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INFLUENCE OF TOOL SPEED AND LUBRICATION ON MECHANICAL PROPERTIES OF COLD EXTRUDED ALLOY CuCrZr

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ABSTRACT

In most instances friction is preferably reduced to zero by the introduction of a lubricant. The lubrication problems are one of the most delicate problems in cold forming. The influence of lubrication on wear, friction, forming force, temperature, material and geometrical properties and finally costs is very important.

In the paper the influence of lubrication and tool speed on material properties (such as tensile and yield strength, elongation, reduction of area, hardness, electrical conductivity etc.) in cold forward extrusion of the copper alloy CuCrZr has been examined. Many experiments at different lubrication friction coefficient and different tool speed were carried out. The results are presented in a form of diagrams.

1. INTRODUCTION

In the majority of metalworking processes the workpiece is deformed by means of a contacting die. The pressure required for deformation generates a normal stress to the die surface, and movement of the workpiece relative to the die surface generate a shear stress at the interface.

Thus a classical tribological situation arises, with friction at the die-workpiece interface, and with potential for wear of both die and workpiece materials. Mitigation of these effects then calls for the introduction of a lubricant.[1]

The success or failure of such lubrication has important consequences on the quality of the issuing product, and also on pressures, forces, energy requirements and often on the mechanical and other properties of the product. The choice of the right lubricant and its proper application is very important. Despite the extremely wide range of conditions under lubricants must function, some systematic approach to selection can be made.

Final selection is almost always a matter of compromise, but there are some fairly general, desirable attributes:

- separation of die and workpiece surfaces
- prevention of cold welding (pressure welding)
- controlled friction
- control of surface temperature
- easy handling, safety and low costs

2. EXPERIMENTAL WORK

In the frame of the experimental work the process of cold forward extrusion of a cylinder from the copper alloy CuCrZr was analysed. This is a copper-chrome-zirconium alloy with high electrical and thermal conductivity and excellent mechanical and physical properties also at elevated temperatures. It is used as electrode material in spot, seam and butt resistance welding of low carbon steel sheets. Further it is used for manufacture of various components for resistance welding equipment

The cylinders of dimension Φ22 mm x 32 mm were extruded in a special tool for forward extrusion (Fig.1) at 20°C temperature, at three different values of tool speed v_{tool} (12 mm/s, 16 mm/s and 25 mm/s) and three different lubricant friction coefficients μ (0,05, 0,09 and 0,16). The effective strain was in all cases ε_e = 1,29.

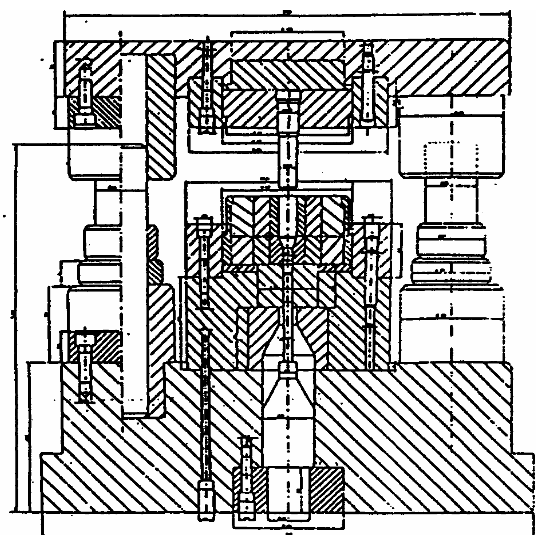

Fig 1. Experimental tool for cold forward extrusion.

The measurement of lubricant friction coefficients was carried out by using the ring-compression test. Increasing friction presents increasing resistance to free expansion of the ring, resulting a decrease of the ring internal diameter. Thus lubricants can be ranked simply by measuring the change in internal diameter and height of the ring.

