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RESEARCH

Lubricant As Parameter Of Processing Tribomechanical System In The Process Of Wire Drawing

Treatment process of the wire drawing is characterized by conditions in which intensive development of the tribological matters is to greater extent determined by process efficiency and the product quality. Contribution to the reduction of negative effects of friction and wear is possible to be achieved, first of all by optimum choice of lubricants in the function of the processing condition parameters.

This paper presents research experiences from this area. They are based on the results gained in laboratory conditions with modelling of the processing tribomechanical system, as well as in immediate production practice.

Keywords: *wire drawing, lubricating, friction, wear*

1. INTRODUCTION

Wire drawing is form of material plastic deformation, where under the influence of drawing force in the matrix (drawing tool) the length is increased, and the wire diameter is decreased.

However, the wire volume remains unchanged - basic drawing characteristics.

Wire elongation can be single-stage or multi-stage, which depends on the machine design, i.e. on the matrices number and number of drawing wheels ordered in series, on which the elongation is performed.

During the drawing process, steplike drawing wheels are cooled and lubricated with suitable emulsion, because in that way, the sliding friction is reduced between the wire and steplike drawing wheels and thus created friction heat is taken away.

During drawing wire through the matrix on the contact surfaces between the wire, working cone and matrix cylinder, sliding friction appears. Because of the influence of friction heat and deformation heat of the material of which the matrix core is made, softens it and that is the reason why the matrix wear is increased. After the wire comes out of the matrix cylinder, contact temperature which is about 700°C, abruptly decreases to some medium temperature of about 250°C. Broaching of the wire through the matrix cannot be imagined without emulsion as the lubricating agent that will serve as thin film between the wire and working surfaces of the matrix. In that way, the sliding friction is transferred from metal surfaces on the emulsion molecules.

By using the emulsion, the following is achieved:

- smaller strength for drawing wire through the matrix
- increase of the matrix life on the same dimension
- after the broaching, the wire surface is light and smooth
- increase of the speed of the wire drawing through the matrix.

The application of polar lubricants decreases the material reduction on drawing. Polarity and chemical reactivity when drawing wire can be controlled efficiently in technological process by varying constituent contents such as: fats, additives, soaps, emulsifiers etc. Therefore, plain lubricants are not sufficient to meet the requirements in the process of wire drawing.

Performed research had the aim to develop the lubricant for Cu wire drawing that meets the mentioned requirements and to achieve the following:

- universality of the lubricant application - one product for fine, medium and rough drawing

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- economy in application – lower application concentrations and
- to meet strict ecology requirements.

This paper presents the achieved results in laboratory and exploitation conditions.

2. RESULTS OF TRIBOLOGY TESTING

Testing of tribology characteristics of the chosen lubricant are of the model type and they are performed on improved tribometer TR-95 with block-on-disk contact geometry.

Experimental contact pair meets the requirements of the appropriate ASTM standard and it consists of rotary disc with the diameter of 35 mm and width of 6.35 mm made of copper with 99.9% purity and a stationary block with the width of 6.35 mm made of steel of steel Č 6980 hardness 62-64 HRC.

2.1. Testing conditions

Conditions for tribological testing are given in table 1

Table 1.

Working conditions	Sliding speed - 1,465 m/s Normal force - 5 daN Contact duration - 1200 s
Environmental conditions	Room temperature - 24 to 26 °C Atmospheric conditions
Tested lubricants	Emulsifying oil MF-TS 99/020 Emulsifying oil MF-TS 99/021
Varied concentrations	3%, 6% i 12%
Measured values	Friction and wear parameters Medium block temperature

General characterstics of these lubricants are given in tables 2. and 3.

2.2. Measuring results

Table 4.

Lubricant	Concentration %	Average friction coefficient
MF-TS 99/020	3	0.107
	6	0.111
	12	0.123
MF-TS 99/021	3	0.114
	6	0.118
	12	0.113

Comparison of the friction coefficient of these lubricants is shown on the Figure 1.

