electronice şi pentru satisfacţia consumatorului.** De-a lungul fazei de implementare a tuturor proiectelor trebuie rezolvate o multitudine de probleme şi provocări. Unele sunt stăpânite prin reproiectare şi muncă asiduă, altele cer mai multă investire din partea fabricantului. Fiabilitatea este unul din atributele majore care determină alegerea componentelor electronice pentru aplicaţiile critice privind securitatea instalaţiei. De aceea ingineria fiabilităţii trebuie să facă parte integrantă din proiectarea produsului şi din dezvoltarea sistemului. Proiectanţii de sisteme au la dispoziţie câteva posibilităţi pentru a îmbunătăţi fiabilitatea şi durata de viaţă utilă a produselor. Aceste metode sunt discutate în lucrare.

Marina V., Marina Viorica. **Cu privire la termomecanica proceselor reversibile.** Progresul ştiinţific şi tehnologic este în mare măsura condiţionat de nivelul de cunoaştere a comportării materialelor în funcţie de structura lor şi istoria acţiunii exterioare. Studiul relaţiilor dintre tensorii tensiune şi deformaţie nu poate fi realizat în afara principiilor generale ale termodinamicii. Pornind de la aceasta realitate vom examina în mod detaliat principiile termodinamicii la nivel local.

Rachier V., Sobor I., Chiciuc A. **Evaluarea resurselor energetice eoliene ale Moldovei.** În conformitate cu Planul Naţional de Acţiuni în Domeniul Energiei din Surse Regenerabile a Republicii Moldova, energia electrică regenerabilă va fi produsă din cea eoliană şi până în anul 2020 este necesar de circa 400 MW capacitate eoliana. În lucrare se face o încercare de a evalua potenţialul energetic eolian folosind programe de calcul moderne, datele de intrare topografice, date istorice despre vânt ale Serviciului Hidro-meteorologic de Stat şi măsurători pe teren efectuate în perioada 2002-2003 şi 2010-2013 la înălţimi de 30-70 m deasupra nivelului solului. Pentru cele trei regiuni de dezvoltare economică ale Republicii Moldova - sud, centru şi nord sunt produse hărţile resurselor eoliene în termeni de viteza medie anuală a vântului, densitatea de putere eoliană şi capacitate electrică eoliana instalata. Valorile maxime ale vitezei medii anuale ale vântului şi densitatea de putere eoliană la 100 m deasupra nivelului solului sunt: la sud - 8,08 m/s şi 518 W/m^2, centru - 8,05 m/s şi 501 W/m^2, nord - 7,56 m/s şi 605 W/m^2.

Ivashenko N., Bulyandra A., Verbitskiy B., Lutzik Yu., Bernic M., Ciobanu E. **Despre structura poroasă a pulpei sfeclei de zahăr.** În articolul este prezintă analiza efectuată asupra unui volum de pulpă de sfeclă de zahăr, curbele integrală şi diferenţială de distribuţie a microporilor după raza acestora şi aria suprafeţei lor. La fel este prezentată influenţa microporilor asupra procesului de uscare.

Cucu O., Todos P., Guvir S., Ghencea C. **Eficientizarea managementului stagiilor de practică – un imperativ al timpului.** Un rol important în formarea universitară a viitorilor specialişti revine stagiilor de practică, acestea fiind un prim pas spre adaptarea şi integrarea studenţilor în mediul profesional. Eficienţa stagiilor în mare măsură depinde de calitatea monitorizării procesului „organizare – desfăşurare - evaluare" a acestora. În baza analizei situaţiei existente la capitolul dat în articol este argumentată necesitatea îmbunătăţirii managementului stagiilor de practică. Sunt propuse o serie de măsuri concrete, referitoare la acest compartiment şi anume: implementarea sistemului de monitorizare online a procesului de desfăşurare a stagiilor de practică; aplicarea criteriul cumulativ de evaluare finală a stagiilor. Unul din avantajele evidente a măsurilor propuse este motivarea studenţilor de a avea o atitudine responsabilă faţă de toate activităţile preconizate în perioada desfăşurării stagiilor de practică.

Pîntea V., Maciuga A., Radu R., Stoicev P., Kulev M. **Fenomenul de superluminescenţă în compuşii ternari de tipul** $CdGa_2S_4$. In lucrare sunt expuse rezultatele investigaţiilor asupra influenţei condiţiilor de excitare (temperatura, intensitatea, durata impulsului excitant) şi se propune mecanismul fenomenului de superluminescenţă, fenomen care a fost înregistrat pentru compuşii $CdGa_2S_4$ în anumite condiţii de excitare a luminescenţei: energie înaltă a fluxului de electroni $100 keV$ şi durata impulsului $(10^{-3}\, s)$ la temperatura $80\, K$.

Sveatenco N. **Influenţa proprietăţilor termovâscoplastice ale subelementelor modelului structural asupra caracteristicilor termovâsco-elastice ale materialului.** Un element de volum macroscopic omogen şi izotrop poate fi reprezentat sub forma unui conglomerat compus dintr-un număr infinit de subelemente legate cinematic între ele. Elementul de structură se identifică cu mulţimea particulelor materiale, care se grupează după un parametru comun, ce guvernează fenomenul considerat. Subelementele posedă numai proprietăţi elementare, însă în rezultatul interacţiunii la scara macroscopică pot fi descrise diferite fenomene. Se consideră că funcţiile reologice, care reflectă proprietăţile termovâscoplastice ale subelementelor, depind de viteza de deformare a elementului corpului, ceea ce influenţează caracteristicile termo-vascoelastice ale materialului. Coerenţa cinematică a subelementelor conduce la influenţa reciprocă a fenomenelor de diferită natură.

Derevianko V.N., Nechitaylo N.P. **Ancrasarea biologică a membranelor de ultrafiltrare în timpul funcţionării.** Această lucrare analizează factorii, care duc la murdărirea elementelor membranei în timpul funcţionării. O atenţie specială este acordată depunerilor pe elementele membranei, care este factorul de bază, care duce la scăderea critică a performanţelor membranei. Au

fost stabilite criteriile de bază de creştere a controlului depunerilor. Au fost propuse modalităţi de dezvoltare a tehnologiei membranei, care va permite evitarea depunerilor sau reducerea costului membranei. Noile tehnologii trebuie să fie dezvoltate pentru a controla depunerile. Acest lucru va extinde în mod semnificativ domeniul de aplicare a ultrafiltrării pentru tratamentul apelor naturale şi reziduale.

Manoli I., Beiu I. **Oportunitatea utilizării gazului natural comprimat în transportul public de călători.** În acest articol sunt prezentate aspectele tehnice şi economice de adaptare a vehiculelor la alimentarea cu gaz natural comprimat. Un alt factor important care influenţează asupra costurilor de operare privind folosirea CNG au fost legate de depozitarea gazelor. În lucrare sunt prezentate metodele actuale de stocare a aprovizionării cu gaze naturale.

Chiricuţă I. **Reducerea impactului asupra mediului a zgurilor de oţelărie prin utilizarea lor în structuri rutiere.** Articolul analizează posibilitatea utilizării zgurii de oţelărie în construcţiile rutiere. Depozitarea acesteia în halde pune serioase probleme de mediu, prin ocuparea unor mari suprafeţe de teren şi instabilitatea straturilor de haldare, ce ating grosimi de zeci de metri. Rezultatele experimentale au confirmat posibilitatea utilizării cu succes a zgurii de oţelărie ca înlocuitor al agregatelor naturale în straturile rutiere. Prin aceasta se realizează o scădere semnificativă a costului lucrărilor (zgura, fiind un deşeu industrial, este mult mai ieftină decât agregatul natural). De asemenea, utilizarea agregatelor din zgură are ca rezultat protejarea mediului înconjurător, prin eliminarea spaţiilor de depozitare a zgurii şi prin conservarea ambientului natural (extracţia agregatelor naturale poate perturba apa freatică, poate accentua eroziunea etc.).

Rusanovschi M., Stoicev P., Rusanovschi V. **Compararea parametrilor geometrici ai cationilor în aliajele de cobalt (III) şi rodiu (III).** În lucrarea propusă sunt prezentate rezultatele investiţiilor, privind 11 structuri cristaline pentru compararea deosebirilor conformaţionale cationilor geometrici şi compararea cantitativă ale metalelor tranzitive de Co(III) şi Rh(III) cu liganzi TSC(tiosemicarbazid) şi Halcogencarbami. (Tio, Seu), distribuiţi simetric pe coordonata Lig-M-Lig. În baza sistemei propuse stă tratarea empirică de fixare a conformaţiilor, care-s testul de bine sunt studiate. În lucrare sunt analizate şi totalizate datele despre compuşii coordinativi a metalelor tranzitive Co(III) şi Rh(III).

Bârsan, A. **Posibilităţi de optimizare a cinematicii mecanismelor malteze.** Lucrarea propune câteva variante de optimizare a cinematicii mecanismelor de tip maltez. Sunt prezentate trei mecanisme: mecanismul maltez cu canale curbe, mecanismul maltez cu canale de tip „Y" şi mecanismul maltez clasic acţionat prin intermediul unui mecanism cu camă.

Bostan I., Dulgheru V. **Transmisiilor planetare precesionale: tehnologii de generare.** Unele probleme ale transmisiilor mecanice pot fi rezolvate cu efecte speciale prin dezvoltarea de noi tipuri de transmisii pe baza transmisiilor planetare precesionale cu angrenaj multipar, care au fost dezvoltate de către autori. Multiplicitatea absolută a angrenajului precesional (până la 100% perechi de dinţi aflate simultan în angrenare, comparativ cu 5% -7% - în angrenajele clasice) asigură creşterea capacităţii portante, masă şi dimensiuni reduse. Articolul prezintă aspectele teoretice ale generării profilelor non-standarde ale dinţilor.

Guţu M. **Analiza palei din material compozit ϕ turbinei eoliene, folosind un model de elemente finite.** Această lucrare prezintă designul final al palei turbinei eoliene mici executate din poliester armat cu sticla (GRP), dezvoltat la Universitatea Tehnică a Moldovei prin analiză cu element finit (FE). Variabilele de proiectare sunt considerate legate de parametrii de materiale compozite: direcţia fibrelor, direcţia straturilor, grosimea învelişului grosime bazate pe numărul de straturi compozite. Drept constrângeri sunt deformaţiile vârfului palei, eforturile admisibile şi vibraţiile de rezonanţă ale palei. În funcţie de rezultatele analizei FE pala optimizată va fi destul de rigidă în condiţii de furtună, va suporta frecvenţe de rezonanţă periculoase şi va cântări aprox. cu 20% mai puţin.

Livinţ G., Lucache D. D., Dănilă E. **Controlul suspensiei magnetice a unui sistem de volant.** Lucrarea tratează stabilitatea unui sistem de stocare a energiei cu volant magnetic, cu ajutorul unui controller polinomial RST. Comportamentul sistemului este analizat pe baza variaţiei parametrilor constructivi şi a perturbaţiilor, utilizând programe de simulare.

Puiu C., Iagăru R., Puiu V., Neamţu Fl. V. **Estimările prin măsurarea satisfacţiei consumatorului.** Această lucrare îşi propune să susţină faptul că un proces de măsurare a satisfacţiei consumatorului efectuat într-un mod obiectiv şi corect poate oferi datele şi informaţiile necesare pentru a face compatibile, în cadrul procesului, toate părţile participante. Acesta va avea ca rezultat o valoare durabilă la consumator şi o orientare participativă a propriilor angajaţi şi parteneri în măsură pentru valoarea adăugată.

Dogotaru S., Ursu M. **Viziuni asupra administrării fondului locativ.** Prezenta lucrare analizează situaţia în domeniul locativ, privind administrarea clădirilor ce aparţin mai multor proprietari. În rezultatul privatizării fondului locativ şi urmare unor deficienţe în legislaţie, blocurile locative au rămas să fie administrate de către serviciile specializate ale autorităţilor locale, care întâmpină mari dificultăţi în procesul de întreţinere a activelor încredinţate. Autorii scot în evidenţă problemele identificate şi propun soluţii pentru redresarea situaţiei în clădirile ce au caracteristicile condominiului, accentul de bază fiind pus pe responsabilizarea proprietarilor pentru întreţinerea blocurilor locative.

ABSTRACT

Băjenescu, T.-M. I. **Some key elements for a better reliability of electronic devices, and consumer satisfaction.** There are many problems and challenges which must be overcome during the implementation phase of all projects. Some are overcome with engineering redesign and hard work, while others require more investment by the manufacturer. Reliability is one of the major attributes that define the choice of electronic components for safety-critical applications. That is why reliability engineering should be an integral part in product and system development. There are several ways in which designers can assist in improving the reliability and lengthen the life of products. These methods are discussed in the paper.

Marina V., Marina Viorica. **Regarding to thermomechanics of irreversible processes.** The scientific and technologic progress is conditioned by level of knowing of material behaviour in function of his structure and history of exterior action. Studding of relations between stress and strain tensors can't be realized without the basic thermodynamic principles. We will exam in basic way the thermodynamic principles at the local level.

Rachier V., Sobor I., Chiciuc A. **Assessment of wind energy resource of Moldova.** According to Moldova's National Renewable Energy Action Plan, renewable electricity will be produced mainly from wind and by 2020 is necessary about 400 MW wind capacity. In this paper an attempt is made to assess the wind energy potential using modern software, topographical input data, historical wind data from State Hydrometeorological Service and field measurements conducted during 2002-2003 and 2010-2013 at heights of 30-70 m above ground level. For three Moldova's development regions - south, center and north are produced wind resources maps in terms of average annual wind speed, wind power density and installed wind capacity. Maximum values of annual average wind speed and wind power density at 100 m above ground level are: south – 8,08 m/s and 518 W/m^2, center - 8,05 m/s and 501 W/m^2, north – 7,56 m/s and 605 W/m^2.

Ivashenko N., Bulyandra A., Verbitskiy B., Lutzik Yu., Bernic M., Ciobanu E. **About pore structure of sugar beet pulp.** The article presents some beet pulp micro-pore volume, integral and differential distribution curves of micro-pores by radiuses, effective pore radius, and surface area. It is shown their influence on the drying process.

Cucu O., Todos P., Guvir S., Ghencea C. **Streamlining the management of internships - an imperative of the time**. An important role in university training of the future specialists lies on the internships, which is a first step towards adapting and integrating students into the professional environment. The efficiency of internships largely depends on the quality of monitoring their "organization - deployment – evaluation" process. Based on the analysis of the existing situation, in this article it is underlined the necessity to improve the management of internships. There are proposed a number of concrete measures regarding this issue, namely: implementation of online monitoring of the internships' deployment process; application of the cumulative criterion for the final evaluation of internships. One of the obvious advantages of the proposed measures is to motivate students to take a responsible attitude towards all activities envisaged in the period of internships.

Pîntea V., Maciuga A., Radu R., Stoicev P., Kulev M. **Super luminescence phenomenon in ternary compounds of type** $CdGa_2S_4$. The paper presents the results of investigations on the influence of excitation conditions (temperature, intensity, exciting impulse duration) and proposes the mechanism of super luminescence phenomenon, a phenomenon that was recorded for the compounds under certain conditions of excitation of luminescence: high-energy electrons flow $100\,keV$ and impulse duration $\left(10^{-3}\,s\right)$ at the temperature $80\,K$.

Sveatenco N. **Influence of the thermoviscoplastic properties of the structural model subelements on the thermoviscoelastic characteristics of material.** The volume element V_0, being isotropic and homogeneous at the macroscopic level, can be represented as a conglomerate composed of an infinite number of kinematically connected subelements. Structural element identifies the set of material particles, which grouped according to a common parameter governing the considered phenomenon. Subelements possess only simple properties, but in result of their interaction at the macroscopic level one may describe various phenomena. It's assumed that rheological functions, reflecting thermoviscoplastic properties of subelements, depend on the rate of deformation change of the body element, and this fact influences the thermoviscoelastic characteristics of material. The kinematic coherence of subelements leads to the interdependence of phenomena of the different nature.

Derevjanko V.N., Nechitaylo N.P. **Biological fouling of ultrafiltration membranes during operation.** This work analyzes factors, that lead to fouling of membrane elements during operation. Special attention is given to biofouling of membrane elements, which is the basic factor, that leads to critical decrease of membrane performance. Basic criteria of biofouling increase control were found. Ways of membrane technology development, that will allow to avoid or decrease cost of membrane biofouling reducing, were suggested. New

technologies must be developed to control biofouling. This will significantly expand the scope of application of ultrafiltration for the treatment of natural and waste waters

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Manoli I., Beiu I. **The convenience of using compressed natural gas in public transport of passengers.** In the article technical and economical aspects of the vehicle adjustment to CNG supply are presented. Aspects of the diesel oil and petrol engines adaptation to CNG were also brought up. Another significant factor which influences the operating costs of the CNG usage is the gas storage. In the paper, actual methods of storage of the natural gas supply are also presented.

Chiricuţă I. **Reducing the Environmental Impact of Slag Steelworks by Using it in Road Structures.** This article deals with possible use of slag steelworks in road construction. The storage of slag steelworks in waste dumps pose serious environmental problems by occupation of large areas of land and instability of dump layers, which can reach tens of meters in thickness. The experimental results confirmed the successfully use of slag by replacing the natural aggregates in road layers. This provides a significant decrease in the cost of work (slag - an industrial waste - is much cheaper than natural aggregate). The use of slag aggregates also results in environmental protection by removing slag storage areas and conservation of natural environment (extraction of natural aggregates may disrupt ground water, may increase erosion, etc).

Rusanovschi M., Stoicev P., Rusanovschi V. **Comparison of geometric parameters of cations in cobalt (III) and rhodium (III) compounds.** In this paper are given the results of the study of crystal structures in terms of determining the conformational differences, the quantitative comparison of the geometry of complex cations, transition metals of rhodium (III) and cobalt (III) with *TCS*, and rhodium (III) and cobalt (III) dioximins with two symmetric ligands of chalcogencarbamide (*Thio*, *Seu*) on the axial coordinate *Lig - M - Lig*. The basis of the proposed systematics is the empirical approach of fixation of the adequately studied and typical cases of conformation. In this paper are collected, compiled and analyzed data on the structure of transition metal coordination compounds with chalcogene-containing ligands: thiosemicarbazide and chalcogenocarbamides.

Bârsan A. **Some optimization possibilities regarding the kinematics of the Geneva mechanisms.** The paper proposes some kinematical optimizing solutions for the Geneva mechanism. Three mechanisms are presented: a curved slotted Geneva mechanism, a "Y" type Geneva mechanism and a conventional Geneva mechanism driven by a cam mechanism.

Bostan I., Dulgheru V. **Planetary precessional transmissions: generation technologies.** Some problems of mechanical transmissions can be solved with special effects by developing new types of transmissions based on planetary precessional transmissions with multiple gear, that were developed by the author. Absolute multiplicity of precessional gear (up to 100% pairs of teeth simultaneously involved in gearing, compared to 5%-7% - in classical gearings) provides increased lifting capacity and small mass and dimensions. The article presents the theoretical aspects of nonstandard profiles generation.

Guţu M. **Analysis of a wind turbine's composite blades using a finite element model.** This paper presents the final design of glass-reinforced polyester (GRP) blade for small wind turbine developed at the Technical University of Moldova by finite element (FE) analysis techniques. The design variables considered are related to the composite material parameters: fiber direction, layers direction and blade shell thickness based on number of composite layers. The constraints are tip deformations, allowable stresses and resonant vibration of the blade. According to FE analysis results the optimized blade will be stiff enough in storm conditions, will operate out of dangerous resonance frequencies and will weigh approx. 20% less.

Livinţ G., Lucache D. D., Dănilă E. **On controlling the magnetic suspension of a flywheel system.** The paper deals with the synthesizing of a polynomial RST controller to insure the stability of a flywheel energy-storage system. Considering variations of the constructive parameters and perturbation, by means of simulation programs the system behaviour analyses is performed.

Puiu C., Iagăru R.,, Puiu V., Neamţu Fl. V. **Estimates on measuring the consumer's satisfaction.** This work intends to sustain the fact that a process of measuring the consumer's satisfaction carried out in an objective and correct manner, may offer the necessary data and information for making compatible, within the process, all participating parties. It will result a sustainable value at consumer and a participative orientation of the own employees and partners able for added value

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Dogotaru S., Ursu M. **Visions on housing management**. This paper analyzes the existing Housing Stock]n the view of administration of buildings belonging to several owners. Following the privatization of the housing stock and due to shortcomings in legislation, apartment buildings remained to be administered by the specialized services of the local authorities which encounter difficulties in the maintenance of the entrusted assets. The authors highlight the identified issues and propose solutions to address the alleviation of the situation in the buildings that have condominium features, the core focus being put on the owners responsibility to maintain apartment buildings.

SOMMAIRE

doivent être développées pour contrôler l'encrassement biologique. Cela permettra d'élargir considérablement le champ d'application de l'ultrafiltration pour le traitement des eaux naturelles et des déchets

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Manoli I., Beiu I. **La pertinence de l'utilisation du gaz naturel comprimé dans les transports publics.** Dans l'article aspects techniques et économiques de l'ajustement de véhicule GNC offre est présentée. Aspects de l'adaptation de l'huile de moteurs diesel et à essence à GNG ont également été élevés. Un autre facteur important qui influence sur les coûts d'exploitation de GNC étaient stockage de gaz. Dans le papier méthodes actuelles de stockage de l'approvisionnement en gaz naturel sont présentés.

Kirikucè I. **Réduction de l'impact environnemental des crasses, à travers leur utilisation dans les constructions de la route.** L'article traite de l'utilisation du laitier métallurgique dans la construction de routes. Stockage des scories métallurgiques dans les dumps pose de sérieux problèmes environnementaux, occupant de vastes étendues de terre, et leur épaisseur peut atteindre plusieurs dizaines de mètres. Les résultats expérimentaux confirment le succès de scories en remplaçant les agrégats naturels dans les couches de la chaussée. Cela permet une réduction significative du coût (laitier-industriel waste - c'est beaucoup moins cher que les unités naturelles). Utilisation de scories vous permet d'enregistrer l'environnement en réduisant leur zone de stockage et permet aussi d'économiser les réserves naturelles (granulats naturels peuvent se briser de l'eau souterraine peut augmenter l'érosion des sols et donc.

Rusanovschi V., Rusanovschi M., Stoicev P. **Comparaison des paramètres géométriques de cations dans le cobalt (III) et des composés de rhodium (III).** Cet article présente les résultats de l'étude des structures cristallines en termes de définition des différences de conformation, la comparaison quantitative de la géométrie cations complexes de rhodium de métaux de transition (III) et de cobalt (III) avec un TCS , et dioksim rhodium (III) et de cobalt (III) avec deux ligands symétriques chalcogènes carbamide (Thio, Seu) sur la coordonnée axiale Lig - M - Lig . La taxonomie proposée est empirique fixation d'approche suffisamment étudiés et les cas typiques conformation. L'article présente, résumées et analysées des données sur la structure des composés de coordination de métaux de transition avec des ligands contenant un chalcogène: thiosemicarbazide et chalcogènes carbamides.

Bârsan, A. **Des possibilités d'optimiser la cinématique de mécanismes de Malte.** Cet article présente quelques solutions pour optimiser la cinématique des mécanismes de Malte. Ils sont présenter trois variantes des mécanismes optimisés: un mécanisme avec des chenaux curviligne, un mécanisme hybride avec de chenaux en forme de „Y" et un mécanisme de Malte classique entraîner par un mécanisme a cam.

Bostan I., Dulgheru V. **Transmissions planétaire de processionnelle: les technologies de production.** Quelques problèmes des transmissions mécaniques peuvent être résolus avec des effets spéciaux en développant de nouveaux types de transmissions basé sur les transmissions planétaire précessionnelle avec d'engrenage multiples, qui ont été développés par l'auteur. Multiplicité absolue d'engrenage précessionnelle (jusqu'à 100% des paires de dents impliqués simultanément dans engrenage, comparativement à 5% -7% - dans des transmissions classiques) offre une capacité de levage accrue et faible masse et les dimensions. L'article présente les aspects théoriques de la génération des profils non standard.

Gutu M. **Analyse des pales de l'éolienne en utilisant le modèle composite des éléments finis.** Cet article présente la conception finale de polyester renforcé de verre (GRP) pour pale de petite turbine éolienne développée à l'Université Technique de Moldova par éléments finis (FE) Techniques d'analyse. Les variables de conception Considéré comme le matériau composite est lié aux paramètres: la direction des fibres, direction couches et coquille de pale d'épaisseur en fonction du nombre de couches composites. Les contraintes ont des déformations de pointe de la pale, les contraintes admissibles et de la vibration de résonance de la pale. En fonction des résultats de l'analyse FE la pale optimisé sera assez rigide dans des conditions orageuses, soutiendra fréquences de résonance dangereux et pèsera environ 20% de moins.

Livinţ G., Lucache D. D., Dănilă E. **Le contrôle de la suspension magnétique d'un système de volant d'inertie**. L'article traite de la stabilité d'un système de stockage d'énergie avec volant magnétique, en utilisant un contrôleur RST polynôme. Le comportement du système est analysé sur la base de la variation des paramètres constructifs et de troubles, à l'aide des programmes de simulation.

Puiu C., Iagăru R., Puiu V., Neamţu Fl. V. **Les estimations sur la mesure de la satisfaction du consommateur.** Ce travail vise à soutenir le fait qu'un processus de mesure de la satisfaction du consommateur effectuée d'une manière objective et correcte, peuvent offrir les données et informations nécessaires pour faire compatible, dans le processus, toutes les parties participantes. Il en résultera une valeur durable à la consommation et une orientation participative des propres employés et partenaires en mesure de la valeur ajoutée

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Dogotaru S., Ursu M. **Visions de la gestion des logements**. Ce document analyse la situation du logement concernant les bâtiments administratifs appartenant à plusieurs propriétaires. Après la privatisation du fond de logements et en raison de lacunes de la législation, les immeubles d'habitation restaient à être administrés par les services des autorités locales qui rencontrent des difficultés en matière de maintien des actifs qui lui sont confiés. Les auteurs soulignent les problèmes identifiés et proposent des solutions pour améliorer la situation dans les immeubles qui ont des caractéristiques du copropriété, le point central étant mis sur la responsabilité des propriétaires de maintenir les immeubles d'habitation.

РЕЗЮМЕ

Бэженеску Т-М. И. **Некоторые ключевые элементы для повышения надежности электронных устройств, а также удовлетворенность потребителей**. Есть много проблем и задач, которые должны быть преодолены в ходе этапа осуществления всех проектов. Некоторые из них преодолеть с инженерной реконструкции и напряженной работы, в то время как другие требуют больше инвестиций со стороны производителя. Надежность является одним из основных атрибутов, которые определяют выбор электронных компонентов для критичных к безопасности приложений. Именно поэтому надежность техники должны быть неотъемлемой частью в продукции и развития системы. Есть несколько способов, в которых дизайнеры могут помочь в повышении надежности и продлить срок службы изделий. Эти методы обсуждаются в статье.

Марина В., Марина Виорика. **О термодинамике необратимых процессов.** Научный и технический прогресс в большой степени зависит от уровня знания поведения материала в зависимости от его структуры и внешних сил. Изучение соотношений между тензором напряжений и деформаций не может быть реализовано вне основных принципов термодинамики. Предлагаем в работе детально изучить принципы термодинамики на локальном уровне.

Ракиер В., Собор И., Кичук А. **Оценка ветро-энергетических ресурсов Молдовы.** В соответствии с Национальным Планом Действий Республики Молдова по Возобновляемым Источникам Энергии, возобновляемое электричество будет производиться, в основном, на основе ветра, и к 2020 году необходимо около 400 МВт ветровой мощности. В статье делается попытка оценить потенциал энергии ветра с использованием современного программного обеспечения, топографических входных данных, исторических данных Государственной Гидрометеорологической Службы о ветре и полевых измерений, проведенных в течение 2002-2003 и 2010-2013 на высотах 30-70 м над уровнем земли. Для трех регионов Молдовы - юг, центр и север составлены карты ветровых ресурсов. Максимальные значения средней годовой скорости и плотности энергии ветра на высоте 100 м над уровнем земли равны: на юге - 8,08 м/с и 518 Вт/м^2, в центре - 8,05 м/с и 501 Вт/м^2, на севере - 7,56 м/с и 605 Вт/м^2.

Ivashenko N., Bulyandra A., Verbitskiy B., Lutzik Yu., Bernic M., Ciobanu E. **О пористой структуре свекловичного жома.** В статье представлен анализ некоторого объема свекольного микропористого жома, интегральные и дифференциальные кривые распределения микропор по их радиусу, эффективный радиус пор и площадь поверхности. Показано их влияние на процесс сушки.

Куку О., Тодос П., Гувир С., Генча К. **Совершенствование менеджмента учебных практик – требование времени.** Учебные практики играют важную роль в подготовке специалистов, являясь первым шагом в приобщении студентов к будущей профессиональной деятельности. Их эффективность в большой степени зависит от качества мониторинга этапов организации, проведения и оценки результатов практик. На основании анализа текущего момента в данной статье аргументирована необходимость совершенствования менеджмента учебных практик. Предложен ряд мероприятий, способствующий значительному повышению эффективности мониторинга и оценки результатов практик. К основным относятся использование информационных технологий в процессе текущего мониторинга на протяжении всего периода проведения практик и внедрение системы оценки результатов по кумулятивному принципу. Данная система также позволит стимулировать студентов к ответственному подходу в реализации учебных программ практик.

Пынтя В., Мачиуга А., Раду Р., Стойчев П., Кулев М. ***Явление суперлюминесценции в тройных соединениях типа*** $CdGa_2S_4$. В работе представлены результаты исследования влияния условий возбуждения (температура, плотность тока возбуждения, длительность импульса) и предлагается механизм явления суперлюминесценции, явление которое было экспериментально выявлено для $CdGa_2S_4$, при экспериментальных условиях: энергия пучка электронов $100 keV$ и длительность импульса $\left(10^{-3} s\right)$ при температуре $80 K$.

Святенко Н. **Влияние термовязкопластических свойств подэлементов структурной модели на термовязкоупругие характеристики материала.** Макроскопически однородный и изотропный элемент объема может быть представлен в виде конгломерата, состоящего из бесконечного числа кинематически связанных между собой подэлементов. Структурный элемент отождествляется с множеством материальных частиц, которые группируются согласно общему параметру, управляющему рассматриваемым явлением. Подэлементы обладают только элементарными свойствами, однако, в результате взаимодействия между ними на макроуровне появляется возможность описать различные явления. Предполагается, что реологические функции, отражающие термовязкопластические свойства подэлементов, зависят от скорости деформирования элемента тела, что влияет на термовязкоупругие характеристики материала. Кинематическая связанность подэлементов приводит к взаимному влиянию явлений различной природы.

Деревянко В.Н., Нечитайло Н.П. **Биологическое обрастание ультрафильтрационных мембран во время работы.** Эта работа анализирует факторы, которые приводят к загрязнению мембранных элементов в процессе работы. Особое внимание уделяется биообрастания мембранных элементов, что является основным фактором, который приводит к критическому снижению производительности мембраны. Были предложены пути развития мембранных технологий, которые позволят избежать осаждения или снизить

стоимость мембраны. Новые технологии должны быть разработаны для контроля обрастания. Это позволит значительно расширить сферу применения ультрафильтрации для очистки природных и сточных вод

Маноли И., Бею И. **Пригодность использования сжатого природного газа в общественном транспорте**. В статье представлены технические и экономические аспекты регулирования транспортного средства к поставкам СПГ. Были исследованы также аспекты адаптации дизельного топлива и бензиновых двигателей в СПГ. Еще одним важным фактором, который влияет на текущие расходы с помощью СПГ, были хранения газа. В работе представлены фактические методы хранения поставок природного газа.

Кирикуцэ И. **Сокращение воздействия на окружающую среду металлургических шлаков, путем их использования в дорожных сооружениях.** В статье рассматриваются возможности использования металлургического шлака в дорожном строительстве. Результаты экспериментов подтвердили успешное использование шлака, заменив естественные агрегаты в слоях дорожных покрытий. Это обеспечивает значительное снижение стоимости работ (шлак - промышленные отходы - это намного дешевле, чем естественные агрегаты). Использование шлака позволяет сохранять окружающую среду путем сокращения зоны их хранения , а также позволяет сохранить природные запасы (добыча природных агрегатов может нарушить грунтовые воды, может увеличить эрозию почвы, и т.д**.).**

Русановский М., Стойчев П., Русановский В., **Сравнение геометрических параметров катионов в соединениях кобальта (Ш) и родия (Ш).** В данной работе приведены результаты исследования кристаллических структур в плане определения конформационных различий, количественного сопоставления геометрии комплексных катионов, переходных металлов родия (III) и кобальта (III) с *TCS,* а также диоксиминов родия (III) и кобальта (III) с двумя симметричными лигандами халькогенкарбамида (*Thio* , *Seu*) на аксиальной координате *Lig - M - Lig*. В основе предлагаемой систематики лежит эмпирический подход фиксации, достаточно полно изученных и типичных случаев конформации. В работе собраны, обобщены и проанализированы данные о строении координационных соединений переходных металлов с халькогенсодержащими лигандами: тиосемикарбазидом и халькогенокарбамидами.

Бырсан А. **Возможности оптимизации кинематики мальтийских механизмов.** В работе предлагаются несколько вариантов кинематики мальтийских механизмов. Представлены три механизма: мальтийский механизм с криволинейными канавками; мальтийский механизм с канавками типа *„Y”* и классический мальтийский механизм, приводимый через кулачковый механизм.

Бостан И., Дулгеру В. Планетарные прецессии передачи: технологии изготовления. Некоторые проблемы механических трансмиссий могут быть решены при помощи специальных эффектов, развивая новые виды трансмиссий на основе планетарных прецессионных передач с многопарным зацеплением, которые были разработаны авторами. Абсолютная многопарность зацепления (до 100% пар зубьев одновременно участвуют в зацеплении в сравнении с 5% -7% - в классических зубчатых передачах) обеспечивает повышенную нагрузочную способность и небольшие массу и габариты. В статье представлены теоретические аспекты изготовления зубчатых колес с нестандартным профилем зубьев.

Гуцу М. **Анализ лопасти из композитного материала для малых ветровых турбин с использованием конечно-элементной модели.** Статья представляет окончательный дизайн лопасти из полиэстера армированного стекловолокном (ВРП) для малых ветровых турбин, разработанный в Техническом университете Молдовы методом конечно-элементного анализа (FE). Рассматриваемые проектные параметры связаны с параметрами композитного материала: направление волокон, направление слоев и толщина оболочки лопасти на основе количества композитных слоев. В качестве ограничений взяты деформации конечной части лопасти, допустимые напряжения и резонансные вибрации лопасти. По результатам конечно-элементного анализа оптимизированная лопасть будет достаточно жесткой в штормовых условиях, будет работать в зоне опасных резонансных частот и будет весить примерно на 20% меньше.

Ливинц Г., Лукаке Д.Д., Дэнилэ Е. **Об управлении магнитной подвеской маховика.** Работа посвящена синтезу полиноминального контроллера RST для обеспечения стабильности системы хранения энергии с маховиком. Поведение системы анализировано на базе изменения конструктивных параметров и возмущений, используя программы моделирования.

Пую Л., Ягару К.П., Пую В., Нямцу Фл.Б. **Оценки путем измерения удовлетворенности потребителя.** Эта работа намерена поддерживать тот факт, что процесс измерения удовлетворенности потребителя, осуществляется в объективной и корректной форме, может предложить необходимые данные и информацию, чтобы сделать совместимыми, в рамках процесса, всех участвующих сторон. Это приведет к устойчивому значению для потребителя и широкого участия собственных сотрудников и партнеров в оценке добавленной стоимости.

Доготару С., Урсу М. **Некоторые взгляды на процесс управления жилыми домами.** Настоящая работа выполнена с целью анализа состояния дел по управлению жилищного фонда, в частности многоквартирных жилых домов. В результате приватизации жилищного фонда, в следствии некоторых пробелов в законодательстве, многоквартирные жилые дома управляются муниципальными предприятиями, несмотря на то что почти весь жилой фонд является в частной собственности. Содержание и ремонт жилых домов муниципальными предприятиями выполняется неудовлетворительно, собственники же почти полностью отстранены от процесса управления. Авторы выявляют проблемы, характерные для данного сегмента деятельности и приводят ряд предложений которые могут способствовать развитию управления в жилищном секторе.

SOME KEY ELEMENTS FOR A BETTER RELIABILITY OF ELECTRONIC DEVICES, AND CONSUMER SATISFACTION

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1. INTRODUCTION

Reliability is one of the major attributes that define the choice of electronic components for safety-critical applications. Studying the reliability of electronic components is a natural tendency of human beings in the aim to prolong the life of a technical system on the world market; a company that manufactures electronic systems is trying to get the largest share of the market. For reaching this goal, in the design of reliable equipment, a good selection of the components to be used must be performed, with special focus on reliability issues, in order to minimize any failure risk. That is why it is recommended to study the reliability of electronic components as a necessity for obtaining a reliable system, which could be easily sold on the market [1].

Today, most of the companies understand that the reliability must be built in at the design phase and, then, monitored during the whole manufacturing process. *Reliability building* means the totality of techniques and procedures having the goal to ensure a foreseen reliability level for a given product. This concept is linked with *reliability assessing*, which cover the whole evaluation system aiming to find out and record, during and after the manufacturing process, the reliability level of the batch of products. This evaluation system contains tests, electrical measurements, failure analysis and statistical processing of data [2].

According to reliability building rules, the reliability issues must be taken into account even at the design of the process / product, the so-called design for reliability (DfR), and also during the manufacturing, by monitoring the process reliability. A special attention must be given to the selection of most reliable items from a batch of products, which could be made by screening or by burn-in.

Nearly every week, every day, we learn of another company that has failed; and this rate of failure will increase, while profit margins are shrinking, and information highway is changing the way consumers make buying decision. These changes have made it easier for consumers to choose the best product for their individual needs; they can now determine their product needs at any place, anytime, and for the best price. The information age allows today's consumer to research an entire market efficiently at any time and with little effort; conventional shopping is being replaced by "smart" shopping. A big part of smart shopping is getting the best product for the best price.

Manufacturers who did not participate in the quality revolution of the last decades were replaced by those that did. They went out of business because the companies with high-quality systems were producing products at a lower cost. Today, consumers demand products that not only meet their individual needs, but also meet these needs over time.

Reliability engineering should be an integral part in product and system development. Reliability engineering technology means all of the activities are necessary to assure that the product is safe to use, is appropriately designed and manufactured for ease of usage, is reliable in every day application, is durable over the expected useful life, and is producible at minimum cost. Reliability predictions, based on handbooks or similar approaches, are historically highly inaccurate and can lead to very poor design decisions. The design team is fully aware of the importance of high reliability, and reliability is given a high priority.

In many cases, significant improvements in reliability can be achieved at minimal cost, especially when reliability improvement is addressed as part of the design process. Without knowing the environment that a given component will see, or at least some reasonable bounds for the usage environment, a design team cannot be confident that a given component will be reliable. The manufacturer conducts early testing that is specifically designed to precipitate failures so that the design can be improved early in the program. The manufacturer conducts highly accelerated life testing and highly accelerated stress screening. These tests should be conducted with specific failure mechanisms in mind. Corrective actions need to be identified and implemented. The manufacturer uses reliability engineering and management tools like Failure Modes and Effects

Analysis (FMEA) and Reliability Growth. It is critical that these tools and analyses be directly linked to the design team.

Reliability improvement is a major goal in many applications. Accelerated life testing is a well known technique for reliability improvement of electronic systems. The reliability of a system is affected by the reliability of its components and the way they are interconnected to serve its intended mission under certain operating conditions. Failure of components due to fatigue crack growth is a major problem in industry. The failure process initiates with the presence of small cracks which can cause catastrophic fracture or slow crack growth. When treating a problem of this type, many aspects of the problem should be treated as random variables. The probabilistic finite element method (PFEM) has been shown to be a practical approach for solving problems of this type.

The reliability of an electronic system is a function of the reliability of its subsystems. The board on which the components are assembled is more important that these since its reliability seriously affect the reliability of the overall system. The reliability of the manufactured printed circuit board (PCB) is a function of both the reliability of the components used on the board itself. Many designers forget the importance of the underlying board in the reliability of the overall electronic system.

The inclusion of redundancy to a system to increase its reliability is expensive in weight and size as well as cost. At the same time operating costs decrease, as component reliability is increased, through savings in warranty costs, repairs, maintenance, shut down due to failure and restart time. An investigation into design improvements to unreliable components is likely to show that there is an overlap between the normal capability distribution curve of a particular item and its duty distribution (e.g. component strength capability and applied load distribution). To effect an improvement requires a safety margin between the two curves.

There are several ways in which designers can assist in improving the reliability and lengthen the life of products. These methods are discussed in the following sections.

2. EFFECTS OF ENVIRONMENT

The most important environmental components with respect to degradation of electronic devices are particles and water vapour.

Optoelectronics are playing increasingly important role in communications. Cost increasing bandwidth demand, and reliability are some of the reasons for the importance of optoelectronics in communication. The internet explosion, e-commerce, and the increasing data networks will continue this drive.

The reliability of most electronics is established by performing various accelerated life tests. These tests generally provide stresses that are much higher than those to be experienced in service. The purpose of these tests is to cause the component to fail, thereby identifying the weakest failure mode. The same mode of failure and the failure mechanism must be carefully characterized and observed at all the test conditions. Any deviation in the failure mode with change in stress conditions is an indication that the test may not be valid in predicting the failure at use condition.

For most electronics, these accelerated tests conditions are generally linked to the junction temperature. Hence, these components and the mechanisms that cause their failures are assumed to be thermally activated. It is also important to state that the mode of failure must not be confused with the failure mechanism.

The devices are tested at increasing time intervals; failed units are removed from test and failure analysis is performed. Cross-sectional analysis of the failed devices is performed. Scanning electron microscopy (SEM) and energy dispersive x-ray spectroscopy (EDS) are used to characterize the various interfaces. Surface sensitive Auger electron microscopy (AES) and x-ray photoelectron spectrometry / spectroscopy (XPS) are not successful in characterizing the interface to the silver epoxy.

In some instances, failed devices are revived by scratching the aluminium pad to the epoxy bleed out left behind a lot of epoxy that was difficult to sputter through, even after 24 hours, for AES or XPS analysis.

The main population failures are quite different from the weak population. Although the failure rate is decreasing in this population, it is temperature dependent.

At higher temperatures, the change in shape factor indicates that probably different degradation mechanisms are present. If the main population continues to fail at decreasing failure rates, this suggests that oxidants are being generated within the package to sustain oxide growth and cause failure.

If the failures observed within the screened population supports the assertion that at high

temperatures, oxidants are being generated within the package, this proves the hypothesis. These oxidants cause aluminium oxidation and oxide growth. The oxidants are probably generated due to epoxy degradation.

Although the epoxy is cured at temperatures in excess of 110°C prior to package sealing, some of the reaction products might still be trapped within cured mass. These reaction products that are generally oxidants and high in water content subsequently outgas within the sealed package, cause device failure. Changing the metallization from the reactive aluminium to a noble element like gold can eliminate this failure mode and the associated mechanisms.

The degradation of the devices indicates that there are two distinct populations. One population is weak and fails quickly; the other, the main population, is more resistant to the degradation. The weak population is a small fraction of the total population.

A reliability model indicates that the weak population can be effectively screened from the total population.

3. ROBUST DESIGN

Robust design methodology comes a great way in improving engineering productivity. The customer satisfaction can be ensured when one considers the cost of failure of a product along with the noise factors such as environmental variation, manufacturing variation, and component deterioration. Robust design has proven to be very effective for improving quality, manufacturability, and reliability of products and processes at low cost, and simultaneously reducing development interval. Since the introduction by Taguchi [3] in the 1990s, the method has resulted in significant quality improvement in many industries.

Taguchi methods to robust design focus on the principles of producing higher quality goods faster and cheaper, with more consumer satisfaction. The idea is to develop a family of products or processes that are optimized so in the future all that is required is proper scale-up. These approaches use non-standard statistical analyses with a novel methodology to approach manufacturing processes, which can be applied in numerous ways.

The main principles behind the Taguchi method for robust design are: *(i)* Robustness is first, adjusting average to meet the target is last. *(ii)* To improve product quality, and product reliability[1], parameter design is first, tolerance design is last.

This "two-step" optimization technique utilizes the idea that improving the functionality of a process will reduce the variability, thus resulting in more precise control of the product quality. To incorporate the Taguchi method into product improvement engineering, three design criteria must be considered: (a) *System Design* - Development of a system to meet a defined objective. (b) *Parameter Design* - Selection and optimization of controllable parameters within the system. (c) *Tolerance Design* - Determination of limitations in variability for each parameter.

