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RESEARCH

Influence of Lubricant Type and Concentration on Compressibility and Strength of Pressed Pieces Obtained by Axial Metal Powder Pressing

Certain effects, additions of different types and concentrations of lubricants to metal powder, can be considered through numerous characteristics. The most important ones are: blend filling densities, flowability, compressibility (compression and densification), density distribution over pressed piece cross section, strength and elasticity of a raw pressed piece, friction magnitude (forces of pressure and expulsion) and die wear. In this paper investigations were performed which had as a goal to point to the influence of lubricant type and concentration on metal powder pressing conditions and the pressed piece characteristics in the technology of the sintered metal parts manufacturing.

Keywords: *lubricants, metal powder, pressing, sintered metal*

1. INTRODUCTION

In order to achieve the required density of the pressed piece and reduce friction and wear of the tools' working elements and expulsion of the pressed piece from the die, it is necessary to apply some kind of lubrication. Addition of the liquid lubricants to powders or to die would create great difficulties, since the adequate flowability of the powder would not be maintained and at the same time it would not be possible to guarantee satisfactory filling of the die. This is why exclusively are applied only the separable solid particles of lubricants in the powder form. Such lubricants, as additives, must possess certain complex of characteristics related to various requirements that appear during the pressing process. Some of the requirements are mutually contradictory, what has, a s a consequence, that selection of type and quantity of lubricant is often done empirically or by analogies.

Powder lubricant is added to base metal powder (which can be pure or with alloying components), and then it is mixed in convenient blenders. During the pressing process lubricant is, together with metal powder, exposed to pressing pressure. During sintering, already in the first phase (presintering), the lubricant evaporates at the temperature of 550°C, leaving no traces on the sintered piece.

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Certain quantity of lubricant is added in different (mass) amounts, with respect to quantity of metal powder, and usually that concentration is between 0.5 and 1.0 %.

Studying the phenomenon of lubrication of metal powders is numerous and various, and conclusions that can be drawn from them are different by their significance, either due to incomplete characterization of materials or due to possible interactions between different lubricants and metal powders, namely tools [1, 2, 3, 4, 5]. That is why for characterization of certain type lubricant, type of metal powder and tool, it is always the safest to define experimentally influences and rules.

Certain effects of adding different lubricants to metal powder can be considered through the following characteristics: type of lubricant, apparent blend density, flowability, compressibility (of compression and densification), density distribution over the pressed piece cross-section, strength and elasticity of the pressed piece, magnitude of the friction tribological parameters (by the forces of pressure and expulsion) and wear of die and other working parts of the tool.

According to basic requirements of the powder metallurgy, experiments were conducted that have, as a goal, to point to a significance of influence of the type and concentration of lubricant onto the pressing regime and mechanical properties of the pressed pieces. Experimentally was tested the influence of type and concentration of lubricant on the compressibility and strength of the pressed piece. In this way, actually, the preliminary investigations are done, which determine the powder pressing regimes and create conditions for estimation of the pressed piece mechanical properties and selection of tribo elements of the system tool-pressed piece.

2. EXPERIMENTAL PROCEDURE AND DISCUSSION OF RESULTS

2.1. Basic types of lubricants for lubrication of metal powders

Parallel with development of metallurgy the efforts were made to develop the lubricants as well. Earlier were applied additives like stearic acid, oleic acid, salts of these acids, paraffin, molybdenum sulfide, graphite, polyvinyl spirit, glycerin, camphor, etc. The most applied lubricants today are: zinc stearite, metalub and kenalub, that are applied also in these experiments.

1. Zinc stearite is a mixture of higher fat acids and the most frequently is obtained by precipitation or fission,
2. Metalub represents improved zinc stearite, where the content of zinc is reduced to 9 %,
3. Kenalub is the newest developed lubricant. This is basically amide wax with addition of zinc stearite and maximum content of 2 % zinc as a metal.

Characteristics of these lubricants are given in table 2.1, and their properties are described in detail in [1].

