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THE INFLUENCE OF THE TECHNOLOGICAL PARAMETERS ABOUT THE MECHANICAL CHARACTERISTICS OF THE PIECES OBTAINED THROUGH DIE-FORGING IN SEMI-LIQUID STATE

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ABSTRACT:
The paper shows some particularities of the die-forging in semi-liquid state of the metallic materials, points out the advantages of using this process for producing the pieces and accomplished a study looking the influence of the technological parameters of the process about the mechanical characteristics of the pieces (tensile strength, elongation and Brinell hardness).

KEYWORDS:
semi-liquid state, die-forging, technological parameters, mechanical characteristics

1. INTRODUCTION

The aim of the metallurgic and metallic materials processing industry consists in developing and reaching of some new materials, with improved properties and performances, low costs and finding of some new processing methods, mixed or non-conventional, to allowed producing of some parts having high mechanical characteristics at a low price.

A relative new method within the forming technologies that fulfill these aims is the die-forging of the semi-liquid materials, also called *thixo-die-forging.* The expression *thixo* comes from the word *thixotropy*, expression used by H. Freundlich in 1935, in order to define the property of the solutions and suspensions to gel formation when being in latent state and to become fluid when being stirred. The phenomenon is a reversible isothermal transformation, the denomination coming from the Greek word *tixis* – touch, contact and *tropos* – change, modification. So, the thixotropy means the capacity of modifying the body by contact, respectively by external mechanical influences: shocks, vibrations, stirring, shaking, etc [1].

The basic principle of die forging in semi-liquid state is to produce parts within the solidification range of the alloy. Within this range, a part of the material is already liquid, while other parts are totally solid. In order to have a thixotropic behavior, the solid phase has to be made of spherical (globular) particles covered in liquid phase.

Figure 1 presents a model of the semi-liquid die-forging, where the processing stages are pointed out: elaboration of alloy (a); alimentation of the mold with alloy

and the mechanical agitation through vibrations (b); the forming in presence of the vibrations (c); product resulted out of the processing (d).

The processing of the metals and metallic alloys in semi-liquid state offers many advantages as comparing to the conventional processing methods (casting in liquid state and forging, die-forging, stamping in solid state), advantages that come out of the behavior and characteristics of the materials in semi-liquid state. So, due to the heat content, lower than that of the liquid metal, high processing speeds can be applied, the wear of the deformation tools being lower.

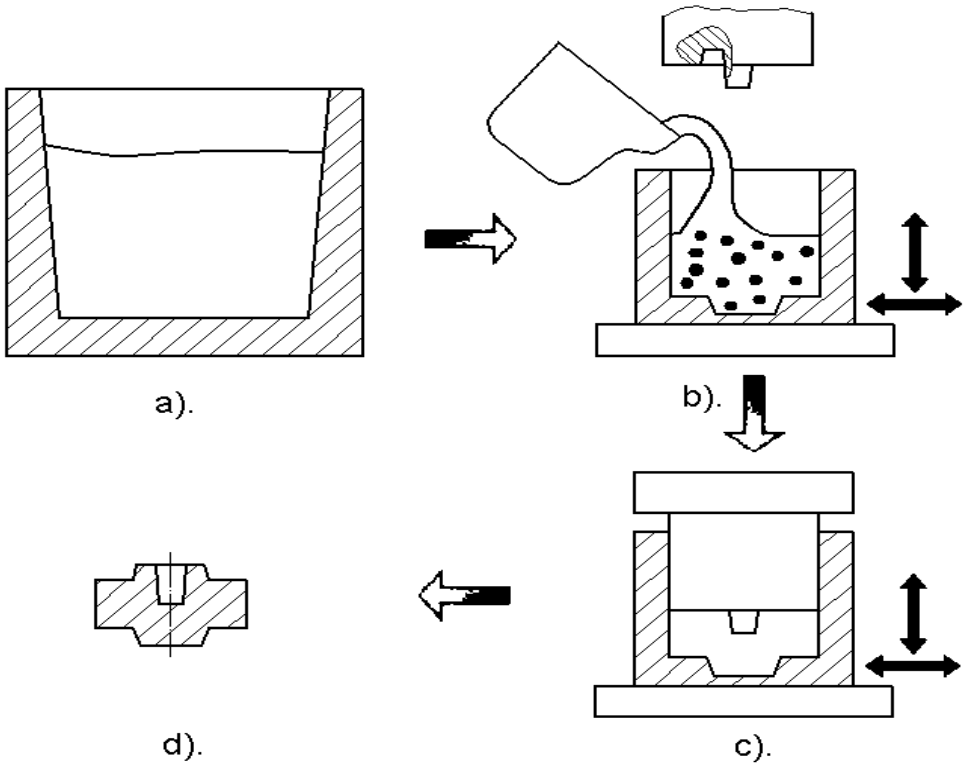


FIGURE 1. The model of the die-forging in semi-liquid state [2]

The presence of the solid during the filling of the die and the controllable viscosity, that is higher than that of the liquid metals, makes possible to reach parts with low blister cavities, with low macro and micro-segregation and with a fine micro-granulation structure. The gas captation is also low, and the parts have an excellent surface quality.