The most important advantages of robust design include providing a simple and systematic framework for identifying critical characteristics in products or systems, and achieving best quality and reliability characteristics while minimizing the variation and cost.

To maximize robustness engineers improve the intended function of the product and increase their noise to factors which can lead to a decrease in performance. Engineers can simplify their designs and the process to reduce the cost [4]. Results: *(i)* Improvement through quality, reliability, and durability. *(ii)* Manufacturing cost reduction. *(iii)* Design cycle time reduction. *(iv)* New knowledge.
Assuring quality, reliability, and safety is an integral part of product development. But companies often address product quality to late using disjoint processes with inadequate cross-functional communication. Non managing quality and reliability in an integrated way throughout the product lifecycle (Figure 1) is costly to companies, both in profitability and reputation.

Robust design is a very powerful tool to use during product development to minimize the sensitivity of the product performance to variations in the manufacturing condition and the variations in the environment the product is used. Robust design has been proved to be a very good tool to mitigate the sources of variation in the product development.

[1] Product reliability is quantified as MTBF for repairable product and MTTF for non-repairable product. As the product matures, the weaker units fail, the failure rate becomes nearly constant, and products have entered what is considered the normal life period. As components begin to fatigue or wear out, failures occur at increasing rates. Wearout in industrial electronic devices is usually caused by the breakdown of electrical components that are subject to physical wear and electrical and thermal stress. It is this area that the MTBF calculated in the useful life period no longer apply. A product with an MTBF of ten years can still exhibit wearout in two years.

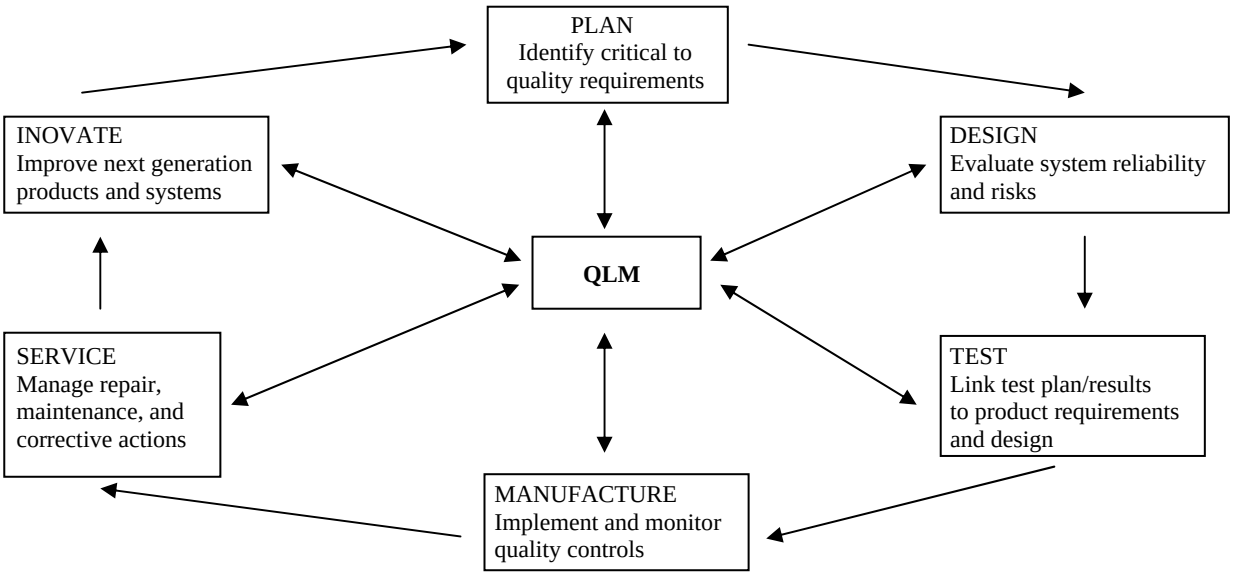

Figure 1. Quality lifecycle management (QLM) unites the quality-related activities of each stage in the product lifecycle through a single database platform (After [3]).

4. DESIGN FOR RELIABILITY (DfR)

Design for reliability aims to understand, identify and prevent underlying failures even before the devices are build. In developing the design for the products, the following characteristics are usually missed: *(a)* key failure modes and failure rate of the product, *(b)* key failure mechanisms that may be present in the service environment, *(c)* usable life of the product, *(d)* cost of maintenance required to maintain the inherent reliability, *(e)* availability, and *(f)* rigorous testing (Design for reliability and quality). This relatively new concept is an important step in building the reliability of a product or of a component (with other words, to achieve the built-in reliability), being linked with the concept called concurrent engineering (CE). CE is a feature that ensures the design is not completed before reliability requirements are identified and dealt with. Basically, the DfR consists of the following two elements:

a) A collection of design rules for making an electronic component reliable, not only electronically, but also mechanically and visually. The design rules have to be continuously updated, to reflect the best practices ensuring the maximum component reliability. *Robust design* and *thermal design* produce the major part of these rules.

b) Predictive methods able to asses the reliability of the future device, based on design data and on models describing the time and stress behaviour of similar products. An example of predictive method based on fuzzy logic, applied for the manufacturing of electronic components, is given in [5a].

The component reliability is influenced by the materials, the concept and the manufacture process, but strongly depends on the taking over input control conditions, so not only the component manufacturer, but also the equipment manufacturer may contribute to the reliability growth of the equipment. If the failure rate of the equipment is constant during the real life, this is a consequence of a good component selection during the manufacturing process. The choice of components makes the product.

The DfR approach starts with capturing the customer voice, translated in an engineering function [5b]. Then, a design immune to the action of perturbing factors must be created, and this can be done with the Taguchi methods. This means: *(i)* to develop a metric capturing the function while anticipating possible deviations downstream, and *(ii)* to design a product that ensures the stability of the metric in the presence of deviation. Finally, the design team must use reliable prediction methods. In principle, DfR means to pass from evaluate and repair to anticipate and design.

In recent years, several approaches to integrate robust design [6 - 11] have been proposed. The reliability-based design optimization (RBDO) is a method to achieve the confidence in product reliability at a given probabilistic level, while the robust design optimization (RDO) is a method to improve the product quality by minimizing

variability of the output performance function. Since both design methods make use of uncertainties in design variables (and other parameters), the two different methodologies have been integrated to develop a reliability-based robust design optimization (RBRDO) method [12].

Physics of failure (PoF) is a key approach of implementing DfR in a product design and development process. PoF is knowledge of how things fail, and the root causes of failures. On the other hand, the PoF approach can be time intensive and not always definitive (limited insight into performance during operating life) [13].

A multi-objective framework for reliability-based robust design optimization was proposed, which captures degradation behaviour of quality characteristics to provide optimal design parameters [14]. The objective function of the multi-objective optimization problem is defined as quality loss function considering both desirable and undesirable deviations between target values and the actual results. The degradation behaviour is captured by using empirical model to estimate amount of degradation accumulated in time *t*.

5. PROCESS RELIABILITY

The reliability of a product depends directly on the quality of the manufacturing process. Once established, this quality must be kept at the same level during all the period of product fabrication, this feature being covered by the term process reliability. Process reliability is a method for identifying problems, which have significant cost reduction opportunities for improvements. Very often the problems have roots in the operations area [15].

In order to ensure appropriate process reliability, the following elements must be taken into account:

- Wafer-level reliability (WLR), notion which covers all the activities focused on achieving a reliability goal for the wafer: quality of the equipment, materials and environment, synergy of the technological factors, test structures for monitoring the reliability level, and so forth;
- Reliability-driven assembly process, meaning an assembly process which has sufficient tight controls where the reliability level is adequately monitored.

Device traceability (DT) and statistical process control (SPC) must be ensured during the previous two technological steps.

6. ENVIRONMENTAL STRESS SCREENING (ESS)

ESS is a process in which environmental stimuli, such as rapid thermal cycling and random vibration, are applied to electronic devices in order to precipitate latent defects to early failure. An equally important and inseparable aspect of the screening process is the devices electrical testing that is done as part of the screen, so as to detect and properly identify the defects that have been precipitated to failure.

Contrary to popular belief, ESS does not increase the inherent reliability of a product. The inherent reliability of a product is driven primarily by the design. ESS is not a substitute for, but an integral part of a sound reliability program conducted during the design and development phases.

Changes in manufacturing techniques may eliminate some latent defects and introduce new ones. To remain effective, the ESS program must evolve.

7. RELIABILITY CENTRED MAINTENANCE (RCM)

RCM focuses on preserving system functions by identifying, characterizing, and prioritizing the failure modes that can cause functional failures. As described by Mubray [16], the application of RCM is associated with the application of seven basic steps: *(i)* Identification of functions and their associated desired performance standards; *(ii)* Definition of functional failure; *(iii)* Identification of failure modes; *(iv)* Documentation of the effects of failure; *(v)* Quantification of failure; *(vi)* Analysis of functions, functional failures, failure modes, and their criticality to identify opportunities for improving performance or safety; *(vii)* Establishment of maintenance tasks.

Once the described methodology is applied, the desired optimization of maintenance of system is achieved, and the following too achieved: greater safety and environmental integrity; longer useful life of equipment, optimal spare parts inventory and a comprehensive database of failure modes and actions to prevent them.

8. A NEW HYBRID METHODOLOGY

The paper [17] presents a hybrid methodology for conceptual design of large systems with the goal of enhancing system reliability. It integrates the feature of several design methodologies and maintenance planning concepts with the traditional reliability analysis, characterized by technical improvements, higher reliability, and customer satisfaction at the minimum cost. By bringing the reliability early in the conceptual design stage, higher reliability and lower cost can be achieved.

9. NANOTECHNOLOGIES

Research and development pursue the further miniaturization of devices; the integration of semiconductor electronic devices with various materials and functions is essential for the sustainable development of microelectronics in the future. The "more than Moore" approach is aimed at the development of semiconductor electronic devices by the diversification of functions and the improvement of the performance of systems by the introduction of new technologies, such as MEMS technology.

Recent technologies that realize low power consumption using new materials and structures rather then by miniaturization are sometimes classified as "more than Moore" technologies. In contrast, "beyond CMOS" refers to approaches used to create devices that exhibit performance exceeding that of CMOS on the basis of different principles from those of CMOS. "Beyond CMOS" includes the approach of information processing using the degree of freedom other than electric charges (Figure 2).

10. NANOMATERIALS

In recent years nanomaterials have attracted increasing amounts of attention based on their novel electronic, mechanical, chemical, and quantum confinement effects. In particular, carbon nanomaterials such as fullerenes, nanotubes and graphene have been the focus of intense attention due to their exceptional electronic and mechanical properties. However, aside from the diverse suite of highly attractive properties of these materials it has become increasingly apparent that in order to successfully utilise these materials in real-world technological applications, novel integration strategies between the nano and the macroscopic world will be critical to their application. In order to do this, the chemical functionalisation and thus compatibilisation of nanomaterials has been identified as a principle strategy towards this goal.

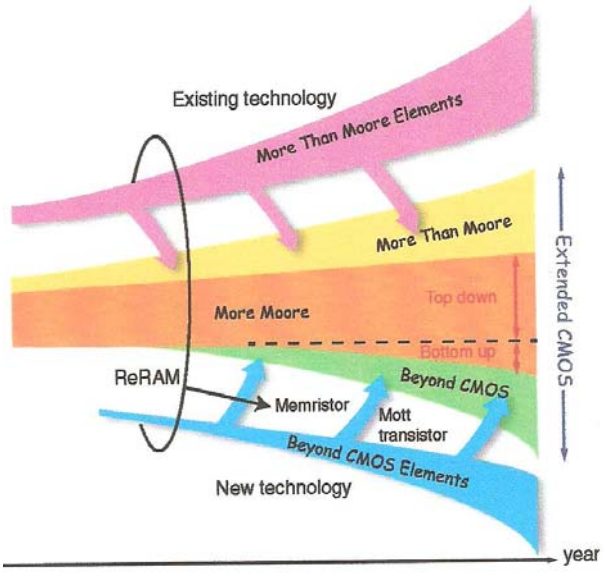

Figure 2. Relationship among three research directions of "more Moore", "more than Moore", and "beyond CMOS" (After [19]). The device technologies based on "more than Moore" and "beyond CMOS" are accelerating the research and development of device technologies based on "More Moore", expanding the range of applications of CMOSs.

Research activities concerning carbon nanotubes and their chemical functionalisation have begun, in order to facilitate self-assembly with nanoparticle materials. This strategy was highlighted as a viable means to directly control the assembly of hybrid nanomaterials. It was followed the presentation of research concerning graphene and graphene oxide and the strategies of doping and chemical functionalisation in the context of electronic devices and mechanical composites. Following the enormous interest in 1D and 2D carbon nanomaterials, alternative materials have received much attention on account their electronic, mechanical and optical properties. The surface functionalisation of these novel nanotube and nanosheet materials is introduced and discussed in the context of their utilisation as electronic devices and their application as substrates, dopant, dielectric, and barrier layers for electronic devices.

11. NANOPACKAGING

We touch on two important measurement topics: evaluation of coating protection and measuring the performance of high temperature interconnects. Ranges of coating materials are now available with varied properties that can be selected for specific applications. The protection can be measured using Surface Insulation Resistance (SIR) testing; the results highlight the importance of coverage. Another key performance indication is the adhesion strength of the coating to the substrate, and a newly developed test method, where the adhesion challenges lie. Finally, measuring the whisker mitigation potential by coatings has a great importance.

There increasingly is a desire to place electronics in high temperature environments, down well applications for example. Sintered silver joints once formed with their high melting point offer an attractive solution to the interconnect issue. To date sintered silver is not offered as an interconnect solution for surface mount assembly, but have found applications in high power semiconductors. The mechanical performance and the fatigue properties of these interconnect can be measured.

12. QUALITY AND RELIABILITY IS AT RISK

Advance technology development and wide use of the World Wide Web have made it possible for new product development organizations to access multi-sources of data-related customer complaints. However, the number of customer plaints of highly innovative consumer electronic products is still increasing; that is, product quality and reliability is at risk. The paper [20] aims to understand why existing solutions from literature as well as from industry to deal with these increasingly complex multiple data sources are not able to manage product quality and reliability. Three case studies in industry are discussed. On the basis of the case study results, this paper also identifies a new research agenda that is needed to improve product quality and reliability under this circumstance.

13. CONCLUSIONS

There are many problems and challenges which must be overcome during the implementation phase of all projects. Some are overcome with engineering redesign and hard work, while others require more investment by the manufacturer.

Altering the layout of a printed circuit board (PCB), reducing the number of electronic components in a device, or choosing a capacitor with a different base material are all methods of tackling the critical issue of improving product reliability. Self regenerating systems offer an opportunity to increase life and reliability of products, with an additional benefit of an extension in the period between overhauls. Usually there will be a higher initial cost, due to greater complexity in a design that incorporates regeneration arrangements; normally this can only be justified if there is likely to be an overall saving due to reduced operating costs. One exception might be where extremely high reliability and long life are vital criteria.

It is important to recognise the value of overload protection as a method of enhancing life and reliability, especially now that electronic sensors, possibly coupled with micro-computer control, offer rapid response; the cost of an electronic protection system is unlikely to be a constraint.

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REGARDING TO THERMOMECANICS OF IRREVERIBLE PROCESSES

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INTRODUCTION

Deformable solid is a thermodynamic system, which can receive or yield to environment the mechanical work, electrical or magnetical tasks, heat, etc. The state of deformable solid is reflected with the help of thermodynamic variables, such as temperature and spherical tensor. Knowledge of thermodynamic variables equates to recognize the currents state of the deformable solid.

In this paper we study in detail the influence of thermodynamic variables: the stress tensor and temperature, on the thermodynamic processes which occur in the solid under action of exterior forces.

In this way we obtain passage from the formulation of principles of thermodynamics in global variables to local variables.
Through local variables may be described under a unitary form all inhomogeneous thermodynamic processes.

1. THE FIRST PRICIPLE OF THERMODYNAMICS

Mechanical Power of surface and volume forces which acted upon C' in current configuration (K) at t moment $t \in [t_0, t_n]$ is given by relationship

$$P = \int_{A'} \vec{t}\vec{u}dA + \int_{v'} \rho\vec{b}\vec{u}dv,$$

$$\vec{u} = \frac{d}{dt}(\vec{u}), \qquad (1)$$

Integrals are taken in current configuration (K).

The caloric power obtained by C' can be written by form

$$Q = \int_{A'} c_i n_i dA + \int_{V'} \rho z dV, \qquad (2)$$

where $c_i \in c_i(x_1, x_2, x_3, t)$ is amount of heat received by C' thought conduction per unit area of his boundaries, but $z \in z(x_1, x_2, x_3, t)$ is quantity of heat received by C' thought radiation per unite of mass and time.

The experience shows, that for all thermodynamic processes which bind the initial state at t_1 moment a final state at t_2 moment, where $t_1, t_2 \in [t_0, t_M]$, integral

$$\int_{t_1}^{t_2} (P + Q)dt \qquad (3)$$

has the same value, than integrals $\int_{t_1}^{t_2} Pdt$ and $\int_{t_1}^{t_2} Qdt$ depend in general not by only states of system at t_1 and t_2 moments but the thermodynamics processes which linking them. Plus, is found that (3) integral is proportional with system mass, if this system is homogeneous.

These experimental results involve the existence of some variable of extensive state, called the total system energy, which satisfies the equation

$$\dot{E} = P + Q. \qquad (4)$$

The relationship (4) is called the energy balance equation, represents the math express of the first thermodynamic principles.

The difference

$$U = E - K \qquad (5)$$

between total energy of system and his kinetic energy

$$K = \frac{1}{2}\int_V \rho \dot{u}_i \dot{u}_i dV \qquad (6)$$

Is called the internal energy. As *E* and *K* are extensive variables, *U* should be the same extensive variables, and we can write

$$V = \int_V \rho e v V\,, \qquad (7)$$

where *e* is internal energy intensity per unit mass.

Introducing (1), (2) şi (5) - (7) în (4) obtain

$$\frac{d}{dt}\int_V \left(\frac{1}{2}\dot{u}_i\dot{u}_i + e\right)\rho dV =$$

$$= \int_A \left(t_j^{(\vec{n})}u_j + c_i n_i\right)dA +$$

$$+ \int_V \rho\left(b_j\dot{u}_j + z\right)dV\,. \qquad (8)$$

One the other hand, from

$$t_i^{(\vec{n})} = t_{ij}n_j\,, \quad n_j = cos(\vec{n},\vec{e}_j)$$

we obtain

$$\vec{t}\vec{u} = t_i^{(\vec{n})}\dot{u}_i = t_{ij}n_j\dot{u}_i\,. \qquad (9)$$

Substituting (9) in (8) and taking into account the equality

$$\frac{d}{dt}\int_V \left(\frac{1}{2}\dot{u}_i\dot{u}_i + e\right)\rho dV =$$

$$= \int_V \left(\frac{1}{2}\dot{u}_i\ddot{u}_i + \dot{e}\right)\rho dV$$

obtain

$$\int_V \dot{e}\rho dV = \int_A \left(t_{ij}n_j\dot{u}_i + c_i n_i\right)dA +$$
$$+ \int_V \left[\rho\left(b_i - \ddot{u}_i\right)\dot{u}_i + z\right]dV \qquad (10)$$

Using in this relation the Gauss-Ostrogradski relation

$$\int_A t_{ij}n_j dA = \int_V \frac{\partial t_{ij}}{\partial x_j}dV = \int_V t_{ij,j}dV$$

will transform the surface integrals in volume integrals.

$$\int_A \left(t_{ij}\dot{u}_i\right)n_j dA = \int_V \left(t_{ij}\dot{u}_i\right)_{,j}dV =$$

$$= \int_V \left[t_{ij,j}\dot{u}_i + t_{ij}(\dot{u}_i)_{,j}\right]dV$$

$$\int_A c_i n_i dA = \int_V c_{i,i}dV\,.$$

Consequently we obtain

$$\int_V \dot{e}\rho dV = \int_V \left(t_{ij.j} + \rho b_i - \rho\ddot{u}_i\right)dV +$$
$$+ \int_V t_{ij.j}\left(\dot{u}_i\right)_{,j}dV + \int_V \left(c_{i,i} + z\right)dV \qquad (11)$$

Taking into account in this relationship the equation of motion of continuum

$$t_{ij,j} + \rho b_i = \rho\ddot{u}_i$$

and that any tensor can be decomposed in symmetric and antisymmetric components

$$\left(\dot{u}_i\right)_{,j} = \dot{u}_{ij} + \dot{\varpi}_{ij}\,,$$

$$\dot{u}_{ij} = \frac{1}{2}\left[\left(\dot{u}_i\right)_{,j} + \left(\dot{u}_j\right)_{,i}\right],$$

$$\dot{\varpi}_{ij} = \frac{1}{2}\left[\left(\dot{u}_i\right)_{,j} - \left(\dot{u}_j\right)_{,i}\right]$$

will find

$$\int_V t_{ij,j}\left(\dot{u}_{i,j} + \dot{\varpi}_{ij}\right)dV = \int_V t_{ij}u_{ij}dV\,,$$

$$t_{ij}\dot{\varpi}_{ij} = 0 \qquad t_{ij}\dot{\varpi}_{ij} = 0\,. \qquad (12)$$

Replacing the past relationships in (11) and observing that sub domain is arbitrary, obtain

$$\dot{e}\rho = t_{ij}u_{ij} - c_{i,i} + z\,,$$

$$q = -c_{i,i} + r\,. \qquad (13)$$

The last relation expressed the local shape of balance equation of energy. We notice that the first thermodynamic principle allow establish of mechanic equivalent of heat, so, from dimension point of view, will have $[calorie] = ML^2T^2$.

2. THE SECOND THERMODYNAMIC PRINCIPLES

The first principle of thermodynamic can be interpreted like a possibility of transformation of mechanical work in heat and mutual with a single condition, that the total energy of system remain the same. That way this principle does not require no one restriction on evaluation meaning of thermodynamic processes. Contrary, the second thermodynamic principle has introduced the discrimination between reversible and irreversible processes. The passing criterion of system from reversible state in irreversible is contained the second thermodynamic principle, which operates with two new definitions temperatures T and entropy S. Is supposed, that in each t moment exists one scalar field $T = T(x_1, x_2, x_3)$ determined in each point of deformable solid. Size T is called the absolute temperature of material particle M, which in t moment is in (x_1, x_2, x_3) point. The absolute temperature T has never had the negative values. The unite of thermodynamic temperature is taken by Kelvin. This new value can't be related in natural way with fundamental units of mass, length and time.

After Clausius for any process exists a state extensive variable S called entropy. dS variation of this state function will consist from dS_e variation thanks interaction with rest of the universe and from dS_i variation thanks to phenomena which have place in interior of system

$$dS = dS_i + dS_e \qquad (14)$$

Allowed, that dS_e variation is given by

$$\rho dS_e = \frac{dq}{T}\,, \qquad (15)$$

but dS_i of

$$\rho dS_i = \frac{d\varpi}{T}\,, \qquad d\varpi \geq 0\,, \qquad (17)$$

equality taking place in case of reversible processes, in case of inequality, the process is irreversible. From (16) – (18) results that

$$\rho T\dot{S} = q + \dot{\varpi}\,, \qquad \dot{\omega} \geq 0\,, \qquad (18)$$

These relationships represent the second thermodynamic principles. An another form of this inequality, convenient for applications, can be obtained taking into account the local form (13) of the first principle. Than result

$$\dot{e} = T\dot{S} + \dot{\varpi}_r\,, \qquad (19)$$

where

$$\dot{\varpi}_r = \frac{1}{\rho}\left(t_{ij}\dot{u}_{ij} - \dot{\varpi}\right) \qquad (20)$$

The second thermodynamic principle can be obtained starting from different assumptions of physic nature. So, Clausius reach to this result starting from another idea: is impossible that one consequently of one string of changes suffering to one system to decrease to complete transformation of one quantity of heat to mechanic work. Caratheodory used the more general hypothesis, he admitted that is impossible to reach to all thermodynamic states near the initial arbitrary state through one adiabatic process $(dQ = 0)$. The thermodynamic processes for them $T = const.$, so $dT = 0$, is called isothermal, in case of one reversible isothermal process dQ is a total exact differential.

Both S entropy and U intern energy are sizes which can't be calculation than making an abstraction of additive constant S_0, respective ε_0, in practice this thing is sufficient, because these constants disappeared from calculus. Actually, S_0 constant can be determined by means of Nernst theorem, which stated that at zero temperature entropy S is equal with zero.

One thermodynamic process, for which entropy is constant, $dS = 0$ is called isothermal, the second thermodynamic principle is showed us

that reversible and adiabatic processes are isentropice.

3. CONCLUSIONS

Was obtained the local expresses of thermodynamic irreversible processes, expressed by thermodynamic variables the stress tensor and temperature.

Starting with general thermodynamic principles the structure of relation between strain tensor and gradient of displacement was defined, in function of way of define the stress tensor.

In this way was demonstrated, that the definition of strain tensor can't be defined in independent way.

So, synthesis of mechanical and thermo dynamical principles is necessary not only at stage of constructing of governing equations and at stage of elaboration of geometric relations.

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ASSESSMENT OF WIND ENERGY RESOURCE OF MOLDOVA

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1. LEGAL AND INSTITUTIONAL FRAMEWORK IN MOLDOVA'S RENEWABLE ENERGY SECTOR

The energy sector in Moldova faces several problems: strong dependence on the import of natural gas, oil and oil products, outdated technology for the generation and distribution of electricity. According to official statistics in 2012 gross domestic energy consumption amounted to 2145 ktoe, of which 94% was imported. Natural gas is exclusively imported from Russia and is the main fuel for electricity generation and district heating. The electricity produced locally (about 20%) is insufficient and the excess demand is compensated by imports from Transnistria (this territory is not under the control of Moldovan authorities) and Ukraine [1].

Through the Energy Strategy, adopted in 2007 (new version was adopted on February 5, 2013), Moldova has addressed, for the first time in its history, to the use of renewable energy as a viable alternative to compensate the lack of indigenous energy resources. The major piece of primary legislation in the Renewable Energy domain is the Law on Renewable Energy Sources (RES) approved in 2007. Both documents set an ambitious goal: to increase the proportion of RES in the domestic energy mix to 20 % by 2020. The last document in the area of RES - National Renewable Energy Action Plan (NREAP), was approved on 27 December 2013. NREAP is a key document of Moldova's energy policy to promote the use of RES to achieve key strategic objectives of enhancing energy security, long-term development in terms of environmental protection and climate change mitigation. NREAP defines sectorial targets to achieve 20 % of energy from RES by 2020, and establishes legislative action, regulatory and administrative provisions necessary to achieve these objectives [2].

According NREAP, renewable electricity will be produced mainly from wind and by 2020 is necessary about 400 MW wind capacity. At the same time we must answer to the question – does wind potential exist in Moldova? The European Bank for Reconstruction and Development commissioned in 2004 a study concerning the wind potential of the Eastern European Countries, including Moldova. The wind energy potential assessment was based on previous estimates for the USSR in a 1989. According to this study of Moldova's wind technical potential does not exceed 500 MW [3].

In this paper an attempt is made to assess the Moldova's wind energy potential using contemporary software, topographical input data, historical wind data from State Hydrometeorological Service and field measurements conducted during 2002-2003 and 2010-2013 at heights of 30-70 m above the ground level.

2. APPLICABILITY OF THE WIND ATLAS METHOD IN GEOGRAPHY AND CLIMATIC CONDITIONS OF MOLDOVA

2.1. Briefly about the geography and climate of Moldova

Moldova is a republic situated in south-eastern Europe, between two countries: Romania and Ukraine. The area of this small country is about 0,3 percent of the total area of the European space and is 33 844 km2. Moldova belongs to the former Soviet Union. Its independence was proclaimed on August 27, 1991.

The relief of Moldova is a hilly plain, having a slope from northwest to southeast with an average height above sea of 147 m, Figure 1. The northern landscape of Moldova is characterized by gently rolling of the Dniester Hills (up to 300 in elevation) interlaced with small flat plains in the valleys of the numerous creeks (at 150 m). These hills have an average altitude of 240 meters and a maximum altitude of 320 meters. The Central Plateau, at an average elevation of about 350 to 400 m, is interlaced by flat valleys, and scoured depressions. Steep forest-clad slopes account for much of the terrain. There is the country's highest point, Balanesti Hill, which reaches about 425 m. In the south along the left side of the Prut river are situated

the Tigheci Hills (average 200 m, maximum 301 m).

Moldova's climate is moderately continental, with some modification of conditions by the Black Sea. The summers are warm and long, with temperatures averaging between 20°C and 25°C, but can sometimes reach 40°C during heat waves. The winters are moderately cold and dry, with daytime January temperatures between -4°C and -7°C, and minima often far below -10°C.

Moldova is influenced by two major climatic factors [4] during the warm season - the Azorean anticyclone, in the cold season - the Siberian anticyclone. Wind regime is formed under the action of two pressure centers stationed over the North Atlantic and Eurasian, and is characterized by the dominance of two contrary wind directions: north - west and south - east. This explains the relatively high proportion of winds from the north - west (25-35 % annually) and from the south - east (15-25 %).

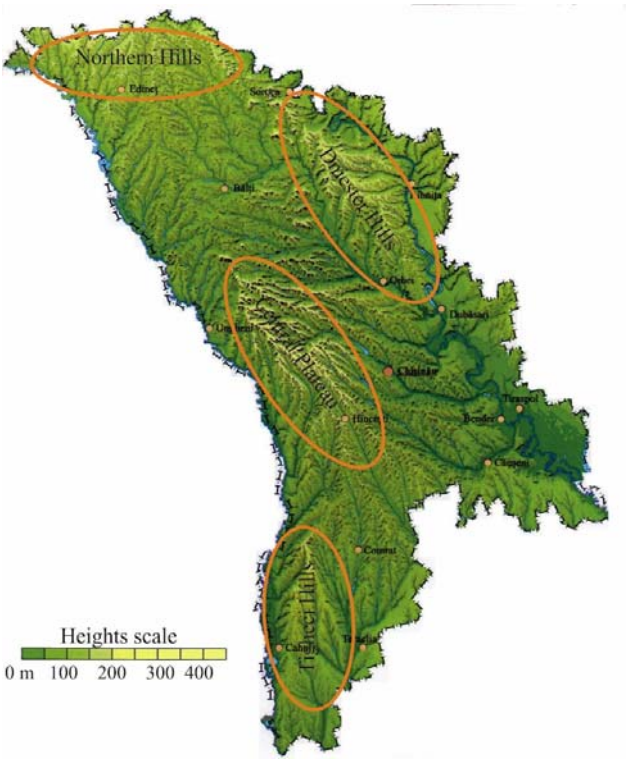


Figure 1. Moldova's relief.

2.2. Wind Atlas Method: applicability to topography of Moldova

For this study we use the Wind Atlas Method [5] and Wind Atlas Analysis and Application Program (WAsP) [6]. The Wind Atlas Method is developed for various wind applications ranging from wind analysis to siting of wind turbines and calculating power production. It was introduced in 1989 by Risø National Laboratory in Denmark and has since then become an industry standard for wind resource assessments.

The WAsP transforms wind data from existing meteorological masts to describe the wind's proprieties at specific sites within a radius of up to 100 km.

WAsP contains models for the vertical extrapolation of wind data taking into account sheltering of obstacles, surface roughness changes and terrain height variations. These models are used twice in the process of predicting the wind resource at a site from wind measurements at a different site. At first step, named Wind Atlas analysis model, the regional wind climatology is calculated from a measured time series of wind speed and direction, i.e. wind speed distributions for 12 directional sectors for the geostrophic wind are calculated. It is then assumed that the geostrophic wind climate is representative also for the predicted site. At second step, named Wind Atlas application model, the WAsP are then used to predict the wind resource for the prediction site from the wind climatology calculated in the first step. The output consists of predictions of mean wind speed, wind power density, Weibull wind speed distributions in 12 directional sectors and turbine power output.

Accurate predictions using the WAsP package may be obtained if both sites - the reference and predicted one are:

- subject to the same weather regime, defined by the typical scale of the prevailing synoptic weather systems;
- the prevailing weather conditions are close to being neutrally stable;
- the surrounding topography is not too steep, i.e. sufficiently gentle and smooth to ensure predominantly attached flows and minimal large-scale terrain effect such as channeling.

Next, we consider whether the topography of Moldova meets the conditions of applicability of the WAsP.

The influence of the topography on the accuracy of WAsP predictions was investigated in the papers [7-11]. The authors of these papers have made the following conclusions regarding the limitations and accuracy of WAsP model:

1. The most important factor for the accuracy of WAsP predictions in the steep terrain is the ruggedness of the terrain, described by the ruggedness index (RIX) of the reference and predicted sites. This index must be zero or a few per cent at most. The ruggedness index of a given site is defined as the fractional extent of

the surrounding terrain which is steeper than a critical slope, θC. In our case the critical slope is θC = 0,3. In other words, the slope angle is equal to 17 degrees. The second indicator is ΔRIX, called orographic performance indicator.

2. If one or both of the two indexes is larger than zero, prediction errors must be expected. The orographic performance indicator ΔRIX is defined as the difference in the percent between the predicted and reference sites RIX indexes.
3. If the reference and predicted sites are equally rugged (ΔRIX ~ 0%) the prediction errors are relatively small. If the reference site is rugged and the predicted site less rugged or flat (ΔRIX < 0) the overall prediction is underestimated with a negative error. Conversely, if the reference site is flat or less rugged than a rugged predicted site (ΔRIX > 0), the overall prediction is overestimated with a positive error.

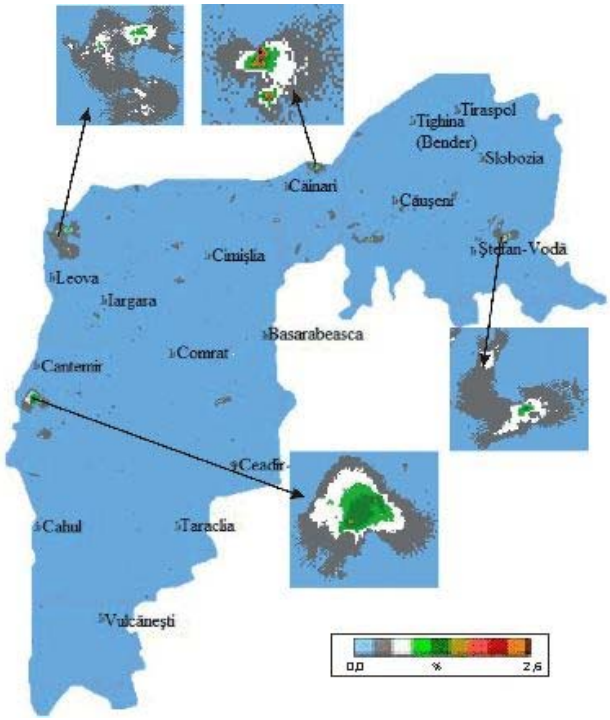


Figure 2. Moldova's south region: ΔRIX map.

4. If the ΔRIX varies between +6,0 and -6,0%, than the wind speed prediction error does not exceed ±5 % [11].
5. Two characteristics of the topographical map are important for the wind speed predictions: the contour line interval and the accuracy of the digitized map [7]. The recommendations are following: prediction errors decrease with decreasing contour line interval-an interval of 20 m or less provide fairly accurate predictions; the prediction errors are large (6%) when grid cell sizes are greater than 100 m.

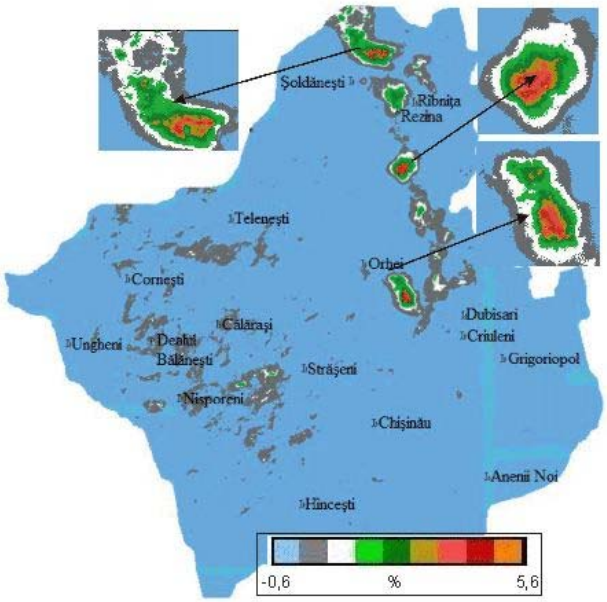


Figure 3. Moldova's central region: ΔRIX map.

In this paper we studied the topographical peculiarities of the economic development regions of Moldova – south, center and north. The aim of the study was to identify if terrain ruggedness and available input topographical data do not exceed the values indicated above.

RIX and ΔRIX values, respectively, for south, central and north economic development regions were calculated. The maximum values of RIX and ΔRIX are presented in the Table 1. We use the map with contour line interval equal to 20 m and grid size of 100×100 m.

Table 1. RIX and ΔRIX maximum values

Region	RIXmax, %	ΔRIXmax, %
South	2,7	2,6
Central	6,2	5,6
North	4,6	4,6

Figures 2-4 show the ΔRIX maps for above mentioned regions and critical areas in which ΔRIX has maximal values. The steepest areas, in which ΔRIX reaches maximum values, are located along the river Dniester (see Figure 3 and 4).

We note that the calculated values of RIX, ΔRIX and the available topographical input data do not exceed those recommended. In other words, topography of Moldova fits the operational envelope of the WAsP model and wind energy potential assessment can be made with an acceptable accuracy. Validation results are provided in the section IV.

3. RESULTS OF THE WIND ENERGY RESOURCES ASSESSMENT

This section presents an overview of the wind energy resources of Moldova in terms of average annual wind speed, wind power density and wind electric potential in terms of installed capacity. For this, the Wind Atlas Method, briefly described in the section B, was used.

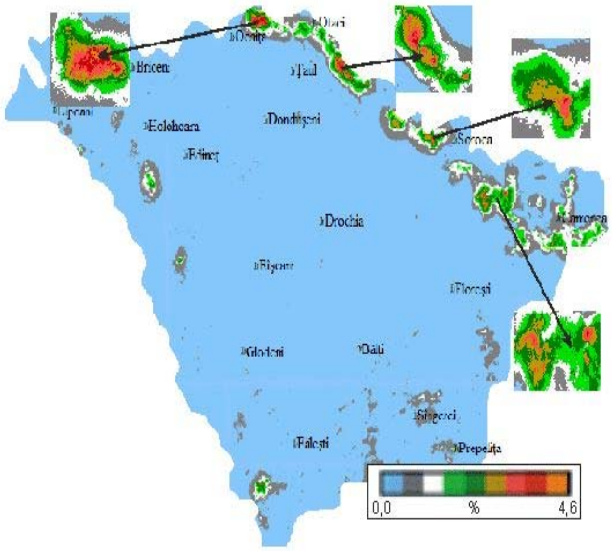
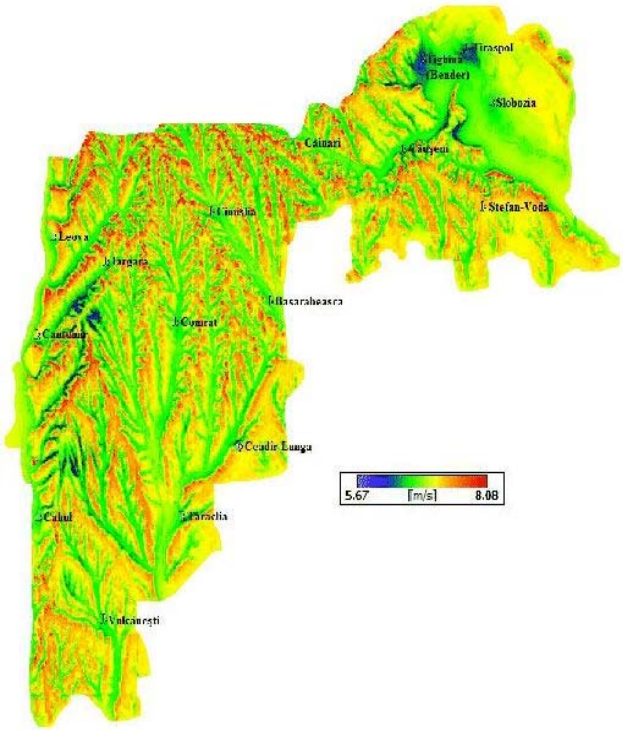


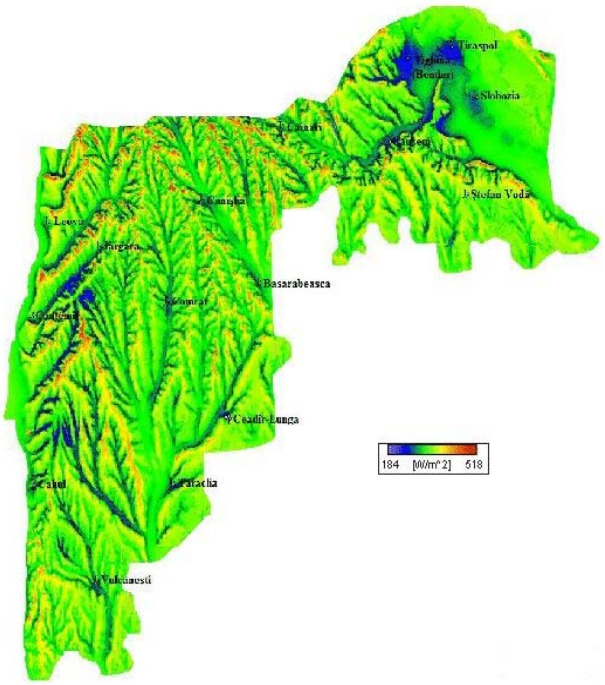
Figure 4. Moldova's north region: ΔRIX map.

Moldova's territory was divided into three regions which coincide with the three development regions - south, center and north. In order to predict wind speed, direction and power density were performed the following steps:

1. For each region a representative meteorological station was selected. In the south this is Ceadir - Lunga station. Regional wind climatology was obtained by using the raw data for an 11 years period. Respectively, for north region – Balti station and raw data for a 10 years period. In the central region all meteorological station are highly sheltered and neither one can't be considered as representative. For the central region were used raw wind data measured in 2010-2013 years period on the highest point of Moldova - Balanesti Hill and conducted by the Technical University of Moldova. Anemometer tower height is 30 m a.g.l.
2. By using WAsP 9.1 software package, the wind maps for two heights – 50 and 100 m a.g.l., were calculated.
3. Using the wind power density map were identified location areas with wind potential greater than 350 W/m^2. If the wind power density of a grid cell was less than 350 W/m2, then the potential was set equal to zero.
4. Next, we calculated the electric wind potential using the assumptions: installed capacity per km^2 is equal to 5 MW.



a)



b)

Figure 5. South region wind energy potential at 100m: *a - wind speed; b - wind power density*.

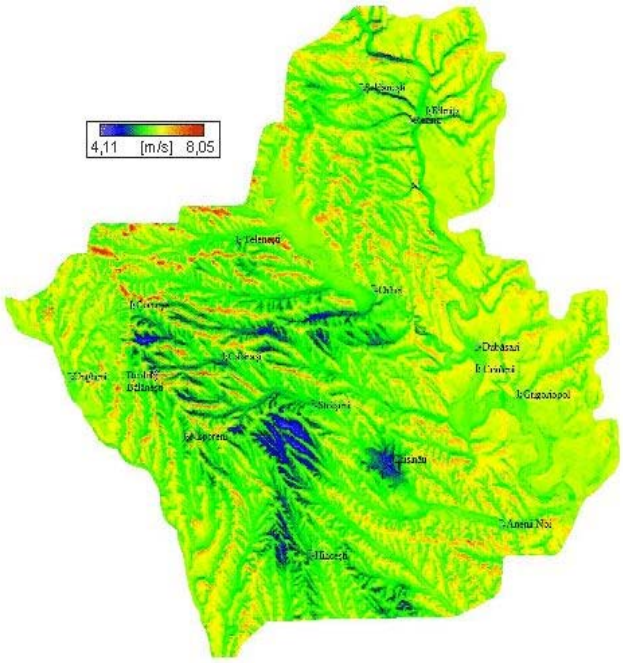
The wind energy potential Maps at a height of 100 m a.g.l. are shown in Figure 5 - 7.