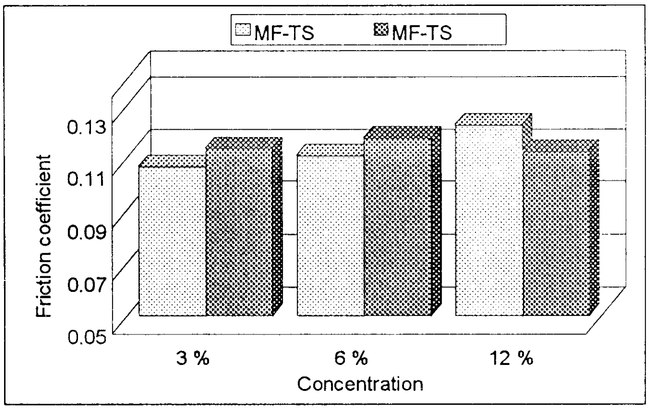


Figure 1.

From the point of friction coefficient, optimum concentration of the lubricant MF-TS 99/020 lubricant is 3%. The influence of the emulsion concentration on the friction coefficient in lubricant MF-TS 99/021 is very small, and the lowest value amounts to the concentration of 12%.

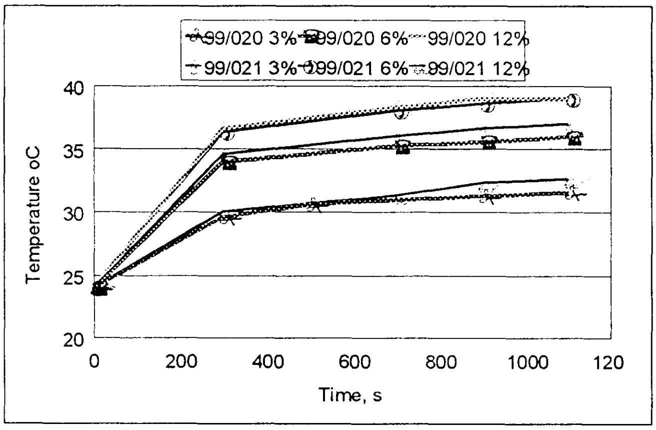
Table 2. Concentrate

General characteristics	Method	Units	MF-TS 99/020	MF-TS 99/021
Appearance	visual	-	homogeneous	homogeneous
Density at 20 °C	ISNO 3675	g/cm^3	0,925	0,955
Saponification number	DIN 51558/1	mgKOH/g	9,50	10,66
Saponification number	DIN 51559/1	mgKOH/g	65,00	70,69
Stability +40 °C +20 °C -20 °C	JUS B.H3.536	- - -	Stable Stable Stable	Stable Stable Stable

Table 3. Emulsion

Appearance	visual	-	Milky white	Milky cream
ph value	ISO 4316	-	8,50	8,40
Stability at 20 °C 0 h 24 h 48 h	visual	 - - -	 Stable Relatively stable Unstable	 Stable Relatively stable Unstable
Cu Corrosion (5%-emulsion in town water) 7 days at 40°C	ASTM D 130	Degree	Does not work	Does not work (Emulsion changes colour)
Foaming property (5% and softened water)	"OIMETA"	cm/min	Does not foam	150/2

During the friction process, average block temperature is measured occasionally. Block heating in the function of time, varied lubricants and emulsion concentrations is shown in the diagram on the Figure 2. It can be seen that the stationary temperature ranges from 32°C to 39°C. There is a direct corelation between the friction coefficient level and the temperature.



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Development of the wearing process is characterized by intensive transfer of disk material onto the block contact surface. Thus, regular strap of the transferred copper appears on the block, which, in time, is partially removed in the form of fatigue wear and there is gradual wear of block material.

Measured average widths of the strap wear for the varied contact conditions are given in the table 5. There are also shown appropriate values of the wear degree calculated as relation of strap wear width and friction time, i.e. resistance to wear - reciprocal value of the wear degree.