2.2. Preparation and pressing of the powder blend in order to determine compressibility and strength of the raw pressed piece

For conducting these experimental investigations the adequate blends of the Fe powder and lubricant were formed. All the three types of lubricants, given in Table 2.1 were applied and their concentrations were varied (within limits that are applied in industrial conditions), namely, the percentage amounts that were added to total quantity of the Fe powder.

After the measurements of the corresponding quantities of lubricants and the Fe powder, their blending was performed in the double-coned blender (of the volume of 15 l). The blending time was 10 minutes. Powders with lubricant blends were pressed at the laboratory hydraulic press (type *Zim-Armavir* with maximum force of 1250 kN, produced in SU). The pressing die was made of Č 4150 steel (average surface roughness R_a = 0.27 μm), which gives the sample sizes 31.75 x 17.7 mm = 403.2 mm^2.

The pressed pieces were pressed with height of 5 mm, and their density was varied within intervals applied in the manufacturing conditions (6.2, 6.4, 6.6 and 6.8 g/cm^3). The powder blends were formed from all the three types of lubricants with various concentrations of lubricants (0.6, 0.8 and 1.0 %). From each blend and for each density f5 pieces were pressed whose average arithmetic values constituted results shown in diagrams in Figures-1 - 9.

2.3. Results of experimental determination of the powder blend compressibility

Based on measurements results the diagrams were formed (Figures 1, 2 and 3). These diagrams show dependence of the pressed piece density on the pressing pressure for different types and percentage amounts of lubricants.

In all the three diagrams it is obvious that the higher concentration of lubricant, until the certain density, namely the certain pressing pressure, increases the blend compressibility. If that density is exceeded the higher concentration of lubricant worsens the compressibility. That transient phase is at the density

Table 2.1. Review of characteristics of lubricants applied in experiments

No.	Type and name of lubricant	Melting point [°C]	Average particle size [μm]	Apparent density [g/cm^3]
1	Zinc stearite (ZS)	115	5	0.258
2	Metalub (M)	118	30	0.29
3	Kenolub (K)	100-140	30	0.35

level of 6.6 to 6.7 g/cm^3, what can be seen from Figures 1, 2 and 3. These observations comply with the described behavior of increased presence of lubricant in the powder blend [1]. Reasons for this are due to the incompressibility of lubricants.

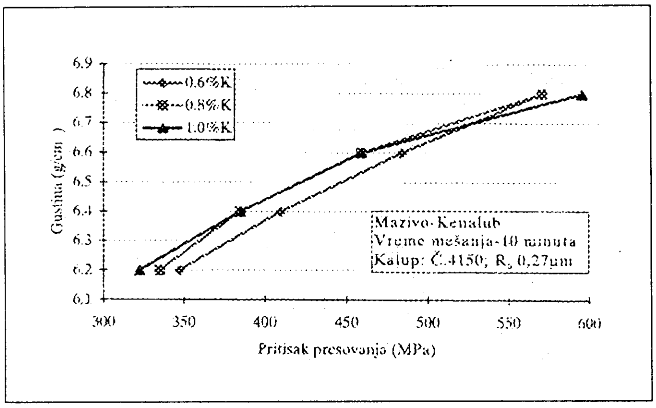

Figure 1.

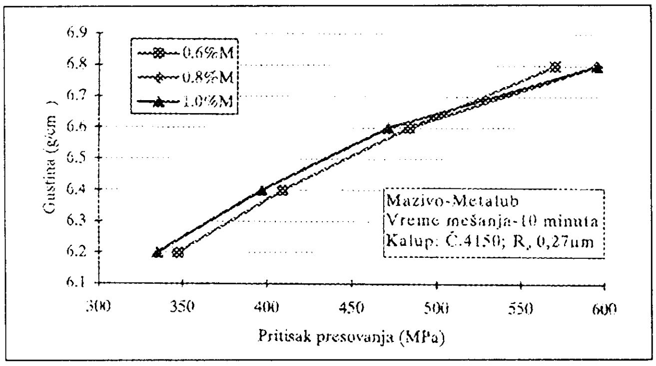

Figure 2.