The main obtained outputs are the above presented color-coded maps in units of W/m2 for wind power density and, respectively, in m/s for wind speed. We have classified the Moldova's wind potential in several classes starting at moderate power density scale of 350-400 W/m^2 and ending with excellent scale with power density of 450-600 W/m^2. The power density and proportion of windy land for each wind resource scale is listed in Table 2. Figures are presented for the three development regions and whole country. Area of the country is equal to 33 844 km^2.

Table 2. Moderate to excellent wind resource at 100 m above ground level.

Wind resource scale	Potential, W/m^2	Land area					
		South		Central		North	
		km^2	%	km^2	%	km^2	%
Moderate	350-400	4456,0	13,2	22,0	0,06	4876,0	14,4
Good	400-450	600,5	1,8	2,7	0,008	1454,0	4,3
Excellent	450-500	13,0	0,04	0,23	0,0007	202,8	0,6
Excellent	500-550	0,1	0,0003	0,0	0,0	28,2	0,08
Excellent	550-600	0,0	0,0	0,0	0,0	4,3	0,01
Total for each region		5069,6	14,1	24,9	0,07	6565,3	19,4
Total for whole country		11659,7 km^2 or 33,6 %					

A special importance for harnessing wind energy has knowledge of the wind power capacity that can be installed in each region. To estimate the wind power capacity we must know the land area with high wind potential and power that can be installed on a unit area, for example, 1 km^2.



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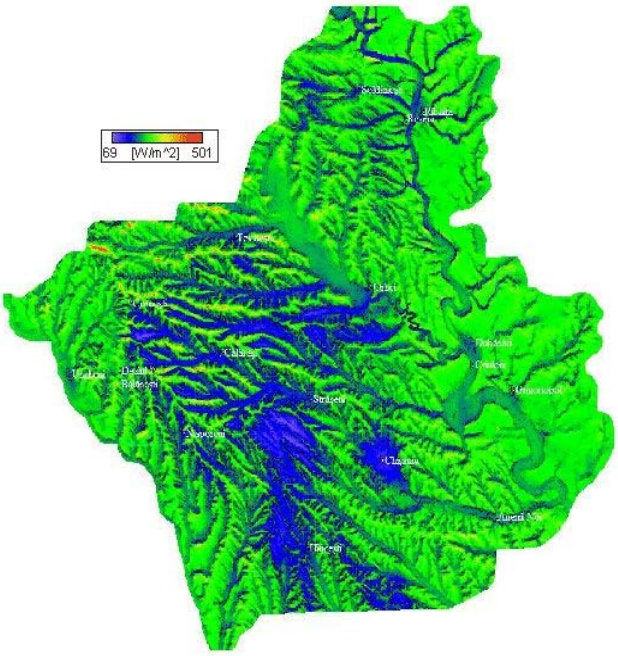

b)

Figure 6. Central region wind energy potential at 100 m: *a - wind speed; b - wind power density*.

Table 3. Moderate to excellent wind power capacity at 100 m above ground level.

Wind resource scale	Potential, W/m^2	Power capacity, MW		
		South	Central	North
Moderate	350-400	22280	110	24380
Good	400-450	3003	13,5	7270
Excellent	450-500	65	1,0	1015
Excellent	500-550	0,5	0,0	140
Excellent	550-600	0	0,0	21,5
Total for each region		25350	124,5	32827
Country's total power capacity		58302		

The land areas with high wind potential are listed in Table 2, but concerning the capacity per 1 km^2, there is no common opinion. In various published writings different figures are proposed. Thus, [3] indicates 10 MW/km^2, [12] recommend 5 MW/km^2, [13] and [14] - between 6 and 7 MW/km^2 and [15] - 16 MW/km^2. We accepted a conservative assumption of 5 MW/km^2. The wind power capacity for each resource scale and for each region is listed in Table 3.

The wind resource listed in Table 2 and power capacity listed in Table 3 represents the potential that is not reduced by factors such as land use exclusions: roads, lakes, urban and rural settlements, forests, protected areas, airports and other limitations imposed by the civil and military aviation, electronic communication systems, natural gaz pipelines etc.

4. VALIDATION OF THE RESULTS

European Wind Atlas authors proposed two methods to validate the results of wind resource assessment: meteorological stations intercomparisons and validation against measured wind data at different heights above ground level. [5]. We used the second method. For this, the calculated annual mean wind speed, power density and Weibull coefficients were compared with measured data obtained at the same height. The results are included in the Table 4.

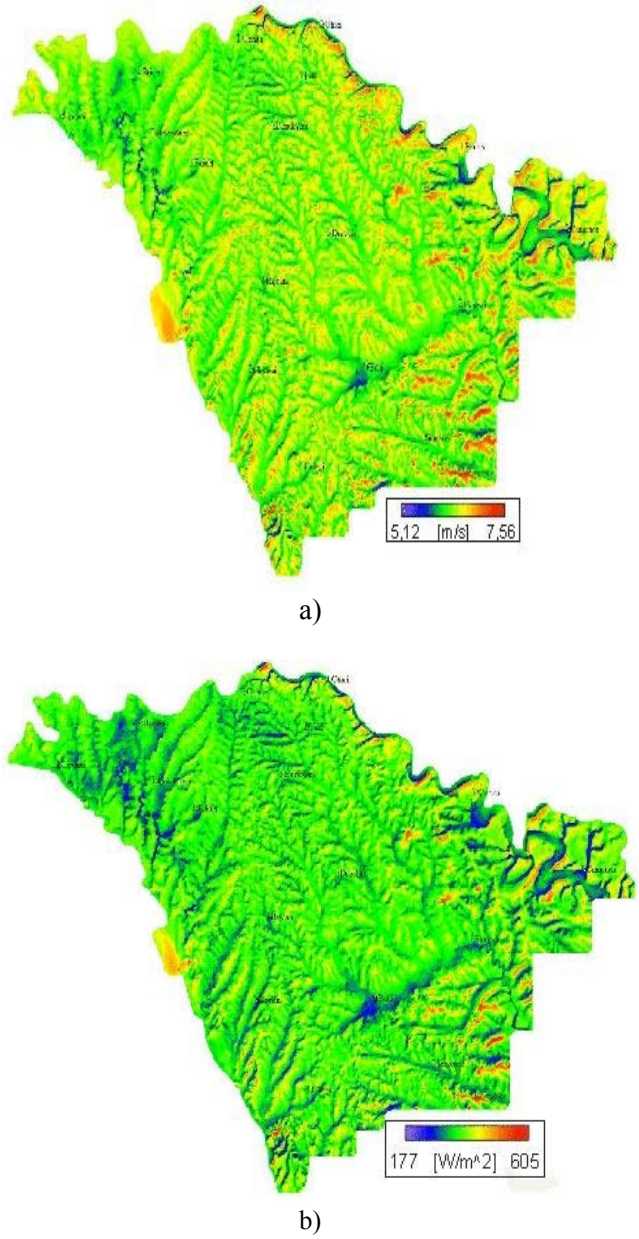

Figure 7. North region wind energy potential at 100 m: *a - wind speed; b - wind power density.*

The wind speed and power density prediction errors were calculated as $(X_{Calc}/X_{Meas.}-1)100$, there X_{Calc} and $X_{Meas.}$ is, respectively wind speed or power density.

Table 4. Valitation against the measured data different hights.

Region	South		Central		North	
District	Ciadir-Lunga		Hincesti		Donduseni	
Height, a.g.l., m	50		60		75	
Wind speed, m/s	Meas.	Calc.	Meas.	Calc.	Meas.	Calc.
	6,44	6,48	5,82	5,89	6,29	6,11
Wind speed error, %	+0,6		+1,2		-2,9	
Power density, W/m^2	289	277	218	201	241	230
Power density error, %	-4,2		-7,8		-4,6	
A, m/s	6,9	7,3	6,6	6,6	7,1	6,8
K	2,28	2,33	2,11	2,44	2,57	2,61

5. CONCLUSIONS

The topography of Moldova territory meets the conditions of applicability of the WAsP. The maximum value of orographic performance indicator ΔRIX is equal to 5,6 % and corresponds to central region of the country. Wind speed prediction error doesn't exceed 2,9%, respectively, for wind power density – 7,3 %.

The largest areas of windy land are located in the northern and south economic regions, respectively, 19,4% and 14,1% of the total area of the country. The central economic region brings a negligible contribution to the total wind resources. Here the windy land is only 0,07 % of the total area of the country. Causes are: large forested areas, high density of rural and urban settlements. Instead, on the ridges of the hills were identified annual average wind speeds which exceed 8,0 m/s.

At the height of 100 m a.g.l. Moldova's wind energy resources are much higher than the predicted in the former USSR using as input data the measurement results at the height of 10 m a.g.l. About 34 % of the country area has a wind potential between 350 and 600 W/m2. Even, if this area will be reduced by 20 times due to the different constraints, on the remaining area (about 1,7 % from entire country area) can be installed a wind power capacity of 2900 MW. This capacity is about 3 times higher than the current maximum power consumption.

ACKNOWLEDGMENT

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ABOUT PORE STRUCTURE OF SUGAR BEET PULP

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INTRODUCTION

Our task was to study low-temperature drying modes of plant material, required to obtain more detailed information on the mechanism of internal heat and mass transfer during the drying process. The object of research was selected – beet pulp, byproduct of sugar production. Based on the structure of the sugar beet tissue, referred to as pulp dispersed strongly structured products with low porosity, which do not crack during drying. [1]

1. MATERIALS AND METHODS

Method of prof. P. Lutsik [2] was used to determine the structural characteristics of the pulp. This method is suitable for both rigid bodies with solid skeleton and bodies which are limited to swell in a state of hygroscopic swelling.

The experimentally obtained beet pulp isotherms [3] identify the following characteristics: micro-pore volume, integral differential distribution curves of micro-pores radiuses, effective pore radius, surface area, etc. It was assumed that the pulp is a partially porous water-swellable material, and the micro-pores are cylindrical. For the calculation were used the desorption curves, corresponding to pores completely filled with liquid and moisture meniscus of spherical shape. Micro-pores radiuses were determined using the equation Thomson-Kelvin.

Micro-pore volume filled with moisture, was determined by multiplying the number of adsorbed moisture at given $\varphi = \frac{p}{p_0}$ on the molar volume of water.

Integral F(r) micro-pore distribution function:

$$F(r) = U / U_{max}$$

where U and U_{max} are Integral F(r) micro-pore distribution function:

$$F(r) = U / U_{max}$$

where U and U_{max} are the equilibrium and maximum (hygroscopic) moisture content of pulp at given value $\varphi = 1$.

Figure 1 shows the integral curves F (r) for the distribution of micro-pores of the size of pulp at different temperatures T 1 - 298 2 - 232 3 - 343 K.

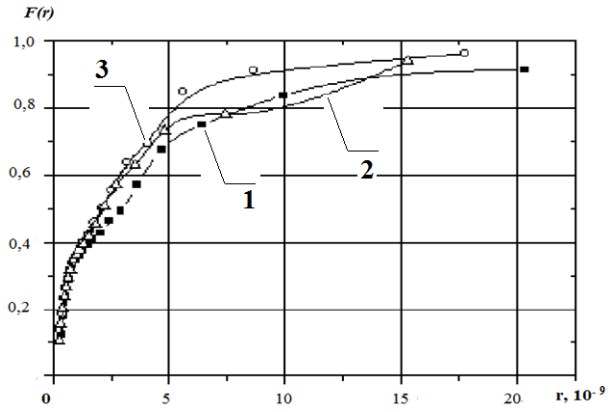

Figure 1. Integral F (r) distribution curve of micro-pore radiuses for beet pulp at temperatures T: 1 – 298; 2 – 323; 3 - 343 K.

As can be seen from the figure, the micro-pore volume increases dramatically, ranging from minimum values $r_o \approx 7 \cdot 10^{-10} m$ to $r \approx 60 \cdot 10^{-10} m$. Further cumulative distribution does not change significantly and is close to a linear distribution with growth values *r*.

Differential distribution function *f(r)* of micro-pores was found as the derivative of the cumulative distribution $f(r)=dF(r)/dr$. Calculations were carried out by discrete differentiation using OriginPro. Differential distribution curves *f(r)* of micro-pores on their radiuses in the beet pulp, are shown in Fig. 2.

As can be seen from figure 2, the maximum values of all curves reach minimum values when $7 \cdot 10^{-10} m \le r \le 12 \cdot 10^{-10}$ *m*. This indicates that the pulp has the largest number of micro-pores of that size. Curve 1 at *T = 298 K* shows small peaks at $r \approx 13 \cdot 10^{-10}$ *m* and $r \approx 37 \cdot 10^{-10}$ *m*, covering a wider range of radiuses. Increasing the temperature of the research object leads to the appearance of minor peaks (curves 2 and 3 in Fig. 2) which shifts to

smaller radiuses of micro-pores. Last, in our opinion, can be explained by the shrinkage of the skeleton beet chips with increasing its temperature, and hence a decrease in the equilibrium moisture content.

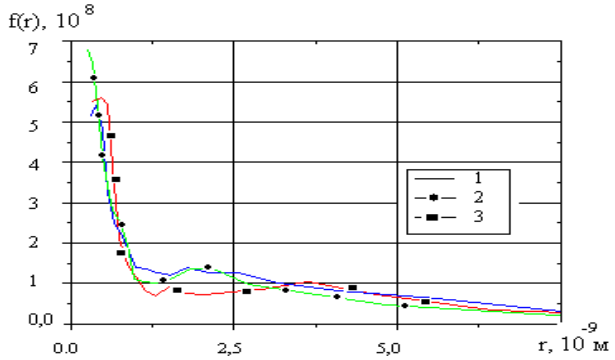

Figure 2. Differential f (r) curve distribution for the micro-pore radiuses beet pulp at temperatures T1 – 298, T2 – 323, T3 – 343 K.

The size of the equivalent radius r_e [4] of molecular vapor flow determined by using one of the methods of the approximate integration, has units of length and depends on the distribution curve of pore radius:

$$r_e = \frac{\int_{r_o}^{r_{max}} r^2 f(r)dr}{r_{max} - r_o}$$

where r_o is the minimum radius of micro-pores; r_{max} – the maximum radius of micro-pores; $f(r)$ – the differential micro-pores distribution curve. Results are presented in Table 1.

Table 1. Equivalent radius r_e of beet pulp pores.

T, K	298	323	343
$r_e, 10^{-10}$ m	11,32	11,10	8,10

The amount of adsorbed moisture in poly-molecular layer u_p, as well as the maximum hygroscopic moisture condition u_r, was found on desorption isotherm curve. The indicated isotherm was also built in the coordinates BET [5] and more accurately find moisture monolayer u_m.

The calculated values of these quantities for sugar beet pulp: u_m=0,04 kg/kg, u_p≈0,14 kg/kg, u_g=0,40 kg/kg – at temperature 298K; u_m=0,038 kg/kg, u_p≈0,11 кg/кg, u_g=0,294 kg/kg – at temperature 323 K; u_m=0,03 kg/kg, u_n≈0,9 kg/kg, u_r=0,26 kg/kg – at temperature 343K. In industrial rotary dryers, beet pulp is dried to a water content u=0,115 kg/kg (W=13 %). Thus, in the drying process removes all the capillary moisture, and only a minor part of the moisture poly-molecular layer adsorption.

2. CONCLUSION

The data on the moisture monolayer u_m allowed evaluating the specific surface of micro-pores. The value for the specific surface area of beet pulp at 298, 323 and 343 K are 141,8 m^2/g 134,8 m^2/g and 106,4 m^2/g, respectively.

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STREAMLINING THE MANAGEMENT OF INTERNSHIPS - AN IMPERATIVE OF THE TIME

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Internships are part of mandatory initial university training programs (both at Cycle I - Bachelor and Cycle II - Masters) and are oriented towards achieving specific and generic competences in a field of professional training / specialization [1, 2]. They represent the interference segment between the study process and professional activity being a first step towards adaptation and integration of students in the professional environment.

Internships in a higher education institution include the specialization (didactic, pedagogical, technological, production) internship, and the Bachelor / Master internship. The types, stages, place, period of deployment and duration of internships is determined by the educational institutions (faculties / departments) in strict accordance with the learning outcomes and the expected competencies for the field of study / specialty / specialization. Internships are organized based on special programs / contracts concluded in this respect with institutions and industrial enterprises [2]. The framework plan for higher education [1] defines the minimum duration of these internships: 10-15% of the total number of credits at cycle I - Bachelor and not less than 10 credits at cycle II - Masters.

Each university has its own regulation, programs and guidelines for the organization of internships, developed by specialized departments based on the provisions of the Framework Regulation on internships in higher education [2], for example, see: Regulation on the organization and deployment of students' internships at TUM, 2010 [3], GUIDELINE on the organization and deployment of internships, TUM, 2010; Internship notebook for undergraduate students at Bachelor level - cycle I and Master level - cycle II, TUM 2011 which are located on the website of TUM [4]. The way internships are organized may vary greatly from one institution to another, the type of internship, but the effectiveness of internships depends largely on the management of the internship cycle "*organization - deployment – evaluation".*

The analysis of the current situation at Technical University of Moldova (TUM) shows that we have a number of drawbacks in this regards and it is necessary to take some concrete measures to improve the management of internships. For example, until now outdated methods are used to monitor the process of deployment of internships, which probably were effective a few decades ago, but are inadequate under current conditions. In the period when the share of large enterprises in the Republic's economy was essential, the students of an academic group were usually assigned to 2-3 companies. The current monitoring, in this case, was carried out by periodic visits to the enterprise of the internship supervisor from the department when he/she checked the internship progress, being able to discuss with both the trainees and the internship supervisor at the enterprise.

As a result of structural changes in the economy of the Republic of Moldova in recent decades the share of small and medium-sized has increased essentially. Under these conditions, the distribution of trainees in large groups to a single company becomes ineffective. Thus, there is a need to distribute them into groups of 1-2 students in a large number of enterprises, institutions and companies. In these circumstances, monitoring the progress of internship deployment by the supervisor from the department through visits to enterprises is no longer an optimal control method.

Figure 1 shows the situation at TUM regarding the number of enterprises, used as bases for internships, and the number of students involved in internships. On average, there are more than eight students distributed at a company, who are from different specialties and different years of study. Thus, students from an academic group are assigned to 8-10 enterprises often located in different places. In these circumstances, the internship supervisor from the university manages to visit a limited number of companies, meeting the majority of students-trainees only at the defending of the internship report. The process of monitoring the internship deployment becomes extremely complicated due to dispersed locations of internship sites, but also because of the overlapping of the period of internships and teachers' holidays. Often, the current monitoring of internships is not undertaken. It is obvious that in such circumstances,

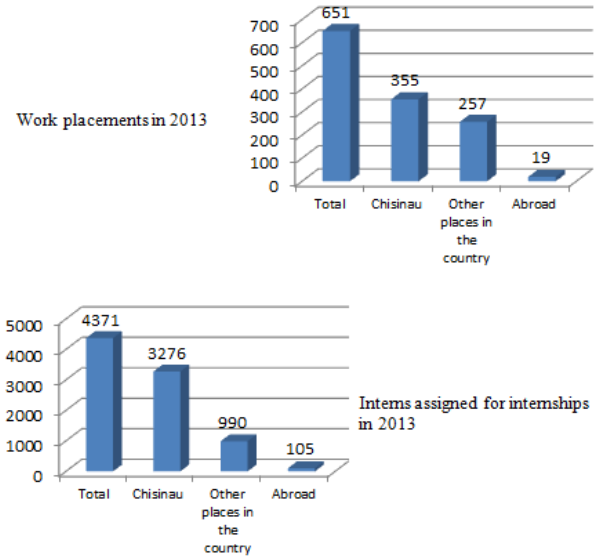

Figure 1. Internships at the Technical University of Moldova.

internship supervisors from the department need new much more effective tools for monitoring the deployment of internships.

One way to streamline the management of internships in companies is the implementation / use of modern information technologies. For online complex monitoring of the deployment process of internships, an optimum tool would be the electronic platform of e-learning type. At TUM, for distance training of the students the educational platform "*Moodle*" is implemented and widely used. It can be successfully used for monitoring internships, being provided with a distinct module "Internships" for students and internship supervisors. This module (Figure 2) allows the operative exchange of information between the supervisor and trainee / group of trainees, view online weekly reports of trainees sent to the internship supervisor from the department and their storage; sending the current tasks that are to be met, objections and other information by the supervisor to each trainee or group of trainees; import by the users of useful documents placed on the "*Moodle*" platform (Internship notebook), chat communication among students and others.

Compared with traditional methods of monitoring the internship deployment process, the use of this educational platform "*Moodle*" has a series of obvious advantages, the most important being:

- ✓ high efficiency in monitoring and interactive management of process development, irrespective of the number of companies where students undertake their internship and geographical location of these companies;

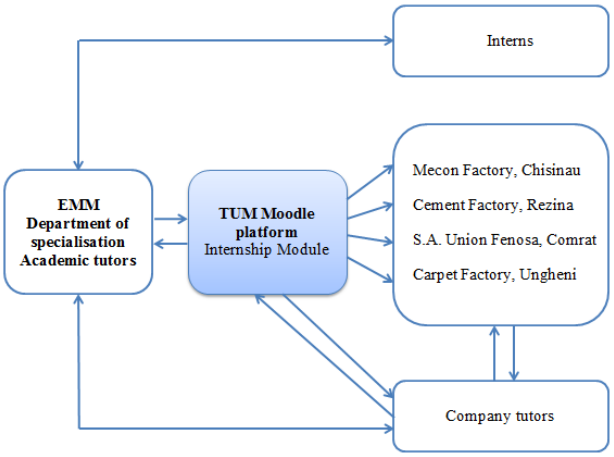

Figure 2. Moodle platform - an important tool for monitoring internships.

- ✓ minimization of financial expenditures and saving the time required for monitoring (compared to traditional methods, which involve expenses for supervisors' trips to enterprises in other localities, where the trainees carry out their internships);
- ✓ operative monitoring and evaluation of students' activities throughout the internship period and, if necessary, take corrective measures and, consequently, ensuring the good quality of practical training of future specialists;
- ✓ familiarization with information technologies both of the students and teachers in professional areas and daily life etc.

In general, using the module "Traineeships" on the platform "*Moodle*" provides undertaking the following steps:

- initial training of internship supervisors from the department in the use of the educational platform "*Moodle*" and the module "*Internships*";
- creating an account on the platform "Moodle" for internship supervisors from the department;
- creating groups of trainees in the module "Internships" and obtaining the access password for each group;
- initial training of students in the use of the educational platform "*Moodle*" and the module "*Internships*";
- creating an account on the platform "Moodle" for each trainee and ensuring their access to the module "*Internships*", using the group password;
- importing the internship notebook by trainees from the platform "*Moodle*";
- writing weekly reports on the internship progress by trainees and sending them to the internship supervisors from the department;

- evaluation of treinees' weekly reports by internship supervisors from the department;
- final evaluation of treinees by internship supervisors from the department.

In the second semester of the academic year2012-2013, the educational platform "*Moodle*" was used, in testing regime, for monitoring the deployment of internships in five academic groups (74 students) from the Faculty of Power Engineering (FPE), Faculty of Constructions, Geodesy and Cadaster (FCGC) and the Faculty of Textile Industry (FTI) of TUM. For example, the method was tested at the Department "*Building Technology*" of FCGC in the course of deployment of production and managerial internships in the academic groups CIC-101 and CIC-102, specialty "*Construction and civil engineering*". Practically, there were tested all the possibilities of the platform: sending weekly reports by trainees to the supervisors from the departments by attaching graphic materials, photos etc.; communication of supervisors with students and of the trainees / trainee groups with each other through messaging and organization of chats etc. The results of internships deployment in the above mentioned groups have demonstrated the rationality and efficiency of the module "Internships" on the platform "*Moodle*". Both internship supervisors from the department and students-trainees mentioned the usefulness and convenience of using this platform. In particular, they mentioned the performance of this tool, supervisors emphasizing the essential improvement of the quality of current monitoring of internship deployment process compared with conventional methods currently used.

Another measure to streamline the management of internships is improving the existing system of assessment of internships. From our point of view, for the evaluation of internships it is necessary to apply the cumulative criterion similar to the one used at the final evaluation of the taught subjects. A strong argument in favor of this statement is the implementation of online monitoring system of internship deployment process, which was mentioned above. Applying this tool allows to evaluate current activities of trainees (by analyzing weekly reports by supervisors, taking into account the report delivery deadline for students and other factors), and, therefore, provides conditions for the use of the evaluation cumulative criterion. This fact motivates students to take a responsible attitude towards all activities envisaged in the period of the deployment of internships. Based on the experience acquired during the deployment and evaluation of internships in the academic year 2012-2013, we consider that for the evaluation of activities there can be adopted the following values of the share indices: current activities (including assessment of activities by the internship supervisor from company) - 40%; the report (including, if applicable, papers, PowerPoint presentations, etc.) - 30% and defending of the colloquium - 30%.

Based on the above stated achievements, the following **conclusions and recommendations** can be made:

1. Platform „*Moodle*" is an effective tool for current monitoring of internships and can be recommended for widespread use at all TUM's specialties.
2. Implementation of online monitoring of the internships deployment process allows to apply the cumulative criterion of final evaluation of internships and thus motivate students to take a responsible attitude towards all activities envisaged in the period of the internships.
3. In the context of those mentioned, it is necessary to improve the "*Guidelines on the organization of internships*", taking into consideration the possibilities of using the platform "*Moodle*" as a monitoring tool and the need to apply the cumulative criterion of final evaluation of internships.

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SUPER LUMINESCENCE PHENOMENON IN TERNARY COMPOUNDS OF TYPE $CdGa_2S_4$

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INTRODUCTION

In the family of new multifunctional materials, one scientific interest, both fundamental and applicative, presents ternary compounds $A^{II}B_2^{III}C_4^{VI}$, namely $CdGa_2S_4$ which are materials with unusual crystalline structure and with physical properties that are unique and remarkable: fairly wide interval of optical transparency, high values of the coefficient of nonlinear optical susceptibility, particularities which determine the application of these compounds for nonlinear optics domain, optoelectronics and photonics.

From the family of ternary compounds $A^{II}B_2^{III}C_4^{VI}$, the compound $CdGa_2S$ has been studied. For this compound, advanced technologies of growth, experimental methods of composition and crystalline lattice structure control have been implemented. Luminescence properties of $CdGa_2S$ are widely studied in a number of works by applying different types of excitation: photons [1], accelerated electrons, X-rays [2].

EXPERIMENTAL RESULTS AND THEIR ANALYSIS

The technology of preparation of the samples under investigation is exposed in [3] and

is based on the chemical reactions of transport in which iodine is used as the carrier agent.

The investigations carried out by us, luminescence excitation was performed with a stream of accelerated electrons and X-rays with energies from the range $(50 \div 100)\,keV$. The experimental installation was assembled based on electron microscope УЭМВ-100К.

The sample was fixed on a support of copper, cooled by means of liquid nitrogen and introduced into the working chamber of the microscope, in which the vacuum, not less than 10^{-4} *mm Hg,* was maintained.

The system of the luminescence radiation capture and recording adjusted by electron microscope is represented in figure 1. This system contains the optical component which enables to accumulate optical radiation from the crystal surface and the cathode luminescence recording component.

By using the quartz lenses and mirrors, the flow of light from the sample surface was focused on the photomultiplier and the opening of device M-2. There were used a photomultiplier ФЭУ-18 and other recording devices for the wavelengths in the range *(3800 -7800)* Å .

It was also used the modulator engine of type ДИД-2, which possesses a stable circular frequency and is powered by a three phase generator with the frequency $360\,Hz$ and amplitude $36\,V$. The given system modulation allowed obtaining

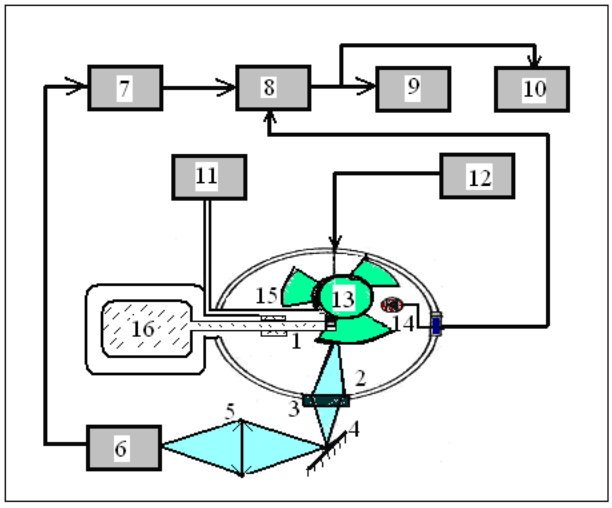

Figure 1. The system of the luminescence radiation capture and recording: 1-*sample for research; 2,5-quartz lens; 3-the window of quartz; 4-mirror; 6-dispersing system based on diffraction mirror; 7-photomultiplier;8-synchronous detector; 9-potentiometer recorder; 10-electronic voltmeter; 11-temperature stabilizer; 12-power block for modulator; 13-modulator; 14- base power source; 15- thermocouple; 16-vessel Diuar.*

current flow impulse duration of $100\ \mu s$.

To establish the temperature in the range $(80 \div 300)\ K$, an electric stove that is powered by a stabilizer included within the microscope has been used. Temperature control is performed using a thermocouple "copper - constantan".

In figure 2 are exposed super luminescence spectra for mono-crystals $CdGa_2S_4$ at temperature $80\,K$. For purpose of detailed researches of stimulated radiation in $CdGa_2S_4$, the investigations on the cathode-luminescence of mono-crystals $CdGa_2S_4$ have been performed in the range of energies $(2,00 \div 2,30)\,eV$ at temperature $80\,K$ and the density of the current flow $j_1 = j_2 = 1,5 \cdot 10^{-3}\ A \cdot cm^{-2}$. The electrons beam energy in both cases was $100\,keV$.

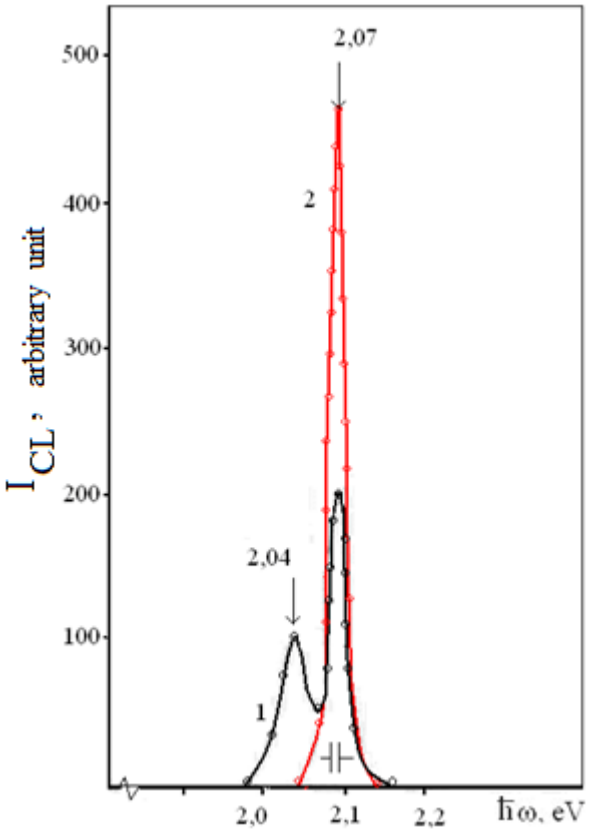

Figure 2. Super luminescence spectra of mono-crystals $CdGa_2S_4$ at $80\,K$.

Excitation densities and impulse durations:
$U = 100\,keV$; $j_1 = j_2 = 1,5 \cdot 10^{-3}\,Acm^{-2}$;
$\tau_1 = 10^{-3}\,s$; $\tau_2 = 10^{-2}\,s$.

Corresponding results obtained under this experiment and based on analysis of mono-crystals $CdGa_2S_4$ cathode-luminescence spectra, energy maximums (peaks) at $2,07$ and $2,04\ eV$ were registered; the top has semi-width $0,10\ eV$. It is known [4] that in the conditions of given excitation, super luminescence, namely the stimulated radiation, is characterized by a non-linear increasing of the luminescence intensity into energy maximum of the spectrum and a nonlinear narrowing of emission strip semi-width at $80\,K$. Penetration depth of the electrons reached about to $32,4\,\mu m$.

Based on the investigations results we propose the model of energetic levels and optical transitions in the energy band gap, which ensures super luminescence phenomenon in this compound, the model in which an evident role plays holes and electrons traps (CA and CE) (fig. 3).

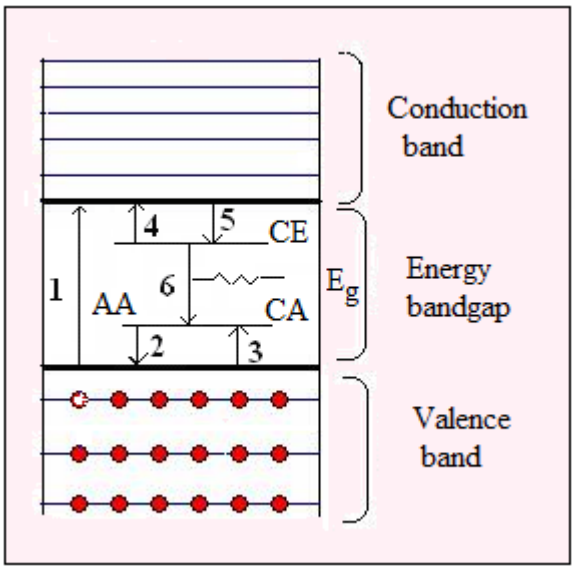

Figure 3. The model of energetic levels and optical transitions in the energy band gap in mono-crystals $CdGa_2S_4$ which ensures the super luminescence phenomenon: *CE - electron traps; CA - traps for acceptors (holes); AA - deep acceptors: 1 - transitions in the conduction band; 2, 3 transitions in CA; 4, 5 - transitions in CE; 6 - emission transition which ensures super luminescence.*

Transition direction of electrons and holes ensures the process of accumulation of electrons and, respectively, of holes in deep traps of the

appropriate type. Captured electrons and also holes can be released as heat and under the action of electromagnetic radiation, in this case - of accelerated electrons [5]. Based on release of electrons concentrated on deep traps, the intensive recombination of them with holes from ionized centers occurs, that causes a transitions avalanche of type 6, which produces the phenomenon of super luminescence in $CdGa_2S_4$.

Thus we notice that the model of energetic levels and optical transitions in the energy band gap which ensures the super luminescence phenomenon in compounds $CdGa_2S_4$ exposed in figure 3 is also confirmed by luminescence of high persistence for some samples of this type synthesized in special conditions [6].

Certain characteristics of the mono-crystals $CdGa_2S_4$ cathode-luminescence spectra at temperature $80\ K$ are exposed in table 1.

Table 1. Characteristics of the mono-crystals $CdGa_2S_4$ cathode luminescence spectra at $80\ K$.

No	***Excitation density (j)***	***Impulse duration (τ)***	***Semi-width in the emission strip***	***Position of energy max.***
	$A \cdot cm^{-2}$	s	eV	eV
1.	$1,5 \cdot 10^{-3}$	10^{-3}	0,20	2,07
2.	$1,5 \cdot 10^{-3}$	10^{-2}	0,10	2,04

The results of investigations carried out on the nonlinear optical properties of $CdGa_2S_4$ and in the first place, the possibility to determine the experimental conditions in which the phenomenon of super luminescence occurs is a problem solving which would open real perspectives for promoting this material as an active element for lasers.

CONCLUSIONS

According to results of experimental researches we conclude that for the ternary mono-crystals of type $CdGa_2S_4$ grown by transport chemical reactions method with iodine as a carrier agent, in the excitation with accelerated electrons, the super luminescence phenomenon has been recorded – the cathode luminescence strip with the maximum energy $2,07\ eV$, the semi-width of top in the emission strip constituting $0,10 eV$, its intensity is of the order of 10^2 times greater than strips recorded by the excitation with impulses whose duration is ten times less.

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INFLUENCE OF THE THERMOVISCOPLASTIC PROPERTIES OF THE STRUCTURAL MODEL SUBELEMENTS ON THE THERMOVISCOELASTIC CHARACTERISTICS OF MATERIAL

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INTRODUCTION

Every material, being isotropic and homogeneous at the macroscopic level, may be represented as a conglomerate composed of an infinite number of kinematically connected elementary compositions of the material particles, which are grouped according to a common parameter governing the considered phenomenon. Structural elements possess only simple properties, but in result of their interaction at macroscopic scale one may describe very complex phenomena.

In the investigated model functions, reflecting thermoviscoplastic properties of subelements, are regarded as depending on the rate of deformation change of the body element, which in turn influences the thermoviscoelastic characteristics of material. The kinematic coherence of subelements leads to the interdependence of phenomena of the different nature.

1. BASIC EQUATIONS OF THE STRUCTURAL MODEL

The macroscopic element, being at the original time in natural state, is subjected to mechanical and thermal action. It is assumed that during deformation the material behavior depends significantly on the rate of loading and heating. To describe the microheterogeneous medium behavior the macroscopically homogeneous volume element V_0 of the polycrystalline body is considered to be composed of an infinite number of kinematically connected subelements with different thermorheological features. These subelements are successively involved in a process of irreversible deformation.

Subelement is identified with the set of all material particles inside the conglomerate V_0 that have the same irreversible strain tensors

$$\overline{p}_{ij} = \widetilde{p}_{ij}, \qquad \overline{p}_{ij} = \left\langle \widetilde{p}_{ij} \right\rangle_{\overline{V}}, \tag{1}$$

where $\overline{p}_{ij}$ implies average irreversible strain of the subelement with the volume $\overline{V}$.

Particles of the same subelement may have different orientations and situations in the conglomerate space. Because the granules of the polycrystalline aggregate are nonuniformly deformed so that the mass and the volume of a single accepted subelement can be arbitrarily small. It is evident that proceeding from the selection of material particles in the accordance with the irreversible strain tensor other thermo-mechanical quantities change from a material particle to other one in the given subelement.

Let us represent the stress and strain tensors of the macroelement of the microheterogeneous aggregate as a sum of deviators and spherical tensors:

$$t_{ij} = \sigma_{ij} + \sigma_0 \delta_{ij}, \qquad \sigma_0 = t_{ii}/3, \tag{2}$$

$$d_{ij} = \varepsilon_{ij} + \varepsilon_0 \delta_{ij}, \qquad \varepsilon_0 = d_{ii}/3. \tag{3}$$

Components of the strain and stress deviators of the volume element are the weighted means of the strains and stresses deviators of the subelements

$$\sigma_{ij} = \int_0^1 \overline{\sigma}_{ij} d\psi, \qquad \varepsilon_{ij} = \int_0^1 \overline{\varepsilon}_{ij} d\psi, \tag{4}$$

where as the state parameter, identifying quantities $\overline{\sigma}_{ij}$ and $\overline{\varepsilon}_{ij}$ with certain subelement, is chosen weight of the irreversibly deformed subelements $\psi \left(0 \le \psi \le 1\right)$, reflecting the sequence of the subelements transition from the reversible to irreversible state under the initial loading.

Describing inelastic behavior of polycrystalline aggregate, it's very important to evaluate the influence of the heterogeneous distribution of irreversible deformations in the interior domain V_0 on the macroscopic relationships between stresses and strains. Therefore the local interconnection in the examined model is established between reversible and irreversible deformations:

$$\overline{\varepsilon}_{ij} = \overline{e}_{ij} + \overline{p}_{ij}, \tag{5}$$

$$\varepsilon_{ij} = e_{ij} + p_{ij}, \qquad \varepsilon_0 = \left(e_0 + \varepsilon_T\right) + p_0. \tag{6}$$

Rate of change of the irreversible deformation path length is the state parameter that reflects the sensitivity of subelement to rate of external action's change:

$$\dot{\bar{\lambda}} = \sqrt{\dot{\bar{p}}_{ij}\dot{\bar{p}}_{ij}}. \qquad (7)$$

Evolutional equation of the state parameter $\bar{s}$, characterizing the isotropic hardening owing to the modification of structure in the irreversible processes, is accepted as

$$\dot{\bar{s}} = \begin{cases} a\dot{\bar{\lambda}}, & \bar{s} < \bar{x}(\gamma,\upsilon), \\ \dot{\bar{x}}, & \bar{s} = \bar{x}(\gamma,\upsilon). \end{cases} \qquad (8)$$

At the beginning of the irreversible deformation process $\bar{s}\big|_{t=0} = s_0$, where s_0 depends on the type of the heat treating of the material. If at the start of the process of the irreversible deformation the material is in the structurally stable state, then $s_0 = 0$.

The relation between the kinematic hardening $\bar{r}$ and the state parameters is expressed as follows

$$\bar{r} = \begin{cases} a_0\bar{p}, & a_0\bar{p} < \bar{x}_0(\gamma,\upsilon), \\ \bar{x}_0(\gamma,\upsilon), & a_0\bar{p} = \bar{x}_0(\gamma,\upsilon), \end{cases} \qquad (9)$$

$$\bar{r} = \sqrt{\bar{r}_{ij}\bar{r}_{ij}}, \qquad \bar{r}_{ij} = \bar{r}\frac{\bar{p}_{ij}}{\bar{p}}. \qquad (10)$$

Kinematic relations and local physical laws of deformation are given within the limits of the examined structural model assuming that all types of interactions between subelements in the conglomerate are formed only under the influence of average connections, i.e. material particles in the aggregate do not deform independently, but only in a coordinated manner.

The interaction between two subelements is realized by means of the interactions between material particles which are appertained to the different subelements. This fact is reflected by replacement of the local state parameters in physical equation for subelement on the average values of the whole set:

$$\gamma = \frac{1}{\psi_\lambda}\int_0^1 \dot{\bar{\lambda}}(\psi')d\psi', \qquad \upsilon = \frac{1}{\psi_\upsilon}\int_0^1 \bar{\upsilon}(\psi')d\psi', \quad (11)$$

$$\dot{s} = \frac{1}{\psi_s}\int_0^1 \dot{\bar{s}}(\psi')d\psi', \qquad 0 \le \psi_\lambda, \psi_\upsilon, \psi_s \le 1, \quad (12)$$

where γ is the average rate of change of the irreversible strain in the subset of subelements, being under the loading above the elastic limit; υ describes inelastic volume variation; ψ is the distinctive parameter of subelement which during the initial loading coincides with the weight of irreversibly deformed subelements when this subelement exceeded the elastic limit; ψ_λ, ψ_υ, ψ_s – summary weights of subelements for which the corresponding parameters $\dot{\bar{\lambda}}$, $\bar{\upsilon}$, $\dot{\bar{s}}$ are nonzero.

The state parameter υ describes rheological effects of the subelement, and is expressed by the ratio of the volume variation and its limit possible value, being the same for all subelements

$$\upsilon = \frac{1}{\varepsilon_{0k}}\int_0^1 (\bar{\varepsilon}_0 - \beta\bar{e}_0)d\psi, \qquad (13)$$

or taking into consideration that

$$\varepsilon_0 = \int_0^1 \bar{\varepsilon}_0 d\psi, \qquad e_0 = \int_0^1 \bar{e}_0 d\psi, \qquad (14)$$

we obtain

$$\upsilon = \frac{\varepsilon_0 - \beta(\upsilon)\dfrac{\sigma_0}{K(\upsilon)}}{\varepsilon_{0k}}, \qquad (15)$$

where K is the volume compressibility modulus.

Differentiating (15) with respect to time we find the loading conditions at $\upsilon = const$:

$$\dot{\varepsilon}_0 = \beta\dot{e}_0 = \beta\frac{\dot{\sigma}_0}{K}. \qquad (16)$$

As was demonstrated in [9], for $\beta = 1$ the deformation process at $\upsilon = const$ corresponds to isothermal loading.

In monotonous processes throughout the subset of irreversibly deformed subelements only active processes of loading occur, that corresponds to the monotony of the evolution of weight of irreversibly deformed subelements in these processes. This means that towards ψ the single separation boundary forms between reversibly $\psi' < \psi \le 1$ and irreversibly $0 \le \psi \le \psi'$ deformed subelements. The variations $d\bar{p}$ in all irreversibly deformed subelements have one and the same sign.

