ELABORATION AND INVESTIGATION OF THE TECHNOLOGICAL LUBRICANTS FOR SEPARATING AND FORM CHANGING OPERATIONS AT THE COLD STAMPING

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INTRODUCTION

Wide usage of cold stamping for operations of separation and forming in engineering industry requires the utilization of highly effective technological lubricants (TL) improving the wear resistance of stamps operating members and the quality of production.

A range of liquid lubricants and lubricant-coolants for different purposes, having anti-wear and anti-fretting properties, containing highly disperse solid lubricants has been developed in Ukraine and Russia.

TL is used to improve the wear resistance of stamp operating members, the accuracy of production and the quality of the cut-off surfaces. TL must meet a range of requirement such as: high separation capacity and polarity; ability to prevent adhesive bonds between the metals of stamp and blank; high anti-wear properties under great pressures and temperatures; easiness of application/removal; non-toxicity.

Perspective suggests development of new multi-purpose synthetic lubricants that can be used as a base for TL used in metal machining and plastic working.

1. LABORATORY STUDY TL

Laboratory and production tests were used in the research procedure to estimate applicability of the developed TL. Separation and forming operations involved in plastic metalworking do not easily lend themselves to accurate simulation in laboratory, although other applications of lubricants de. As for the accurate simulation of separation, namely hole punching, useful information may be found in [1].

Different procedures are employed to estimate technological properties of lubricant for sheet metal stamping [2]. As a rule, standard instruments for defining metal-sheet stampability are used for TL estimation. Drawing of cylindrical and semispherical caps are drawn i.e. Swift, Engelgardt, Fukui methods, TSNIITMash technique are used, as well as embossing indentation according to Erikssen using instruments of different design.

TL developed by the Technical University of Moldova on the basis of synthetic solid lubricants being products of interaction between metal hydroxides (such as iron, cobalt, cadmium, copper, titanium, hydroxides etc.) and kaprolaktam [3-5] were subject of our research, TL were made as pastes with conventional letter designations “K”, “M”, “H”. The paste composition was as follows: solid lubricant as powder having particles size within the range of 9…10 μm – 60 % by weight and petroleum oil “ИС-20” (GOST 20799-75) – 40 % by weight. Both ingredients were thoroughly mixed during one hour and the mixture was allowed to stand for the following 24 hours at room temperature. We tested also the lubricant for cold plastic metalworking [6]. The lubricant composition was (% by weight): hydrated calcium lubricant – Grade “C” (GOST 4366-76) Solid oil – 67, product of interaction between kaprolaktam and copper hydroxide – 20; sulfur - 3; kerosene – 10. For comparison we tested also: Grade “ИС-20” oil, Grade “C” Solid oil, Grade “УСсА” (GOST 3333-80) lubricant, paste “Molyka” (ĞSSR) and graphite lubricant “Meta G3” (ĞSSR).

Laboratory research comprised tests of all lubricants on the four-ball friction machine (Barrelage machine). Besides, all TL were tested in laboratory while estimating metal sheet stamp ability by procedures, which will be described below. Production tests involving blanking, holes perforation and cupping were carried out at the “Elektromashina” plant Chişinău.

A four-ball friction machine was used to carry out the test according to the procedure requiring one minute and employing balls with diameter 12,75x10^{-3} m at axial loads applied on the four balls pyramid from $\mathbf{P_{ax}}$ = 700 N to $\mathbf{P_{ax}}$ = 3000 N. The bowl with three bottom balls was being filled with the TL under test till it covered the balls.

Three tests were made under the lowest axial load. A microscope was employed to measure the diameter of wear pattern formed on the bottom balls after each test.

Type "Stereoscan-4" scanning electron microscope was used to study the TL effect on the micro relief formed on the shearing die working surface. The research showed that the most acceptable surface micro relief in the process of die wear was formed in presence of TL (paste "K") containing solid lubricant on the basis of kaprolaktam [3]. The results obtained were especially encouraging when the working surfaces of the punch were knurled. The peaks were triangular in profile with the 900 - vertex corner. They were pitched $1.0x10^{-3}$ m and $0.5x10^{-3}$ m deep on the punch (blade) working surface. Knurling has a positive effect on wear reduction, which may be explicable by the fact, the furrows serve as cavities to hold TL and retain it.