The results of the ring-compression test for three lubricants gave us these values:

- Molyduval Carat : μ = 0,05
- Castrol KPO 2097 oil: μ = 0,09
- Imperium grease: μ = 0,16

To determine the influence of lubrication on mechanical and electrical properties of extruded pieces tensile tests, Brinell hardness measurements and electrical conductivity measurements were carried out. Tensile strength, yield strength, reduction of area and elongation were determined with tensile test on the tensile machine. Brinell hardness was measured by measuring instrument WPM, electrical conductivity of extruded samples was measured by the Sigmatest instrument. Many experiments were done to provide reliable results.

3. RESULTS AND DISCUSION

The diagram on the Figure 2 presents the change of tensile strength R_m, yield stress $R_{p0,2}$, reduction of area Z and elongation A_5 as a function of lubrication friction factor μ. at the constant tool speed v_{tool} =12 mm/s. The results at different friction factor are very similar and the difference between them is less then 4 %. In that point of view it is possible to say that the lubricant friction factor does not effect importantly the measured mechanical properties of the extruded alloy. Of course this conclusion can be made only for lubricant friction factor interval from μ= 0,05 to 0,16.

If we compare the mechanical properties before and after forward extrusion we can notice higher tensile stress (14%) and yield stress (28%) but lower reduction of area (7%) and elongation (8%) after the extrusion process.

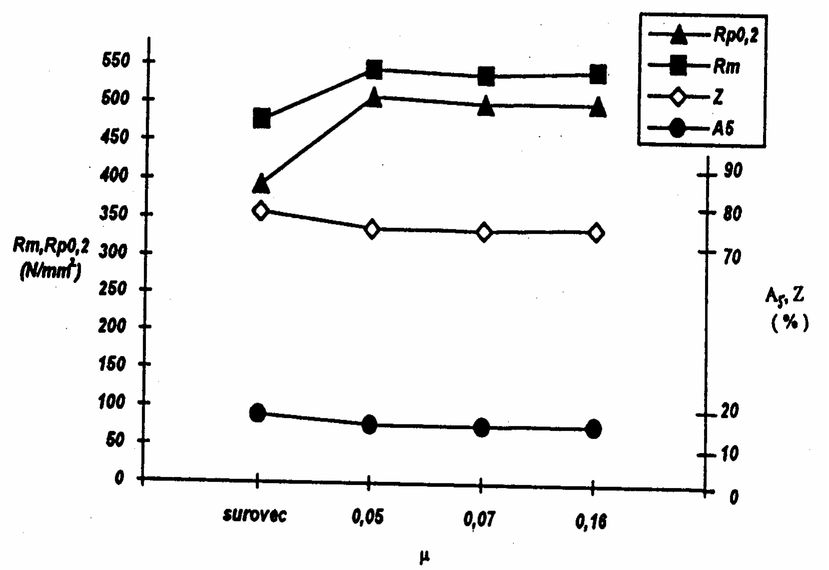

Fig 2. Influence of lubricant friction factor μ on tensile stress (R_m), yield stress ($R_{p0,2}$), reduction of area (Z) and elongation A_5 (surovec = unformed alloy)

The diagram on Figure 3 shows the change of mechanical properties at the constant lubricant factor μ = 0,05 but different tool speed. Tensile and yield stress are decreasing (about 5%) with higher tool speed while elongation and reduction of area are increasing (for about 4 %).