The phenomenon of the auto concordance of irreversible strain processes of subelements can be represented according to the concept of the average connections in the way of two equations [2, 6], which can be written in the case of a monotonous process as follows:

– the yield condition for the subelement under the influence of structural modifications in conglomerate

$$\bar{e}_{ij}\frac{dp_{ij}}{d\lambda}=\tau(\psi,\gamma,\upsilon)+s+\bar{r}\cos\alpha\,, \qquad (17)$$

$$d\bar{p}\big|_{\psi>\psi'}=0\,,\quad d\lambda=\int_0^{\psi'}d\bar{\lambda}\,d\psi\,, \qquad (18)$$

$$s\big|_{\bar{s}<\bar{x}}=a\lambda\,,\qquad \gamma=\frac{\dot{\lambda}}{\psi'}\,; \qquad (19)$$

– the law about the general orientation of the irreversible yield processes in subelements

$$\frac{d\bar{p}}{d\bar{\lambda}}=\frac{dp}{d\lambda}\quad\text{or}\quad\frac{d\bar{p}_{ij}}{d\bar{\lambda}}=\frac{dp_{ij}}{d\lambda}\,, \qquad (20)$$

that means

$$\cos\bar{\alpha}=\frac{\bar{p}_{ij}}{\bar{p}}\frac{d\bar{p}_{ij}}{d\bar{\lambda}}=\frac{p_{ij}}{p}\frac{dp_{ij}}{d\lambda}=\cos\alpha\,, \qquad (21)$$

where the functional τ represents scalar properties of subelements in the structurally stable state and can be identified with the initial yield point of subelement; $\bar{\alpha}$ is the angle between the tangent to the irreversible strain path and irreversible strain vector.

Equations of the kinematic connection between subelements, satisfying the first law of thermodynamics, were obtained in [4,6,7] on the basis of the stresses and strains fluctuations principle, formulated by V. Marina [3]:

$$\Delta\bar{t}_{ij}=-B\Delta\bar{d}_{ij}+\alpha\sqrt{\frac{B(B+K)}{3}\Delta\bar{d}_{nm}\Delta\bar{d}_{nm}}\;\delta_{ij}\,, \qquad (22)$$

$$\alpha=\begin{cases}1, & dacă\quad \bar{d}_{nm}\bar{d}_{nm}>d_{pq}d_{pq}\\ -1, & dacă\quad \bar{d}_{nm}\bar{d}_{nm}\le d_{pq}d_{pq}\end{cases},$$

$$\bar{t}_{ij}=t_{ij}+\Delta\bar{t}_{ij}\,,\qquad \bar{d}_{ij}=d_{ij}+\Delta\bar{d}_{ij}\,, \qquad (23)$$

$$\left\langle\Delta\bar{t}_{ij}\right\rangle=0\,,\quad\left\langle\Delta\bar{d}_{ij}\right\rangle=0\,,\quad\left\langle\Delta\bar{t}_{ij}\Delta\bar{d}_{ij}\right\rangle=0\,, \qquad (24)$$

where $\Delta\bar{t}_{ij}$, $\Delta\bar{d}_{ij}$ are stresses and strains fluctuations; K is the volume compressibility modulus; B is the internal parameter, reflecting simultaneously the heterogeneity of the processes of deformation and loading of subelements in the conglomerate.

In consequence of the decomposition of stresses and strains fluctuations into the deviators and the spherical tensors

$$\Delta\bar{t}_{ij}=\Delta\bar{\sigma}_{ij}+\Delta\bar{\sigma}_0\delta_{ij}\,,\quad \Delta\bar{d}_{ij}=\Delta\bar{\varepsilon}_{ij}+\Delta\bar{\varepsilon}_0\delta_{ij}\,, \qquad (25)$$

two groups of equations are obtained

$$\Delta\bar{\sigma}_{ij}=-B\Delta\bar{\varepsilon}_{ij}\,, \qquad (26)$$

$$\Delta\bar{\sigma}_0=\alpha\sqrt{\frac{BK}{3}\Delta\bar{\varepsilon}_{nm}\Delta\bar{\varepsilon}_{nm}}\,, \qquad (27)$$

$$\alpha=\begin{cases}1, & dacă\quad \bar{\varepsilon}_{nm}\bar{\varepsilon}_{nm}>\varepsilon_{pq}\varepsilon_{pq}\\ -1, & dacă\quad \bar{\varepsilon}_{nm}\bar{\varepsilon}_{nm}\le\varepsilon_{pq}\varepsilon_{pq}\end{cases}.$$

Assuming that the elastic properties of subelements and of the body element are identical

$$\bar{e}_{ij}=\frac{\bar{\sigma}_{ij}}{2G(\gamma,\upsilon)}\,,\quad e_{ij}=\frac{\sigma_{ij}}{2G(\gamma,\upsilon)}\,, \qquad (28)$$

the equations of fluctuations of reversible and irreversible strains are obtained from (26)

$$\bar{e}_{ij}-e_{ij}=m\left(p_{ij}-\bar{p}_{ij}\right),\quad m=\frac{B}{B+2G}\,. \qquad (29)$$

Unknown internal parameter m is determined on the basis of the principle of the measures discrepancy, formulated by V.Marina [3-4]: in all real interactions in conglomerate the discrepancy between the macroscopic measure and the suitable microscopic analogue reaches extreme values

$$\left\langle\bar{\sigma}_{ij}\bar{\varepsilon}_{ij}\right\rangle-\left\langle\bar{\sigma}_{ij}\right\rangle\left\langle\bar{\varepsilon}_{ij}\right\rangle=Extr\,. \qquad (30)$$

Parameter of the kinematic scheme m, as follows from extremum of the discrepancy Δ [6,8], depends on the linear hardening coefficient a_0:

$$m=-a_0+\sqrt{a_0+{a_0}^2}\,. \qquad (31)$$

The internal parameter B is determined from the relation (29):

$$B(\gamma,\upsilon)=2G(\gamma,\upsilon)\frac{m}{1-m}\,. \qquad (32)$$

2. PROPORTIONAL LOADING

We will examine the deformation of the body element along a rectilinear trajectory to determine the rheological functions $\tau=\tau(\psi,\gamma,\upsilon)$, reflecting thermoviscoplastic properties of the subelements.

Tensor properties of subelements in conglomerate under proportional loading are given, taking into account that the directrixes of the deviators of reversible e_{ij}, $\bar{e}_{ij}$ and irreversible p_{ij}, $\bar{p}_{ij}$ strains coincide:

$$\frac{\bar{e}_{ij}}{\bar{e}}=\frac{e_{ij}}{e}=\frac{\bar{p}_{ij}}{\bar{p}}=\frac{p_{ij}}{p}=a_{ij}\,, \qquad (33)$$

$$\bar{e} = \sqrt{\bar{e}_{ij}\bar{e}_{ij}}\ , \quad \bar{p} = \sqrt{\bar{p}_{ij}\bar{p}_{ij}}\ . \tag{34}$$

Inserting (28) and (6) into (33) we find

$$\frac{\sigma_{ij}}{\sigma} = \frac{\varepsilon_{ij}}{\varepsilon} = a_{ij}\,, \tag{35}$$

$$\sigma = \sqrt{\sigma_{ij}\sigma_{ij}}\ , \qquad \varepsilon = \sqrt{\varepsilon_{ij}\varepsilon_{ij}}\ . \tag{36}$$

The local relation between reversible and irreversible strains (29) is represented in the form:

$$\bar{e} - e = m\left(p - \bar{p}\right). \tag{37}$$

In the monotonous process the irreversible deforming law (17) for the group of the irreversibly deformed subelements $0 \le \psi \le \psi'$ is written as:

$$\bar{e} = \tau\left(\psi, \gamma, \upsilon\right) + s + \bar{r}\,, \tag{38}$$

where

$$\cos\alpha = \frac{p_{ij}}{p}\frac{dp_{ij}}{d\lambda} = 1, \quad s = ap\,, \quad \bar{r} = a_0\bar{p}\,. \tag{39}$$

According to (37), for the group of subelements, operating in the reversible domain ($\psi' < \psi \le 1$, $\bar{p} = 0$), the elastic strains of subelements are identical and coincide with the limit elastic strain in the boundary subelement $\psi = \psi'$:

$$\bar{e} = e + mp = \tau\left(\psi', \gamma, \upsilon\right) + s\,. \tag{40}$$

The function $\tau\left(\psi', \gamma, \upsilon\right)$, reflecting thermoviscoplastic properties of the subelements without regard the structure evolution, can be expressed in terms of macroscopic quantities:

$$\tau\left(\psi', \gamma, \upsilon\right) = e + \left(m - a\right)p\,. \tag{41}$$

Differentiating (37) and (38) at a constant values of the state parameters γ and υ, we can conclude that the rate of change of the irreversible deformation has the same value for all of the subelements from the subset $\psi \le \psi'$

$$\dot{\bar{p}} = \frac{\dot{e} + \left(m - a\right)\dot{p}}{a_0 + m}, \tag{42}$$

$$\dot{e} = \frac{d}{dt}\sqrt{e_{ij}e_{ij}}\ , \qquad \dot{p} = \frac{d}{dt}\sqrt{p_{ij}p_{ij}}\ . \tag{43}$$

According to the average connections concept

$$\dot{p} = \int_0^1 \dot{\bar{p}}\,d\psi = \int_0^{\psi'} \dot{\bar{p}}\,d\psi + \int_{\psi'}^1 \dot{\bar{p}}\,d\psi = \int_0^{\psi'} \dot{\bar{p}}\,d\psi\,. \tag{44}$$

Thus the distinctive parameter of subelements ψ' can be represented by the following relation

$$\psi' = \frac{\dot{p}\left(a_0 + m\right)}{\dot{e} + \left(m - a\right)\dot{p}}\,. \tag{45}$$

In the monotonous process of deformation along a rectilinear path from (7) and (33)-(34)

$$\dot{\bar{\lambda}} = \frac{d}{dt}\sqrt{\bar{p}_{ij}\bar{p}_{ij}} = \dot{\bar{p}}\,. \tag{46}$$

Substituting (46) into (11) and taking into account that $\dot{\bar{p}}$ has the same value for all of the irreversibly deformed subelements $\psi \le \psi'$

$$\gamma = \frac{1}{\psi'}\int_0^{\psi'} \dot{\bar{p}}\,d\psi = \dot{\bar{p}}\,, \qquad \dot{\bar{p}}\Big|_{\psi > \psi'} = 0\,. \tag{47}$$

Inserting (42) into (47), the state parameter γ is expressed as

$$\gamma = \frac{\dot{e} + \left(m - a\right)\dot{p}}{a_0 + m}\,. \tag{48}$$

The structure of the relation (48) follows that within the limits of the investigated model the condition of continuity of the material transition from reversible to irreversible state is satisfied automatically.

Indeed, we note that at the initial moment of the flow $\dot{p} = 0$ so the parameter γ is proportional to rate of the total strain change $\dot{\varepsilon} = \dot{e}$:

$$\gamma = \frac{\dot{\varepsilon}}{a_0 + m}\,. \tag{49}$$

Therefore the considered model does not provoke any uncertainties in the moment of the material transition from reversible to irreversible state.

Let's pass in (48) to rates of change of the modules of the stress and strains deviators

$$\gamma = \frac{1 - m + a}{a_0 + m}\frac{\dot{\sigma}}{2G} + \frac{m - a}{a_0 + m}\dot{\varepsilon}\,, \tag{50}$$

where

$$\dot{\varepsilon} = \frac{d}{dt}\sqrt{\varepsilon_{ij}\varepsilon_{ij}}\ , \qquad \dot{\sigma} = \frac{d}{dt}\sqrt{\sigma_{ij}\sigma_{ij}}\ . \tag{51}$$

We'll examine the isothermal loading of the thin-walled tubes with the tensile force F and the internal pressure P_i. The radial stress t_{rr}, being of order of internal pressure, can be neglected in comparison to the axial t_{zz} and circumferential $t_{\varphi\varphi}$ stresses

$$t_{zz} = \frac{F}{2\pi Rh} + \frac{P_i R}{2h}\,, \qquad t_{\varphi\varphi} = \frac{P_i R}{h}\,. \tag{52}$$

The orientation of the loading path in the space of axial t_{zz} and circumferential $t_{\varphi\varphi}$ stresses we'll define by the parameter

$$\zeta = \frac{t_{\varphi\varphi}}{t_{zz}}, \qquad (53)$$

and determine the ratio of tensile force and the internal pressure

$$\frac{F}{P_i} = \frac{2-\zeta}{\zeta}\pi R^2. \qquad (54)$$

In [10] it was established that in laboratory conditions the simplest experiment at the constant parameter γ is the experiment at the constant velocity of the gripping device motion $\dot{d}_{zz}$, if the orientation of rectilinear path of loading in the space of stresses t_{zz} and $t_{\varphi\varphi}$ is specified as follows:

$$\zeta = \frac{2-\eta}{1+\eta}, \qquad \eta = \beta\frac{2G}{K}\frac{m-a}{1-m+a}. \qquad (55)$$

The stress-strain diagram obtained by isothermal loading at $\dot{d}_{zz} = const$ is plotted in the space of the deviator modules of reversible and reversible strains $e \sim p$ (figure 1)

$$\sigma = \sqrt{\frac{2}{3}\left(\zeta^2-\zeta+1\right)}\,t_{zz}, \quad \varepsilon = \sqrt{\frac{3}{2}}\left(d_{zz}-\varepsilon_0\right), \qquad (56)$$

$$e = \sqrt{\frac{2}{3}\left(\zeta^2-\zeta+1\right)}\,\frac{t_{zz}}{2G}, \qquad p = \varepsilon - e, \qquad (57)$$

where d_{zz} is axial strain of the thin-walled sample.

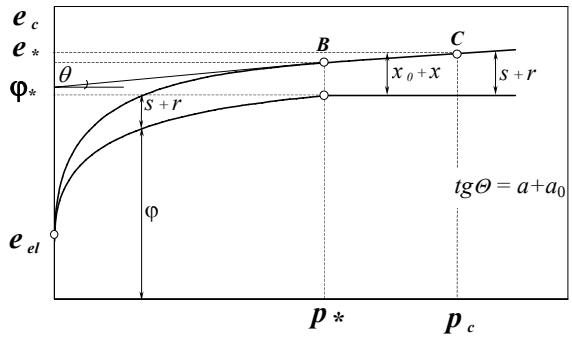


Figure 1. Diagram of the proportional loading of the thin-walled tubes by axial force and internal pressure at the constant temperature and the rate of change of the axial strain.

Taking into consideration that at $\varepsilon = \varepsilon_{el}$ is still satisfied the relation

$$\varepsilon_0 = \frac{1-2\nu}{3}d_{zz}, \qquad (58)$$

we can write the expression for the parameter γ (49) in this way

$$\gamma = \sqrt{\frac{2}{3}}\,\frac{1+\nu}{a_0+m}\dot{d}_{zz}, \qquad (59)$$

where ν is Poisson's ratio, $\dot{d}_{zz}$ is the velocity of the gripping device motion.

By means of the diagram $e \sim p$, obtained under isothermal proportional loading, the thermo-viscoplastic properties of subelements can be determined at $\gamma = const$, $\upsilon = const$:

$$e = \varphi(p,\gamma,\upsilon) + s + r. \qquad (60)$$

During the scleronomous and isothermal loading we have $e_{,p} = \varphi_{,p} + a + a_0$, hence the relations (41) and (45) are obtained as follows

$$\tau(\psi',\gamma,\upsilon) = \varphi(p,\gamma,\upsilon) + (m+a_0)p, \qquad (61)$$

$$\psi' = \frac{a_0+m}{\varphi_{,p}+m+a_0}. \qquad (62)$$

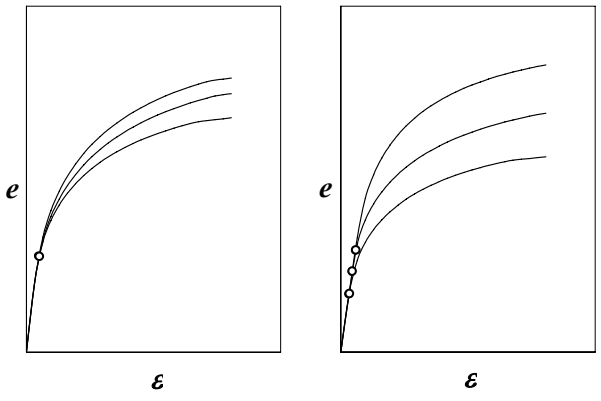
Thus, the thermoviscoplastic properties of subelements are determined on the basis of the proportional loading diagrams $e = e(p,\gamma,\upsilon)$ at the various constant value of the state parameters γ and υ.

In the investigated model it's considered that rheological functions $\tau(\psi',\gamma,\upsilon)$, reflecting thermoviscoplastic properties of subelements without regard the structure evolution, depend on the average rate of change of irreversible deformations γ. In the classical theories, conversely, it is assumed that rate of change of irreversible deformation depends on the stress. In the case of a single-element model both concepts lead to the same results. However, for a conglomerate, consisting of a finite or infinite number of subelements, these concepts lead to different results in describing the behavior of the material.

The functional $\tau(\psi',\gamma,\upsilon)$ represents the limiting elastic strain in the structurally stable state (without hardening). As long as all subelements in the volume element V_0 are in the reversible state, the weight of irreversibly subelements stressed beyond the limit of elasticity $\psi' = 0$. Taking into account (41), (61) and (49), we obtain

$$\tau(0,\dot{\varepsilon},\upsilon)=\varphi(0,\dot{\varepsilon},\upsilon)=\varepsilon_{el}(\dot{\varepsilon},\upsilon). \qquad (63)$$

The classical theories follow that the elastic limit of the conglomerate does not depend on the strain rate $\dot{\varepsilon}$ (figure 2).



a) **b)**

Figure 2. Influence of the strain rate $\dot{\varepsilon}$ on the elastic limit of the conglomerate: ***a)*** *in the classical theories;* ***b)*** *in the investigated model.*

3. THERMOVISCOELASTIC PROCESSES

It's possible to distinguish three stages of deformation during monotonic loading of the system of subelements. At an initial stage, all subelements operate in the elastic domain, because the processes, occurring under the condition $\varepsilon \le \varepsilon_{el}(\gamma,\upsilon)$, will be called thermoviscoelastic. If $\varepsilon_{el}(\gamma,\upsilon)<\varepsilon<\varepsilon_{*}(\gamma,\upsilon)$, then the part of the subelements is in the reversible state and the other in irreversible. Such processes can be called thermoviscoelasticplastic. In the third stage of the conglomerate deformation all subelements operate beyond the limit of elasticity $\varepsilon>\varepsilon_{*}(\gamma,\upsilon)$. In this case it is about the thermoviscoplastic processes. Further we'll analyze in detail the thermoviscoelastic process.

In the thermoviscoelastic process all subelements are in the reversible state, so in the volume element V_0 of the polycrystalline body the weight of irreversibly subelements stressed beyond the limit of elasticity $\psi'=0$.

Under proportional loading tensor properties of subelements in conglomerate are given by (35), taking into consideration that the directrixes of the deviators of stresses σ_{ij} and total strains ε_{ij} coincide (35):

$$\sigma_{ij}=\frac{\sigma}{\varepsilon}\varepsilon_{ij}. \qquad (64)$$

In this case

$$\sigma=2G(\gamma,\upsilon)\varepsilon\le\sigma_{el}=2G(\gamma,\upsilon)\varepsilon_{el}(\gamma,\upsilon). \qquad (65)$$

The volume compressibility modulus K is assumed independent of rate of strain change, so the following relationship between spherical tensors of stresses and strains is satisfied

$$\sigma_0=K(\upsilon)(\varepsilon_0-\varepsilon_T), \qquad (66)$$

where ε_0 is the total volume modification; ε_T – non-mechanical volume change (thermal $\alpha_T T$, structural, etc.).

Taking into account (65) and (66), Poisson's ratio is determined by the formula

$$\nu(\gamma,\upsilon)=\frac{K(\upsilon)-2G(\gamma,\upsilon)}{2[K(\upsilon)+G(\gamma,\upsilon)]}=\frac{1}{2}\left(1-\frac{E(\gamma,\upsilon)}{K(\upsilon)}\right). \qquad (67)$$

From (67) it follows that if shear modulus G increases then Poisson's ratio ν is reduced. This phenomenon has wide experimental confirmation [1, 5, etc.].

According to (65) the thermoviscoelastic processes are determined by two factors: the relationship between shear modulus G and state parameters γ and υ, as well as the extension of the thermoviscoelastic state of the body element $\varepsilon_{el}(\gamma,\upsilon)=\tau(0,\gamma,\upsilon)$.

Duration of the reversible state with respect to the deformation is determined not thermoviscoelastic properties, defined by function $G=G(\gamma,\upsilon)$, but by thermoviscoplastic properties defined by function $\varepsilon_{el}=\varepsilon_{el}(\gamma,\upsilon)$. This phenomenon is not peculiar to subelements, taken separately, and follows from the kinematic coherence of system of subelements. As a result, despite the fact that the deformation of the volume element starts at zero rate of change of macroscopic deformation $\dot{p}=0$, but in the weakest subelement $\dot{\bar{p}}>0$ therefore, proceeding from (48), we obtain for the variable state parameters γ and υ

$$\gamma=\dot{\bar{p}}=\frac{\dot{\varepsilon}-\varepsilon_{el,\gamma}\dot{\gamma}-\varepsilon_{el,\upsilon}\dot{\upsilon}}{m+a_0}. \qquad (68)$$

As a result of this the elastic limits of subelements $\tau(\psi,\gamma,\upsilon)$ become dependent on the rate of deformation change of the body element, which in turn leads to a change in the value ε_{el}. Thus, the thermoviscoplastic properties of the

subelements due to the continuity of the material transition from reversible to irreversible state influence thermoviscoelastic characteristics of material. The kinematic coherence of subelements leads to the interdependence of phenomena of the different nature.

To determine the duration of the reversible deformation of the body element we use the condition of continuity of material transition from reversible to irreversible state. At the beginning of the micro flow $t = t_1$, taking into account that $\dot{p}(t_1) = 0$

$$\gamma(t_1) = \frac{\dot{\varepsilon}(t_1) - \varepsilon_{el,\upsilon}\dot{\upsilon}(t_1)}{m + a_0}, \qquad \dot{\gamma}(t_1) = 0. \qquad (69)$$

Taking into account (69) in the condition $\varepsilon \le \varepsilon_{el}(\gamma, \upsilon)$ we obtain the equation to determine moment of occurrence of flow

$$\varepsilon_{el}\left(\frac{\dot{\varepsilon}(t_1) - \varepsilon_{el,\upsilon}\dot{\upsilon}(t_1)}{m + a_0}, \upsilon(t_1)\right) = \varepsilon(t_1). \qquad (70)$$

Equations (69), (70) are convenient to use when histories of change of deformation $\varepsilon = \varepsilon(t)$ and temperature $\upsilon = \upsilon(t)$ are defined.

The viscoelastic properties affect only the length of reversible state, if the shear modulus $G(\upsilon)$ is independent of the loading rate. In the case when histories of the loading $\sigma = \sigma(t)$ and heating $\upsilon = \upsilon(t)$ are given, expressions (69) and (70) can be represented in the form

$$\gamma(t_1) = \frac{1}{m + a_0}\left[\frac{\dot{\sigma}(t_1)}{2G} - \left(\frac{\sigma(t_1)G_{,\upsilon}}{2G^2} + \varepsilon_{el,\upsilon}\right)\dot{\upsilon}(t_1)\right], \quad (71)$$

$$\varepsilon_{el}\left(\frac{\dfrac{\dot{\sigma}(t_1)}{2G} - \left(\dfrac{\sigma(t_1)G_{,\upsilon}}{2G^2} + \varepsilon_{el,\upsilon}\right)\dot{\upsilon}(t_1)}{m + a_0}, \upsilon(t_1)\right) = \varepsilon(t_1). \quad (72)$$

System (69) and (70) naturally reflects the phenomenon of delay of yield, which follows from the concept of continuity of the material transition from reversible to irreversible state. Based on this concept is possible to describe a series of thermoviscoelastic effects on the level of the body element, endowing subelements only thermoviscoplastic properties. Also it automatically removes problem of the boundary between the thermoviscoelastic and thermoviscoplastic properties of the material.

If the shear modulus *G* depends on the rate of deformation and loading, it is necessary to concretize structure of the state parameter γ in the thermoviscoelastic domain. We assume that the expression for γ (50), obtained from the analysis of behavior of system of subelements in irreversible domain, remains unchanged under reversible loading.

Under proportional loading the system of constitutive equations is written as:

$$\sigma = 2G(\gamma, \upsilon)\varepsilon, \qquad \varepsilon \le \varepsilon_{el}(\gamma, \upsilon), \qquad (73)$$

$$\gamma = \frac{1 - m + a}{a + m}\frac{\dot{\sigma}}{2G} + \frac{m - a}{a + m}\dot{\varepsilon}. \qquad (74)$$

Independence the stress deviator from the deformation path in the reversible domain is shown in figure 3.

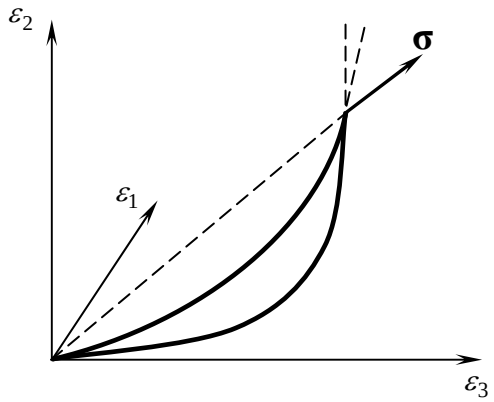


Figure 3. Deformation path in the space of the total strains.

Integrating (74) for zero initial conditions, we calculate the variation of stress (strain) for a given process of change of temperature and strain (stress).

If during loading the strain exceeds the value $\varepsilon_{el}(\gamma, \upsilon)$, then irreversible deformations occur in the macroelement. The relationship $\sigma \sim \varepsilon$ is complicated and modification of the system of the constitutive equations (73)-(74) becomes invalid.

CONCLUSIONS

In the investigated model it's considered that the elastic limits of subelements $\tau(\psi', \gamma, \upsilon)$ depend on the rate of deformation change of the body element γ, which in turn leads to a change in the value ε_{el}. Thus, the thermoviscoplastic properties of the subelements, due to the continuity of the material transition from reversible to irreversible state, that the structure of the relation (48) confirms, influence thermoviscoelastic characteristics of

material. The kinematic coherence of subelements leads to the interdependence of phenomena of the different nature.

In the classical theories, conversely, it is assumed that rate of change of irreversible deformation depends on the stress. In the case of a single-element model both concepts lead to the same results. However, for a conglomerate, consisting of a finite or infinite number of subelements, these concepts lead to different results in describing the behavior of the material. The classical theories follow that the elastic limit of the conglomerate does not depend on the strain rate $\dot{\varepsilon}$.

The resulting equations of thermoviscoelastic process (73)-(74) describe the characteristic features of material in reversible domain. Under loading at constant rate of strain change $\dot{\varepsilon} = const$ this system follows as $\dot{\sigma} = const$ and vice versa, which results to a linear relationship between stress and strain in such tests. System (73)-(74) are describing the creep in the experiments when $\sigma = const$ and stress relaxation of the body element when $\varepsilon = const$.

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BIOLOGICAL FOULING OF ULTRAFILTRATION MEMBRANES DURING OPERATION

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INTRODUCTION

Membrane technologies are widely used for treatment of various water mediums and solutions, such as saline and brackish waters, wastewaters, yeast cream, liquids in milk and brewing productions etc. The subject matter of membrane using is filtration cycle duration, or operational period. In terms of economics membrane fouling is the main obstacle to using membrane filtration. To evaluate the applicability of membrane technologies a detailed analysis of treated water is performed, and in most cases experimental justification is required. Different waters can have different composition, which is defined by the place of wastewater generation and that influences filtration cycle duration. However, contaminants can be divided into groups of determination contaminants, and such division will allow to minimize mistakes in selection, designing and operation of membrane systems.

Membranes are subject to fouling with colloidal particles, inorganic, organic and biological organisms. So [1] fouling of semi-permeable membrane partition surface can be characterized by different factors as well as by their complex, which depends on physic-chemical processes of natural water and wastewater treatment. For example, oil-product presence in any water considerably decreases performance of membrane elements. Generality of factors, that lead to membrane performance decrease, allows to analyze them and reduce negative influence by including additional filtration stages.

1. ANALYSIS OF PARAMETERS AND FACTORS, THAT LEAD TO DECREASE OF MEMBRANE PERFORMANCE

Analysis of factors, that lead to decrease of membrane performance showed, that the chief factors are adsorption of suspended and solute organic and inorganic components, chemical interaction of membrane material and solute agents, biofouling from feed water. It happens due to membrane capability to permeate one material and reject the other. Therefore appearance of high concentration of rejected particles over the membrane surface is an essential fact. Highly concentrated materials form a layer, which results into increase of resistance to mass transport. This resistance is called concentration polarization. Thus it may be concluded that polarization processes appear in all baromembrane methods of water treatment. Membrane fouling is most often the limiting factor of their application. Agreeably, membrane fouling may be considered to be lowering of membrane operational surface. And this causes decrease of flow under predicted membrane capability. Some parameters, that affect time of membrane fouling are listed below:

- kind and concentration of solutes and solvents;
- membrane type;
- pore size distribution;
- membrane surface and material properties;
- hydrodynamics of membrane module.

Membrane fouling can be associated with processes of adsorption, chemical interaction, pore covering or appearing of contamination above the pores (so called "cake").These factors can cause partial or full blocking of membrane operational surface or coating membrane surface with a layer of particles.

2. BIOLOGICAL FOULING

Biofouling is called by the authors [2] the Achilles' s heel of membrane filtration methods. This is because microorganisms can continuously increase using biodecomposed admixtures from feed water, even if they were 99% rejected on the previous filtration stages.

Biofouling can be caused by the following negative factors [3-7], that influence membrane systems:

- permeate flow decrease due to formation of biofilm, which reduces membrane surface permeability;

- increase of pressure drop across the membrane, which requires increase of pressure to the bulk fluid;

- membrane biodegradation, caused by acid medium which is result of biofilm activity co-products appearance on membrane surface. For example, cellulose acetate membranes are the most susceptible to biodegradation.

- increase of rejected particles penetration and water quality degradation due to concentrating of contaminants in the biofilm, which enlarges the extent of concentration polarization.

- increase of power inputs for water pressurizing through membrane.

Exact understanding of bacteria generation process and biofilm formation will allow providing of undisturbed operation of natural water and wastewater treatment systems with minimum membrane fouling and, also, prevent irreversible membrane modifications. Bacterial surface contamination (e.x. biofilm formation) can be divided into 3 phases: microorganisms transport to the surfaces, fixation on membrane surface, further growth of microorganisms.

Membrane systems design is complicated, it has many extended surfaces, chinks and dead spaces in pipelines and fitments. Elements, included into membrane have a huge surface area, which is easily accessible for microorganisms fixation and growth. These surfaces are particularly subject to biofouling.

When designing membrane systems and calculating their usage efficiency in different productions one should take into account costs, required for maintenance of water microbiological safety (especially in productions, where bacteriological pollution is critical for end product). This can be seen in nutritional, medical, pharmaceutical and electronic productions. In these cases it is incorrectly to save on pipelines and stop valves.

The easiest and the most effective way of preventing biofilm growth on the membrane surface is control of general microbial number. While carrying out control and registration of microbiological contamination it is necessary to observe tendencies of microbiological quality changes in feed and filtered water. Depending on the source of water and season, water can show variable contamination level. Therefore, before designing membrane systems it is necessary (if possible) to examine quality of feed water during the year. But this is not a key method for surface water sources. Bacterial growth often depends on factors, which are hard to predict or foresee and it is very important to understand if there is a tendency to contamination growth. Also it is not always possible to carry out permanent control of water microbiological characteristics in time, which provides membrane performance, which will not lead to irreversible processes.

In work of Flemming H.-C and co-authors [8] it is shown that biofilm forms in three days. Due to bioadhesion this time is enough to cover the whole membrane surface with biofilm. Ghayeni and co-authors [9-10] researched initial adhesion of wastewaters bacteria, which belong to Pseudomonas family, by reverse osmosis membrane. Their research showed, that first irreversible processes of bacteria fixation on the membranes start in several minutes after delivery of feed flux to membrane. It was determined, that bacteria films add more membrane resistance, than concentration polarization, caused by other contaminants of feed flux. It was determined, that microorganisms of Pseudomonas family quickly fix on the membrane surface. Pseudomonas aeruginosa is a gram-negative mobile rodlike bacterium, obligatory (strict) aerobe. Its size - 0.5-0.8 micron thick and 1.5-3 micron length. Widespread in nature. Can be found in biofilm and in plankton form, i.e. a separate bacteria, that moves using its polar flagellum. With that Pseudomonas Aureginosa is one of the most mobile microorganisms, that can be found in water specimens from natural sources. Blue pus bacillus can not only be preserved for a long time in environment (wet atmosphere and water), but also multiply fast. Comfort temperature is 37 ^{o}C, but it can also grow at 42^{o}C. Research works on formation of biofilm on reverse osmosis membranes were carried out by M. Herzberg and M. Elimelech [4]. As a result of experimental studies it was found that due to high concentration of protein and possibility of microorganisms fixation on the membrane surface, Blue pus bacillus grows more intensive in a layer, close to membrane.

Basing on the foregoing it may be concluded that due to high level of nutrients in natural water this bacillus can well multiply on membranes. In case of nutrition lack bacteria growth is considerably slower and biofilm covers not the whole membrane surface. These findings are confirmed by experimental researches, obtained in works [10-11].

3. CONCLUSIONS

Membranes biofouling is one of the factor, that brings down appeal of this method of water and wastewater filtration.

For successful membrane ultrafiltration technology performance periodic sanitation is required.

One of perspective development path is using membranes, that have bactericidal properties and their design should prevent biofilm formation.

The most perspective development path is adding modifying components to membranes material or inoculating of modifying material with bactericidal properties.

New technologies must be developed to control biofouling. This will significantly expand the scope of application of ultrafiltration for the treatment of natural and waste waters

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THE CONVENIENCE OF USING COMPRESSED NATURAL GAS IN PUBLIC TRANSPORT OF PASSENGERS

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INTRODUCTION

Tendency to reduce the emission of noxious products of diesel oil combustion in engines, treatment of the CNG as a fuel seems to be promising. It seems that in the future ecological aspects will matter more and more in Republic of Moldova with the UE adherence rules. So, considering ecological advantages of the CNG as a fuel, probably this technology will be more widespread. Obviously, the development of this technology requires the competitive price of the CNG with respect to the traditional fuels. The rapid increase of the number of vehicles can be observed. It is connected with undesirable phenomena: air pollution, soil pollution, water pollution and noise. It is estimated that the road transport is the main source of these effects. One of the methods of changing this situation is the replacement of the fuel type. The good alternative seems to be the utilization of the natural gas. It can be stored in a vehicle as Liquid Natural Gas (LNG) or Compressed Natural Gas (CNG). It also increases the level of fuel diversification in vehicles. It decreases economical dependency on the chosen fuel provider, what makes the company situation more secure. Utilization of natural gas as vehicle fuel bring not only the economical, abut also social and ecological benefits.

1. TECHNIQUE OF COMPRESSED NATURAL GAS USAGE

1.1. Gas fueling stations

In Republic of Moldova there are about 10 natural gas refueling stations − it is appreciably too less. Unfortunately the arrangement of the gas stations is very adverse. Most of them are located in Chisinau. An increase of the amount of cars fueled by CNG is possible only in the case of higher number of refueling stations. Employees working on the refueling stations have to be specially trained to serve the gas high-pressure facilities. The proper fire-fighting and flame-proof protection is also important.

1.2. Fuel tanks

Compressed natural fuel tanks have to be very refractory and leak proof. Gas pressure level is about 20 MPa, so it is necessary to use proper material for container wall. Nowadays, steel containers are widely used. Weight and huge dimensions are the main disadvantages. The container weight increases real vehicle weight which produce additional fuel consumption and decrease vehicle performance. For this reasons, new materials, as for example composites, are putted into commission. The composite containers durability is higher than the steel ones and their weight can be even three times lower. Internal side of this containers is made from aluminum and external from carbon fiber. The only disadvantage is the higher price of this containers comparing to the steel. On the other hand, lower weight causes lower consumption of the fuel.

According the requirements of the “Technical Inspection Agency”, CNG containers have to be periodically controlled. It is recommended to do this every three years.

1.3. Internal combustion engine

It is easier to adapt a gasoline engine. The problem is bigger in a diesel engine, widely used in buses and trucks. Removing fuel system and replacing it with the gas system is required. Engine supplied with the compressed natural gas (CNG) works similarly to a spark ignition engine. The engine needs construction changes like: decrease compression ratio, alternative form of chamber combustion and putting in the ignition system. Typical CNG fuel system is shown in Figure 1. Gas comes from a high pressure fuel tank (20 MPa). The gas pressure is decreased to the level of about 0,8 MPa in a three-stage reducer. This low pressure gas is mixed with the air and constitutes the combustible mixture, which is provided to combustion chamber.

To reduce nitric oxides, oxidize carbon monoxide and another hydrocarbons, the engine can be equipped with three-way catalyst. The three-way

catalyst works properly only with a stoichiometric coefficient of the air factor (λ) from the range of 0,98-1,02. The only possibility to achieve this value is the application of a microprocessor engine control system. Important part of the engine control system uses lambda sensor which measures oxygen level in exhaust fumes. According to this value combustible mixture is prepared.

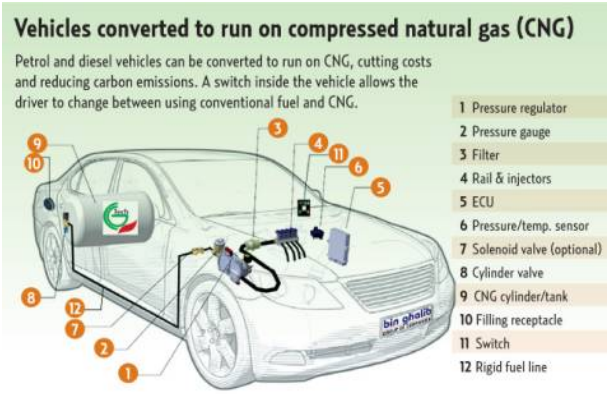

Figure 1. Wiring diagram of the CNG cars.

The start of the cold engine is trouble-free. The main advantage of the CNG is a high anti-knock index, which assures a non-detonation combustion and engine smoothness prolonging the durability of the engine.

Preparation of the combustible mixture is easier with gas than with gasoline. Good quantity of the gas fuel is obligated for the proper engine operation. EN ISO 15403: 2005 describes gas properties requirements for being used as a fuel in car engines.

2. ECOLOGY OF COMPRESSED NATURAL GAS ENGINES

Compressed natural gas is a mixture of light paraffinic hydrocarbons, for instance: methane (83-99%), ethane, propane or butane. Apart from desirable components, the compound is made of foulants like nitrogen, hydrogen sulfide or carbon dioxide. After proper processing, the natural gas is suitable for vehicle supply. There are many advantages of usage of this fuel instead of diesel oil or gasoline.

Transport of the natural gas is safer than of the liquid fuel. The density of the natural gas is lower than of the air. In case of container damage or non-hermetic insulation, gas quickly moves up and does not create flammable mixture. In the event of the road accident with liquid fuel tanker, the risk of soil, water or air pollution is higher than in case of the gas piping transport.

Derivatives of the oil combustion cause the huge emission of very dangerous pollution like dust, poly nuclear aromatic hydrocarbons or benzene. These substances are classified as carcinogenic substances entailing the increase of the cancer cells. Application of the compressed natural gas reduces drastically the quantity of these dangerous substances in fumes. Emission of other gaseous pollutants is also limited.

Table 1. Decrease of polluant emission by the replacement of gasoline and diesel with CNG.

	Gasoline/GNC	**Diesel/GNC**
CO	60-80%	70-90%
NMHC	85%	40-60%
NO_x	50-80%	80-90%
PM	-	99%
CO_2	20%	25%
Noise	-	40%

The CNG usage as a fuel decreases CO_2 emission to the atmosphere even to 25% over gasoline or diesel fuels, which reduces the risk of greenhouse effect. NO_x emission is also lower which influences the decrease of the risk of acid rains. Moreover, NO_x is also a greenhouse gas, so the reduction of its emission decreases also the danger of the global warming. The CNG usage also reduces the non-methane hydrocarbons (NMHC) and particle matters (PM) emission too. These two substances influences the smog growing, especially in the cities. The PM emission reduction is near 100%. The CNG does not contain any sulfur compounds so its usage as vehicles fuel is more safe for buildings, especially old ones.

Buses propelled by the CNG fit all norms, even the most restrictive ones. Since October 2009, new acuter limits of emission of pollution have been enacted, nevertheless the CNG still fits all confines. Noise level generated by the CNG engines can be even with 40% lower than diesel engines, which is desirable effect in cities and in densely populated built-up grounds.

3. ECONOMIC OUTLOOK FOR DEVELOPING CARS POWERED BY COMPRESSED NATURAL GAS

For the society, economic efficiency determines cost-effectiveness of the investigated project. For commercial projects, financial aspects are the most important. For non-commercial projects very important are also non-financial benefits, like environmental impact. A project is economically efficient when investment outlays and

operating costs are less than social benefits. It means it is efficient in the apprehension absolute. Relatively, economic project takes it to satisfy one concrete requirement of the population which is implemented by least financial cost. For researching efficient economical analysis should be employed, which allows to evaluate both financial and social benefits. The main purpose of the economical analysis is the expression value of the projects. It is necessary for proper share of the public resources between competitive investment projects.

As it can be noticed, investment in compressed natural gas is cost-effective just in determined conditions. The difference between the CNG and gasoline /diesel price is very important. When the difference increases, the profitability of the CNG usage also increases. When the difference decreases, the profitability also decreases significantly. The price of the diesel fuel was much higher than of the CNG in previous years. Therefore, it is possible that many cities will introduce buses fuelled by the natural gas. On the fuel prices huge influence have taxes, especially excise duty. Currently, the natural gas price is lower than of the other fuels. Taking into account the increase of the natural gas prices, introduction period of the buses in urban transport companies can be inconvenient. It is possible that companies could not invest in more ecological but much expensive CNG buses due to the increase of the operating costs.

Important for the introducing of the CNG buses in the urban transport companies is its price. The CNG buses are much more expensive (in comparison with the diesel buses supply) by the fact that the CNG technology is new, permanently improvement and the quantity of production of the CNG vehicles is quite small. It is the reason why many companies are not able to buy CNG buses.
Subsidies are the element which significantly redounds to distribute alternative fuels in the transportation.

Currently, there is a possibility to get it from the European Union and from the council funds. This is one of the aspects which leads to increase the usage of the gas fuel in public transportation in the last few years. However, the new technology on the market in the close future could be more profitable.

Vehicles supplied by Liquid Natural Gas (LNG) are used in many countries of Europe. The main advantage is smaller size of LNG storage, in comparison with the CNG. By dint of it, LNG could be real competitive for the buses supplied by compressed natural gas, diesel or gasoline.

Biogas can be also very useful. It is stored as compressed gas. So, buses fuelled by the natural gas can be directly fuelled by biogas. Experts said that in Republic of Moldova are many unused farm wastes which could be used for biogas production and which now are thrown out on landfill. The Main disadvantage of this technology is the small amount of refueling stations.

CONCLUSIONS

In last few years, it can be observed a pronounced increase of interest regarding to the usage of the compressed natural gas as a fuel for the public transportation. Despite financial, economical and ecological advantages, the process of implementation of the natural gas in vehicles in Republic of Moldova is quite slow. One of the reasons is the necessity to invest in refueling stations. The unstable macroeconomic policy and the threat of excisable duty cause the increase of the gas price, which makes the investments very risky. On the other hand, small quantity of gas users makes project unprofitable. Only long-term, well-defined and green policy could bring on increase of interest for the CNG usage as engine fuel. Moreover, the main purpose of the big cities long-term policy should be the improvement of the passengers comfort in public transportation for which the inhabitants will pay. The increase of the overcrowding streets by vehicles will be a norm in the future extorting development of the public transportation, which is passenger-friendly. Natural gas vehicles should fit these conditions.

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CONSIDERATIONS ON USING SLAG STEELWORKS IN ROAD CONSTRUCTION

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1. GENERAL ASPECTS

13 million tons of slag were produced annually in Romania, resulting from production processes of iron and steel. Its storage in waste dumps involves serious environmental problems by occupation of large land areas and instability of dump layers, which can reach tens of meters in thickness. Therefore there was always a concern for the best use of this product. These efforts have led to almost total use of metallurgical slag, especially as construction mineral material and as fertilizer. By using different technologies, liquid slag can be processed to produce a wide range of products certified for use in road and hydrotechnical construction or agriculture. The high rate of use of metallurgical slag is not achieved by any other industrial product.

In metallurgy two major types of products (waste) are defined, named depending on the end product desired to be obtained, as follows:

a) high blast furnace slags obtained in the manufacture of iron in the crucible of furnace at temperatures of max. 1600 °C, consisting of impurities of iron ore (Si, Al) combined with calcium and magnesium oxides of mineral flux.