TL laboratory tests performed on the four-ball friction machine were analyzed and conclusions were drawn that the lubricant for metal plastic working [6] has good anti-wear properties although it contains a considerable lesser amount of solid lubricants based one kaprolaktam [5] i. e. 20 % by weight.

The lubricant is made by thoroughly mixing solid oil "C" with sulfur and the product of interaction between kaprolaktam and powder zed copper hydroxide [5]; the latter having particles size of 9…10 µm.

The lubricant can be recommended for usage in separation processes as its two indices, namely, critical and sticking loads are comparable with those of the TL recommended for precision stamping of structural and special steel up to $5x10^{-3}$ m thick (Type "XC–147" (TU 38 101612–76) lubricant) and with lubricants recommended for medium and deep drawing (Type "Ukrinol-23" and "XC–170" lubricants).

Type "XC-147" and Kurtiss lubricants (FRG) employed in separation processes at the punched-card machines plant in Ryazan (Russia) showed several drawbacks. They failed to affect positively the stamp durability and to withstand temperature conditions in the drawing process, since they are decomposed. They failed also to prevent corrosion of metal parts under the action of direct sunbeams.

The lubricants decomposed when metal was degreased by trichlor-ethylene and failed to protect metal parts against corrosion within a period of 50 days.

2. EXPERIMENTALY EXAMINATION TECHNOLOGICAL LUBRICANTS

Experimental procedures of evaluation of sheet metal stamp ability were employed to estimate TL efficiency. Stamp ability test was performed on Type "МТЛ-10Г" machine that cut a spherical indentation in a sheet of Grade "08 кп" steel $1x10^{-3}$ m thick. The drop in force due to the break of the indentation indicated the test end. The results were compared with performed with Grade "ИС-20" oil and with no lubricant (table 1). The punch only was lubricated. Comparative results are given.

Table 1. Results of tests on "МТЛ-10Г" machine

Forge drawing without lubrica-tion	Forge drawing with suggested lubrica-tion **TL /6/**	Forge drawing with lubrica-tion by oil **"ИС-20"**	Forge drawing with lubrica-tion by cup grease **"C"**	Forge drawing with lubrica-tion by cup grease **"C" + 20 %** of graphite **"ГМ-Д"**
Depth of spherical hole, $\times10^{-3}$ m				
10,10 9,50 10,00	10,21 10,36 10,19	10,10 10,15 10,05	10,10 10,22 10,18	10,20 10,18 10,19
Mean values of hole's depth, $\times10^{-3}$ m				
10,10	10,26	10,10	10,18	10,19

Type "P-10" static tensile test machine indented balls with the diameter $6,3x10^{-3}$ m and hardness 60…62 HRC in samples of Steel "45" (GOST 1577–81) greased with lubricant [6]. Comparison made with samples of Steel "45" with no lubricant. Forces exercised on the balls were 500, 2000, 3000 and 4000 N. The indentation depth (**h**) was measured after the test and the ratio **h/r** was calculated (**r** – ball radius) (table 2).

Table 2. Results of tests on "P-10" machine

Force of pres-sing in sphere, **N**	Models without lubrication		Lubricated models	
	h $\times10^{-3}$ m	**h/r**	**h** $\times10^{-3}$ m	**h/r**
500 2000 3000 4000	0,11 0,40 0,58 0,82	0,035 0,127 0,184 0,260	0,11 0,41 0,62 0,85	0,035 0,230 0,195 0,269