Independently from the lubricant type, it can be clearly seen, that the wear parameter represents the function of the emulsion concentration. Therefore, in the first case, optimum concentration is 3% and in the second 12%. Besides from the wear aspect, these concentrations are optimum also from the aspect of friction.

Apart from it, that different optimum concentrations are suitable for the tested lubricants, different level of resistance to wear is also suitable for them, as it is illustrated on the Figure 3. through percentage index.

Table 5.

Lubricant	MF-TS 99/020			MF-TS 99/021		
Concentration (%)	3	6	12	3	6	12
Wear (mm)	0.635	0.770	0.869	0.973	0.950	0.86
Wear degree (mm/h)	1.910	2.330	2.630	2.950	2.880	2.600
Resistance to wear (h/mm)	0.52	0.43	0.38	0.34	0.35	0.38

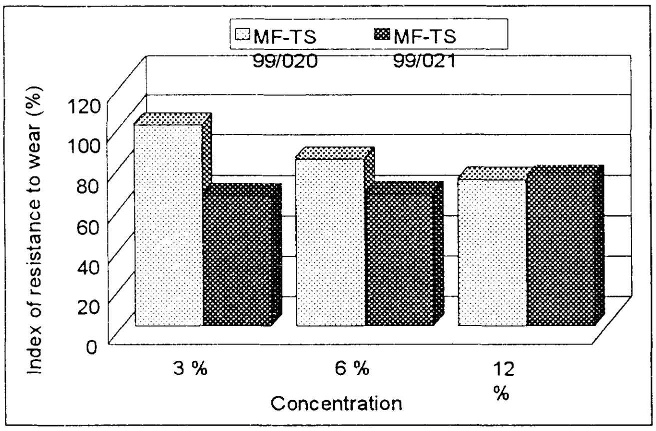

Figure 3.

3. EXPLOITATION TEST RESULTS

3.1. Test conditions

Table 5.

Machine	„HENRICH" for eight-wire fine drawing TYPE 21
Drawing material	Cu wire
Technical characteristics	
max. input dimension	8x2,00 mm
Final dimension	8x 0,15-0,50 mm
max. speed	30 m/min
Wire number	8
Wire elongation	21 % const.
Emulsion flow	48 m^3 /h, 0,5 bar
Purification	hydro-cyclone
Tools	diamond matrices - manufacturing PHILIPS-ESTEVES
Matrices Number	21. Matrix series d_2=0,20 mm ∅ consists of 18 matrices with diamond insert
Material:	Cu wire purity 99,9995
Dimension	8x 0,20 mm
Drawing speed	25 m/s
Elongation	21 % const.
Product emulsions	MF-TS 99/020 and MF-TS 99/021