Depending on the cooling methods, there are three types of products:

- air-cooled blast furnace slag (gross) slowly solidified under atmospheric conditions;
- granulated slag, solidified rapidly under the action of water;
- expanded slag, obtained by successive treatment controlled: air/water.

b) steelworks slag, obtained in the manufacture of steel, composed of silicates and aluminoferits of calcium and oxides (of calcium, iron, magnesium, manganese).

Depending on the furnace used there are:

- converter slag (Oxygen insufflation) or Lintz - Donawitz process, called LD or BOF;
- electric arc furnace slag, called EAF;
- Siemens - Martin slag, which are no longer produced but still exist in the steel plants dumps [1].

Recovery of these by-products, in particular blast furnace slag dates back to 1900 (road foundations, cement fabrication, etc.). Used alone or mixed with other natural products.

Since the 1940s Germany, the main producer of iron and steel, began to use these products processed or raw in qualified areas (especially in construction), while imposing specific requirements of use.

In our country it has been shown by experimental works that slags are able to replace natural aggregates (totally or in a certain percentage). Yet the government interest was reduced because of the impossibility of processing them to improve their technical characteristics, though economically, financial effort required was reduced.

Processing slag stored in dumps of steel and iron production plants, for using the non-ferrous materials resulting after recovering iron is a concern of specialists from around the world.

Non-ferrous materials, from which the ferrous material was eliminated 100% are known in literature as 'by-products', separated in cathegories depending on the grain sizes. They can successfully replace natural aggregates used in road and hydraulic construction, civil engineering, railways and even can be used as fertilizer for acid soils. [2]

Their properties namely density, crushing strength, compressive strength, water absorption, resistance to freezing – thawing, resistance to abrasion and grinding, define the way of application and the scope of these sorted materials called *'artificial aggregates'*.

Use of steelworks slag aggregates in the roadside lead to numerous technical and economic advantages for both the user and the manufacturer by:

a) diversification of road construction materials;

b) reducing construction costs by replacing natural aggregates;

c) eliminating waste storage dumps obtained from steel works and therefore environmental protection;

d) maintaining the bearing capacity within the operating parameters of the road system, offered by the carbonic solidification of aggregates and the ease in achieving optimum compaction;

e) the properties of steelworks slag aggregates allow development of roads which

does not influence the environment under the action of climatic factors (rain, freeze - thaw, etc.).

f) reducing the risk of permanent deformations due to stability to mechanical and thermal actions in service;

g) ensure the service life of roads, safe and comfortable, due to texture that gives roughness and high resistance to skidding.

The fundamentals of metallurgical slag plant-use are the technical regulations which set the properties, requirements and tests for these materials. [3]

2. CURRENT SITUATION REGARDING USE OF STEELWORKS SLAG IN ROAD STRUCTURES

It is estimated that worldwide since 1978, more than half of steelworks slag production has found an application in road construction, as follows:

- Basic layers: 35 - 57%
- Layers of foundation: 3-6%
- Bituminous layer: 7-13%

Germany, which is the largest steel-producing of all European countries, has used the steelworks slag since 1974 (currently being used 97% of the total production) [4]

At the European level a committee of representatives of 10 European countries was formed, aimed at investigating and implementing the use of slag, increasing the area of their use or application and last but not least development of common European standards based on research, country-specific rules and instructions. (European Project to develop the technical specification on the use of steelworks slag).

Because of the research in the last 30 years, almost 70% of slag resulting as a by-product of the electric arc furnaces and steelworks converter is used in qualified application areas by fulfillment the requirements of standards and/or national or international specific regulations. [5]

In Germany, steelworks slag aggregates are used frequently for mechanically stabilized foundations, execution of related works of roads or link and base layers with bituminous binders as well as for execution of wear layers with classic or special asphalt mixtures.

In conclusion, in many European countries steelworks slag have been used successfully as construction materials for roads, both in foundation and base layers and the upper layers of road structure [6].

3. CURRENT SITUATION OF SLAG DEPOSITS IN ROMANIA

In order to highlight the economic potential of a deposit area and to create an image on the changes caused to the environment, one of the existing slag dumps in our country, namely dump Buituri, will be presented.

3.1 General aspects regarding the formation of dump

Formation of the dump began in 1967 with the first slag deposits on the valley Hărăoani, deposits that were made from an average level of land of 255 m.

With the achievement of 321.93 m deposit level and the increasing of slag dump instability, expansion of deposit area to a new location was needed.

To ensure the stability of land in the area were executed development works consisting of construction of supporting spurs at the foot dump and water management works, that is conducting ditches and drains to collect rainwater.

The maximum deposit level currently averages 340 m and dump the slag is spread over an area of approx. 80 ha, totaling approx. 50 million m^3, ie approx. 150 million tons of slag.

Dump height is not uniform throughout the area occupied, steps with heights between 5 and 50 m and widths of 20-150 m.

Slag dump structure is varied and uneven, the slag mass consisting of approx 70%, steelworks slag, approx. 30% blast furnace slag, contamination with refractory broken brick and unselected steel scrap to dump 44, or mechanically driven as drops in the slag. [7]

By processing slag excavated from dump Buituri the following by-products are obtained:

- Scrap iron recovered

From the mass processed results about 6.5% scrap recovered with a purity of approx. 85-90%, the remainder - 15% - must be processed before placing in oven.

- Gross slag recovered

Gross slag recovered is 78.5% of slag processed. It was considered that 6.5% is the percentage of scrap and 15% are technological losses. Finished products made by processing slag and their use are:

- 10% iron slag, used in metallurgical processes
- about. 68.5% iron free slag, used in:
- Civil engineering 3%
- Cement industry 6%
- Construction of roads 1%
- Construction of highways 90%

4. TESTS CARIED OUT ON ASPHALT MIXTURES WITH STEELWORKS SLAG

For the beginning, two asphalt concrete compositions rich in pearls type BA 8 (Series I) using D 80/100 bitumen and type BA 16 (Series II) using D 100/120 bitumen were made.

Aggregates used were crushed slag (5-8 and 8-16 sort), natural sand river and limestone filler.

The physico - mechanical values were determined on cubic and cylindrical specimens made of mixtures (series I and II), prepared with different percentages of bitumen.

Then, two other asphalt concrete compositions, rich in pearls, type BA 8 (series III) and BA 16 (series IV), of crushed slag used as aggregate (sort 5-8 and 8 - 16), crushed sand 0-4, natural sand 0-4 and limestone filler, were prepared.

By analysing the results of determinations one founds that:

- By using sorts 0-5, 5-8 and 8-16 of crushed slag (LIDONIT) there resulted an optimum bitumen percentage of 7% for BA 8;
- By eliminating LIDONIT sort 0-5 and replacing it with crushed sand (0-4), the percentage of bitumen decreased to 5,75 % (using the same type of bitumen D 80/100), which shows high porosity and high specific surface of this sort. In addition, the high content of CaO (9.0%) results in swelling in the pavement layer after execution;
- Development of swelling for mixtures of type BA 8 and BA 16 (series I-IV) shows that the values recorded does not go beyond 1%, which shows a good behavior in time to water;
- Both bulk density values and Marshall stability values exceed the required minimum of SR174-1, which provides good resistance to the combination of traffic and climatic factors.

5. CONCLUSION

The experimental results presented confirmed the successfully use of slag by replacing the natural aggregates in pavement layer.

This provides a significant decrease in the cost of work (slag - an industrial waste - is much cheaper than natural aggregate).

The use of slag aggregates also results in environmental protection by removing slag storage areas and conservation of natural environment (extraction of natural aggregates may disrupt ground water, may increase erosion, etc.).

Disadvantages of using steelworks slag in road layers could be the following:

The risk of heavy metals in the composition of aggregates of steelworks slag, which could be washed by rainwater and could infest the groundwater. To eliminate this risk a leaching test should be performed by a specialized institute.

Possibility of changing the volume by increasing or decreasing the height of the layer due to free lime hydration. To eliminate this risk is recommended as good waterproofing the upper layers and appropriate drainage works to prevent entry of rainwater into the base or foundation layers of the road system as well as aging of slag before use.

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COMPARISON OF GEOMETRIC PARAMETERS OF CATIONS IN COBALT (III) AND RHIDIUM (III) COMPOUNDS

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INTRODUCTION

It is known that many substances can form conformers, which with the same structural formula have different spatial structure (conformation). Under the conformation we understand the geometric shapes of molecules, passing into each other without changing the valence angles and bond lengths, for example, by rotation about single bonds [1]. The phenomenon of conformation is used in stereochemistry as one of the methods for studying the spatial structure of molecules of organic and inorganic substances, in particular complex and chelate compounds. The spatial structure of substances has a great influence on the physical and chemical properties (direction and speed of reaction and others).

In the work [2] is given the systematics of structural data of heteromolecular compounds built from heterogeneous molecules of polyatomic ions.

The main issues solved by the authors are: development of the principles of systematics of heteromolecular crystals, study of general laws of the structure of this class of compounds on the basis of statistical processing of data in the literature, study of peculiarity of particles packing into heteromolecular crystals of coordination compounds, study of contact conformation in crystals of coordination compounds, quantitative comparison of geometry of symmetrically independent complex molecules, as well as the impact of supersymmetry in heteromolecular crystals of coordination compounds.

In this paper we set out to explore the study of crystal structures in terms of determining the conformational differences, the quantitative comparison of the geometry of complex cations, transition metals of rhodium (III) and cobalt (III) with *TCS*, and rhodium (III) and cobalt (III) dioximins with two symmetric ligands of chalcogencarbamide (*Thio, Seu*) on the axial coordinate *Lig - M - Lig* [3].

1. TYPES OF CONFIRMATIONAL DIFFERENCES

The basis of the proposed systematics is the empirical approach of fixation, adequately studied and typical cases of conformation. For coordination compounds are distinguished the following types of specific differences affecting the first or second coordination sphere of transition metal:

1. Differences in the conformation of metallocycles.

2. Differences in the method of articulation of metallocycles.

3. Differences in rotations around single metal-ligand bonds.

4. Differences in the relative position of the ligands in equal (or close) coordination polyhedrons.

5. Differences in the chirality of mirror-equal metallocycles.

2. DIFFERENCES IN THE CONFORMATION OF METALLO-CYCLES

Uncoordinated thiosemicarbazide has a flat structure and exists in two stereoisomeric forms in cis- and trans-configurations depending on the rotation of hydrazine group NH_2 around the *C-NH*-bond. Free *TSC* in crystalline state has a trans-configuration. Likewise, it also behaves in connection with silver, where *TSC* is a monodentate ligand. In other crystal structures, examined by us in the literature review and in this paper, *TSC* has the cis-conformation, being a bidentate ligand. In these compounds, as already noted, it forms stable five-membered chelate metallocycles *MTSC - RhSCN(1)N(2)*, coordinating with the metal through the sulphur and nitrogen atoms of the hydrazine group [3].

The question of the spatial structure of cycles is considered in detail in the paper [1]. There is also stated that any molecule, including cyclic, tends to take such a spatial form, in which the sum of all the "stresses" (Bayer - valences deviation from their

normal position unfavourably creates an increase in the energy storage of molecules; Pitzer - forced deviation from the most favourable odd conformation; tension caused by the mutual repulsion of converged atoms at the expense of Van der Waals forces; bond stress – (change of normal interatomic distances) and internal energy are minimal. Author [1] indicates that the cycles, starting with a four-membered one, have non-planar structure, thereby reducing the Pitzer stress. Each cycle is characterized by a geometric figure. For the five-membered ring the stable form is the envelope, for a six-membered – bath or chair.

According to data on X-ray structural analysis of crystal structures studied by us I - XI complex cations have octahedral structure. Analysis of plane equations passed by MLS through metallocycles of coordination polyhedra I-VI shows that metallocycles have the shape of an envelope, their shape and spatial orientation being diverse. In the crystal structure *[(TSC)$_3$]Cl$_3$* conformational envelopes of metallocycles of molecules *MTSC-I* and *MTSC- III* have an open triangular portion oriented upwards, in *MTSC-II* – downwards. A similar structure and opposite orientation of metallocycles is observed in the complex cation of crystal structure *[(TSC)$_3$]Cl$_3$3H$_2$O Rh*, where *MTSC-III* is oriented with the triangular portion of the envelope downwards, and *MTSC-II* and *MTSC-I* – upwards. The equations of planes, passed OLS through the metallocycle atoms, and the relative deviations from them of these atoms are given in Table 1.

Table 1. Crystallographic characteristics of the investigated compounds.

№ of struc-ture	**Compound**	**A** **α**	**B** **β**	**C** **γ**	**Z**	**R**	**N**
I	[Rh(TCS)$_3$]Cl$_3$	15,396(2) 90	9,193(3) 90	11,496(1) 80,0(1)	4	0,065	3664
II	[Rh(TCS)$_3$]Cl$_3$3H$_2$O	10,135(2) 90	9,726(4) 90	19,960(1) 108,10(2)	4	0,060	4043
III	[Co(TCS)$_3$]Cl$_3$3H$_2$O	10,043(2)	9,715(1)	20,013(4) 108,0(3)	4	0,150	660
IV	[Co(TCS)$_3$]Cl$_3$3H$_2$O (violet modification)	14,801(5) 90	10,115(3) 90	12,662(4) 97,07(3)	4	0,030	1660
V	[Rh(TCS)$_3$]Cl$_3$3H$_2$O (green modification)	13,507(4) 90	9,901(2) 90	16,131(2) 103, 96(4)	4	0,071	1077
VI	[Rh(TCS)$_2$Cl$_2$]ClH$_2$O	12,458(4) 94, 75(3)	13,792(2) 107,21(4)	8,098(6) 96,82(2)	4	0,072	1200
VII	[Co(DH)$_2$(Thio)$_2$]NO$_3$H$_2$O	7,905(1) 90	11,480(3) 90	23,141(6) 98,34(4)	4	0,048	2309
VIII	[Co(DH)$_2$(Seu)$_2$]NO$_3$H$_2$O	7,978(2) 63,83(2)	11,558(3) 75,45(2)	12,935(4) 82,37(2)	2	0,088	3584
IX	[Co(MH)$_2$(Thio)$_2$] NO$_3$H$_2$O	17,703(3) 90	8,873(12) 90	12,477(7) 98,401(6)	4	0,051	1004
X	[Rh(MH)$_2$(Thio)$_2$] NO$_3$H$_2$O	17,820(2) 90	8,964(2) 90	12,572(3) 98,03(2)	4	0,031	1606
XI	[Co(DH)$_2$(Thio)$_2$] NO$_3$	19,624(4) 90	8,934(3) 90	12,338(2) 91,06(5)	4	0,056	1941

Table 1 shows the parameters of metallocycles, α-angle between the planes of the three- and four-membered parts of the envelope (folding angle) for each metallocycle. In complex cations of both modifications $[Co(TSC)_3]Cl_3 3H_2O$ and V structures the spatial orientation of the two metallocycles is opposite [3]. The third metallocycle *MTSC-III* in structure IV and *MTSC-I* in V have practically a planar structure with the folding angle close to 180°. Consequently, thiosemicarbazide, as already noted, forms with the transition rhodium (III) and cobalt (III) metals stable metallocycles having the most favourable to it conformation of half-open or open envelope. In such cyclic compounds two main types of spatial isomerism – geometrical and optical may occur simultaneously. Chemical and physicochemical differences of the compounds appear to be explained by a conformational difference between them.

3. DIFFERENCES IN THE METHOD OF METALLO-CYCLES

Conformation of this type can be realized in fairly complex aggregates with polydentate ligands. Differences in rotations about single metal-ligand bonds in the examined structures are observed in cobalt (III) and rhodium (III) dioximins.

4. DIFFERENCES IN THE RELATIVE POSITION OF THE LI-GANDS

Trithiosemicarbazide compounds of cobalt (III) and rhodium (III) exist as two geometrically isomeric forms, differing in chemical and physicochemical properties, as well as the in geometric structure. Indeed, the X-ray analysis of these compounds I-VI shows a different location of *TSC* ligands in coordination octahedra. The spatial orientation of *TSC* ligands in structures I-IV is characteristic for the coordination octahedron of the cis-isomer, in structure V – for trans-isomer. *TSC* ligands in two independent complex cations of structure V occupy a cis-position [3].

Dioximins of trivalent cobalt and rhodium with the chalcogencarbamide also form coordination octahedra at the expense of four nitrogen atoms, dioximin molecules and two sulfur atoms. Dioximin molecules, in particular *(DH)* and *(MN)*, are located in a plane and form conditionally the so-called equatorial segment. The remaining two chalcogencarbamide ligands (*Thio* and *Seu*) occupy transpositions with respect to the equatorial moiety. Thus, the metal atom is located almost in the center of a distorted octahedron formed by six atoms: four *N* trans-ligands of dioxidans and two S (Se) - chalcogencarbamide. By the mutual arrangement of ligands in the literature exist and are described the cis-dioximins and trans-dioximins of trivalent transition metals. The structure of investigated cobalt (III) and rhodium (III) dioximins of structures VII-IX is appropriate to refer to trans-dioximins.

5. DIFFERENCES IN THE GEOMETRY OF COORDINATION POLYHEDRAL

Comparing the same type of bond lengths and valence angles in the structures of rhodium (III) and cobalt (III) with sulphur- and selenium-containing ligands, we have not found significant geometric changes in the shape of octahedral polyhedra. Complex cations, formed by nitrogen and sulphur (selenium) atoms of *TSC Thio*, *DH* and *MH* ligands in the investigated crystal structures, are slightly distorted octahedra due to unequal radii of the atoms entering into the coordination of the metal and other factors associated with the change of bond lengths and valence angles.

Thus, in this paper are collected, compiled and analyzed data on the structure of transition metal coordination compounds with chalcogene-containing ligands: thiosemicarbazide and chalcogenocarbamides.

CONCLUSIONS

1. The structure of coordination compounds of cobalt (III) and rhodium (III) with thiosemicarbazide is determined by the method of X-ray structural analysis. On the basis of structural material analysis is shown:

a) The octahedral coordination of *Co* and *Rh* with ligand joining by the chelate *S*, **N**-type is realized in compounds I-VI. Upon coordination there occurs a substantial delocalization of the electronic density in metallocycles.

b) The reason for the difference in the complex of physico-chemical properties consists in the isomerism thereof: in compounds I-IV is realized the face shape of the octahedron, in V – the edge one.

c) It is shown that the properties of one geometric isomer of *[M(TSC)$_3$]*-type complex (II, III and IV) strongly depend on the nature of molecule packing in the crystal.

d) In the bis-ligand complex of V is revealed the presence of supersymmetry elements in the crystal.

2. The structure of cobalt and rhodium compounds with dioximins containing as axial ligand chalcogencarbamide molecules is determined. On the basis of information structural analysis is shown:

a) The octahedral coordination of the metal with the transposition of sulfur-containing ligand with respect to the equatorial moiety (EM) is realized in structures VII - XI.

b) For the first time is proven the fact of non-valence interaction of chalcogencarbamide with the metallocycle (EM), which leads to the effect of ligand-induced proton shift in the latter. After the example of compounds VI and VIII a new type of isomerism in cobalt (III) dioximins is revealed.

c) The isostructural properties of the complexes of different composition IX - XI are shown, which is determined by the major contribution of intermolecular hydrogen bonds in the formation of the crystal structure.

3. On the basis of crystal-structural analysis of compounds I - XI their conformational and geometric differences are revealed.

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KINEMATICS OPTIMIZATION OF THE GENEVA MECHANISMS

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INTRODUCTION

A number of different mechanisms can be used to convert the uniform rotary motion into intermittent rotary motion. The simplest of these mechanisms is the Geneva mechanism. The major disadvantage of the conventional Geneva mechanism is that the output motion starts and ends with nonzero values of acceleration. This problem limits the usefulness of the Geneva mechanism to low speed applications. In order to eliminate the shock of loading caused by these nonzero initial and final accelerations, two directions can be considered in the existent literature:

- transforming the straight radial slots into curved slots;
- using an intermediary mechanism to rotate non-uniformly the driving pin.

1.GENEVA MECHANISM WITH CURVED SLOTS

Based upon the geometry and the kinematics of the Geneva mechanism with curved slotted wheel, studied by R.G. Fenton in [2], this paper presents the main characteristics of this mechanism.

1.1. Modeling parameters

The following parameters are used to characterize the Geneva mechanism with curved slots (see Figure 1):

N – number of slots in the wheel;

θ_0 – the half angle between the axes of symmetry of any two consecutive slots, $\theta_0 = 180/N$;

$\varphi_1^{(0)}$ - the initial position angle of the crank, $\varphi_1^0 \in [110^o, 160^o]$;

φ_1 - the current position angle of the crank;

$\varphi_2^{(0)}$ - the initial position angle of the wheel;

φ_2 - the current position angle of the wheel;

α_0 – the supplement of the initial position angle of the crank, freely selected by the designer, within certain practical limits, $\alpha_0 = 180^o - \varphi_1^0$;

t_m – the motion time of Geneva wheel at a full rotation of the driving crank;

t_p – the pause time of Geneva wheel at a full rotation of the driving crank;

σ - the indexing ratio, $\sigma = t_p/t_m$, or if the angular velocity is constant, the indexing ratio can be also expressed as $\sigma = (180 - \alpha_0)/\alpha_0$;

L – the distance between the driving crank and the wheel axis, O_1O_2;

R – the driving crank radius, O_2P;

R_d – the wheel radius;

$\Delta\theta_0$ – one half of the offset between the entry point, A, and the exit point, C, of the slot.

1.2. Aspects concerning the geometry and the kinematics

The geometry of the curved slotted Geneva mechanism was studied by Fenton in [2]. In order to define this mechanism, it is necessary to impose the fulfillment of the geometrical conditions by the displacement function, as it follows:

$$\begin{aligned} \varphi_2(\varphi_1)\big|_{\kappa_1=\varphi_1^0} &= \varphi_2^0; \\ \varphi_2(\varphi_1)\big|_{\kappa_1=\varphi_1^0+2\alpha_0} &= \varphi_2^0 - 2\theta_0 \end{aligned} \tag{1}$$

and the kinematical conditions:

$$\left.\frac{d\varphi_2}{dt}\right|_{t=0} = 0; \left.\frac{d\varphi_2}{dt}\right|_{t=t_m} = 0; \tag{2}$$

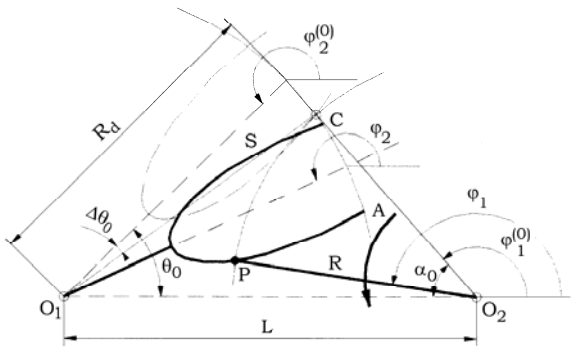


Figure 1. Fenton's Geneva Mechanism

$$\left.\frac{d^2\varphi_2}{dt^2}\right|_{t=0} = 0; \left.\frac{d^2\varphi_2}{dt^2}\right|_{t=t_m} = 0. \tag{3}$$

To diminish the acting shocks of the mechanism, it is recommended that the maximum acceleration value to be as small as possible. In (1), the most representative displacement functions are studied. In Table 1, the corresponding maximum acceleration values for each studied displacement function is presented, considering the same configuration for the Geneva mechanism. All the mentioned displacement functions fulfill the imposed geometrical and kinematical conditions (1) and (2). After analyzing these maximum acceleration values, it can be concluded that the modified trapezoidal displacement function ensures the lowest acceleration peak.

Table 1. Displacement functions.

The displacement functions	$\left.\frac{d^2\varphi}{dt^2}\right\|_{max}$
Cycloidal	$\pi \frac{\theta_0}{\alpha_0^2}$
Modified trapezoidal	$2{,}444 \frac{\theta_0}{\alpha_0^2}$
Modified sine	$2{,}764 \frac{\theta_0}{\alpha_0^2}$
Polynomial 3-4-5	$2{,}886 \frac{\theta_0}{\alpha_0^2}$
Polynomial 4-5-6-7	$3{,}756 \frac{\theta_0}{\alpha_0^2}$

By changing the slot shape from a straight radial line to a curved line, a Geneva mechanism with improved kinematical characteristics is obtained.

1.3. The "Y" type Geneva mechanism

Analyzing the Fenton's Geneva mechanism, it can be seen that the pressure angle reaches the value of 90^o [1], fact that renders the transmitted force, zero.

The "Y" type Geneva mechanism represents a hybrid mechanism between the conventional Geneva mechanism and the Fenton's one, This new mechanism was designed with aim to extend the optimization criteria, considering, also, the minimizing of the pressure angle, in order to improve the force transmitting properties of the mechanism.

According to Figure 2, the supplementary modeling parameters are (the previous presented remain available):

$\varphi_1^{(1)}$ - the position angle of the driving crank at the entrance of the linear zone of the slot;

$\varphi_2^{(1)}$.- the position angle of the wheel, when the driving crank enters the linear zone of the slot.

The proposed Geneva mechanism is named of type "Y" according to the shape of the slot in the wheel. The characteristic profile of the slot is represented by the line ABB'BA (see Figure2). Three zones characterize this profile:

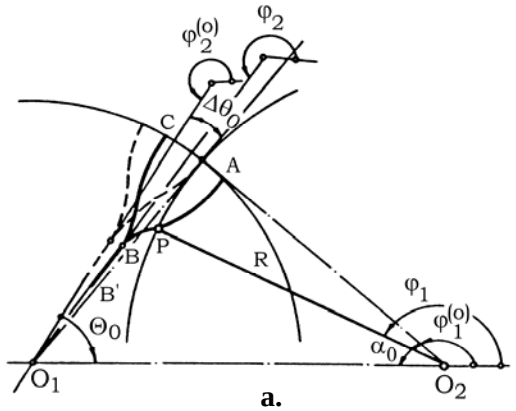
AB – curvilinear zone of the slot, on which the driving pin enters the slot (Figure 2, a);

BB'B – radial linear zone of the slot, similar to the conventional mechanism, which corresponds to the middle of the motion period (Figure 2, b);

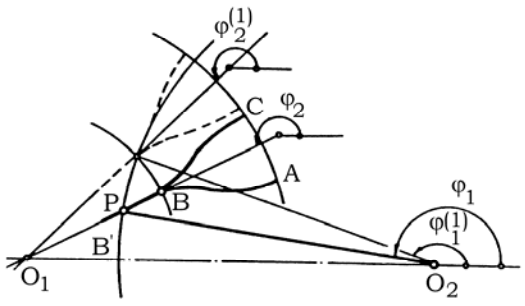
BC - curvilinear zone of the slot, on which the driving pin leaves the slot.

These three zones of the slot are imposed by the optimization criteria, as it follows:

- the kinematical optimization criteria (zero values for acceleration at the beginning and at the end of the Geneva wheel motion) fulfilled by adopting the curvilinear zones of the slot. These slot zones will be modeled by 5^{th} degree polynomial displacement functions;



a.



b.

Figure 2. "Y" Geneva mechanism.

- considering the qualities of the conventional Geneva mechanism regarding the efficiency of power transmission, reflected by zero values of the pressure angles, a straight radial zone of the slot replaces that curvilinear slot zone of the Fenton's mechanism, characterized by important values of the pressure angle.

Therefore, the displacement function of the proposed mechanism is a compound function with three different analytical expressions, corresponding to the three zones of the slot. This compound displacement function is presented in Table 2.

The values of the polynomial coefficients of the displacement function characteristic for the entering and leaving zones of the slot will be established by considering premises:

- the displacement, velocity and acceleration functions are continuous;
- the displacement, velocity and acceleration functions have to fulfill the geometrical and the kinematical conditions, modeled by the relations (1) and (2).

The "Y" type Geneva mechanism represents a generalization the different types of external Geneva mechanisms, being a hybrid solution between the conventional Geneva mechanism with straight radial slots and Fenton's mechanism with curvilinear slots.

Table 2. The displacement function for a "Y" type Geneva mechanism.

Slot zone	**Profile type**	φ_1	φ_2
AB	Curvilinear	$\varphi_1^{(0)}...\varphi_1^{(1)}$	$\varphi_2 = a_1\varphi_1^5 + a_2\varphi_1^4 + a_3\varphi_1^3 + a_4\varphi_1^2 + a_5\varphi_1 + a_6$
BB'B	Rectilinear	$\varphi_1^{(1)}...360^o - \varphi_1^{(1)}$	$\varphi_2 = \pi + atg\dfrac{\dfrac{R}{L}\sin\varphi_1}{1+\dfrac{R}{L}\cos\varphi_1}$
BC	Curvilinear	$360^o - \varphi_1^{(1)}...360^o - \varphi_1^{(0)}$	$\varphi_2 = b_1\varphi_1^5 + b_2\varphi_1^4 + b_3\varphi_1^3 + b_4\varphi_1^2 + b_5\varphi_1 + b_6$

2. GENEVA MECHANISM DRIVEN BY A CAM MECHANISM

The obtained advantages by using an appropriate intermediary driven mechanism, in order to rotate non-uniformly the driven crank of a conventional Geneva mechanism are:

- the nonzero acceleration values at the beginning and at the end of the motion of the Geneva wheel can be eliminated;
- the acceleration peak of the Geneva wheel is decreased in comparison with the Geneva wheel without driven mechanism;
- the dwell to motion time ratio can be freely selected by the designer, therefore the using flexibility of this mechanism is increased;
- the input and the output elements of the compound mechanism can be coaxial assembled.

2.1. Modeling parameters of the compound Geneva mechanism

The compound Geneva mechanism, studied in this chapter, is obtained by a serial connection of a conventional Geneva mechanism with an intermediary driven cam mechanism. The main geometrical modeling parameters are presented in Figure 3.

The supplementary notations are the following:

φ_{1a} - the current position angle of the driving cam;

$\varphi_{1a}^{(0)}$ - the position angle of the cam which corresponds to the entering of the pin in the slot of the Geneva wheel.

2.2. Kinematical considerations regarding the compound Geneva mechanism

Considering that the displacement function of the intermediary driven mechanism is $\varphi_1 = \varphi_1(\varphi_{1a})$, depending on the chosen displacement function of the cam mechanism, and the displacement function for the conventional Geneva mechanism, imposed by the mechanism construction, $\varphi_2 = \varphi_2(\varphi_1)$, for the compound mechanism the displacement function becomes:

$$\varphi_2 = \varphi_2(\varphi_{1a}). \tag{4}$$

After successive differentiation of the displacement function (4), the velocity and the acceleration of the mechanism are obtained, as it follows:

$$\frac{d\varphi_2}{d\varphi_{1a}} = \frac{\partial\varphi_2}{\partial\varphi_1}\frac{\partial\varphi_1}{\partial\varphi_{1a}}; \tag{5}$$

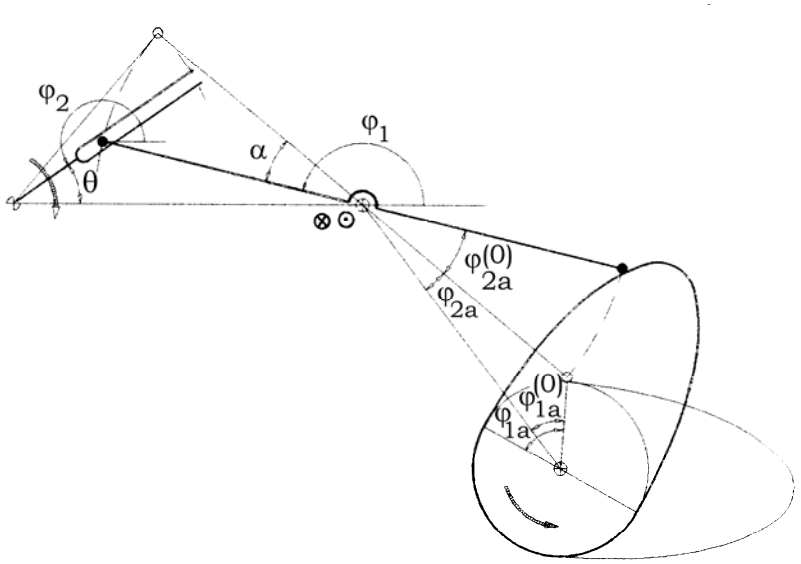


Figure 3. Geneva mechanism with driven cam mechanism.

$$\frac{d^2\varphi_2}{d\varphi_{1a}^2}=\frac{\partial^2\varphi_2}{\partial\varphi_1^2}\left(\frac{\partial\varphi_1}{\partial\varphi_{1a}}\right)^2+\frac{\partial\varphi_2}{\partial\varphi_1}\frac{\partial^2\varphi_1}{\partial\varphi_{1a}^2}. \qquad (6)$$

Considering the kinematical optimization criteria imposed to the compound mechanism (zero acceleration values at the beginning and at the end of the Geneva wheel motion), and after analyzing the relation (6), for the driven mechanism the following conditions are imposed:

$$\left.\frac{\partial\varphi_1}{\partial\varphi_{1a}}\right|_{\varphi_1=\frac{\pi}{2N}(N+2)}=0;\left.\frac{\partial\varphi_1}{\partial\varphi_{1a}}\right|_{\varphi_1=\frac{\pi}{2N}(3N-2)}=0. \qquad (7)$$

The displacement function for the driven cam mechanism may be any of the displacement functions recommended in the literature, such as: the linear displacement function, the harmonic displacement function, the cycloidal displacement function etc. From all of these, considering in the same time the geometrical acting conditions and the kinematical criteria (7), the most appropriate are the cycloidal and the polynomial displacement functions.

3. CONCLUSIONS

All the proposed solutions, for improving the kinematical characteristics of the conventional Geneva mechanism, fulfill the imposed criterion to ensure zero acceleration values at the beginning and at the end of the Geneva wheel motion.

The "Y" type Geneva Mechanism represents a generalization of the different types of Geneva mechanisms with modified slots, rendering also a better transmission of the forces in the mechanism, due to optimum values for the pressure angle.

The compound Geneva mechanism driven by a cam mechanism doesn't need a complex technology to obtain the wheel, as the other proposed solutions, ensuring in the same time the possibility of coaxial assembling for the input and output elements.

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PLANETARY PRECESSIONAL TRANSMISSIONS: GENERATION TECHNOLOGIES

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1. INTRODUCTION

A problem for engineering companies (especially in the metalworking industry, automotive, chemical and metallurgical industries) is to satisfy the ever-increasing requirements to the transmissions used in majority of industrial machinery and technological equipment related to bearing capacity, compactness, mass and dimensions, low cost of production, etc., and, in particular, to kinematical characteristics, structural compatibility with other aggregates of the equipment, etc. Gearings are considered the most sophisticated components of machines. Machine reliability depends very much on the gearing mechanical transmission operation, in general. The quality indices of traditional gears were increased largely by changing involute gearings, and by creating new gearings, such as Novikov-Hlebanija [1] Symark [2], etc.

In the field of planetary transmission it was considered properly to follow the way of developing new types with increased performances. Scientific analysts consider that in the field of technical sciences worldwide an essentially new type of mechanical transmission is being invented every 20-25 years. Thus, the German engineer L. Braren developed the cycloid planetary transmission "CYCLO" in 1923 [3]. The Russian engineer A. Moskvitin invented the harmonic friction transmission in 1944 [4] and in 1959 the American engineer C.W. Musser developed the harmonic gear transmission [4].

In the late 70ies a new type of mechanical transmission has been developed at the Polytechnic Institute of Chisinau (now the Technical University of Moldova). The new type of mechanical transmission entered into international terminology circuit as planetary precessional transmission (PPT). The first patent was issued under this name in 1983 [5,6]. Planetary precessional transmission differs from the classical one by the new principle of motion and load transformation and transmission, i.e. by using sphere-spatial motion of the satellite and variable convex – concave profile. Due to these innovative features gearing multiplicity in planetary precessional transmission reaches 100% (in classical transmissions - 3-7%) which provides increased bearing capacity, reduced dimensions and weight, extended kinematical range ± 10 ... ± 3599 (in harmonic transmissions 79 ... 300), high kinematical accuracy, etc. The research team involved in research on precessional planetary transmissions published over 800 scientific articles, obtained about 170 patents, implemented about 20 practical achievements in the field of fine mechanics and specialized technological equipment, in robotic complexes for the exploration of ferro - manganese concretions from the World Ocean bottom (USSR concept), in spaceflight technique, etc.

Know-how in the elaboration of multicouple precessional gear, manufacturing technology and control methods, and a range of precessional transmission diagrams belong to the research team from the Technical University of Moldova.

- The specific character of sphere-spatial (precessional motions of the precessional transmissions pinion make impossible the utilisation of classical involute teeth profiles. This fact requires the elaboration of new profiles adequate to the sphere-spatial motion of pinion, which would ensure high performances to the precessional transmission. Carrying out on the principle of the transfer function continuity and gear [5] based on the principles of the transfer function continuity and gear multiplicity which aims to:
- the elaboration of the gear mathematics model with account of the peculiarities;
- the analytical description of teeth profiles by a system of parametric equations on spherical surface and normal teeth section for inner and plane gear;
- CAD determination of geometrical and cinematic parameters influence of the gear upon the teeth profiles shape and the justification of their rational limits of variation;
- the elaboration of the theoretical basis evaluation of teeth gear multiplicity in precessional transmissions;
- area definition of gear multiplicity existence by 100% teeth couples.

- the production of non-standard teeth profiles requires a new manufacturing technology. In the complexity of problem "*gear-synthesis-profile study- manufacturing*" the elaboration of efficient methods of teeth manufacturing which ensures a maximum productivity and reduced cost while satisfying the requirements related to the gear with precessional motion plays an important role. To solve this problem the following has been done:
- we elaborated the mathematical model of teeth generation which shows the interaction of teeth in precessional gear;
- we investigated the kinematics of the mechanism of method realisation for teeth generation;
- we determined the tool path of motion and the family envelope of the generating surface by using the computer;
- we elaborated and manufactured from metal milling and tooth grinding tools, inclusively their longitudinal modification.

2. GENERATION TECHNOLOGIES

2.1. General remarks

Development of mechanical transmission with gear, different from the classical one, requires complex research in various fields. This finding refers to planetary precessional transmission with multicouple gear, which is characterized by essential constructive-kinematical features. In solving complex problems related to "*gear synthesis - profile research – fabrication*" an important role belongs to developing efficient methods of teeth manufacturing, which would ensure maximum productivity, reduced cost and quality.

Manufacture of precessional gear wheels with convex-concave and variable tooth profile cannot be achieved by existing generation technologies, but through fundamentally new technology. Generation technology of precessional wheel teeth must ensure continuity of motion transformation function with the following conditions: non-standard and variable tooth profile, and satellite carrying out sphere-spatial motion with a fixed point. To achieve the above, a new procedure for teeth processing is proposed by self-generating method with precessional tool against rotating blank [7,8].

To develop the theoretical basis for generating tooth profile by running the precessional tool it is necessary to determine the character of continuous contact of the tool cutting edge and profile of the processed wheel tooth for a complete "*tool-blank*" precessional cycle. In this connection a mathematical model of tooth self-generating method by running the precessional tool was elaborated, which fully reflects the actual interaction of teeth in precessional transmission. For this purpose the following was described:

- kinematical connection of the precessional tool with the blank that ensures continuity of motion transformation function in the linkage "*tool-blank*";
- path of motion of the tool centre in the fixed system of coordinates;
- path of motion of the tool centre in the movable system of coordinates, connected with the rotating blank;
- the generating contour of the tool in the movable system of coordinate and the system envelope of generating surfaces of the tool for a cycle of precession;
- projection of tool contour envelope in the plane system of coordinates.

2.2. Technological system for teeth generation by sphere-spatial motion of tool as truncated cone

2.2.1. Kinematics of gear generation system

To achieve teeth generation method a tool carrier device was developed, which diagram is shown in Fig. 1. In the designed device the node, which involves the tool in sphere-spatial motion, is stopped from rotating around the common axis of the main shaft-blank - a kinematic joint. Rotation of blank 3 and main shaft 1is coordinated by the division kinematic chain of machine tool.

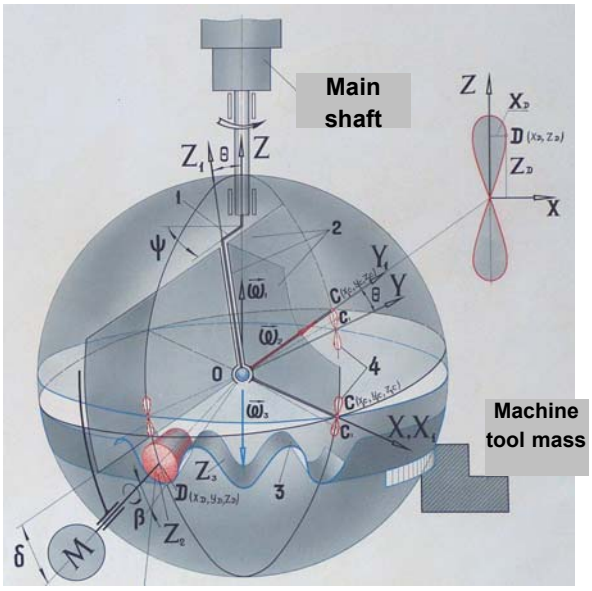

Figure1. Principled spatial diagram of teeth processing method by precessional tool running.

Kinematic joint of tool with the body must be built so as to ensure continuity of the transmission function of rotation motion, i.e. $\omega_1/\omega_3 = const$. Continuity of transmission function of rotation motion is determined by path of motion of point C, belonging to the movable system of coordinates. To research the kinematics of the device that involves the tool in precessional motion: Imaginary satellite gear (profile generating tool) 2 with an imaginary number of teeth Z_2 (determined by the machine-tool kinematics) gears with the blank 3, fixed on machine-tool table, with the number of teeth $Z_2=Z_2\pm1$. At a turning of the main shaft 1 the blank rotates at angle ψ_3, that corresponds to the angle between the difference of the wheel teeth:

$$\psi_3=\frac{2\pi}{Z_3}(Z_2-Z_3). \quad (1)$$

To define the position function of the given device $\psi_3 = f(\psi)$ it is necessary to determine beforehand the equations of the tool motion in the fixed $OXYZ$ and movable $OX_1Y_1Z_1$ systems of coordinates. The link between the mentioned systems of coordinates is determined by the Euler angles. Sphere-spatial motion of tool (imaginary wheel) at uniform rotation of the main shaft 1 ω_1 is described by the system of equations

$$\psi = \omega_1 t, \quad \theta = const., \quad \varphi = \varphi(t), \quad (2)$$

Design of the working device for teeth generating technology should provide limitation of tool rotation around the main shaft of the tool-machine by a certain technical solution, for example by kinematical coupling „*bolt-gutter*".

In this case the coordinates of the bolt contact point C (fig.2) with the groove in the movable system of coordinates OX1Y1Z1 will be:

$$X_{1C} = 0, \qquad Y_{1C} = R_c, \qquad Z_{1C}=0, \quad (3)$$

where R_c is the radius of point C location.

At sphere-spatial motion of tool 2, the motion of point C located in plane OZX is limited by the groove walls, i.e. the condition is realised for each value of ψ :

$$X_C = 0. \quad (4)$$

Using the transition matrix of the movable system of coordinates $OX_1Y_1Z_1$ connected with the tool and the bolt limiting its rotation around the shaft Z in the fixed system of coordinates, condition $X_c = 0$ o can be written in the form:

$$X_C = \left\| \begin{matrix} X_{1c} \\ Y_{1c} \\ Z_{1c} \end{matrix} \right\| = 0. \quad (5)$$

Or in extended form

$$X_c=a_{11}X_{1c} + a_{12}Y_{1c} + a_{13}Z_{1c} = 0$$

By replacing a_{11}, a_{12} *and* a_{13} in (4) we obtain:

$$X_c = X_{lc}(\cos\psi\sin\varphi - \sin\psi\sin\varphi\cos\theta) - \\ -Y_{lc}(\cos\psi\sin\varphi + \sin\psi\cos\varphi\cos\theta) + Z_{lc}\sin\psi\sin\theta = 0 \quad (6)$$

For the contact point of the bolt with the groove coordinates (5) we have:

$$X_c = -R_c(\cos\psi\sin\varphi + \sin\psi\cos\varphi\cos\theta) = 0. \quad (7)$$

Thus,

$$(\cos\psi\sin\varphi + \sin\psi\cos\varphi\cos\theta) = 0. \quad (8)$$

By solving equation (8) we determine the linkage equation between the angle of tool self-rotation 2 and the angle of rotation of the main shaft:

$$\varphi = -arctg(\cos\theta tg\psi). \quad (9)$$

In such case the equations of tool 2 precessional motion take the form:

$$\psi = \omega_1 t, \quad \theta = const. \quad \varphi = -arctg(\cos\theta\cdot tg\psi). \quad (10)$$

To establish the dependence of the angle of rotation of blank ψ_3 on the angle of rotation of the main shaft ψ we describe the blank motion composed of the involved rotational motion with the crank of the main shaft ψ_{3e} and the relative motion of rotation with regard to the crank of the main shaft ψ_{3r}.