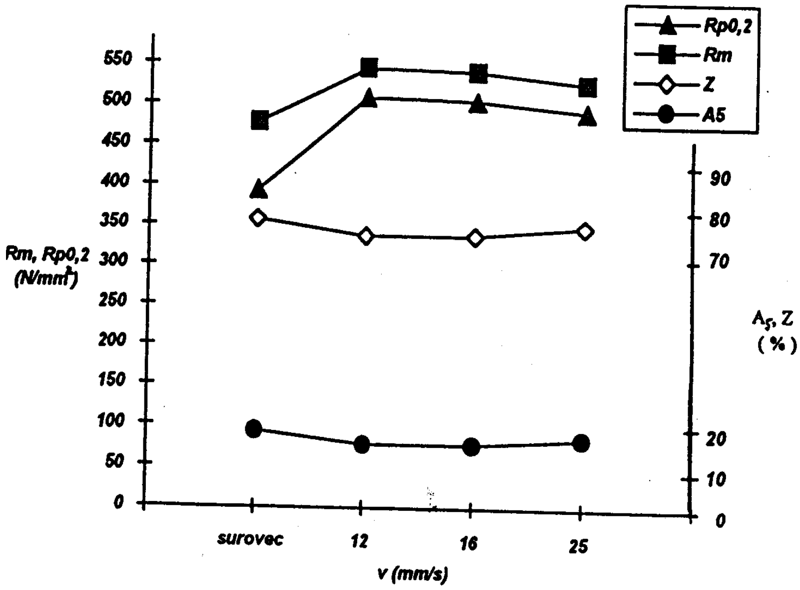

Fig 3. Influence of tool speed (v) on tensile stress R_m, yield stress $R_{p0,2}$, reduction of area Z and elongation A_5 at lubricant friction factor μ =0,05 (surovec = unformed alloy)

By means of Brinell hardness measurement in several measuring points of the extruded part (Fig. 4) it was possible to determine the influence of the strain and lubricant friction factor to hardness. Figure 4 presents the measuring points on the extruded alloy CuCrZr.

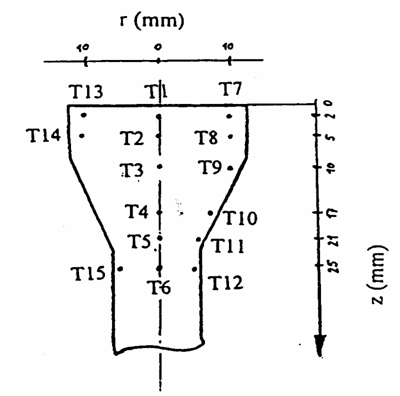

Fig 4. Measuring points of extruded alloy for Brinell hardness

The highest values of Brinell hardness was measured on the exit of the deforming zone of extruded part. This value was 181 HB which is 25% more then Brinell hardness of the unformed alloy. Figure 5 shows the influence of lubricant friction factor to Brinell hardness of the extruded alloy, measured in points according to Fig. 4.

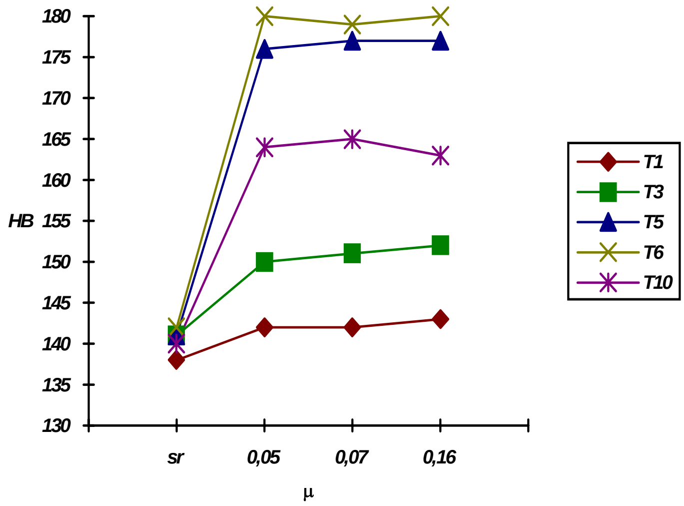

Fig 5. Change of Brinell hardness in several points of extruded alloy as a function of lubricant friction factor μ (sr. =unformed alloy, v_{tool} =12 mm/s)

According to diagram on Fig. 5 the influence of lubricant friction factor to Brinell hardness has no big importance. The differences between values of Brinell hardness in the same measuring point of the extruded alloy but at different lubricant friction factor μ are less then 5 %. Of course, this conclusion can be made only for lubricant friction factor interval from μ = 0,05 to 0,16.