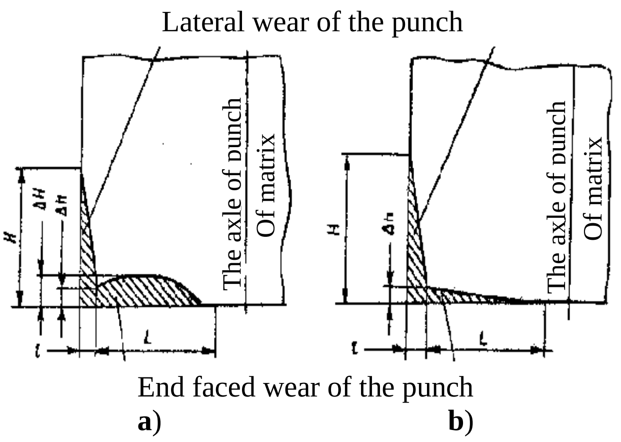

Figure 1. The profile of parted inserted blande's wear**: a –** when **l /t < 0,6 ; b –** when **l /t > 0,6** and with availability of the billet for inserted blande's clamp /**7**/

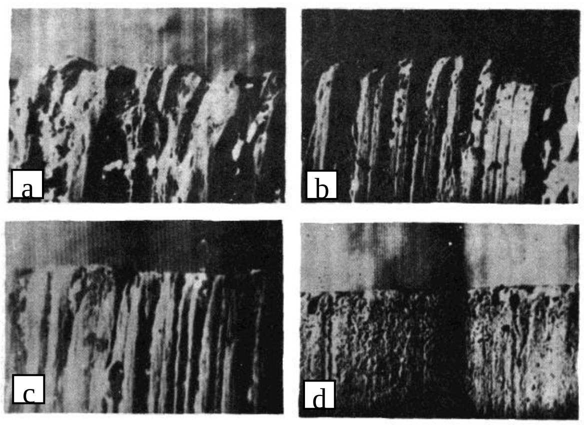

Figure 2. The surfaces of working end faces (punches), which were working in conditions**: a** – without lubrication; **b** – lubrication with oil **„ИС-20"; c** – lubrication with paste technological **„K"; d** – lubrication with paste technological **„K",** when the surface of working end face is reefed
(x500) /7, 8/

Type "K", "M", "H" lubricants and the lubricant for cold metal plastic working [6] were subject to production tests aimed at estimation of the step blade durability while manufacturing blanks for nuts "**M4**" and "**M5**" from Steel "10" (GOST 1577–81) $3x10^{-3}$ m thick F_{ax} =1000 kN press was employed. The step blade (punch) was made of Steel "XI2M" (GOST 5950–73) and then subjected to thermal treatment until attaining hardness 58…60 HRC. Stamping was carried out automatically till the appearance of burrs $0,15x10^{-3}$ m high. The steel strips were being covered with lubricant with a brush immediately prior to stamping. Corresponding values indicating the wear of the step blade working parts were measured (figure 1, 2) /7/.

Lubricant efficiency [6] was estimated while punching holes with diameter $30x10^{-3}$ m in steel sheet $4x10^{-3}$ m thick. Steel "08 кп" was employed. It was measured either how deep the punch penetrated in the material till destruction cracks appeared or the width of the "shining belt". The less the punch got into the steel, the less the force of separation and the more the durability of the punch working surface /9, 10/.

Employment of Type "K", "M", "H" pastes instead of Grade "ИС-20" oil showed a two-threefold increase of the step blade durability. When perforating holes with diameter $4x10^{-3}$ m and simultaneous counter-boring, the durability of the punch increased 1,5 times and the burr height was two times less. When perforating holes with diameter $26x10^{-3}$ m and simultaneous outward flanging in a sheet of Steel "08 пс" (GOST 16523–70) $1x10^{-3}$ m thick, the durability of the punch increased 2…3 times and there were no breaks when Type "K", "M", "H" pastes were employed instead of Grade "ИС-20" oil.

The punch durability increased 2…3 times when punching windows 18x30 mm in Steel "08 кп" (GOST 16523–70) $1x10^{-3}$ m thick if Type "M" paste was employed, in comparison with punching without lubrication. A copper film appears on the punch surface after 1500…2000 strokes, then it shells off and forms all over again. The burr height is about two times less.