In the compound motion of blank $\psi_{3e}=\psi$, and ψ_{3r} represents a certain function $f(\varphi)$ of the angle of rotation of tool φ, that is:

$$\psi_3 = \psi + f(\phi). \quad (11)$$

For ideal precession of the drive mechanism of machine/tool function $f(\varphi)$ will take the form:

$$\psi_3 = \psi + \frac{Z_2}{Z_1}\varphi. \quad (12)$$

By considering equation (9) we obtain the position function of the kinematical linkage mechanism of the device:

$$\psi_3 = \psi - \frac{Z_2}{Z_1} arctg(\cos\theta tg\psi). \qquad (13)$$

Momentary gear ratio of the kinematical linkage mechanism of the device is obtained deriving (13) after ψ:

$$i_{31} = \frac{d\psi_3}{d\psi} = \frac{\omega_3}{\omega_1} = 1 - \frac{Z_2}{Z_3} \cdot \frac{\cos\theta}{\cos^2\psi + \cos^2\theta \sin^2\psi}. \qquad (14)$$

Average gear ratio for a rotation of the main shaft will be

$$i_{31}^{med} = \frac{1}{2\pi}\int_0^{2\pi} i\psi d\psi = \frac{1}{2\pi}\left[\psi - \frac{z_2}{z_3} arctg(\cos\theta tg\psi)\right]\Big|_0^{2\pi} = -\frac{Z_2 - Z_3}{Z_3}. \qquad (15)$$

Analysis of dependence (15) demonstrates that for the ratio of teeth $z_2<z_3$ the direction of main shaft rotation of gear cutting machine and blank (imaginary wheel) coincides, and for the ratio of teeth $z_2>z_3$ is different. Division kinematical chain of machine tool must provide the following kinematical link: at full rotation of the main shaft the blank (imaginary wheel) should rotate under angle $\psi_3 = 2\pi(Z_2 - Z_3)/Z_3$. This kinematical link defines the average gear ratio of the manufactured gear. Given the fact that the kinematical link "*tool – blank*" is done by the machine - tool dividing chain under condition $\omega_1/\omega_2 = const.$, the angular velocity variation caused by the kinematic link mechanism of the tool with the frame will transpose on the tooth profile, therefore, it will introduce a diagram error $\Delta\psi_3$ in the tooth profile. The diagram error $\Delta\psi_3$ can be identified by angular positioning error of the blank ψ_3 relative to position ψ_3^{med} of the same blank, which conditionally would rotate uniformly with the gear ratio $i_{31}^{med} = -(Z_2 - Z_3)/Z_3$. in this case the diagram error will be:

$$\Delta\psi_3 = \psi_3 - i_{31}^{med} = \frac{Z_2}{Z_3}\left[\psi - arctg(\cos\theta tg\psi\right]. \qquad (16)$$

So, the kinematical link of the tool with the frame introduces some diagram error in the tooth profile.

Fig. 2 shows the graph of diagram error of tool position error ψ_3 at one rotation of the main shaft and motion of point D in OZY plan. If point C makes a motion in OZY plane the error is transmitted intact to the tool, and the last generates the tooth profile with the same error. To ensure continuity to motion processing function it is necessary to modify the tooth profile by diagram error value $\Delta\psi_3$ by communicating additional motion to the tool.

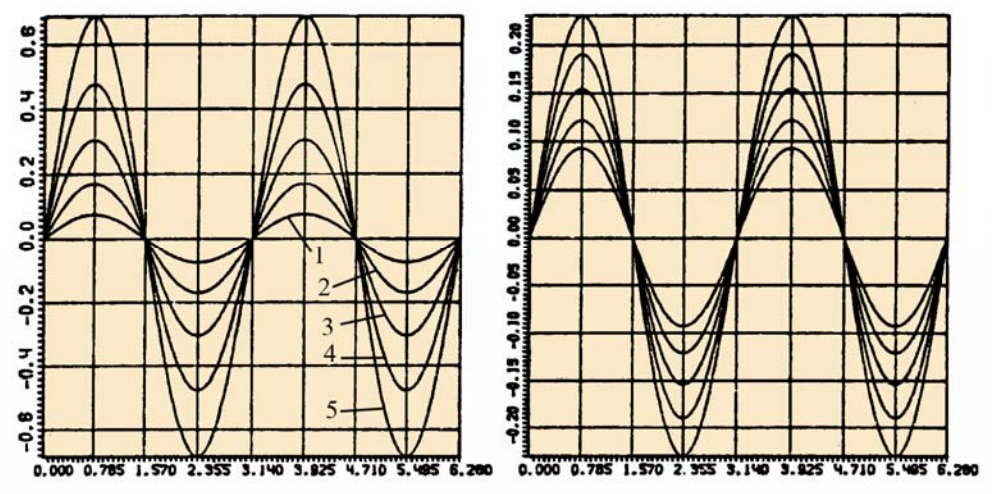

Figure 2. Dependence of tool position error on the angle of rotation ψ of the main shaft for various angles of nutation θ.

Correctness of additional motion of the tool was established using a computer calculation program. It was found that generation precision of the manufactured wheel teeth 3 depends on the continuity of its angular speed $\dot{\varphi}$ of the tool 2. Function analysis (12) shows that for $\varphi = -\psi$ the instantaneous transmission ratio $i_{31} = const.$ For condition $\varphi = -\psi$ from equation (12) we have:

$$\psi_3 = \psi - \frac{Z_2}{Z_3}\varphi = \frac{Z_2 - Z_3}{Z_3}\psi = \frac{Z_2 - Z_3}{Z_3}\omega_1 t.$$

From this analysis we find that any technical solution to eliminate the influence of diagram error of tooth profile precision generation with precessional tool would be 3D profiling of the contact surfaces of the groove of kinematical link mechanism, which supports the bolt (delimiter of rotation). The bolt contact with the shaped surfaces of groove transmits also the reaction torque from the node, on which the tool is installed to the frame. To achieve the proposed technical solution to exclude the error of 3D profiling of supporting surface of the link channel with the bolt it is necessary to describe the profile of contact surfaces with parametric equations. In this case we take an arbitrary point *C* on the tool axis with coordinates X_{1c}, Y_{1c}, Z_{1c} (Fig. 1), and identify the path of motion in the fixed system of coordinates *OXYZ* to satisfy the condition $i_{31}=const$. Using the matrix form for the transition from the coordinate system $OX_1Y_1Z_1$ to the fixed system *OXYZ* we get :

$$\begin{Vmatrix} X_c \\ Y_c \\ Z_c \end{Vmatrix} = A \begin{Vmatrix} X_{1c} \\ Y_{1c} \\ Z_{1c} \end{Vmatrix} \qquad (17)$$

or by components:

$$\begin{aligned} X_c &= a_{11}X_{1c} + a_{12}Y_{1c} + a_{13}Z_{1c}; \\ Y_c &= a_{21}X_{1c} + a_{22}Y_{1c} + a_{23}Z_{1c}; \\ X_c &= a_{31}X_{1c} + a_{32}Y_{1c} + a_{33}Z_{1c}. \end{aligned} \qquad . (18)....$$

where $a_{i,j}$, $i,j = 1...3$ are cosines of angles between the axes of coordinates.

Considering that instantaneous gear ratio $i_{31}=const.$ when $\varphi = -\psi$ then equations (18) are transcribed as:

$$\begin{aligned} X_C &= X_{1C}(\cos^2\psi + \cos\theta\sin^2\psi) + \\ &+ Y_{1C}(1-\cos\theta)\cos\psi\sin\psi + Z_{1C}\sin\theta\sin\psi; \\ Y_C &= Y_{1C}(1-\cos\theta)\cos\psi\sin\psi + \\ &+ Y_{1C}(\sin^2\psi + \cos\theta\cos^2\psi) - Z_{1C}\sin\theta\cos\psi; \\ Z_{1C} &= Z_{1C}\sin\theta\sin\psi + Y_{1C}\sin\theta\cos\psi + Z_{1C}\cos\theta. \end{aligned} \qquad (19)$$

For the case when point „*C*" is placed on axis OY_1 its position is defined by coordinates $X_{1C}=0$, $Y_{1C}=R_c$, $Z_{1C}=0$, and equations (19) take the form:

$$\begin{aligned} X_C &= R_C(1-\cos\theta)\cos\psi\sin\psi; \\ Y_C &= R_C(\sin^2\psi + \cos\theta\cos^2\psi); \\ Z_C &= R_C\sin\theta\sin\psi. \end{aligned} \qquad (20)$$

Equations (20) represent parametrical equations of groove lateral surfaces, by which the limiting bolt of tool rotational motion around the fixed axis OZ, form a kinematical coupling, and provides the condition $i_{31}=const.$ Thus, the shape of groove lateral surfaces by which the bolt forms the kinematical coupling of tool with the casing, described by parametrical equations (20), excludes the influence of diagram errors on tooth profile generated with precessional tool.

2.2.2. Analytical description of the precessional tool path of motion

According to the principle of teeth generation by proposed method the tool should copy with certain accuracy the shape and path of motion of the pin tooth in the real gearing (involving the central wheel with teeth – satellite gear with pin teeth). In this connection it was necessary to research the tool path of motion with the angle of position to the blank $\delta \geq 0$. For this purpose, a point *D* was identified on the tool axis (fig. 3) with coordinates X_{1D}, Y_{1D}, Z_{1D} in the movable system of coordinates $OX_1Y_1Z_1$ and parametrical

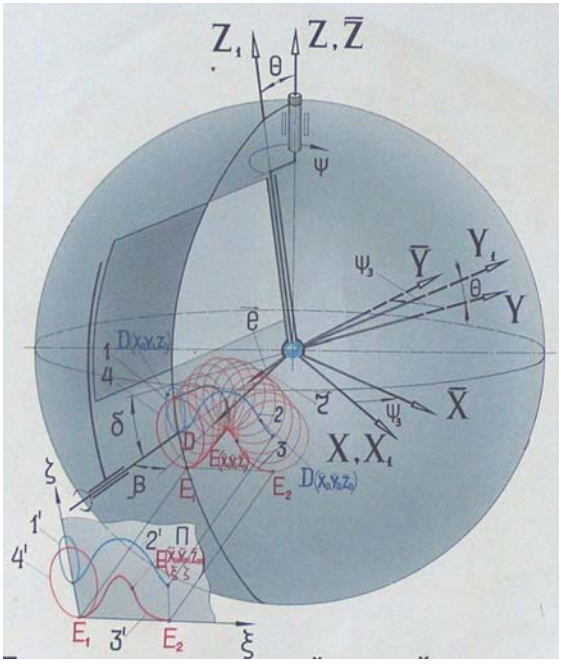

Figure 3. Determination of the tool surface family envelope.

equations of its motion in the movable system of coordinates were described. For i_{31}-*const.* after a number of transformations we obtain:

$$X_D = \alpha_{11}X_{1D} + \alpha_{12}Y_{1D} + \alpha_{13}Z_{1D};$$
$$Z_D = \alpha_{21}X_{1D} + \alpha_{22}Y_{1D} + \alpha_{23}Z_{1D}; \quad (21)$$
$$Z_D = \alpha_{31}X_{1D} + \alpha_{23}Y_{1D} + \alpha_{33}Z_{1D}.$$

$$X_D = X_{1D}(\cos^2\varphi + \cos\Theta\sin^2\varphi) +$$
$$+Y_{1D}(1-\cos\Theta)\cos\varphi\sin\varphi + Z_{1D}\sin\Theta\sin\varphi;$$
$$Y_D = X_{1D}(1-\cos\Theta)\sin\varphi\cos\varphi + \quad (22)$$
$$+Y_{1D}(\sin^2\varphi + \cos\Theta\cos^2\varphi) - Z_{1D}\cos\varphi\sin\Theta;$$
$$Z_D = X_{1D}\sin\Theta\sin\varphi + Y_{1D}\sin\Theta\cos\varphi + Z_{1D}\cos\Theta.$$

For $\delta = 0$ tool coordinates will take the form:

$$X_{1D}=0,\ Y_{1D}=-R_u,\ Z_{1D}=0. \quad (23)$$

In this case the equations of tool motion depending on the angle of rotation ψ of the main shaft will be:

$$X_D = -R_u(1-\cos\Theta)\cos\varphi\sin\varphi,$$
$$Y_D = -R_u(\sin^2\varphi + \cos\Theta\cos\varphi), \quad (24)$$
$$Z_D = -R_u\sin\Theta\cos\varphi.$$

In the case of toothed wheels with angle $\delta > 0$ the tool should be located under the same angle. Then point *D* will have the following coordinates:

$$X_{1D}=0,\ Y_{1D}=-R\cos\delta,\ Z_{1D}=-R\sin\delta, \quad (25)$$

And the equations of the path of motion of tool in the fixed system of coordinates OXYZ have the form:

$$X_D = -R_u\cos\delta(1-\cos\Theta)\cos\varphi\sin\varphi - R_u\sin\delta\sin\Theta\sin\varphi;$$
$$Y_D = -R_u\cos\delta(\sin^2\varphi + \cos\Theta\cos\varphi) + R_u\sin\delta\sin\Theta\cos\varphi;$$
$$Z_D = -R_u\cos\delta\sin\Theta\cos\varphi - R_u\sin\delta\cos\Theta. \quad (26)$$

Exact performance of the tool path of motion according to equations (33) was taken into account in the process of elaboration of the tool-carrier device, shown in fig. 1.

2.2.3. Determination of family envelope of tool generating contour

Tooth profile of the processed wheel represents the family envelope of tool generating contour in its relative motion with the tooth. The envelope is determined from the equations of the working surface of the generating tool and parameters of relative motion at folding.

To simplify the process of envelope determination it is necessary to pass to the

With condition $\varphi = -\psi$ and constant instantaneous gear ratio i_{31}-*const* we have:

coordinates of tool centre *D* in the movable system of coordinates (fig.9), linked with the blank *3*:

$$\overline{X_D} = X_D\cos\psi_3 + Y_D\sin\psi_3;$$
$$\overline{Y_D} = -X_D\sin\psi_3 + Y_D\cos\psi_3; \quad (27)$$
$$\overline{Z_D} = Z_D.$$

where $\overline{X_D}, \overline{Y_D}, \overline{Z_D}$ are the coordinates of the tool centre in the movable system of coordinates; $\psi_3 = \psi/i$ is the blank angle of rotation; i – gear ratio of the kinematical chain "*main shaft - blank*". Equations (27) define the path of motion of the tool centre, evolving on the sphere. Further, the envelope equations on the sphere were defined (curve 3, fig. 3).

Further, we find the tool 1 conical working surface (with geometrical shape as frustum) in the movable system of coordinates, applying the condition known from the differential geometry:

$$\overline{re} = r\cos\beta, \text{or } X\cdot\overline{X}_D + Y\cdot\overline{Y}_D + Z\cdot\overline{Z}_D = R\cdot r\cos\beta, \quad (28)$$

where $\overline{e}$ is the unit vector oriented to the cone axis; β - taper angle of tool.

Wrapping equation 5 on the sphere is obtained as result of solving jointly the equations, which describe the family wrapping of tool 1 working surfaces:

$$\Phi(X,Y,Z,\psi) = X\overline{X}_D + Y\overline{Y}_D + Z\overline{Z}_D - Rr\cos\beta = 0,$$
$$\frac{d\Phi}{d\psi} = (X,Y.Z,\psi) = 0 \quad (29)$$

And the equation of spherical surface:

$$X^2 + Y^2 + Z^2 - R^2 = 0. \quad (30)$$

Therefore we find:

$$\frac{d\Phi}{d\psi} = X\frac{\partial\overline{X}_D}{\partial\psi} + Y\frac{\partial\overline{Y}_D}{\partial\psi} + Z\frac{\partial\overline{Z}_D}{\partial\psi} = 0,$$
$$\frac{\partial\overline{X}_D}{\partial\psi} = \frac{\partial X_D}{\partial\varphi}\cos\psi_3 - \frac{X_D}{u}\sin\psi_3 + \frac{\partial Y_D}{\partial\psi}\sin\psi_3 + \frac{Y_D}{u}\cos\psi_3,$$
$$\frac{\partial Y_D}{\partial\psi} = -\frac{\partial X_D}{\partial\psi}\sin\psi_3 - \frac{X_D}{u}\cos\psi_3 + \frac{\partial Y_D}{\partial\psi}\cos\psi_3 - \frac{Y_D}{u}\sin\psi_3,$$
$$\frac{\partial\overline{Z}_D}{\partial\psi} = \frac{\partial Z_D}{\partial\psi}. \quad (31)$$

$$\frac{\partial X_D}{\partial \psi} = -R\cos\delta(1-\cos\Theta)\cos^2\psi - R\sin\delta\sin\Theta\cos\psi$$
$$\frac{\partial Y_D}{\partial \varphi} = -R\cos\delta(1-\cos\Theta)\sin^2\psi - R\sin\delta\sin\Theta\sin\psi,$$
$$\frac{\partial Z_D}{\partial \psi} = -R\cos\delta\sin\Theta\sin\psi. \quad (32)$$

After introducing (31), (32) into (29) and (30) we obtain:

$$X_o = \frac{-(ab+de)\pm\sqrt{(ab+de)^2+(1+a^2+d^2)(R^2-b^2-l^2)}}{1+a^2+d^2};$$
$$Y_o = aX_o + b;$$
$$Z_o = dX_o + e, \quad (33)$$

where:

$$a = \frac{X_c\frac{\partial\bar{Z}_D}{\partial\psi} - Z_C\frac{\partial\bar{X}_D}{\partial\psi}}{Z_c\frac{\partial\bar{Y}_D}{\partial\psi} - Z_C\frac{\partial\bar{Z}_D}{\partial\psi}},$$
$$a = \frac{R^2\cos\beta\frac{\partial\bar{Z}_D}{\partial\psi}}{Z_D\frac{\partial\bar{Y}_D}{\partial\psi} - Y_C\frac{\partial\bar{Z}_D}{\partial\psi}}, \quad (34)$$
$$d = -\frac{(X_D - aY_D)}{\bar{Z}_D}, \quad e = \frac{R^2\cos\beta - bY_D}{\bar{Z}_D}.$$

Equations (33) determine the envelope on the sphere (curvature 3, fig. 3). To define the envelope of teeth profile in cross section it is necessary to project it in plane *П*, perpendicular on two generators, which cross two minimum successive points of profile on the sphere, i.e. points E_1 and E_2 and the centre of precession „*O*”. Coordinates of points E_1 and E_2 are determined from the relations:

$$X_{E_1} = X_1 = X_o\big|_{\psi=0} = 0,$$
$$Y_{E_1} = Y_1 = Y_o\big|_{\psi=0} = -R\cos(\delta+\Theta+\beta),$$
$$Z_{E_1} = Z_1 = Z_o\big|_{\psi=0} = -R\sin(\alpha+\Theta+\delta),$$
$$X_{E_2} = X_2 = X_o\big|_{\psi=\frac{2\pi z_2}{z_1}}, \quad (35)$$
$$Y_{E_2} = Y_2 = Y_o\big|_{\psi=\frac{2\pi z_2}{z_1}},$$
$$Z_{E_2} = Y_2 = Y_o\big|_{\psi=\frac{2\pi z_2}{z_1}}.$$

Via points E_1 and E_2 is drawn a plane, perpendicular on generators OE_1 *and* OE_2. The equation of this plane is determined from the condition:

$$\left[\overline{E_1E_2}\cdot\overline{E_1E}\right]\left[OE_1\cdot OE_2\right] = 0 \quad (36)$$

where *E* is an arbitrary point on plane. Equation (36) is represented as:

$$\begin{vmatrix} \bar{i} & \bar{j} & \bar{k} \\ X_2-X_1 & Y_2-Y_1 & Z_2-Z_1 \\ X-X_1 & Y-Y_1 & Z-Z_1 \end{vmatrix}\begin{vmatrix} i & j & k \\ X_1 & Y_1 & Z_1 \\ X_2 & Z_2 & Z_2 \end{vmatrix} = 0, \quad (37)$$

or

$$A_1X+B_1Y+C_1Z+D=0, \quad (38)$$

where:

$$A_1=(Z_2-Z_1)(X_2Z_1-X_1Z_2)-(Y_2-Y_1)(X_1Y_2-X_2Y_1);$$
$$B_1=(X_2-X_1)(X_1Y_2-X_2Y_1)-(Z_2-Z_1)(Y_1Z_2-Y_2Z_1); \quad (39)$$
$$C_1=(Y_2-Y_1)(Y_1Z_2-Y_2Z_1)-(X_2-X_1)(Z_1X_2-X_1Z_2);$$
$$D_1=-A_1X_1-B_1Y_1-C_1Z_1.$$

Envelope of teeth profile in cross section was determined by designing the envelope from the sphere on a plane perpendicular on two generators that cross via two minimum successive points of the profile on the sphere. In this case envelope equations of tooth profile in plane will be:

$$X_{0_P} = \frac{D_1X_0}{A_1X_0+B_1Y_0+C_1Z_0}; \quad Y_{0_P} = X\frac{Y_0}{X_0};$$
$$Z_{0_P} = X\frac{Z_0}{X_0}, \quad (40)$$

where X_0, Y_0, Z_0; X_1, Y_1, Z_1; X_2, Y_2, Z_2 are the coordinates of the centre of precession *O* and minimum points on the tooth profile.

Envelope equations of the described coordinates *X,Y,Z* in the system of coordinates *OXYZ* are transcribed as equations with two coordinates ξ and ζ in the system of coordinates $E_1\xi\zeta$ (fig. 3) linked to the described plane with equations

$$E_1E_2 = \sqrt{\left(X_2-X_1\right)^2+\left(Y_2-Y_1\right)^2+\left(Z_2-Z_1\right)^2};$$
$$E_1E = \sqrt{\left(X-X_1\right)^2+\left(Y-Y_1\right)^2+\left(Z-Z_1\right)^2} = \sqrt{\xi^2+\zeta^2};$$
$$E_2E = \sqrt{\left(X-X_2\right)^2+\left(Y-Y_2\right)^2+\left(Z-Z_2\right)^2} = \sqrt{(E_1E_2-\xi)^2+\zeta^2}. \quad (41)$$

We obtain the envelope equations in two coordinates ξ and ζ in the system of coordinates $E_1\xi\zeta$, which represent teeth profile generated by precessional tool from equations (41):

$$\xi=\frac{(E_1E_2)+\left(X-X_1\right)^2+\left(Y-Y_1\right)^2+\left(Z-Z_1\right)^2-\left(X-X_2\right)^2+\left(Y-Y_2\right)^2+\left(Z-Z_2\right)^2}{2E_1E_2};$$

$$\zeta=\sqrt{\left(X-X_1\right)^2+\left(Y-Y_1\right)^2+\left(Z-Z_1\right)^2-\xi^2}. \qquad (42)$$

Fig. 4 shows the profilograms of teeth profile generation with precessional tool performed in CAD/CAM/CAE/ CATIA V5R7. On the profilograms curve 1 (fig.4, *a*) describes the path of motion of the tool centre in the fixed *OXYZ* system of coordinates, and curve 2 – the path of motion

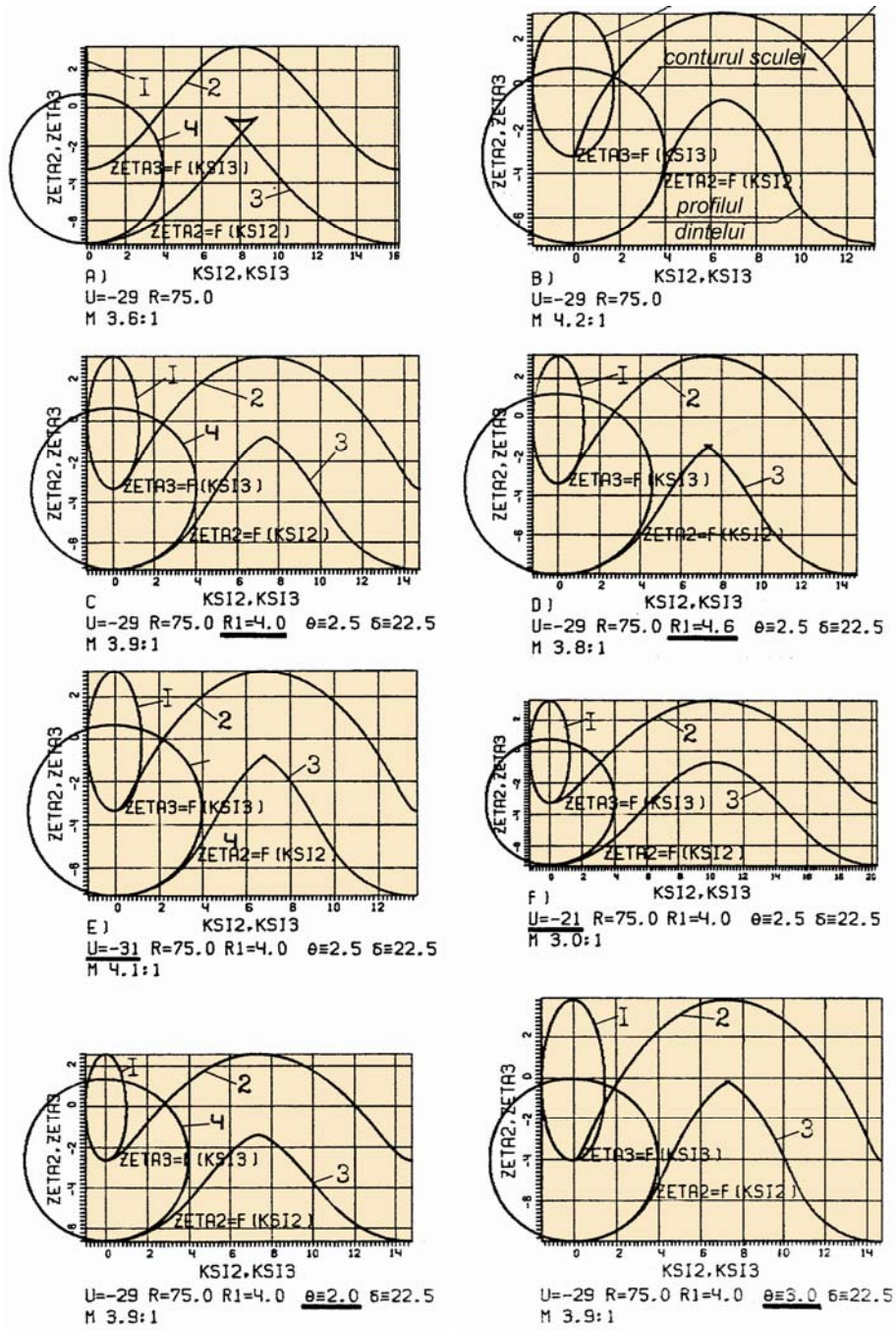

Figure 4. Profilograms of teeth profile generation with cone-shape precessional tool:
1,2 –path of motion of tool centre in the fixed OXYZ and movable OX'Y'Z' systems of coordinates; 3–teeth profile; 4–generating tool contour.

of the tool centre in the movable system of coordinates $O\overline{XYZ}$, curve 3 – family wrapping of precessional tool surfaces (tooth profile), curve 4 - generating tool contour.

Profilogram analysis (fig. 4) demonstrates the degree and direction of influence on generated tooth profile of the position angle of tool δ (conical axoid angle) with regard to the axis of rotation of the blank, tool radius R and gear ratio i of the kinematical linkage "*main shaft - blank*".

2.2.4. Technological equipment for generating teeth with sfero-space motion of truncated cone shaped tool

The profile of central wheel tooth of precessional gear is variable depending on the values of conical axoid angle δ **,** taper angle of the rollers β, the nutation angle θ, the number of teeth of gears Z_1,Z_2 and the correlation between them. Fabrication of these profiles using traditional methods is practically impossible, because for each correlation value of all parameters δ, β, θ and Z tooth profile changes shape, which requires the design and manufacture of the tool with the respective profile.

Therefore a new generating technology was proposed, which carries out a set of profiles of the teeth, using a tool with the same geometrical parameters. The method consists of the following: a series of motions coordinated between them against the rotating blank is communicated to the tool (milling cutter or grinding wheel with truncated cone-shaped geometry). The kinematic link of the blank with the tool provides rotation of one-toothed blank in a closed cycle of the motion communicated to the tool. The tool is given such a shape and motion that allows the processing of any possible profile of the set, including longitudinal and profile modification. The described surface on the peripheral side of the tool against the rotating blank reproduces a certain conceivable body, called the *imaginary wheel* (generators).

Using the kinematic chain of gear cutting machine-tool running, gear blank and the tool are brought in a coordinated motion – running motion, which reproduces the imaginary wheel gearing with the blank. Part of metal is removed at each elementary change of tool position in space in relation to the blank. Therefore the working surface of the wheel teeth processed is obtained as envelope of a consecutive series of positions of rotating tool profile generator contour against the blank.

A tool holder device was developed to realize the demanded motions of the tool (Fig. 5, a), which can be adjusted to gear cutting machines models *5K32P53, 5330P, 53A50, 5A60, 5342,* with accuracy class *GOST 6-77*.

To compensate error diagram of the satellite at its sphere-spatial rotation, a kinematical joint connecting the cross-rail with the body is introduced into the teeth grinder, ensuring continuity of the transformation function of rotational motion $\omega_1/\omega_3 = const.$ in the kinematic chain "*main shaft - tool – blank*". In other words, at teeth processing by proposed method, their profile is corrected by an amount equal to the kinematical diagram error introduced by the sphere-spatial motion of tool with regard to the casing (bed).

It was defined that in real precessional transmissions *2K-H* the link of precessional satellite with the body introduces an error in the driven shaft position. This fact provokes non-uniformity of its rotation at uniform turning of the drive shaft. Drawback is eliminated by transposition of driven shaft position error on the processed tooth profile. Diagram error elimination is achieved through the construction of cross-rail connection joint to the body, which through a cam installed on the crank shaft communicate auxiliary motion to the tool. The joint ensures continuity to the transformation function of rotational motion along the linkage *shaft-crank-tool-blank*. At tooth processing by proposed method their profile is correlated to value of the shift angle of driven shaft introduced by precessional satellite link in the real transmission.

In the developed tool-carrier device the point of intersection of the fixed axis *OZ* with the movable axis OZ_1 of the crank (centre of precession) is on the axis of rotation of the gear cutting machine table. To research the features of interaction between the tool and the wheel processed tooth ($\delta > 0$), which axis coincides with axis *OZ* of the device crank-shaft:

Fig. 5, *a* shows the 3D computer model of the processing device for gear wheels with non-standard profile, designed in *AutoDeskInventor* and simulated in *MotionInventor*. Fig. 5, *b* shows the picture of gear cutting machine-tool endowed with the device for profile generation by precessional tool. Fig. 5, *c* presents samples of gear wheels with non/standard profile, worked out on this machine-tool.

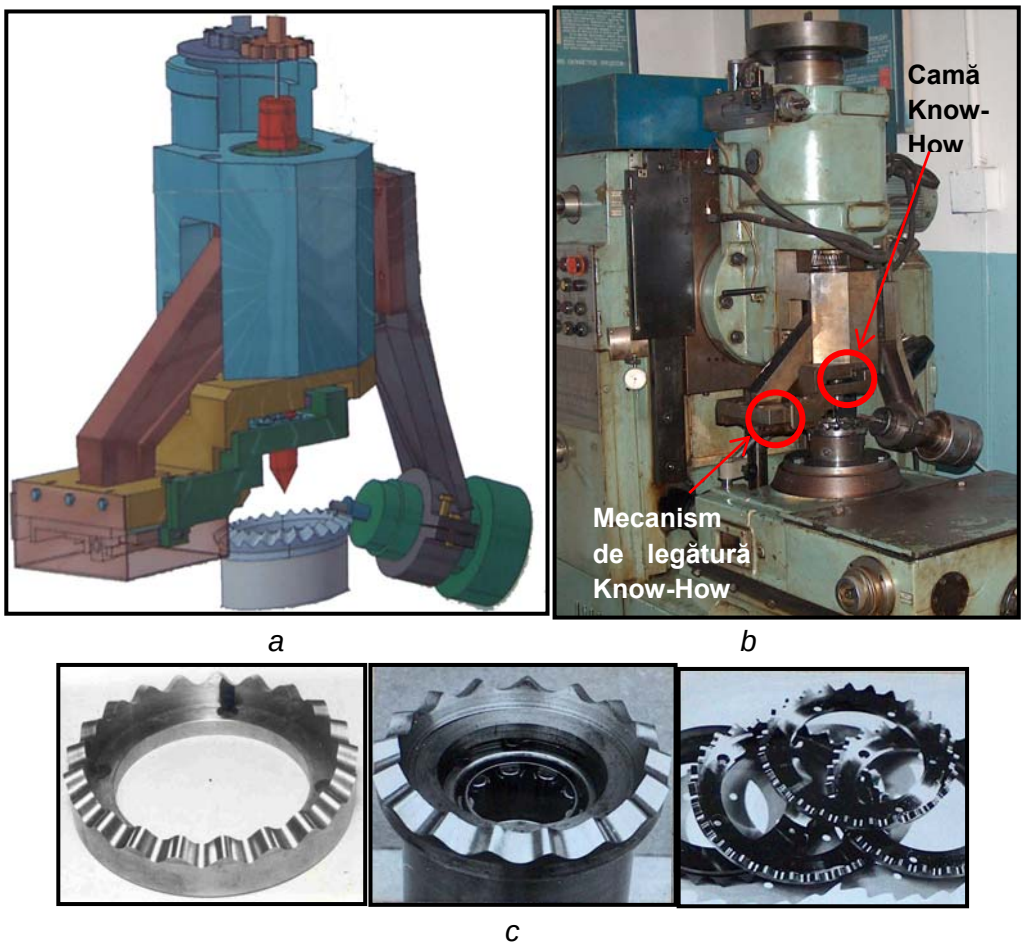

Figure 5. Generation device for gears with non-standard profile (*a*), machine-tool with fabricated device (b) and samples of fabricated gears (c).

4. CONCLUSIONS

Among the characteristics of the estimated results of research in the field of new and efficient drive development we can enumerate the following:

- the elaborated precessional gears ensure: high bearing capacity; high kinematical efficiency; high kinematical accuracy; low noise level and vibrations;
- generation procedure for variable convex-concave teeth profiles provide high efficiency and processing accuracy.

Structural optimization of the precessional transmissions will allow synthesis of new diagrams of precessional transmissions with constant and variable transmission ratio and elaboration of new diagrams of precessional transmissions for specific running conditions.

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ANALYSIS OF A WIND TURBINE'S COMPOSITE BLADES USING A FINITE ELEMENT MODEL

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INTRODUCTION

Along with the development of computer aided design (CAD) tools, design, analysis and manufacturing of wind turbine blades were made very cost effective and feasible.

The main aim of this research is to present some issues concerning structural design optimization of the imported composite blade presently used with the 10 kW wind turbine developed at Technical University of Moldova (TUM) [1].

The blade for TUM wind turbine was bought on the market for a relatively good price. It is strong and rigid but has a rather large weight (30 kg).

The following criteria have taken into account in the process of optimal blade design: minimize blade weight, does not exceed allowable stresses, minimize blade vibration and obtaining its modal frequency out of resonance. Blade mass and cost is mutually dependent and is related on the blade shell thickness. If the composite layer thickness for different blade section is at optimal level then we obtain the improvement of these parameters.

The load analysis of the blade consist of a 3D CAD model analyzed using the FE method.

For static behavior of the blade the very strong winds conditions that occur in Republic of Moldova were considered [2].

Regarding the dynamic behavior of the blade and the entire assembly of the wind turbine are imposed the following conditions: 1) the natural frequencies of the blade at 8 m/s wind speed must be above the ~2.5 Hz frequency of the turbine rotor (130 rpm) and 2) the natural frequency of the blade should be separated from the harmonic vibration of the tower (~1.16 Hz estimated first mod) [11].

Finite Element Model

Blade Geometry. The blade has a length of 3,9m and was designed in Solid Works 2010, Fig. 2 according to [3, 4, 5] and then aerodynamic design optimization was performed using ANSYS CFX module by another member of our research team.

The blade was meshed entirely with 7539 layered shell elements and 7697 nodes in ANSYS Workbench. ANSYS Composite PrepPost (ACP) was used as a preprocessor for composite layups modeling as well as for post processing to check the stresses and the failure criteria that occur in the composite layers Fig. 1. Structural design of the blade and layer schedule is shown in Table 1.

Material Parameters. Material parameters for principal directions in the fiberglass lay-up listed in Table 2 were derived from experimental data for similar fabrics [6, 7, 8] and from the ANSYS Workbench database. The UD 600 (unidirectional fabric and 600 g/m^2 fiber weight) and WR 300 (woven roving and 300 g/m^2 fiber weight) lamina use E-glass fabrics that are embedded in low cost polyester resin. The parameters listed in Table 2 are for the material with 52% fiber volume. Total weight of the blade was obtained of 24 kg for material density 1850 kg/m^3.

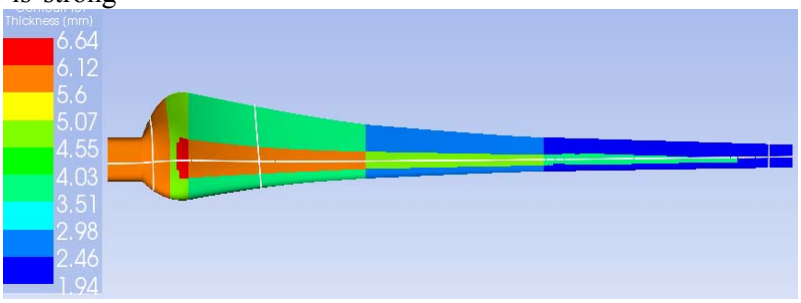


Figure 1. The composite layer thickness for different blade

Static Behavior

Blade Loads. In Republic of Moldova there are from 5 to 50 days per year with strong winds (15 m/s and more), depending by the relief. Wind intensification up to 25 m/s and more takes place relatively seldom, on average 1-2 times per year [2]. Wind turbine is orientated outside of the wind flow at speeds above 15 m/s by a special system.

For safety reasons wind turbine was analyzed at wind speed of 20 m/s. The aerodynamic loads were determined using ANSYS CFX module and were transferred to the static analysis module for structural analysis. For the wind speed specified above, the axial thrust becomes ≈ 4.5 kN and tangential forces were obtained ten times lower.

Table 1. Layer schedule for the blade.

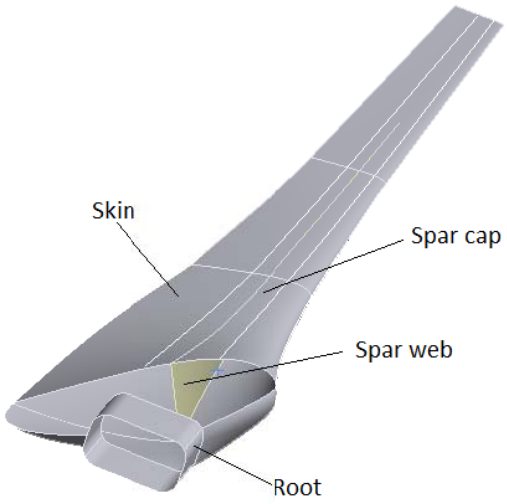


Figure 2. Components in layer schedule.

Component	Radius [mm]	Layer schedule	Thickness [mm]
Root	200 - 400	$[\pm45/0_2/\pm45_7]s$	4,5
	400 - 750	$[\pm45/0_2/\pm45_6]s$	4,25
Spar cap	750-2500	$[\pm45/0_6/]s$	3,76
	2500 - 3500	$[\pm45/0_5/]s$	3,2
	3500 - 4000	$[\pm45/0_2/]s$	2,2
Spar web	750 - 4000	$[\pm45/02/\pm45_3]s$	3,9
Skin	750-2500	$[\pm45_{14}]$	3,5
	2500 - 3500	$[\pm45_{10}]$	2,5
	3500 - 4000	$[\pm45_8]$	2

Table 2. Designed ply material properties necessary as input data in ANSYS Workbench.

Material parameters		E_X [GPa]	E_Y [GPa]	Ez [GPa]	υ_{xy}	υ_{yz}	υ_{xz}	G_{xy} [GPa]	G_{yz} [GPa]	G_{xz} [GPa]	*UTS-L** [MPa]	*UCS-L** [MPa]	Thickness [mm]
Lay-up Material	$UD600[0]_2$	40	15.9	15.9	0.29	0.29	0.29	4.7	3.5	4.7	629	-530	1
	$WR300[\pm45]_4$	15	15	8	0.3	0.3	0.3	4.7	2.7	2.7	144	-215	1

*UTS-L, UCS-L - Ultimate longitudinal tensile and compressive strength.

Also, the aerodynamic forces were calculated as described in [4, 5] using MathCAD software and ≈ 4.7 kN axial load was obtained. For wind turbines with the rotor under ten meters in diameter the gravitational and centrifugal loads are negligible [3, 4].

Flapwise and Edgewise Rigidity. With bending, the blade can fail by either of two processes:

1) material failure due to excessive stresses and/or strains or,

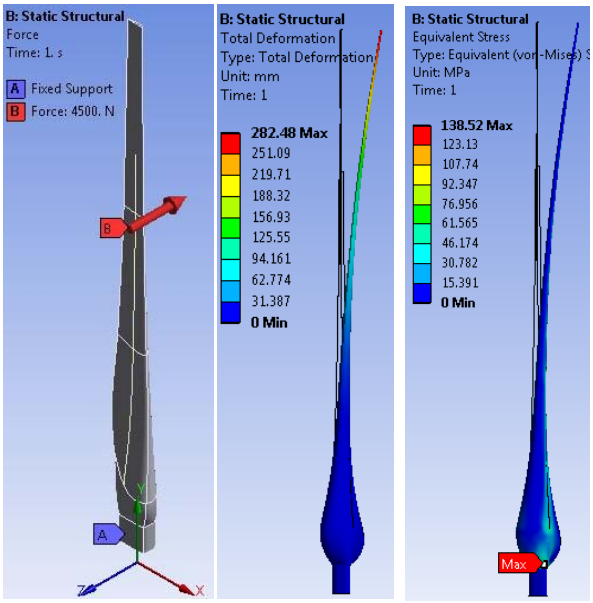
2) geometric instability, otherwise known as buckling. Also, if the blade is not sufficiently rigid in the flapwise direction it may be striking the tower and destroy itself.

To evaluate flapwise rigidity of the blade, this was constrained at the root end surface by fixing all six degrees of freedom and an axial force of 4.5 kN was applied on the blade surface as indicated in Fig. 3 *a*. The resultant deflection profile is illustrated in Fig. 3 *b*, from which it can be seen that the peak tip deflection is 282 mm (the distance from the blade tip to the tower is 480 mm) and the maximum compressive stress is 138 MPa, Fig. 3 *c*.

Bending moment in the edgewise direction is a result of blade mass and gravity which are negligible in our case. For a fully loaded 10 kW generator the maximum torque on the shaft is ≈ 600 Nm. However, to verify the edgewise bending stiffness of the blade, a tangential force of 2 kN was applied to the leading edge of the blade as shown in Fig. 4 *a*. The corresponding deformed geometry and equivalent stress is displayed in Fig. 4, *b* and *c*. The tip displacement is 59 mm and the maximum compressive stress is ≈ 97 MPa

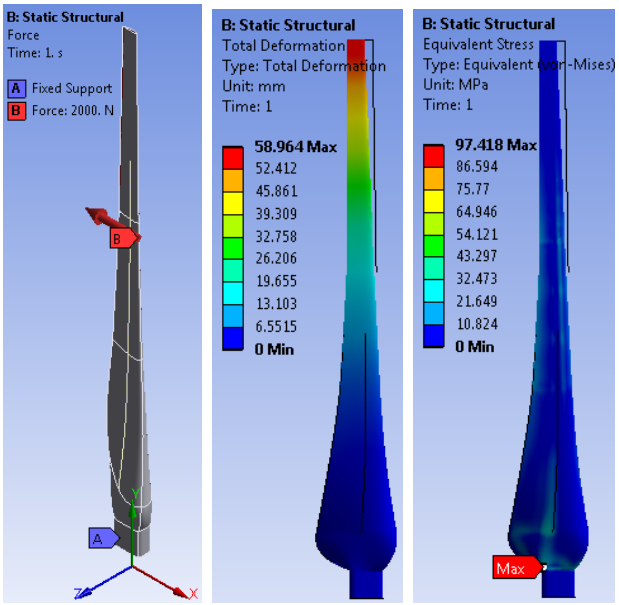
Dynamic Behavior

Harmonic Modes. To estimate the mode shapes and natural frequencies of the blade, a modal analysis was conducted in ANSYS Workbench. For a stopped rotor, the fundamental flapwise and edgewise vibrational modes occurred at frequencies of 7.5 and 15.23 Hz, respectively.



a *b* *c*

Figure 3. Flapwise bending: *a - axial loading, b – total deformation, c - equivalent stress*.



a *b* *c*

Figure 4. Edgewise bending: *a - tangential loading, b – total deformation, c - equivalent stress.*

Because rated speed of the rotor is 130 rpm at 8 m/s wind speed the blade was subjected to these prestressed inertial load. For the spinning blade model the fundamental flapwise and edgewise vibrational modes occurred at frequencies of 7.9 and 15.37 Hz, respectively.