Measurement of the electric conductivity was carried out on the cylinders taken from the root of the extruded alloy. Dimension of these cylinders was Φ 11mm x 16mm and the conductivity was measured by special Sigmatest instrument with measuring frequency of 120 kHz. Many measurements were done to provide reliable measuring results of electric conductivity. Electrical conductivity is decreasing with higher strain. At specimen 1 it is 18 % lower than the conductivity of unformed material. The influence of lubricant friction factor on electrical conductivity of the deformed material is 4 % comparing values for μ= 0,05 and μ= 0,16.

Table 1. Electrical conductivity $\left[\frac{m}{\Omega \cdot mm^2}\right]$ *of the extruded specimens at v_{tool} =12 mm/s*

Specimen 1 (μ = 0,05)	**Specimen 2** (μ = 0,09)	**Specimen 3** (μ = 0,16)	**Unformed alloy**
40, 95	**41, 38**	**42,58**	**50, 30**

4. CONCLUSION

The magnitude of friction needs to be known for more reasons. First, pressures, forces and energy requirements can be calculated only if interface conditions can be describe by shear strength or friction factor. For this, a numerical value must be established. Second, reduces friction is often the main criterion in choosing a lubricant. For this, comparative values are often sufficient. The ultimate choice of the lubricant may have to be based on full – scale operating experience, but such tests can be disruptive and expensive.

The friction can also effects on the material properties during and after forming process. In our experiments this influence was very small, because we used lubricants with low friction factors μ (between 0,05 and 0,16). By using lubricants with higher friction factor, the influence on the mechanical properties could be more important.

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UTICAJ BRZINE ALATA I PODMAZIVANJA NA MEHANIČKE OSOBINE HLADNO ISTISKIVANE LEGURE CuCrZr

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REZIME

U najvećem broju slučajeva radni predmet se deformiše direktnim dejstvom/kontaktom alata i materijala. Usled tangencijalnih napona nastaje trenje na kontaktnim površinama koje ima višestruko negativan uticaj po proces. Pogodnim podmazivanjem može se ublažiti to negativno dejstvo trenja. Podmazivanjem se smanjuje pritisak , sila i utrošena energija a poboljšavaju se mehaničke osobine obratka. Osnovni zahtevi od sredstva za podmazivanje su:

- *da odvoji alat od materijala obratka*
- *da spreči hladno zavarivanje alata i materijal obratka*
- *da smanji trenje*
- *da smanji tempretaturu u kontaktu*
- *da bude pogodan za rukovanje*

Ovaj rad opisuje eksperimentalna istraživanja procesa hladnog istiskivanja legure CuCrZr (bakar-hrom-cink), koja se odlikuje visokim stepenom termičke i električne konduktivnosti. Varirane su brzina (3 nivoa) i vrsta podmazivanja (tri različita sredstva za podmazivanje). Dostignuta je efektivna deformacija od ε_e = 1,29. Određivanje koeficijenta trenja za pojedina sredstva za podmazivanje vršeno je pomoću sabijanja prstena. Takođe su sprovedeni testovi istezanja, merenja Brinelove tvrdoće kao i merenje efektivne konduktivnosti. Merenjima i analizom uzoraka nakon procesa istosmernog istiskanja ustanovljeno je da nakon deformacije raste zatezna čvrstoća za 14% ali se smanjuje kontrakcija preseka (7%) i izduženje (8%). Sa porastom brzine deformisanja zatezna čvrstoća opada dok se izduženje i kontrakcija preseka smanjuje (za oko 4%). Brinelova tvrdoća materijala na izlazu iz matrice za 25% je veća nego tvrdoća pripremka. Ustanovljeno je da koeficijent trenja nema značaja na promenu Brinelove tvrdoće u pojedinim tačkama tela. Specijalnim Sigma testom sa mernom frekvencijom od 120kHz merena je konduktivnost istisnutog materijala. Ta konduktivnost opada sa porastom deformacije. Uticaj trenja na konduktivnost je nesignifikantan, što se vidi iz tabele 1.