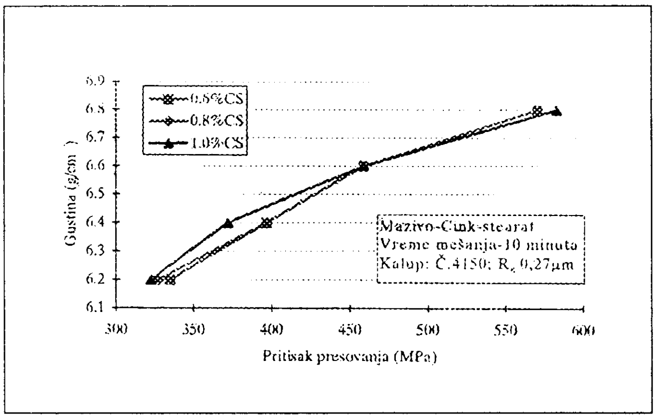

Figure 3.

In Figure 4 is given a diagram in which the compressibilities of powder blends with various lubricants are compared. The highest compressibility is achieved with application of the zinc stearite.

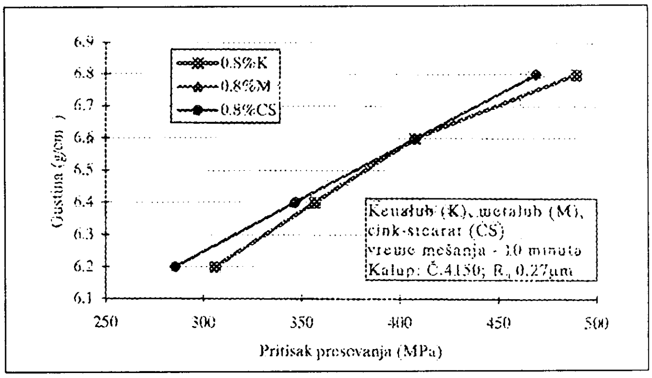

Figure 4.

2.4. Results of experimental determination of the raw pressed piece strength

Investigations of the raw pressed piece strength are the most important mechanical investigation of the pressed piece. This investigation is done according to standards YUS C.A4.058 (1990), namely ISO 3995 (1985).

According to mentioned standards the fracture test of a sample was performed, namely the bending strength test, on a special hydraulic press Walter-Bai (which has two measuring scales, of 1000 N and 5000 N). The average results were calculated as the arithmetic mean of five measurements. Based on these results the diagrams shown in Figures 5, 6 and 7 were formed. In order to compare the influence of different types of lubricants upon the raw pressed piece strength, diagrams shown in Figures 8 and 9 were formed. From these diagrams one can see that the highest strength of the pressed piece give blends of powders with Kenolub based lubricants.

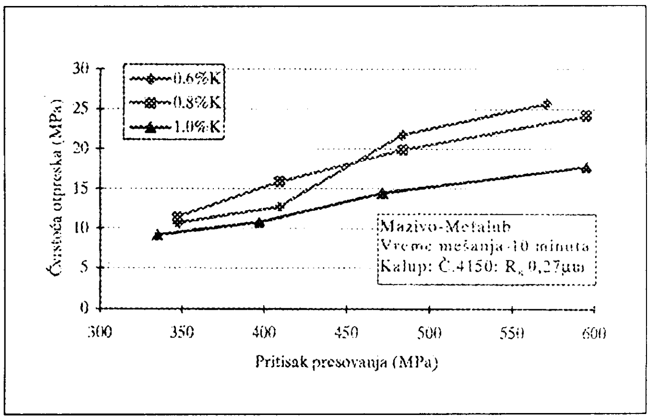

Figure 5.