The frequencies presented in Table 3 compare well with frequencies reported for the presently used blade.

Table 3. Natural frequencies for mode shapes.

Mode shape	Frequency [Hz]			
	New design blade		*Currently used blade*	
	Spinning rotor	*Stopped rotor*	*Spinning rotor*	*Stopped rotor*
1st mode, flap-wise	7.9	7.5	8.1	7.6
2nd mode, edge-wise	15.37	15.23	15.7	15.6

The results were validated, in an approximate manner, using a cantilevered beam model [9, 10]. The first natural frequency (f_1) for a prismatic beam was modeled by

$$f_1 = \frac{1.875^2}{2\pi \cdot l^2}\sqrt{\frac{EI}{m}}\ , \qquad (1)$$

where l is the beam length (m), m - mass per unit length (kg/m) and EI - flexural rigidity (N·m^2).

For the mean values of the flexural rigidity and of the mass per unit length - $f_1 \approx 5.7$ Hz.

FE results are reasonable given the approximate nature of the beam model for the non-prismatic blade geometry.

Periodic Excitations. Sources of periodic excitations for a wind turbine blade are the following:

1) the constant rotational speed (130 rpm) of the turbine rotor and 2) tower vibrations.

For a turbine with a tree-bladed rotor, the aerodynamic frequency of excitation occurs at three times the rotational frequency of the rotor (3 Ω) [4, 5]. To verify possible interactions between these frequencies and the natural frequencies of the different structural components a Campbell diagram was elaborated, Fig. 5. The lines radiating from the origin represent possible excitation frequencies as the rotor spins up to its operating speed. Horizontal curves illustrate the fundamental natural frequencies for the blades and tower. Resonance is likely to occur at points where excitation frequency curves and natural frequency curves cross one another.

The bending flexibility of the tower represents the spring stiffness; the damping is given in the form of a damping coefficient.

For a tubular steel tower with a top mass the first natural frequency (Hz) can be estimated with the following expression [11]:

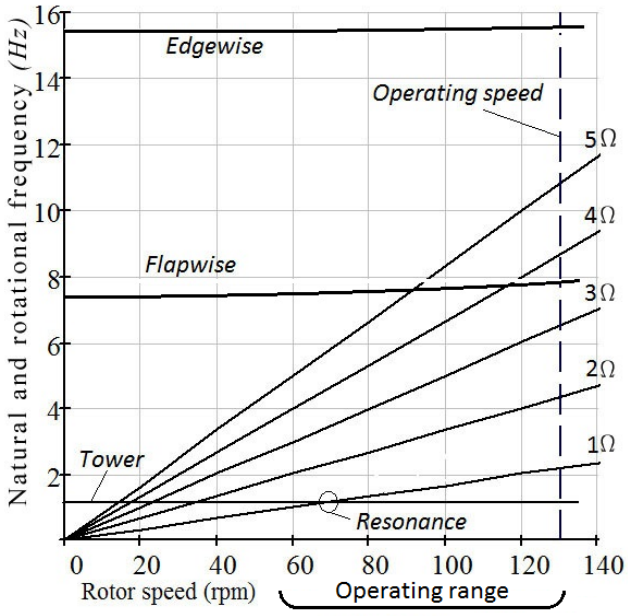


Figure 5. Campbell diagram for 10 kW wind turbine with the new designed blade [4].

$$f_1 \cong \frac{D}{L^2}\sqrt{\frac{E}{104(\frac{M}{\rho_C \cdot \pi \cdot D \cdot t \cdot L}+0.227)\rho_C}}, \qquad (2)$$

where D is tower average diameter (m), L – tower height (m), t – tower wall thickness (m), M – top mass (rotor and generator), ρ_c – density of steel (kg/m^3), E - elastic modulus of steel (Pa).

CONCLUSIONS

In this analysis was found a compromise between optimized parameters of the blade for the TUM 10 kW wind turbine.

Blade structure optimization results are the following:

- mass reduction ≈ 20%;
- maximum tip deflection is 282 mm (the distance from the blade tip to the tower is 480 mm);
- maximum equivalent stress for 20 m/s wind is approx. 138 MPa (215 MPa – ultimate stress);
- Campbell diagram shows that the resonance between tower vibration (~1.16 Hz estimated first mod) and rotor may occur when it has approx. 70 rpm; the FE model indicates that the natural frequencies of the blade are all above the 2.5 Hz rated frequency of the turbine rotor.

To reduce stress concentrations that occur in the matrix of the composite material at the blade root, further measures will be taken. Also, to perform blade fatigue analysis, for the used composite material will be determined alternating stresses at specific cycles and tensile ultimate strength.

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CONTROLLING THE MAGNETIC SUSPENSION OF A FLYWHEEL SYSTEM

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1. INTRODUCTION

Flywheels seem to be highly appreciated in the design of HEV, because of they outperform conventional chemical batteries in many important areas, such as: shorter recharge time, longer driving range, higher reliability and practically absence of the maintenance. Moreover, in the last decade, in the power quality market the flywheel has regained consideration as a viable means of supporting a critical load during mains power interruption.

The main drawback of the flywheel system is its relatively higher cost, but the technical development should significantly reduce the costs of such systems over time.

In [1] and [2] the numeric control of a magnetic bearing destined to be included in a flywheel storage system was synthesized. The paper purpose is to develop the synthesized controller taking into account the disturbance influences of the other flywheel system components.

2. THE FLYWHEEL STORAGE SYSTEM

The electromechanical battery we are studied is composed by a magnetically suspended flywheel, a synchronous motor/alternator and an inductive position transducer (see fig.1). The magnetic suspension has only one active axis and is composed by two hybrid magnetic bearings that act as two electromagnets in opposition. The radial stiffness is assured by the minimum reluctance effect. In the case of the absence of any current through the coils, the radial stability is assured "*passive*" through the presence of the permanent magnets. The chosen drive machine is a disk-type permanent-magnet synchronous machine [4].

3. SYSTEM MODELING

The equations that describe the working state of a hybrid axial magnetic bearing are:

- the electric equilibrium equation of the circuitry constituted by the series connection of the two coils placed each one on the superior and, respectively, the inferior stator of the bearing

$$u(t) = R_t \cdot i + \frac{d}{dt}(\Psi_1 + \Psi_2) \tag{1}$$

Where R_t - the sum of the coil resistances, Ψ_1, Ψ_2 – the total fluxes in the two bearing components

- the mechanical equilibrium equation:

$$m \cdot \ddot{\delta}(t) = -F_{rez} + (F_{ext} + m \cdot g) \tag{2}$$

where $F_{rez} = F_1 - F_2$ is the resultant force of the suspension electromagnets, F_{ext} is the disturbing external force and $m.g$ is the mobile part weight (including the entire shaft with the rotors of the motor and transducer).

The disturbing force F_{ext} is composed by an aleatory part and also by the residual forces from motor/alternator and transducer. For an accurate synthesis of the magnetic-suspension control system, the residual forces must be evaluated.

As concern the permanent magnet disk-rotor machine, their influence is low because of the permanent magnets that are much thicker (5 mm) as the maximum of the air-gap (1 mm). A simulation program based on the finite element method showed us that the disturbance forces created by the motor can not exceed 1 N.

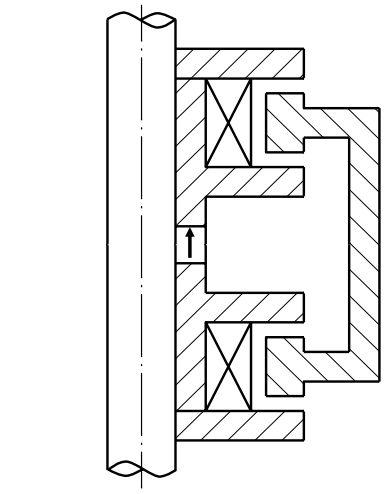
In opposition, the position transducer is a magnetic-type sensor (see fig. 2.a) and produces disturbing axial forces as we can see in figure 2.b.

Considering that the air-gap is the same in the magnetic bearing and in the magnetic position sensor, the disturbing force due to the position sensor can be calculated with:

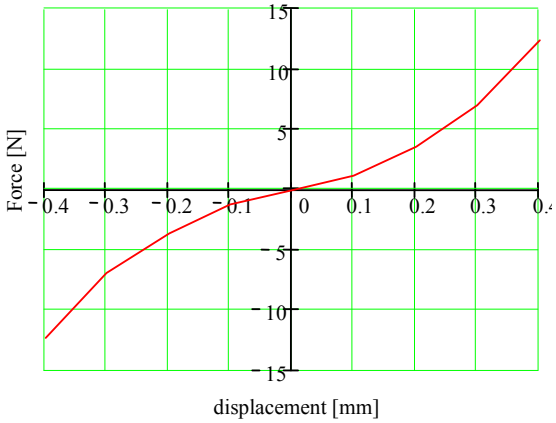
$$F_{PT} = \frac{S_{pt} \cdot h_{MPt}^2 \cdot J_t^2}{\mu_0 [h_{MPt} + 2 \cdot \delta_1(t)]^2} \tag{3}$$

where J_t and h_{MPt} – the magnetization and the thickness of the permanent magnet, S_{pt} - the pole surface, δ_1 – the minimum of the two air-gaps from the transducer magnetic circuit.

We consider a power supply source characterized by the gain factor k_s and a position sensor that have an one-order transfer function. Considering low variations of the system variables a linear input-state-output model is achieved [1]:



a.



b.

Figure 2. *The position sensor geometry and the produced disturbing force.*

$$\dot{x}(t) = A \cdot x(t) + b \cdot u(t) + e \cdot p(t) \qquad (4)$$

$$y(t) = c^T x(t) \quad x = \left[\Delta e \quad \Delta\delta \quad \Delta\dot{\delta} \quad \Delta i \right]^T$$

the state-variables being:

$$x_1 = \Delta e; \quad x_2 = \Delta\delta; \quad x_3 = \Delta\dot{\delta}; \quad x_4 = \Delta i \qquad (5)$$

where $\Delta\delta$ is the air-gap variation, Δi is the coil feeding-current variation and Δe is the variation of the transducer output voltage.

4. EXPERIMENTAL RESULTS

4.1. Controller synthesis

The experimental plant presented in figure 1 is characterised with the following parameters:

- the mobile mass: m_1=1.3Kg (whole system)
- bearing coil resistance: R_B=1.5 Ω
- turn number of the coil: N=180
- remanent magnetisation in bearing: J=0.5 T
- remanent magnetis. in transducer: J_t=1.1 T
- natural frequency ω_{0n}=100 rad.sec^{-1}
- the air-gap sum: $\delta_1+\delta_2$=1.5 mm
- the pos. sensor time constant: T_1 = 0.002 s.
- the initial current: i_0 = 0.2 A

In [1] a controller synthesis considering only the axial magnetic bearing is presented. In this paper we expand the previous controller for the whole flywheel system and analysed their characteristics through numeric simulations in Matlab environment.

To insure the flywheel system stability we chose a polynomial-type control system that is presented in figure 3, where *H(z)* is the plant (the flywheel system including the two converters, numeric-analogue CNA and analogue-numeric CAN) transfer function, $H_R(z)$ is the transfer function of the RST-type controller with two degree-of-freedom and $H_{mr}(z)$ is the transfer function of the model that defines the tracking-rating behaviour between the

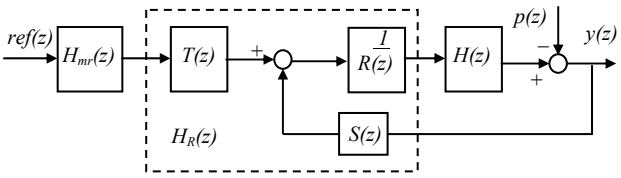


Figure 3. The closed-loop system structure.

reference *ref(z)* and the plant output *y(z)* and *p(z)* is the external perturbation.

Considering a sampling period T_s=0.005 sec, the plant discrete transfer-function yields:

$$H(z) = \frac{B(z)}{A(z)} = \frac{-0.075z^3 - 0.455z^2 - 0.212z - 0.008}{z^4 - 3.728z^3 + 1.086z^2 - 0.384z + 0.026} \qquad (6)$$

In the polynom *B(z)* there can be separate a stabile part $B_s(z)$ and an unstable part $B_i(z)$, so that

$$B(z) = B_s(z) \cdot B_i(z) \qquad (7)$$

where $B_i(z) = k(z - z_1)$ and $B_s(z) = (z - z_2)(z - z_3)$.

Taking into account the structure presented in figure 3, the close-loop transfer function $H_0(z)$ can be expressed through

$$H_0(z) = \frac{B_0(z)}{A_0(z)} = \frac{B(z)T(z)}{A(z)R(z) + B(z)T(z)} \approx \approx \frac{B_i(z)B_{md}(z)}{A_{md}(z) \cdot (z - p_{1f})^{n_f}} \qquad (8)$$

In the last relation, $A_{md}(z)$ is a second-order polynom built with two dominant poles in order to have a desired dynamic behaviour. Considering a second-order element characterised by the natural

frequency $\omega_{nd} = 0.9\omega_n = 90$ rad/sec and a damping factor $\xi_d = 0.8$, its expression yields:

$$A_{md}(z) = z^2 - 1.344z + 0.487 \quad (9)$$

The supplementary pole $p_{1f} = 0.6$ having the order $n_f = 2$ was introduced to improve the dynamic performances of the close-loop system over the high frequency range.

The transfer function $H_{mr}(z)$ of the reference-trajectory model correspond also to a second-order element, which considering the natural frequency $\omega_n = 100$ rad/sec and a damping factor $\xi_d = 0.8$ results:

$$H_{mr}(z) = \frac{-0.08z + 1.53}{z^2 - 1.28z + 0.449} \quad (10)$$

The controller synthesis consists in finding out the four polynoms $R(z)$, $S(z)$, $T(z)$ and $K_0(z)$, which must satisfy a specific condition (that is called Bezout equation) presented in [2].

The expressions we used for these four polynoms are [2]:

$$\begin{aligned} R(z) &= (z-1)(z+r_0)B_s(z) \\ S(z) &= z^{\alpha} + s_{\alpha-1}z^{\alpha-1} + \ldots + s_1 z + s_0 \\ T(z) &= B'_{mc}(z)A_0(z) \\ K_0(z) &= z^2 \end{aligned} \quad (11)$$

where

$$B_{md}(z) = \frac{A_{md}(1)\cdot(1-p_{1f})^2}{k(1-z_1)}.$$

The above mentioned condition can be written in this particular case as follows:

$$A(z)\cdot(z-1)\cdot(z+r_0) + B_i(z)\cdot S(z) = A_{mc}(z)\cdot K_0(z) \quad (12)$$

This equation put in a matrix form is useful to determine the unknown values for r_0, $s_{\alpha-1}, \ldots, s_1, s_0$. For the system parameters and chosen form of the polynoms we found the following numeric expressions:

$$\begin{aligned} R(z) &= z^4 + 0.81z^3 - 1.119z^2 - 0.663z - 0.028 \\ S(z) &= -11.958z^4 + 15.053z^3 - 4.31z^2 + 1.251z - 0.083 \\ T(z) &= -0.046z^2. \end{aligned}$$

4.2. Simulation results

The following figures present few simulation results, for the experimental plant–controller ensemble. For two values of the flotor mass, m_1 and $m_2 = 3m_1$, and for two variants of the control structure (with and without reference-trajectory-model), the system behaviour is studied considering a step-jump of the reference variable.

The variables having index 1 corresponds to the mass m_1 and that having index 2 corresponds to the mass m_2. A supplementary index $*_m$ refers to the case when the reference-trajectory-model is considered. The output voltages of the controller are showed in figures 4...7.

First time, we can see that the presence of the reference-trajectory-model lead just to a low delay in the controller response, both for the m_1 (figure 4) and m_2 (figure 5) flotor masses.

A comparison between the controller responses for the two masses is done in figure 6 (controller without reference-trajectory-model) and figure 7 (controller with reference-trajectory-model).

For the chosen cases, in the figures 8, 9 and 10 the output voltages of the position transducer are presented. One notes that the system displaces with a low delay when the reference-trajectory-model is used and, more, this delay increases corresponding to the flotor mass.

In the figures 11 is showed a magnitude-frequency characteristic corresponding to the perturbation - output variable transfer function, which is called also perturbation-output variable sensitivity function.

The obtained characteristics show a good stability and high dynamic performances for the synthesised numeric controller.

5. CONCLUSIONS

In the paper the influences of the elements composing a flywheel system over the magnetic bearing stability is analysed. In the proposed structure only the use of a magnetic-type position sensor lead to supplementary disturbance forces.

A polynomial-type controller for the whole flywheel system is synthesised. One notice that the presence of the magnetic-type position sensor lead only to some small modifications in the controller structure. This is owed to the identical behaviour of the bearing active forces and the sensor disturbing forces.

Considering variations of the constructive parameters and perturbation, by means of simulation programs the system behaviour analyses is performed. The simulation results show us that the synthesised controller assures, for the proposed flywheel system structure, a good stability and higher dynamic performances even for modifications in the control structure (with and without the reference-trajectory-model).

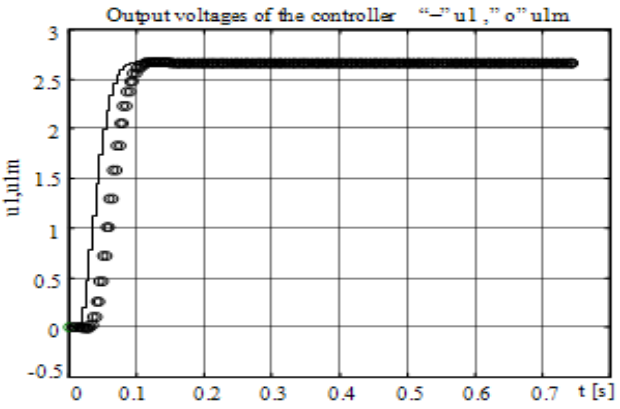


Figure 4.

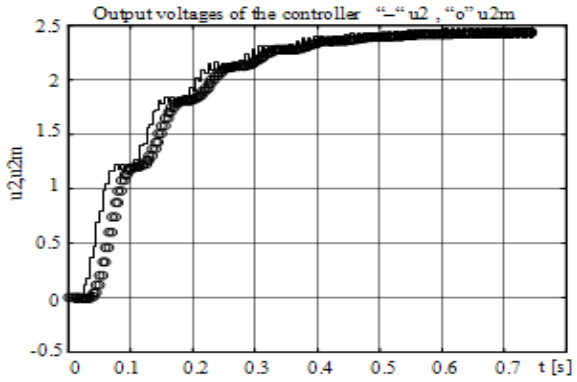


Figure 5.

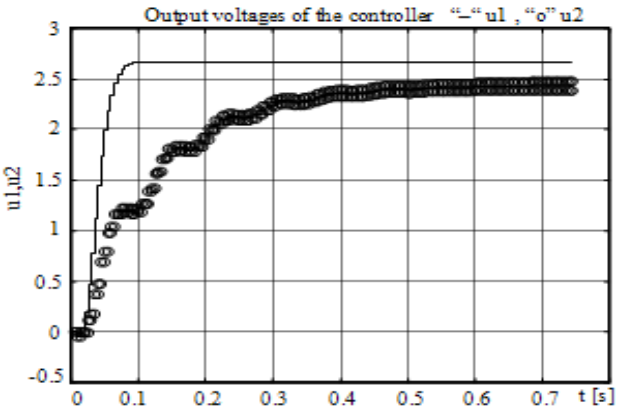


Figure 6.

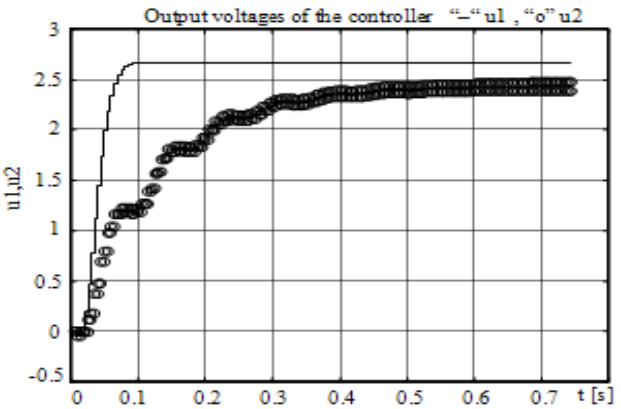


Figure 7.

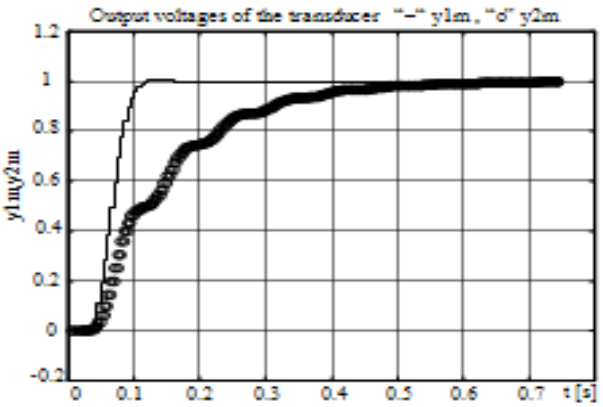


Figure 8.

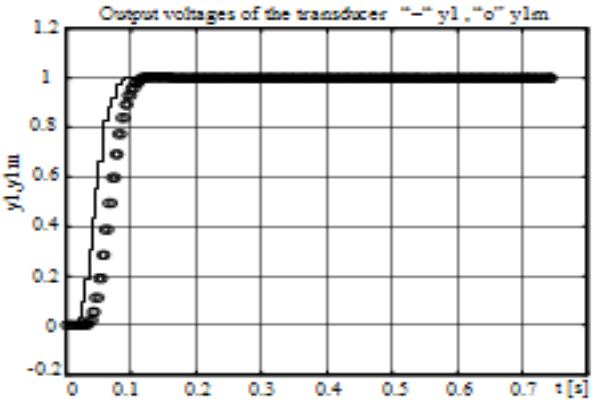


Figure 9.

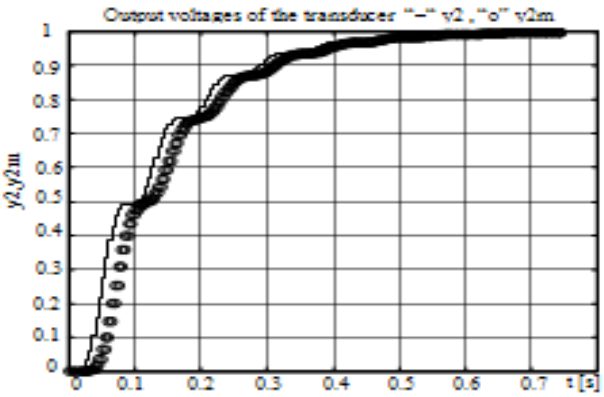


Figure 10.

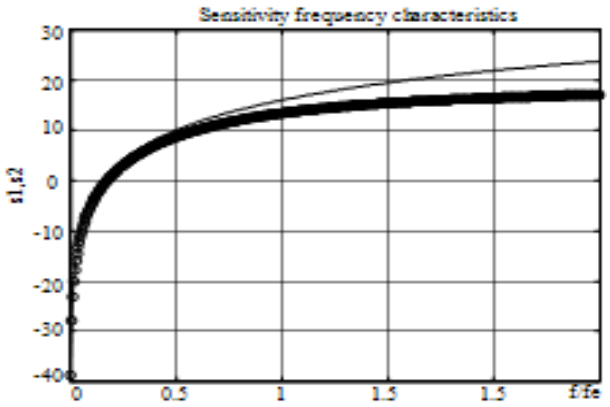


Figure 11.

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ESTIMATES ON MEASURING THE CONSUMER'S SATISFACTION

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1. INTRODUCTION

A process of measuring the consumer's satisfaction, performed in an objective manner, offers data on competitors, market, employees and suppliers as well and these data will stay at the basis of strategies, operations, action, portfolio, products and services of the respective company. Kotller suggests as performing strategies for the current companies, those that use innovative ideas and requirements of the consumers /2/. Top companies develop models of profit generating business that allow the anticipated knowledge of the consumer's satisfaction results on the company performances. Facing such a reality, even when using the process of consumer's satisfaction measurement, several companies do not trust enough in getting those data and information that lead to performance in business. A possible model of the consumer's satisfaction process may be configured, Fig.1.

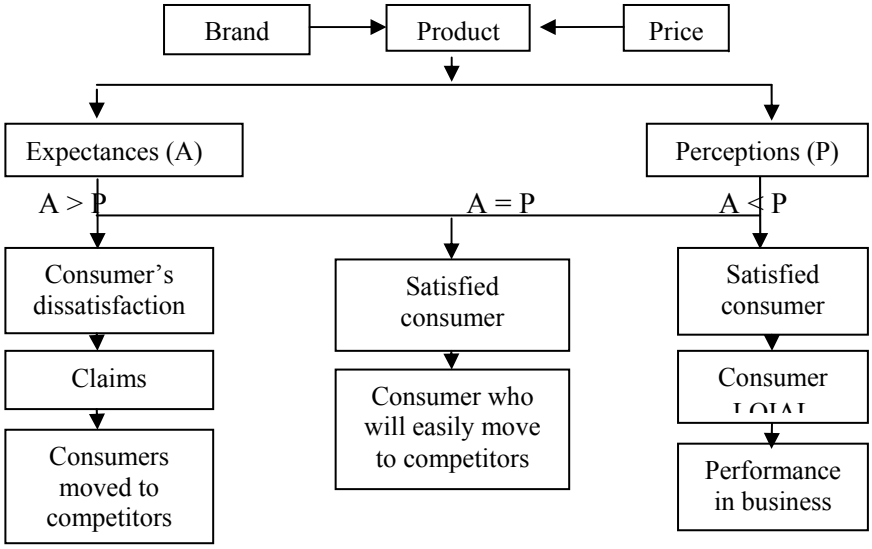

Figure 1. A possible model for consumer's satisfaction measurement**.**

Starting from this model this research aims at determining the consumer's satisfaction degree, identifying the strategies that allow a big international company (*Agricola Internațional*) to get the position of leader and, at the same time, generating reliable recommendations to the top management. The consumers of this company are individuals fully trusting the producers.

2. METHODOLOGY AND SAMPLING

The sample selection includes the following stages: Extracting the representative sampling from the targeted population consisting of the persons living in Bacau, employees, with medium incomes, in urban environment, that use to do shopping in supermarkets and the company's own shops and belong to the 25 - 40 years group of age. The sampling source - the data system from where the sample is extracted belongs to the statistic annuals, yearly reports and private studies. The sampling method has been chosen from the probabilistic sampling category: cluster type sample. N = 117871 – sampling volume. The sample necessary size is considered n = 320 persons. After calculating the sample size the sampling points or the primary sampling units have been settled (UPE = 3). In this study the measuring scale with 4 gradations has been used because, on one side, the respondents have the possibility to decide whether their assessment is positive or not and, on the other side,

they are much easier working with such a measuring scale. The adequate scale being used is: 1 – dissatisfied; 2 – satisfactory; 3 – contented; 4 – very contented.

3. RESEARCH METHOD

The research in this work uses individual interviews based on a questionnaire. The data are collected with the help of the questionnaire that is structured on three interviewing levels, as follows: the first level has the role to measure the consumer's satisfaction and loyalty at a global level with the company products; the second level follows up the measurement of the consumer's satisfaction with the functional parameters; the last level follows up the detailing of the domains measured through the previous level. Opening questions have the role to make the researcher sure that the respondent belongs to the target sample in terms of his/her relationship with the product and social and demographic characteristics.Opening Questions: "*What persuaded you to buy the company products*?", Reponse: "*The quality of Agricola products* " (43%). "*Which are the most important advantages of the company products*?", Reponse: "*They are healthy*" (100%), "*Various preparation modes*" (40%), "*Freshness*" (30%).

3.1. General Evaluation of the Consumer's Satisfaction

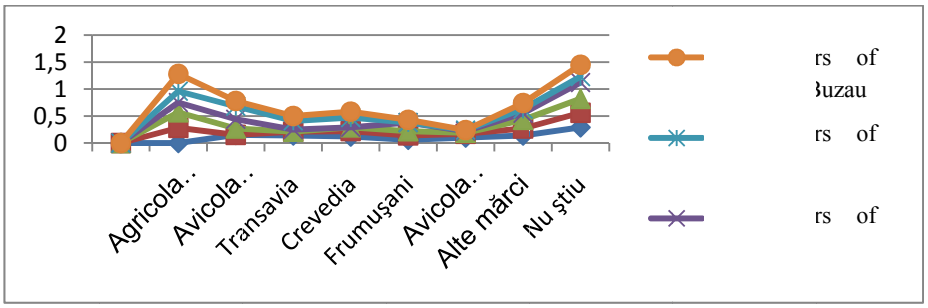

Figure 2. If the brand known by you disappeared from the market, which brand s would you buy?

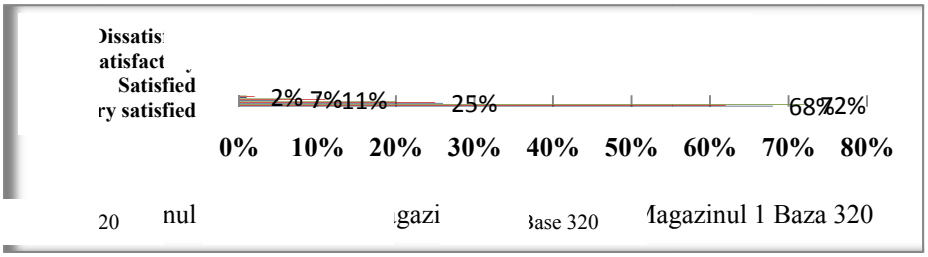

Figure 3. On a scale from 1 to 4 assess how satisfied you are with the company products.

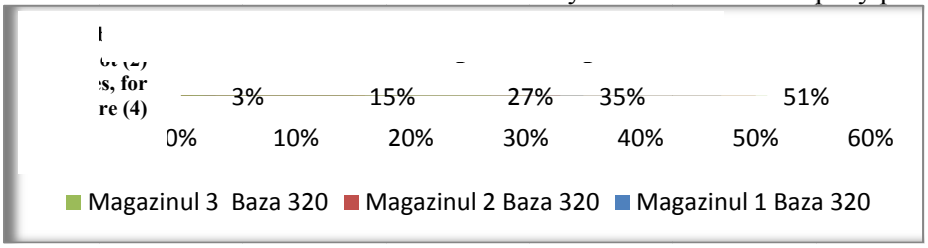

Figure 4. On a scale from 1 to 4, if you should buy more similar porducts, would you buy the company products too?

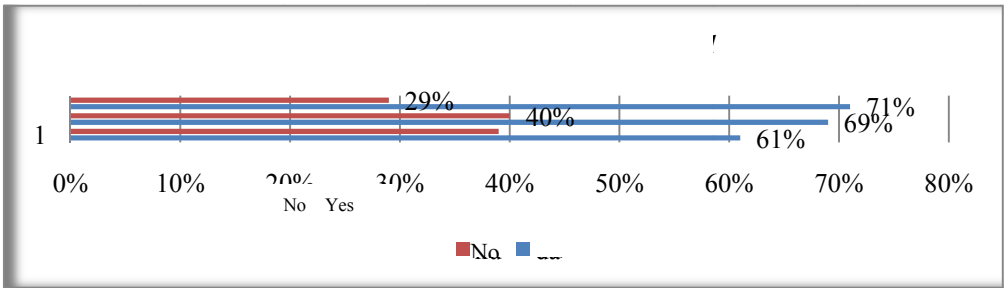

Figure 5. Would you recommend the company products?

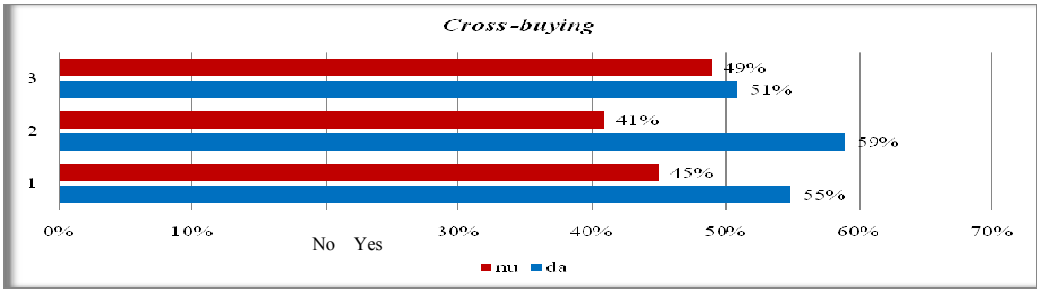

Figure 6. Did you buy more categories of the company products?

3.2.Evaluation of the „Critical Incident"

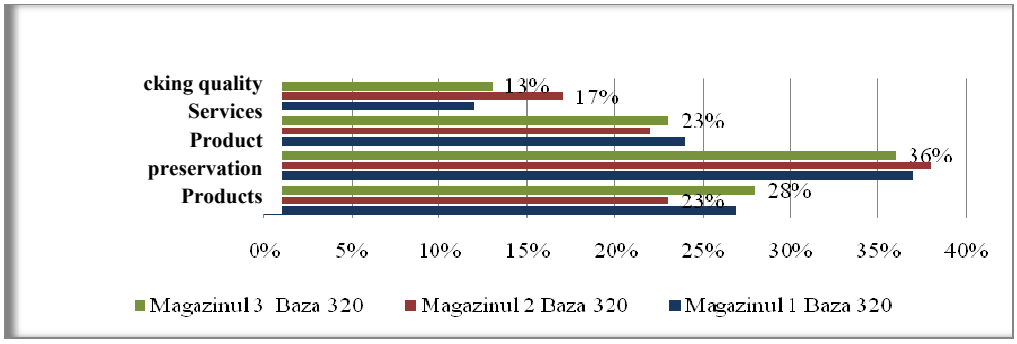

Figure 7. Specify which are your problems with the company porducts.

3.3. Evaluation of satisfaction with the Functional Parameters

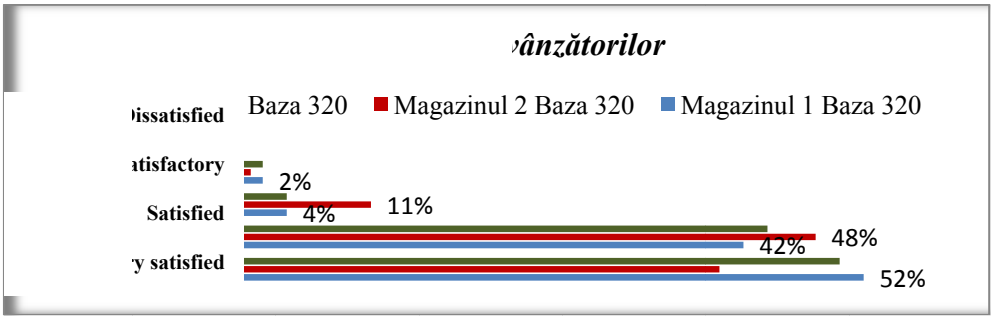

Figure 8. How satisfied are you with our shop assistants' kindness?

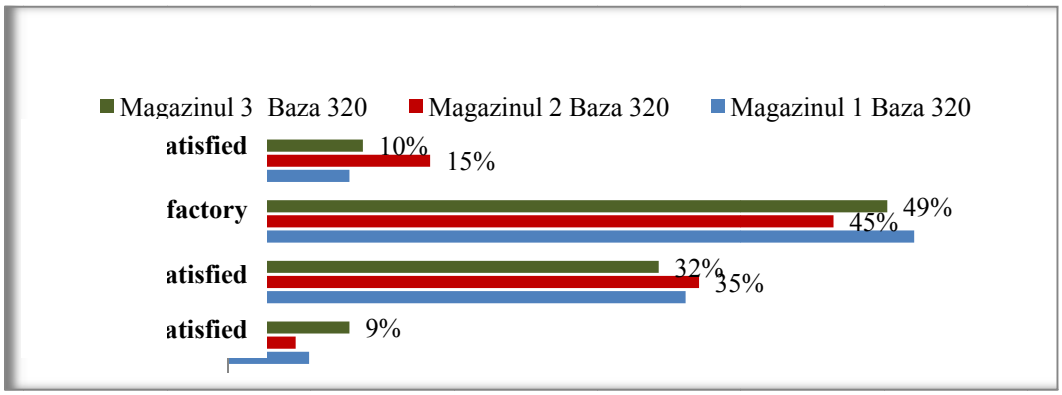

Figure 9. How satisfied are you with the price of the company products?

3.4. Detailed Evaluation of the Performance Criteria

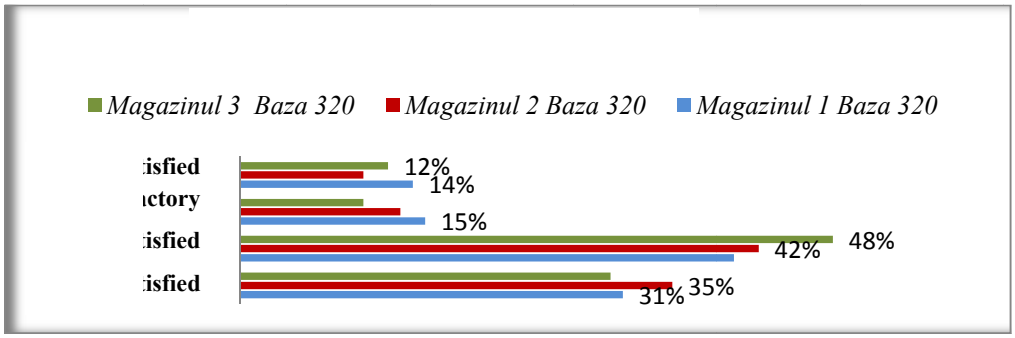

Figure 10. On a scale from 1 to 4 specify how satisfied you are with the product quality.

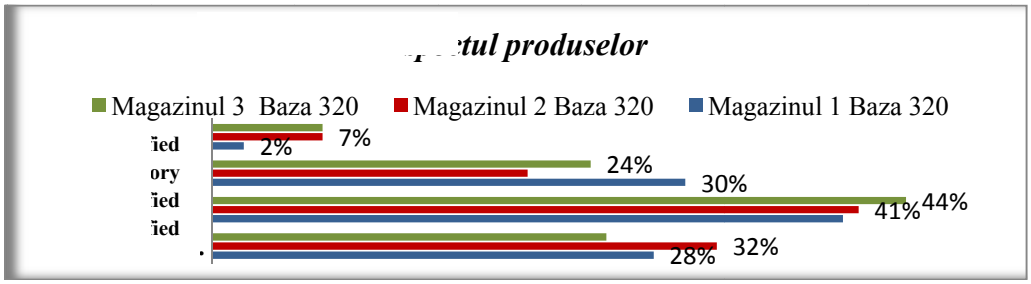

Figure 11. On a scale from 1 to 4 specify how satisfied you are with the product aspect.

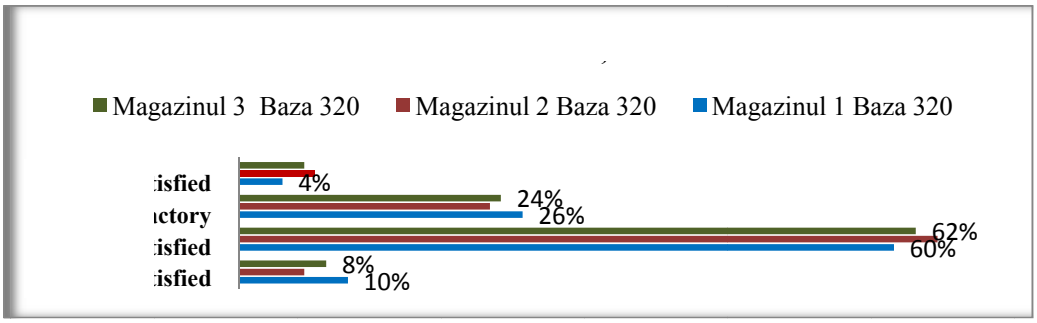

Figure 12. On a scale from 1 to 4 specify how satisfied you are with the quality-price ratio.

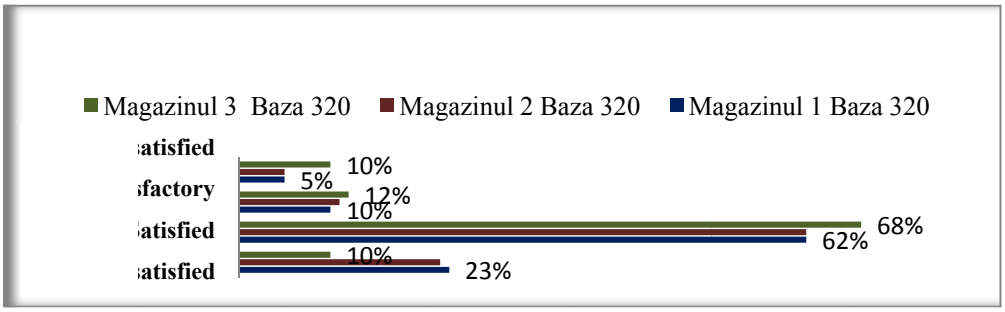

Figure 13. On a scale from 1 to 4 specify how satisfied you are with the promotion manner of the products.

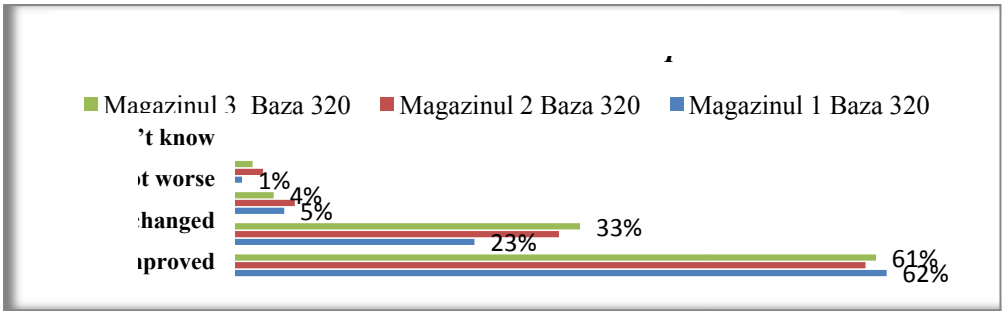

Fig.14. Further to the product promotion, your attitude towards the company: got improved, did not change, got worse, I don't know?

4. CALCULATION OF THE CONSUMER'S SATISFACTION INDEXES

The consumer's satisfaction index *ISC* is calculated through transforming the values into points. For the 4 point scale that has been used, ISC_g (index of global satisfaction plus loyalty) may be calculated as an average of all answers. 4 (very contented) = 100 points, 3 (contented) = 50 points, 2 (satisfactory) = 25 points and 1 (dissatisfied) = 0 points. ISC_g = 86,3 points. The index of satisfaction with the functional parameters is calculated, $ISC_{pf.}$ = 76,2 points. The index of satisfaction with the performance parameters is $ISC_{pp.}$ = 78,14 points.
According to the norms of interpreting /1/, the company's consumer is in general satisfied in a score above the average, but if it relates to the functional and performance parameters, it might be noticed that consumers are generally content, not happy. This is caused on one side by the high prices compared to competitors' and, on the other side, by the problems of quality, preservation and packing of the products. Norms of score interpreting: danger (0 – 70), medium indifference (71 – 80), over satisfaction (81 – 100). /1/

By calculating the global satisfaction index $ISC_g^{\,1}$ = 89,16 and the loyalty index ISC_l = 85,09 the "bi dimensional matrix satisfaction – loyalty that divides consumers into satisfied/dissatisfied and loyal/not loyal" may be determined.