3.2. Results of monitoring in exploitation

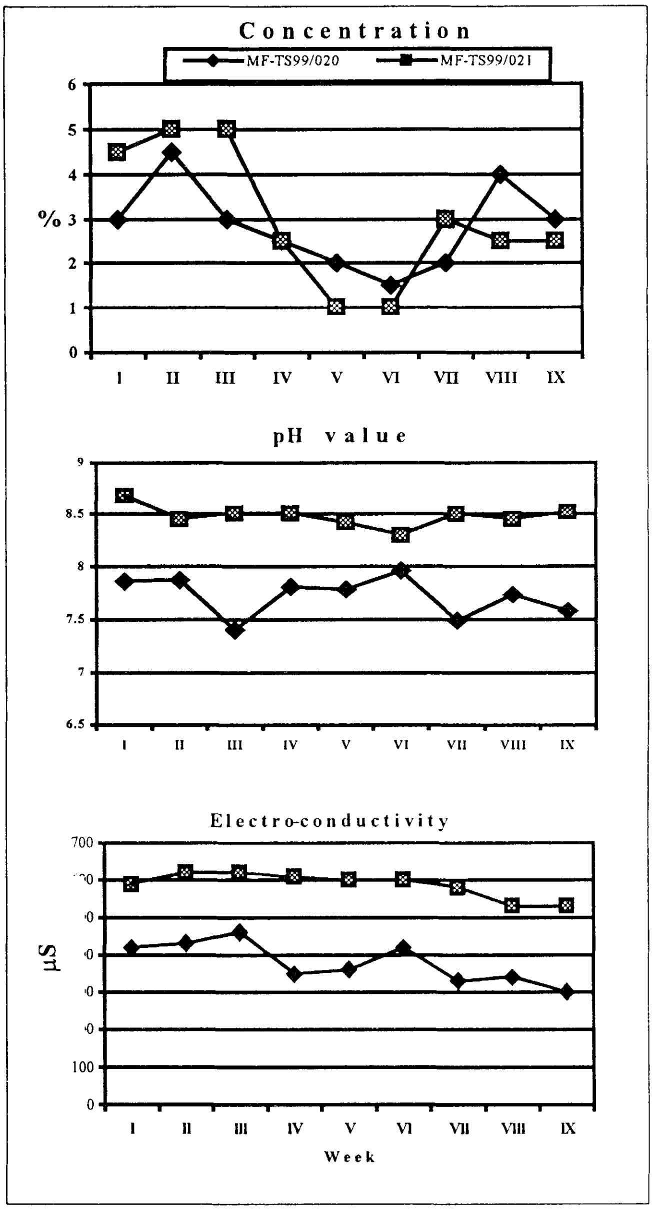

Figure 4.

Exploitation tests are performed by monitoring:

- determination of change of physical chemical characteristics of the working emulsions through the samples,
- registering of the working emulsion behaviour in the production plant
- wear of the tools - matrices and
- drawn wire quality.

Within the 2,5-month period of exploitation even besides the lower applied concentration than prescribed, the stability of the working emulsions was good. There was neither unpleasant smell of the emulsion in the plant, nor the appearance of its negative influence on the skin and eyes of the workers that come in contact with emulsions.

During the process of wire drawing on the tools - matrices there was no sticking and the wire was clean, smooth and with light surface. The quality of the drawn wire ∅ 0,20 mm was completely in accordance with the standard JUS N. C7.101 the round copper wire for electro-engineering drawn to precise measure.

4. CONCLUSIONS

- Tribological properties of the tested lubricants, from the aspects of friction as well as from the aspect of wearing, are the function of the lubricant concentration in the emulsion.
- Change of the emulsion concentration for certain lubricant in the same way influences friction parameters as well as the wear parameters. However, reduction of the concentration from 12% to 3% results in the tribological properties improvement in lubricants MF-TS 99/020, but also aggravating of the tribology properties in the lubricant MF-TS 99/021. Therefore, in the tested range of concentrations, the optimum concentration from the friction aspect as well as from the aspect of resistance to wear, for the emulsion of lubricant MF-TS 99/020 is 3% and for the emulsion of lubricant MF-TS 99/021 12%. Influence of the concentration change compared to the optimum one, to the tribological behaviour of the emulsion is more prominent in the lubricant MF-TS 99/020 and is shown by increase of the friction coefficient for 15% and degree of wear for 37%.
- Obtained results show tribological superiority of the MF-TS 99/020 lubricant compared to the lubricant MF-TS 99/021. It is expressed through smaller friction on the level of 6% and bigger resistence to wear on the level of 36% of concentration for optimum concentrations. Therefore, it is economically very important that the superiority is achieved with 3%-concentration compared to the concentration of 12%.
- Friction process in the conditions of nominal linear contact is characterized by the appearance of adhesive copper transfer from the disk to the contact surface of the steel block, which is manifested as the increased contact dynamics, i.e. as increased dispersion of the friction parameter signal. This appearance, like the average block temperatures during the friction process are the function of the concentration and the type of lubricant in the emulsion. The character of the influence of these variables on the mentioned parameters of dynamics and thermo-dynamics of the process is completely agreeable with the one that is valid for friction and wear parameters.
- Set goals in development and design of the mentioned product from the aspect of ecology and economy are fulfilled. Final quality evaluation of the newly formed product MF-TS 99/020 will be given after finishing the exploitation tests on the operations of medium and coarse copper wire drawing that are in process.

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