The production test results obtained with different TL in blanking nuts **M4** and **M5** show that the wear **ΔH** of the step punch edge was considerably reduced Grade "ИС-20" oil is blended with suitable solid lubricants, produced on the basis of kaprolaktam. Type "K" paste decreases the punch wear, since it facilitates the formation of durable adsorptive lubricating layers on the contracting surfaces, owing to kaprolaktam high surface activity relative to oxides and especially hydroxides on the steel surface. This is feature of all lubricants on the basis of kaprolaktam. The step punch wear proved to be even less when Type "H" paste was employed, which may be explained by the fact that its thermal conductivity is higher than that of Type "K" paste. And it is well-known that wear and durability of the cutting tool are greatly affected by the rate of heat removal in the tool-blank pair, by the heat insulation of the contacting surfaces, by the chemical and physical state of the lubricating layer. We have found out that introduction (up to 5% by weight) of magnesium oxide, having good heat conductivity, affects positively the step punch wears, since it increases the heat conductivity of the lubricating layer. Type "M" paste decreases the step punch wear in comparison with Type "H" paste as it realizes a selective heat transfer, due to the content of solid lubricant [5], comprising copper hydroxide and kaprolaktam (figure 3 /7/).

The profilograms of the edges of step

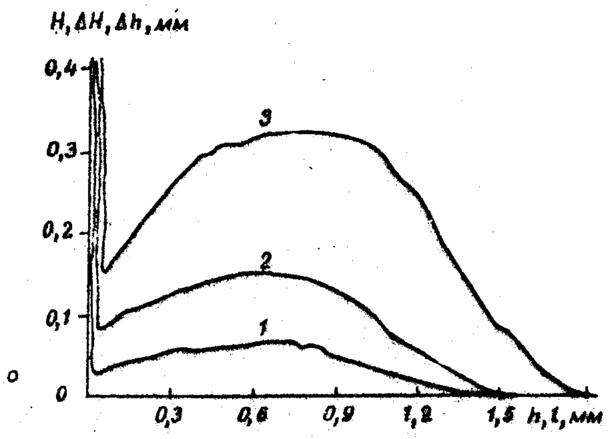

Figure 3. Profilograms of the worn out end faced surfaces of the pitched inserted blade's**: 1 -** in presence of the paste technological **„K"; 2 –** in presence of oil **„ИС-20"; 3 –** without lubrication technological material **(x2000)** **/7/**

punches have shown that employment of solid lubricants on the basis of kaprolaktam in Grade "ИС-20" oil reduces wear although the shape of the worn-out spot remains unchanged. Crater shaped wear of the step punch is incident to metal cutting tool wear. In the punching processes it takes place when the part being blanked has a short length – **l**/t **<0,6**. When **l/t < 0,6**, the surface of the material being stamped slides along the tool surface. The material being stamped gets into the punch and micro volumes of the punch (blade) are being cut. When **l/t < 0,6**, wear due to corrosion may take place at the tool contact surface. This phenomenon may be explained by interaction between "abrasive" particles and tool surface during alternating loading if the wear products are transferred over small distances. When **l/t < 0,6** and Types "K", "M", "H" pastes as well as "Tuk mazaki Molyka" were employed, no superficial defects showed on the worn out surfaces of the step punches (blades). Solid lubricants developed at present on the basis of kaprolaktam and lubricants made on their basis are perspective materials, as their components are easily available and their anti-wear and ant fretting properties are considerably good.

3. CONCLUSIONS

1. The mechanism of the action of the developed lubricants is based on formation of adsorption films, physically and chemically stable, on the working surfaces of the stamp. The films prevent establishing of adhesive bonds between the surface of the stamp working and that of the blank.

2. In comparison with Grade "ИС-20" oil, the TL developed for separation and forming operations makes it possible to increase 1.5…3 times the durability of separation stamps and remove defects incident to fretting corrosion.

3. Increased stamps durability results in a growth in labors productivity due to the reduction of the number of the stamps employed as well as to the reduction of the number of the stamp regrinding operations.

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