Table 3 – Bi-dimensional Matrix Satisfaction – Loyalty /1/

Loyalty index		
	14,91%	35,09%
	39,16%	10,84%

0 Indifference area ← 80 → Optimal area

5. IMPACT OF FUNCTIONAL AND PERFORMANCE PARAMETERS ON THE CONSUMER'S SATISFACTION

This analysis is important because it establishes, indirectly, the importance of various parameters to the global score of the consumer's satisfaction. It starts from the conceptual model.

$$S = f(X_1, X_2, X_3 \ldots\ldots\ldots\ldots X_n) \qquad (1)$$

Notations: S – Global consumer's satisfaction; X_{1-n} – Functional and performance parameters.
The regression analysis will be used and the model will be estimated:

$$S = a + b_1X_1 + b_2X_2 + b_3X_3 + \ldots\ldots + {}_nX_n \qquad (2)$$

Notations: a – Estimated constant; b_{1-n} – Regression

coefficients; X_1, X_2, – Functional parameters; X_3, X_4, X_5, X_6, X_7, X_8, – Performance parameters.

For our sample the following regression coefficients will be obtained, according to the estimates (3) and (4):

$$a_n = \frac{\sum_{i=1}^{n} y \cdot \sum_{i=1}^{n} x^2 - \sum_{i=1}^{n} x \cdot \sum_{i=1}^{n} xy}{n\sum_{i=1}^{n} x^2 - \left(\sum_{i=1}^{n} xy\right)^2}, \quad a_n = \bar{y} - b_n \cdot \bar{x}$$

$$b_n = \frac{n \cdot \sum_{i=1}^{n} xy - \sum_{i=1}^{n} x \cdot \sum_{i=1}^{n} y}{n\sum_{i=1}^{n} x^2 - \left(\sum_{i=1'}^{n} xy\right)^2}, \quad i = \overline{1, n}$$

For the parameter X_1 – shop assistants' kindness and for a 4 point scale (4 – 100 points, 3 – 50 points, 2 – 25 points, 1 – 0 points).

Table 4. Calculated Parameters

X	Y	XY	X^2
61,4	100	6130	3757,6
23,6	50	1180	556,96
11	25	275	121
4	0	0	16
100	175	7585	4451,65

By inserting the data of Table 5 to the relations (3) and (4), it will result: b_n = 1,6 and a_n = 0,02 – that means that, for a consumer's satisfaction increase by one point it will be necessary the parameter X_1 to increase by a score of 1,6. By using the same reasoning, the results will be as follows: Parameter X_2 – price compared to competitors', b_n = 1 (for increasing the consumer's satisfaction by one point the parameter X_2 must increase by a score of 1); Parameter X_3 – product quality, b_n = 1,7 (for increasing the consumer's satisfaction by one point the parameter X_3 must increase by a score of 1,7); Parameter X_4 – product aspect, b_n = 1,74 (for increasing the consumer's satisfaction by one point the parameter X_4 must increase by a score of 1,74); Parameter X_5 – quality-price ration, b_n = 1 (for increasing the consumer's satisfaction by one point the parameter X_5 must increase by a score of 1); Parameter X_6 – product promotion, b_n = 1,14 (for increasing the consumer's satisfaction by one point the parameter X_6 must increase by a score of 1,14); Parameter X_7 – attitude towards company, b_n = 1,67 (for increasing the consumer's satisfaction by one point the parameter X_7 must increase by a score of 1,67); Parameter X_8 – purchase of products due to promotion, b_n = 1,9 (for increasing the consumer's satisfaction by one point the parameter X_8 must increase by a score of 1,9). By inserting the above data to the relation (3), the regression model will have the form:

$$S = 1{,}6\,X_1 + X_2 + 1{,}7\,X_3 + 1{,}74\,X_4 + X_5 + 1{,}14\,X_6 + 1{,}67\,X_7 + + 1{,}9\,X_8 \qquad (5)$$

From the regression model of above the consumer's satisfaction versus the importance of the satisfaction generating parameters may be analysed, thus resulting the opportunities and strong points of the company and its weak points and threats too. The opportunities include those parameters that have a decisive role in determining the satisfaction and loyalty. The recommendations are, in this case, "to maintain and exploit to maximum this competitive advantage. The strong points must include those parameters that are less important in determining satisfaction.

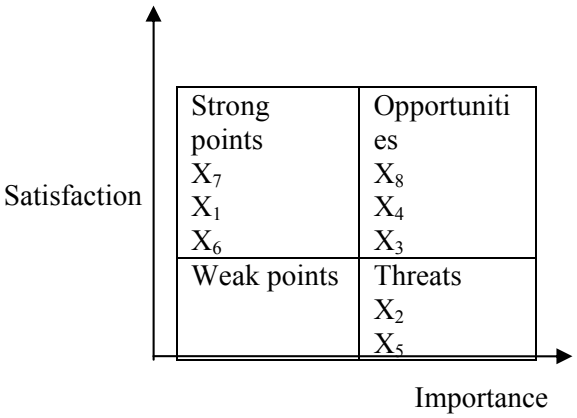

Figure15. Analysis of satisfaction versus importance of satisfaction generating parameters.

Threats include those parameters extremely important in determining satisfaction, but insufficiently met by the company. In this case the improvement of these parameters will determine the highest increase of consumer's satisfaction and loyalty. The weak points contain those parameters of low importance to consumer's satisfaction so that the company efforts must focus on other parameters, more important. Making consumers loyal means that they will buy at a relatively high proportion the products of the company, to recommend the brand, to buy more categories of the company products, to have prices comparable to competitors' and to be satisfied with the quality-price ratio.

5. SPSS RESULTS

Further to the analysis of the tables obtained through applying the SPSS program, it results:

Table 5. ANOVA - The independent variable is I_5.

	Sum of Squares	df	Mean Square	F	Sig.
Regression	1022.855	2	511.427	2.662	.184
Residual	768.574	4	192.143		
Total	1791.429	6			

- Between the consumer's satisfaction and purchase of the company products a medium to strong quadratic relation exists:

$$Y = - 3,904 + 3,094 X – 0, 60 X_2 \quad (6)$$

where: Y – I_5 – question: - *On a scale from 1 to 4, if you should buy more meat products, would you buy the company products too?;* X – Consumer's satisfaction

The sign of the regression parameters shows the fact that there is not a too strong connection between the consumer's satisfaction and purchase of the company's products.

Table 6. ANOVA - The independent variable is I_7.

	Sum of Squares	df	Mean Square	F	Sig.
Regression	873.605	1	873.605	27.330	.003
Residual	159.824	5	31.965		
Total	1033.429	6			

- Direct, strong linear connection between the consumer's satisfaction and brand of company's products. The regression equation has the form:

$$Y = 3,793 + 0,734 X \quad (7)$$

where: Y – I_7 question – *Would you recommend other persons to buy the company' s products, if your opinion was requested?;* X – Consumer's satisfaction

The model construing supposes that for an increase by one unit of the consumer's satisfaction, the brand of the company's products to increase by 0,734 units. Since the question I_7 focuses on the consumer's loyalty, then for X = 1 (i.e. for an increase by one percent of the consumer's satisfaction degree) then Y = 4,527 – the consumer's loyalty degree increases by 4,527 units.

- Strong connection between the consumer's satisfaction and recommendation of the company products. The regression equation has the form:

$$Y = - 1,738 + 1,122 X \quad (8)$$

where: Y – I_6 . question – *Would recommend the company products to a close friend?;* X – Consumer's satisfaction. As such, for an increase of the consumer's satisfaction by one unit, the recommendation of products increases by 1,122 units. Since the product recommendation refers to loyalty, then for X = 1 the consumer cannot be made loyal, but the more the satisfaction degree increases, the more the loyalty possibility increases (X =2, Y = 0,507 / X = 3, Y = 1, 628).

Table 7. ANOVA - The independent variable is P_{10}.

	Sum of Squares	df	Mean Square	F	Sig.
Regression	1054.459	2	527.229	12.335	.019
Residual	170.970	4	42.742		
Total	1225.429	6			

Between the consumer's satisfaction and the price of the company products compared to the competitors' there is a strong quadratic connection. The regression equation is:

$$Y = -2,829 + 2,452 X – 0, 41 X_2 \quad (9)$$

where: Y = I_{10} – *On a scale from 1 to 4 how satisfied are you with our shop assistants' kindness?;* X = Consumer's satisfaction.

The sign of the regression parameters shows the fact that the price of the company products does not consider the consumer's satisfaction. The management should reconsider this attribute and be able to issue products of the same quality at lower prices.

Table 8. ANOVA - The independent variable is I_{13}.

	Sum of Squares	df	Mean Square	F	Sig.
Regression	1013.674	2	506.837	13.512	.017
Residual	150.040	4	37.510		
Total	1163.714	6			

- Between the consumer's satisfaction and the

quality-price ratio there is a strong quadratic connection. The regression equation is:

$$Y = -2{,}243 + 2{,}362\ X - 0{,}16\ X_2 \qquad (10)$$

where: $Y = I_{13}$ - *On a scale from 1 to 4 how satisfied are you with the aspect of the company products?;* X – consumer's satisfaction. The management should consider this attribute and to make products of the same quality, but at lower prices.

6. CONCLUSIONS

1. There is a medium to strong quadratic relation between the consumer's satisfaction and purchase of the company products.
2. There is a strong, direct, linear connection between the consumer's satisfaction and the brand of the company products, as well as between the consumer's satisfaction and the recommendation of the company products.
3. There is a strong quadratic relation between the consumer's satisfaction and the price of the company products, compared to the competitors' prices as well as between the consumer's satisfaction and the quality-price ratio.

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VISIONS ON HOUSING MANAGEMENT

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Free and unhindered access to housing is the right of each citizen of a state, enshrined in the Constitution. All measures taken to achieve the major objectives in housing sector represent one of the priority directions followed by public authorities at all levels.

The State's efforts in implementing the privatization reform in the housing sector have succeeded with the transfer of almost all housing stock to private ownership, although having stopped or failed in achieving an efficient performance in terms of administration and service delivery in housing sector. That positive achievement of the reform is significantly diminished by the lack of a viable and efficient system of building administration that consequently doubts the safety and reliability of the apartment buildings in the future.

To ensure a sustainable process in upgrading the housing stock, including through energy efficiency measures, the State must establish goals and objectives and maintain a consistent approach in implementing the planned actions.

All stakeholders' relations within the maintenance of the housing stock framework have to be addressed in the view of implementation and unconditional compliance with the private ownership right on the property. The State may intervene with regulations aimed only to ensure the resilience and stability of housing stock, security and protection of human health and establishment of reliable tools in stimulating the owners' efforts for maintenance and repairs of buildings and their thermal rehabilitation.

In Moldova, the housing maintenance processes are not quite efficient. The old multi-apartment buildings are in deplorable technical conditions, thus adversely affecting not only the quality of life, but also decreasing the economic value of this property. Lately, the real estate market noted the phenomenon of housing procurements not only for living but also for investment purposes, aiming to protect the invested capital from inflation and other financial risks, or, earning benefits of subsequent sale of property and/or its rental. However, to ensure the building's integrity and avoid its value decrease, a consistent mechanism for regular maintenance and repairs should be established. Under situation when current repairs had not being performed during a long period of time, the building remediation costs become substantial and growing exponentially if not taken necessary measures.

Obviously, all relevant expenses, independently of housing destination - for living or business - are under the responsibility of the property owner. Approx 97% of the housing stock have been privatized and the responsibility for maintenance of apartment buildings – residential and non residential premises located in these buildings - shall be transferred to owners of privatized apartments.

In this context, some important aspects can be highlighted for consideration in achieving the main objective for efficient administration of buildings belonging to multiple owners:

1) Calculation and registration in the Real Estate Register of ownership rights on the shares in common premises/parts of the building for each owner of residential and non residential spaces.

2) The funding the works necessary to maintain the buildings in adequate technical conditions to be organized by creating appropriate permanent funds with applied contributions needed for maintenance.

3) Ensuring state control over compliance with mandatory requirements set out in the legislation for property owners located in buildings with multiple owners.

1) Calculation and registration in the Real Estate Register of ownership rights on the shares in the common premises of the building for each owner of residential and non residential spaces. The existing regulatory framework in the housing sector is being characterized as one with many gaps, which require the redefinition of condominium so as to clearly establish the property relations among all involved stakeholders, and responsibilities arising from property rights. It is impending the development of a relevant legal framework aimed to protect the owners who, in addition to individual properties, have in ownership a share of common parts of the building. In this context, the condominium can be defined, as:

a) *Multi-level building (with apartments) or, where the common property and each section with one or more staircases can be demarcated therein.*
b) *A residential complex consisting of residential and non-residential premises, individual, isolated, lined up or coupled, where the individual properties are interrelated through a common property in forced and perpetual ownership.*

Namely, the collocation - "*forced and perpetual"* - is the legal term that distinguishes the common parts of the building in condominium. Although not clearly enshrined in the special housing legislation and not observed in Moldova, this rule imposes new responsibilities and requirements to the owners (unaware of till date), to undertake measures for the maintenance of common premises of the building as integral parts of jointly owned housing facilities.

According to the Law on Privatization of Housing Stock[1], the privatized apartments have been registered in the Real Estate Register as prerequisite for acknowledgement of ownership right over this property. The registration has been done by the territorial Cadastral offices, at the request of the owners. However, only the parts related to "isolated rooms" - apartments in buildings with multiple owners - were subject to registration, without mentioning the ownership over the common parts of the building. Thus, the non-residential spaces (common parts of the building) remained to be recognized as property of the state or administrative units. It is impossible to explain how this could happen while the Civil Code expressly states that *"in multi-apartment buildings with multiple owners, each owner have the ownership, forced and perpetual, right over a share in the common parts of the building"*[2].

The reason why the Cadastral offices did not register the shares of common premises of the building belonging to each isolated room / apartment is the Article 8 par.(1) of the Law on Privatization of Housing Stock, which provides: *"the privatized homeowners are **co-possessors** of communication and engineering facilities and of places of common use of the building and its adjacent land"*. This provision, in our opinion, take rather a technical foul for inappropriate use of legal terminology, but subsequently entailing multiple problems and confusions related to registration of ownership rights on privatized housing and management of common premises of apartment buildings. Among them, 2 contradictory issues of huge importance can be mentioned:

- the value of common premises of the building (the building structure which is a common element consisting of basic components in a construction estimate) **have been included into the price calculation** of privatized housing, and,

- these common premises have been subject to privatization **separately**.

Furthermore, the fact that the share in the common property have not been registered in the benefit of owners and remained on the balance of public authorities (mostly local), have generated uncertainty in buildings' management processes. In reality, the owners of privatized apartments do not hold any responsibility for the property they own, and therefore, do not undertake any measures to maintain the premises of common use. In addition, the local budgets are forced to cover certain expenditures in housing sector, although such funding does not cover all repair and maintenance needs, and relevant interventions are mostly based on sporadic, chaotic and ineffective actions. Therefore, the housing sector management performed by LPA units is one flawed both, in terms of management quality and sufficiency in funding the housing sector, even if the state or administrative units' ownership therein remained not more than 3% of total housing stock.

As for non-residential premises of buildings, mostly occupied by enterprises, these are not involved in the maintenance of the building in any ways and must be definitely encumbered by the right (obligation) on common parts, and raised the issue at least in the upgrading process of the relevant legislation. These occupied premises represent a substantial share of the common property of apartment building – typically the entire ground level, and in some cases being located on several levels of the building. The need to include the owners of these enterprises in the maintenance and repair of the building is very urgent and concrete actions are necessary to regulate the building administration responsibilities and assign them to all owners, regardless of their ownership nature.

Enforcement of responsibilities, emerged from specifics of ownership right in apartment buildings with multiple owners, can be performed only if the common property shares are transmitted in private ownership, with their registration in the Real Estate Register - this is one of the priority measures to be undertaken. Local governments are being responsible for this process and the lack of finance cannot be the reason of failure in duties the specialized subdivisions are responsible for. Evidently, a huge volume of work has to be done -

someone shall calculate the shares in the common property for each apartment owner and perform the inventory of assets, - but this shall not make the reason of excuse to concerned authorities, and an argument to avoid fulfilling their duties.

2) Funding the works maintaining the buildings in adequate technical conditions. Repair and maintenance works of the housing sector are very expensive and require substantial financial resources, especially when current repairs have not been made for a longer period. Would-be accumulated resources of apartment owners are envisaged to be limited. The current tariffs for technical maintenance of housing sector are low and accumulation accounts of municipal management enterprises could hardly cover the expenses of some minor works.

The situation has become critical and further irresponsible attitude towards housing maintenance can turn into unpredictable consequences. The buildings' technical condition is continuously deteriorating and the risk for buildings' structural damages increases exponentially. Funding is the key element in the buildings' technical and energy efficiency rehabilitation. This requires both, an adequate legal framework and state involvement through housing rehabilitation programs and supportive actions in housing problems for vulnerable population.

It's worth realizing, that the issue of effective housing stock management denotes a high level of complexity. Therefore, the approach should be a matching one, taking into account all legal, economic, financial, social, etc., aspects. Only this way, the citizens' fundamental right - the right to housing – could be effectively secured.

The international practice distinguishes several components of an effective funding scheme for housing repairs. Some of them are worth mentioning:

A. Mandatory payments as contributions to Repair Fund (RF) obligatorily created in each condominium.

B. The lending institutions' resources are made available to homeowners associations, homeowners or administrators, being guaranteed by the accumulations of the Repair Fund secured by owners' contributions.

C. State support in terms of co-financing the rehabilitation / repair (ex. through energy efficiency programs in housing sector) and through financial instruments created for such purposes by the State (bank guarantees, funds, etc.).

All these components must be viewed through the prism of a stable operational and well-organized system with consistent measures from both, the public authorities and the owners of residential and non residential assets of multi-apartment buildings. Further below are described some conditions that will ensure, in our opinion, the successful implementation of mentioned tools.

A. Mandatory payments to Repair Fund (RF). The owners' contribution fees collected to cover the maintenance costs represent the only solution for maintaining the building in appropriate technical condition. This statement is considered an acknowledged one, once the owned housing represents an investment and has its economic value and can generate profits. Though, it happens to Moldova, that the apartments, which have been privatized against Property Bonds, are not considered under economic viewpoint, except for a few special cases. "The local tradition" is to use the apartment as a location of residence of the owner's family. But this cannot justify the lack of responsibility for maintenance of the building where the apartment is located. Therefore, the owners shall be enforced to contribute financially to maintenance and repair of the building they live in.

Moreover, the Law on Quality in Constructions [3] establishes the responsibilities of building owners to perform timely maintenance and repair of building, in accordance with legal and technical norms and followed behaviour in building operation, as well as to ensure any reconstruction, strengthening interventions, etc.

Following the above-mentioned, the extent of responsibilities shall be enforced by Law and not left at the discretion of the building owner – as these responsibilities are ensuring the building operation at appropriate quality level and aiming to protect the people's lives, their property, society and the environment in general. Therefore, all owners of the apartment building are responsible for its technical condition, based on "forced" right on the common premises of the building, thus acquiring the obligation to contribute to the fund required for maintenance works.

However, it won't be easy to convince the owners to pay fees for maintenance and repairs of common premises. One solution would be the creation, through law enforcement, of a Repair Fund, where owners' regular contributions shall be disbursed and used for a consistent and qualitative maintenance of apartment buildings on a transparent basis. Due to continuous deterioration of the apartment buildings, it is necessary for the legislature to urgently regulate the creation of repair

funds, ensuring transparency and providing maximum protection of owners against possible risks. One of essential conditions to be enforced by the laws is the separation of resources (financial flows), i.e. a single Fund[1] and single owners' Association for each apartment building, prohibiting the use of one's resources for other residential buildings, even if several buildings are administered by the same Administrator. Also, for the safety of Fund's resources, a number of conditions will be required to meet, such as:

- The Repair Fund's financial resources represent a shared property of residential and non residential spaces' owners in the multi-apartment buildings;
- The contributions to the Repair Fund are collected in a bank account, stating that the holder of the account (Administrator or Association) cannot dispose the resources otherwise than decided by the owners general assembly.
- The Repair Fund deposits in the bank (the entire amount equal to the amount of mandatory payments) must be provided the same safeguards as for citizens' personal bank deposits.

An efficient method of accumulating contributions to Repair Fund (as a measure against absconding debtors) could be the execution of legal mortgage on private isolated spaces (apartments and non residential premises) for the benefit of owners' Association or owners in condominium. In such cases, the mortgage is obligatorily registered in the Real Estate Register and applicable in cases when the owner does not contribute to the Fund during a certain period of time (ex. 6 months). It should be mentioned that in Moldova, the legal mortgage cannot be established except for amounts due under the tax laws as a result of court decisions [2,4,5]. Therefore, the execution of mortgage in condominium will require modifications made to three laws and the Condominium Law [6] in particular.

The execution of mortgage under the law would be the most effective tool to ensure the accumulation of financial resources in the Repair Fund, but it requires great caution in making such decisions, as mortgaging the property is a very drastic measure against owners, while the apartment is, in most cases, the only place to live. Weak financial situation of apartment owners can generate deprivation of housing facilities, while the authorities being unable to provide rental space for such socially vulnerable population which risk reaching the street. In this context the State may adopt mortgaging procedures for apartments of Repair Fund's debtors, if also provides some supportive complementary tools, for ex.: 1) social rent fund aimed to mitigate the effects of risks generated by loss of housing property, 2) creation of conditions for commercial leasing market development, 3) increase overall welfare of population.

Meanwhile, the state could regulate the conditions whereby the local authorities have the preemption right over the mortgaged apartments for sale, thus increasing the stock of social housing (the correct sale price is determinant for the success of this measure). Subsequently, these apartments may be made available for social housing or rental to former owners, if they meet the qualifications to benefit from social assistance. To this end, this requires preparation and approval of regulations on social housing stock, the modalities of formation and administration of this stock, the conditions for use and indicators for assessing the persons who are entitled to social rent, etc.

B. The lending institutions' resources made available to homeowners associations, owners or administrators. Housing sector requires periodical significant investment in repairs and maintenance to keep the buildings in good condition and to maintain its economic value. Planning and realization of these investments depend on the Administrator's managerial spirit, and its ability to associate the owners to cope with problems related to repairs of common property. The owners / Association may apply for loans offered by financial institutions. The amount borrowed can be guaranteed by Fund resources which are replenished by the owners' contributions. The banks could accept such guarantees, due to the mandatory nature of owners' contributions to the Fund. But pledging the Fund resources requires the approval of all owners in condominium which is very difficult to achieve. The Civil Code, Art. 457 (5) provides that the common property may be mortgaged only with the agreement of all co-owners. In this context, it would be reasonable to set a quorum of 2/3 of the owners to validate the pledge over Fund's resources. The argument for lowering the quorum on pledge approval is that there will always appear some owners who, motivated or not, will not sign the pledge agreement, in spite of joint responsibility to participate in the maintenance and repair of

[1] Fund –Repair Fund for the common property in the building. Do not refer to other funds that can be created upon necessities (ex. Revolving Fund that can be used for payment of utility services, for which the Association shall be empowered to contribute)

common property and being equally responsible for keeping the building in safe and operational condition.

In our opinion, there are several essential conditions ensuring the access to loans for buildings' repairs and thermal rehabilitation purposes: i). the legal status of condominium associations should be very clearly defined; ii). associations must have the right to borrow on behalf of all owners in the building; iii). to be clearly defined the procedures for forced collection of debts from owners who avoid to pay contributions established for rehabilitation / repairs of building.

Presently, the Moldovan legislation does not sufficiently clear stipulate the principles of efficient administration of the apartment building, even ignoring the importance of regulating such real estate intended to ensure a decent living of population. The stability and efficiency of the system can be achieved only if each owner in condominium obligatorily becomes a participant / member of one or another form of association in that condominium.

C. State support in terms of co-financing the rehabilitation / repair works. Housing sector is considered a priority and the state interventions in the sector shall be appropriate. However, the current situation shows an almost total restriction of State interference in the problems related with housing sector. The relevant tasks were assigned to local public authorities, the buildings being all transferred to their subdivisions while the share of the common property have still not been transferred to the owners though most of apartments have been privatized (97%). As a result, we have a confusing situation when the State has not yet finished the privatization process, nor provided LPAs with legal instruments necessary for the administration of multi-apartment buildings.

In addition to the legislation approval process in the sector, the State has the responsibility to intervene with other tools aimed to support the housing sector and offer the population a secure and real realization of ownership right on housing. In our opinion, the state will have to intervene through the following:

- Programs for thermal rehabilitation of buildings incorporated in country's energy efficiency programs, by providing grants to cover shares of repair costs.
- Provide guarantees for repair loans contracted by the owners. In this context, mortgage risk guarantee funds should be created, where the state would be the founder. Such guarantees can be sold, but may be granted to certain categories of people, or, for thermal rehabilitation projects or building strengthening purposes.
- Financial support to LPAs for local rehabilitation programs of apartment buildings.
- Support to vulnerable citizens by compensating a portion or full amount of the debt to Repair Fund. This support shall be allocated directly, through nominative compensations to owners in difficulty.
- Contributions to Repair Fund for the condominium premises owned by the state. The size of the contributions shall be determined by same principles as for private owners.
- Support the process of calculating the share of common property for each apartment building, ensuring the registration of these shares in the Real Estate Register. For this purpose, certain state budgetary resources have to be approved as the process will be an expensive one.

When granting state support in financing the buildings repairs, the following principles shall be considered:

- State co-financing programs should stimulate the repair of common premises and elements of the building.
- A priority for decision-making process in budgetary allocations should be the enhancement of building energy efficiency capacity.
- The volume of funding from state subsidies shall depend on the level of energy efficiency and energy saving rate as a result of performed repairs.
- The power to approve decisions on capital repairs of multi-apartment building belongs to the owners' Association (or body, the Association may delegate this power to).
- The owners' Association shall be the supervisory and control body over the resources accumulated by the owners in the Fund and used for repair works done.
- The same owners' Association shall be responsible for monitoring and control over the utilization of resources for capital repairs allocated through state subsidies.

Some of the most effective state support mechanisms may be considered and required for the following purposes:

1. Co-financing the rehabilitation works aimed to reduce the repair costs of apartment owners and increase the energy efficiency of the building.
2. Creation of commercial agencies / funds guaranteeing the risks emerging from lending to

owners' Associations, which may contribute to the reduction of loan risks.

Being aware that not all owners are prepared to meet the financing obligations for building repairs, and therefore, relevant enforcement mechanisms will be necessary to apply. The same refers to the owners, who are not avoiding but unable to fulfill their financial obligations due to lack of available resources. In both cases, the situation must be resolved by implementing viable mechanisms: by enforcement on the one hand, and by stable mechanisms of social assistance and social housing development on the other hand.

3) State control over compliance with the mandatory requirements set out in the legislation for property owners located in multi-apartment buildings. The success of actions proposed for the implementation of efficient administration of housing can be achieved only when a rigorous control over compliance with legislation by all participants in condominium relations is being assumed.

The need to establish an efficient control over compliance with housing legislation shall not be postponed. The unrepaired buildings since soviet times, being affected by uncontrolled interventions in constructive and resistance elements, require a systemic approach in organizing the operation and technical maintenance, where the control task is one of key elements. Whatever the responsible body is – the State Construction Inspectorate (SCI), State or Municipal Housing Inspection – clear and efficient control procedures are required to be approved with sanctioning powers and punitive measures in addressing shortcomings resulted from mismanagement of condominiums and interventions damaging the building structure.

To achieve the success, it is necessary for a specialized central authority to develop a set of regulatory legislation to support the control process, starting with tasks of control bodies, regulation on activity, control procedures, ways of assessing violations and penalties. Not less important is the determination of authorities (public servants) vested with such duties. In addition, modifications are needed in a number of legislation such as: Contravention Code, Criminal Code and statement of specific measures to attract liability for owners' failures in condominium and for inappropriate interventions in constructions. These legislative amendments should be developed concurrently with the whole set of documents governing the control process. Their elaboration will take into account the complexity of control interventions, staffing needs and time period necessary to control all objects, which actually are practically outside of any management processes and, effectively outside of any control. Since the control over construction process and operational phase are under competencies of State Construction Inspectorate, the elaboration of required procedures and mechanisms might make the task of this body, obviously, with experts' support from various professional organizations.

It is worth mentioning, that the problems of buildings administration and maintenance do not refer only to the economic interests of apartment owners, but also include the life and health security of people, since badly maintained, repaired or rehabilitated buildings represent a major threat and this threat is increasing annually. The currently owned assets still represent some economic value and place of residence for owners' families. Besides continuous reduction of its economic value, the apartment becomes a source of life hazards, chronic diseases, etc. Rehabilitation of building is expensive, and in some cases will be impossible, therefore the State control through SCI or the other structure is determinant.

In our opinion, the supervisory authorities should fulfill the following tasks:

- Detecting and counteracting actions that contradict the housing legislation, the requirements for use and maintenance of housing (individual and common property units);
- Undertaking energy efficiency measures in housing, regardless of the form of ownership of residential and non residential premises and common property.
- Overseeing the process of formation and activity of natural and legal entities practicing the administration of multi-apartment buildings, businesses providing utility and non-utility services in the housing sector, enterprises specialized in repair and maintenance of buildings, and other units engaged in housing activities.
- Monitoring the compliance with mandatory requirements set out in legislation on energy efficiency and installation of measuring devices for energy resources.
- Monitoring and analysis of mandatory requirements set out by law for central and local governments, owners, administrators, service providers, entrepreneurs, in order to enhance the efficiency in the administration of housing sector, to ensure qualitative maintenance and operation of housing stock.

Based on the principle of local autonomy, it may be appropriate to create two levels of control, but with a clear delineation of duties of each authority. The specifics of State control mostly underlie responsibilities ensuring the strength and stability of the building, so the hard work will fall on the State shoulders, as well as funding problems will be also solved easier from the central budget. At the level of administrative units, the control body should be tied to its housing stock and relevant regulatory issues of administration. It is absolutely wrong to believe that all housing problems can be solved locally. Only the State can create sufficient capacity to control sector-specific housing problems, including quality control, and that's because the situation is enormously endangered as seen behind the careless attitude towards maintenance of residential buildings. An optimal formula would be for the State to create the control structures, to perform an inventory, to establish operational procedures, and only afterwards, to gradually transmit the control functions to local authorities, depending on their capacity and ability to take over such functions, step by step, and only upon their request.

In this context, the following immediate tasks can be highlighted and submitted to the authorities for approval:

- Creation of Repair Funds of buildings and ensure the enforcement of contributions thereto, by implementing clear decision-making mechanisms.
- Approval of support programs for the buildings' rehabilitation process, financed from the state and TAU budgets.
- Create mechanisms to guarantee legal mortgage on residential / non residential spaces for claims, supported by social protection mechanisms for those owners who, due to such processes, would remain without living spaces.
- Ensure effective control of the State over the regulated processes.

Only a comprehensive approach and measures undertaken both, by modifying the legislation and approval of housing rehabilitation programs, as well as solving the underlying social problems, we can ensure an efficient administration of apartment buildings, which would lead to the improvement of life quality and eliminating the risks of property loss.

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THE PSYCHOLOGY OF CREATIVITY

"There is no doubt that creativity is the most important human resource of all. Without creativity, there would be no progress, and we would be forever repeating the same patterns".
Edward de Bono

Coincident with Chomsky's critique of Skinner, the tide in theoretical psychology began to turn: Human behaviour could not be accounted for in terms of learned habits – there was creativity throughout all expressions of mind and behavior. The psychologist, Karl Lashley, in fact, had argued years earlier that basic motor behaviors were self-generated and self-organized rather than simply retrieved from literal records within the brain and nervous system. Even human memory, which could be seen as simple retrieval of engrams in the brain, increasingly was seen as a creative process; the past is reconstructed rather than played back in the human mind. The human mind exhibits novelty and inventiveness in much of what it does (Gardner, 1985; Baars, 1986).

Still, humans display degrees of creativity, and psychologists such as Abraham Maslow attempted to identify what personality characteristics were connected with notable creativity in behavior and thinking. Maslow formulated his theory of self-actualizing individuals (similar in ways to Rogers' "*fully functioning persons"*) in whom creativity is especially pronounced. Self-actualizing individuals are autonomous; growth motivated; open to new experiences and learning; spontaneous and "fresh" in their thinking and behavior; playful; ethical; and have high frequencies of peak experiences. At the opposite end of the psychological continuum would be individuals who are more conformist; more motivated by stability and security; and more defensive and closed to new learning and new experiences. Hence, degree of creativity was connected with personality type (Hergenhahn and Olson, 2003; Maslow, 1968, 1972; Rogers, 1961).

Research in split-brain operations (involving the severing of the corpus callosum which connects the two cerebral hemispheres in the brain) conducted by Roger Sperry and Michael Gazziniga (Sperry, 1964, 1968), presented the view that each cerebral hemisphere seems to specialize (to a degree at least) in complimentary functions. The left hemisphere appears more logical, analytic, sequential, detail oriented, and rule governed; the right side appears more intuitive, holistic, simultaneous, and unbound by rules (Hampden-Turner, 1982). As this view gained currency, it was generally accepted that the right hemisphere was the creative half of the brain. The idea from Gestalt psychology that creativity involves holistic thinking seemed to support this view. Holistic insight and/or intuition – the self-organizational dimension of the mind – is where creativity lies. It became popular to develop learning activities that would strengthen right hemispheric capacities (visualization, intuition, big picture thinking) presumably to enhance creativity in individuals. Yet, as the Gestalt psychologists also pointed out, the first and final stages of human creativity involve logical and analytical processes (study and verification), and in considering a fully functional (integrated) brain, it is the working together of right and left – of intuition and logic, of big picture thinking and analysis – that yields intelligent, verifiable and valuable creative results.

In the 1960s Arthur Koestler wrote *The Act of Creation*, a monumental and inspiring study on the history and psychology of human creativity (Koestler, 1964). Pulling together research and thinking from numerous areas – itself an act of prodigious creativity – Koestler presented his "*bisociation*" theory of creativity. For Koestler, high creativity involves synthesizing two (or more) ideas from disparate or disconnected domains; it is seeing the previously unrecognized connection between things. Koestler's description of how Kepler "*bisociated*" the question of the form and dynamics of planetary motion with the structure and dynamics of the Holy Trinity – thus providing a scientifically accurate understanding of the elliptical orbits of the planets around the sun, as well as a theory of astronomical gravity – is a fascinating discussion of the creative mind. Knowledgeable about both of these seemingly disconnected areas of study, Kepler connected them in a way no one could have imagined, thus providing a perfect illustration of Koestler's idea that creativity is the synthesis of already familiar yet disconnected elements. The new builds upon the old through the synthesis of existing elements but the particular insightful combinations realized are unique.

More recently, positive psychology has contributed to the study of human creativity.

Barbara Fredrickson has proposed the "Broaden and Build Theory" of positive emotion and cognition. According to her, positive affective states, such as love, have a constructive impact on cognitive capacities, making the human mind more expansive in scope, more sensitive, more transformational, and more creative. Negative emotions, such as fear and depression, have debilitating effects on intelligence and thinking (Fredrickson, 2005). Thus it is interesting to note, that contrary to the idea that stress provokes creativity, Fredrickson, in line with Rogers and Maslow, sees love, joy, and emotional exuberance as more conducive to creativity.

It is clear that cognitive and emotional processes form a reciprocal or interactive relationship within the human mind, each impacting the other. Negative cognitions tend to produce negative emotional states and vice versa. Hence, as a general rule upbeat emotions such as love, hope, enthusiasm, and courage positively impact human thinking – including creativity – whereas negative emotions such as fear, anxiety, sadness, and depression damp out effective and creative thinking.

Bringing human motivation into the picture, recall that Maslow saw self-actualizing individuals as more growth motivated than stability motivated. Individuals can be more or less motivated toward what is new and different; more or less motivated toward security, safety, and stability. What is new – what is a change in one's way of thinking or behaving – is risky though; seeking out and believing in the new requires courage and hope. Adventure and uncertainty can generate fear and anxiety in humans, pushing them back toward stability and security. Yet, creativity clearly involves sticking one's neck out into the unknown and uncertain. Hence, stability and security motivation (often driven by fear) works against creativity, whereas courage, risk taking, hope, and growth motivation support creativity. It is a common view that creative people are more non-conformist in their personalities and lifestyles, willing to be different, willing to be risky.

As the contemporary philosopher, Paul Feyerabend (1970) argued, "*certainty is one of the cheapest commodities*". A life ruled by the need for certainty and hence mental security is not conducive to creativity. Creativity involves the courage to be wrong, to take chances, to stick one's neck out into the unknown. In fact, highly creative people find it exhilarating to take chances without knowing for sure whether their actions or ideas will pan out; that is the appeal of it. One could propose that highly creative people live more in the future – in so far as the future involves novelty and change – than in the habits and securities of the past.

Mihalyi Csikszentmihalyi, one of the leading modern positive psychologists, has devoted a great part of his career to the study of creativity and flow. For Csikszentmihalyi, "*flow*" is the psychological state in which a person is immersed in a challenging task that requires maximal focus and engagement. Optimal flow is the reverse of either paralyzing anxiety (the task is too difficult for the person's talents) or boredom and tedium (the task is too easy). When a person is in flow, the task requires the full exercise of his or her highest capacities; the person is relatively unselfconscious; and the activity is found intrinsically rewarding, generating a positive affective state. Flow generates creativity. Flow also generates growth and self-actualization. Hence, although there are clearly cognitive elements involved in creative flow, the motivational – emotional factors also play a role. Creativity occurs at the cutting edge of human effort, where the challenge is difficult enough to make the outcome uncertain. A certain amount of stress and risk is necessary – not too much, not too little. As Csikszentmihalyi points out, this is motivating and critical to human happiness (Csikszentmihalyi. 1990, 1996; Csikszentmihalyi and Nakamura, 2005).

Logic, learning, and holistic insight/intuition; synthesis and integration; right and left brain complementarity; cognition, motivation, and emotion; personality and individuality; challenge, sustained effort, and concentration; a conducive environment; and a lifestyle that embraces adventure, uncertainty, non-conformity, and a positive attitude toward the future: all are significant contributory factors to human creativity.

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Column written by professor Valeriu Dulgheru, Ph.D. Dr. Sc. from Technical University of Moldova

PERSONALITIES FROM THE MERIDIANS OF THE ENGINEERING UNIVERSE

Gheorghe Ionescu -Şişeşti was born on the 16th of October in Şişeştii de Jos, a village situated along river Coşuştea, Mehedinţi county. His father, Constantin Ionescu, the village's priest and his mother, a housewife, grew up their 11 children with love, and they educated the 8 ones who lived, four boys and four girls. Gheorghe was the first born and he remained the first in everything.

His life story

He attended the primary school in his native village, where his teacher, Mr. Trandafirescu gathered all the children in one room and taught them the lessons from 1st grade to 5th grade. Gheorghe listened carefully all the lessons and this may be reason he managed to understand how magic the study is. He also enjoyed practical lessons about agriculture and its secrets. His father was very content and believed that his son will follow the same career as his, and this is why he took him the Theological Seminary in Râmnicu Vâlcea. The clerks from the seminar didn't take into account the knowledge or the dreams of candidate Gheorghe Ionescu. He was too young, so he wasn't admitted. The priest Constantin Ionescu thought that his son could stay at home for one year, but he changed his mind and sent him to „*Traian*" High school from Turnu Severin, wanting to transfer him after one year. But, everything went for the best. The student Gheorghe Ionescu, hard-working, disciplined, intelligent, was quickly observed by his teachers. He got a scholarship and then, in the 4th grade he participated to a contest organized in Bucharest by

"*Tinerimea Română*" Society and he took the first prize. He simply was the best. In 1905 he graduated the high school, getting two degrees: one for sciences, other for humanities. He was also the first. From that moment on he could choose any career. He decided to become an agricultural engineer. Although his professors were amazed by his decision, they supported him to go to the Superior School of Agriculture in Hohenheim. The manager of „*Traian*" High school and other 17 teachers signed a petition that contained a description of all his exceptional qualities. Moreover, they got a financial annual aid paid form the county's budget.

In the autumn of 1906, after completing his military duty as a volunteer, he started classes and he got his diploma on the 9th of March 1909 with the mention "*Very well to excellent*". He was remarked for his analytical mind and he was advised to continue his studies at University of Jena, Department of Agriculture in order to get his Ph.d. diploma. He chose a subject related to his village: *The Agriculture of Romania*. On the 11th of February 1911 he got his Ph.D. diploma „*in agriculture, botanics and political economy"* with the distinction *magna cu laude*. He was the second Romanian who got this diploma at University of Jena. The first one was Grigore Antipa who got in 1892 the Ph.D. diploma in natural sciences.

Research, part of his life

In autumn of 1911 he was hired as agricultural engineer at Clenciu-Spanţov farm in Ilfov County. The farm belong to the state, so he was able to use all his skills as a researcher. He had come from Germany with many ideas regarding the modernization of Romanian agriculture. He made numerous scientific experiments for improving the quality of wheat, corn, peas and beans. He presented most of his results at the Agriculture Congress that took place between 18-20 November 1912. The Minister of Agriculture remarked the originality of his paper and the innovating solutions proposed by him and he offered the young researcher a job as administrator of the farm belonging to Central School of Agriculture from Herăstrău. He started his teaching career here, in 1913 as a coordinator of students' practical activities. In 1915 this institution was transformed in an academic institute and it is entitled "*The Superior School of Agriculture from Herăstrău*", and Gheorghe Ionescu was appointed associate professor, and then head of the Department of General Agriculture. He maintained this position until 1958. Research was part of his life, so in 1928 he founded the Central Institute of Agricultural Research where *"the first complex agriculture researches, systematically organized all over the*

country" took place. Twelve experimental research stations were also founded. The purpose of these researches was to obtain highly qualitative species of wheat and corn, to obtain a different use of fertilizers on different types of soil, to apply new methods of improving the sandy soils. In 1943 the A 15 wheat was obtained by selection and cross breeding. These species has a higher productivity and it was cultivated on more than 2 milion hectares until 1965. He also paid attention to theoretical aspects, formulating "*the law of harmonic proportions of greenery factors"*. Moreover, during a conference held at the General Association of Romanian Engineers –AGIR, he said: "*The modern life develops under the sign of mathematics, being neccessary to biologists, economists, but also to artists"*. For these activities he is considered to be the most important personalities of agricultural Romanian school of the XX-th century.

He wrote since his youth.

His first article was written during high school and it was entitled *The rural matter* and it was published in *Albina* magazine. During his military service (1906) he started to collaborate with *Ramuri* magazine from Craiova where he published articles and short stories for 60 years. As a student in Germany he published specialized articles in several magazines: *Câmpul* şi *Jurnalul Societăţii Centrale Agricole din România.* Iată câteva titluri : *Păşunatul vitelor , Livezile şi îngijirea lor, Analiza laptelui.* He continuously wrote until 1961: *Contribuţii la studiul grâului românesc din punct de vedere fitotehnic (1916) ,Lunca Dunării şi punerea ei în valoare (1933), Rapiţa (1934), Cultura porumbului (1936) ,Principalele tipuri de soluri din România (1939), Agrotehnica (1947), Buruienile şi combatearea lor (1955) , La mise en valeur des terrains érodés en Roumanie (1961)* and the list may continue.

Professional Acknowledgment.

In 1925, at Grigore Antipa's proposal, he became part of the Romanian Academy as a associate member, and in 1935 as a full member, increasing the number of members from Oltenia. He was elected vice-president of the Romanian Academy on the 25th of May 1936. He also held this position between 1938 and 1941, 1959 and 1961 respectively. In 1961 he was elected the President of the Romanian National Society of Soil Sciences. He hept this position until the end of his life. He was minister of Agriculture between 1931-1932, 1937-1938 and 1939-1940. He received several extremely valuable distinctions and medals: "*Steaua României*"-1921; "Coroana României"-1922; "*Croix de Commandeur de L'Ordre de Merite agricole*"-1924; "*Chevalier de la Legion d'Honneur*"-1930(Franţa); "*Steaua României cl. I*"-1938; "*Grand officier de la Legion d'Honneur"*-1940 (The French Government). He never forgot his village. He always remembered his teacher, Mr. Trandafirescu and the conditions he studies during his first years ; this is why he built a new school in his native village, Şişeştii de Jos, between 1939 şi 1940. Despite all this, he considered himself *"an ordinary man who tried to do his duty wherever he worked*".

Gheorghe Ionescu Şişeşti died on the 4th of July 1967 , Otopeni.

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