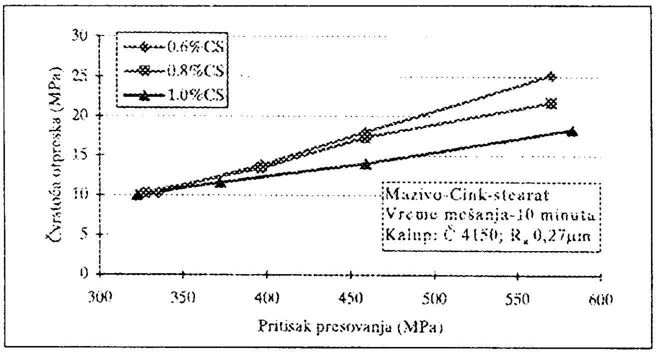

Figure 6.

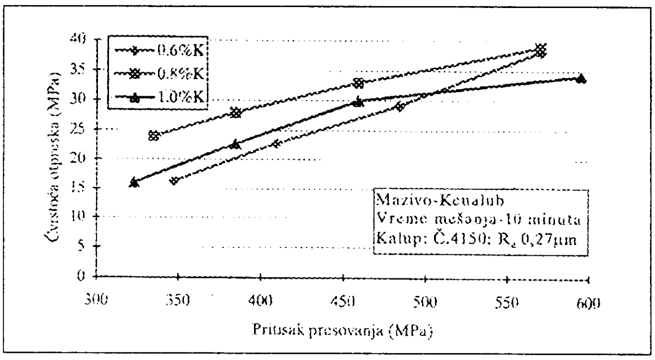

Figure 7.

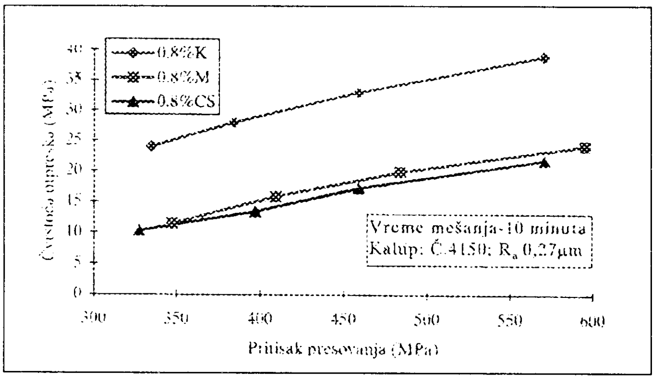

Figure 8.

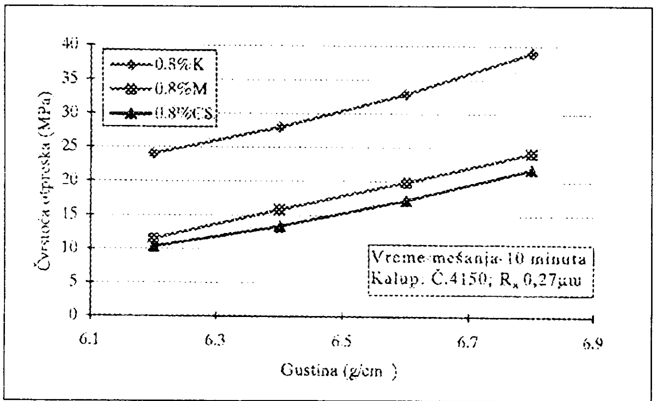

Figure 9.

3. CONCLUSION

Experimental investigations and their results, presented in this paper pointed to the following facts:

- By increasing the lubricants' concentrations to densities up to 6.6 to 6.7 g/cm^3, the compressibility of the powder blend, i.e., the pressed piece also increases. Exceeding the 6.6 to 6.7 g/cm^3 densities, the higher amount of lubricant worsens the compressibility. Reasons for this are in incompressibility of lubricants at higher pressing pressures.
- The raw pressed piece strength reduces with increase of lubricant concentration.
- Different types of lubricants have different influences on the raw pressed piece strength. The highest strength give blends of powders based on Kenolub as a lubricant.
- The future investigations should extend lubricants' concentration intervals and seek for the optimum relations, including all the tested variables.

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