The materials in semi-liquid state have lower flow resistance than the material in solid state, which is why parts having complicated configuration and thin walls can be produced. The energetic consumption is lowered by approximative 35…40% as comparing to the conventional processing methods because of the heating at temperatures within the liquidus range and of the low deformation strains.

2. EXPERIMENTAL EQUIPMENT

Some experiments for determine the influences of the technological parameters upon the mechanical characteristics of the used-up alloys in building machines area, obtained through die-forging in semi-liquid state, are effectuated. The experimental equipment is presented in figure 2 [3].

This is composed by a die and a press die (B), a device for production of mechanical vibrations (C), assembled on the die's basic plate. For the measurement of the temperature in the processed piece (and in the die's walls) are used the equipment D, consisted in one thermocouples T, the module of acquisition AD, the converter CT and the computer PC.

The deformation's pressure is determined using the equipments E, composed by the electronic transducer of pressure TPE, the alimentation source, the converter SCCP and the tachograph IN. These entire modules are assembled on a hydraulic press with a special construction (A).

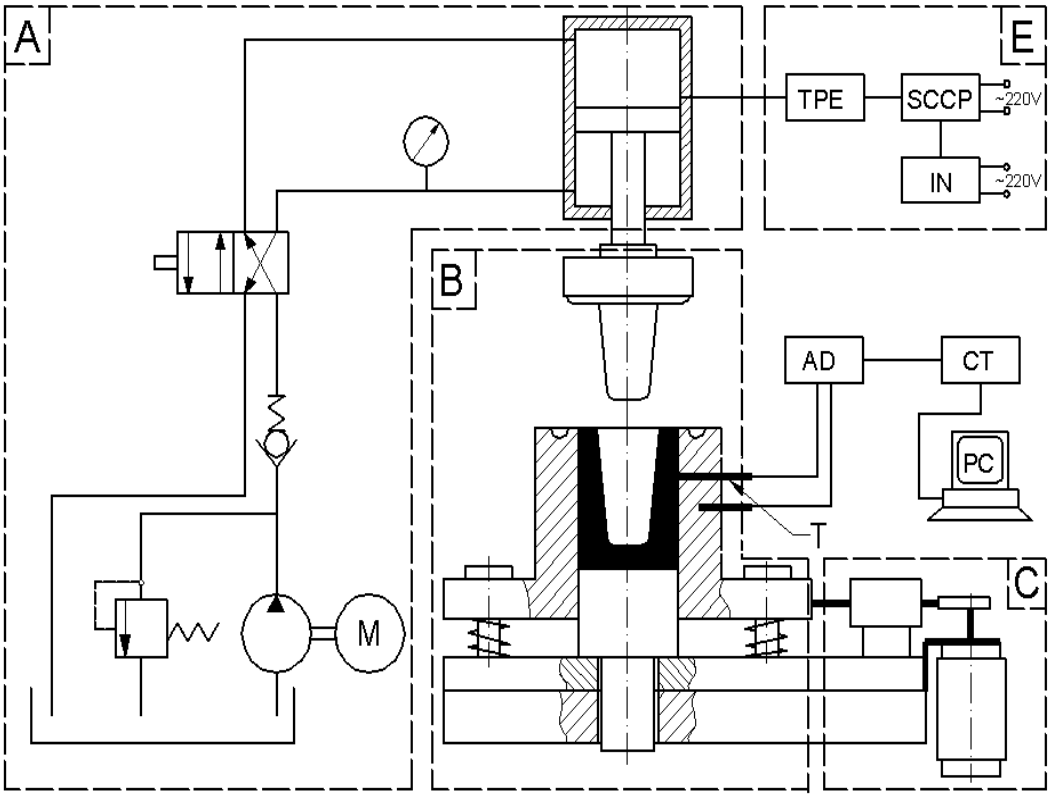


FIGURE 2. The experimental equipment's scheme
for the study of die-forging in semi-liquid state

3. EXPERIMENTAL RESULTS

We effectuated a theoretical analysis regarding the influences of the technological parameters upon the mechanical characteristics of the pieces obtained through die-forging in semi-liquid state. [4] The technological parameters which have a major influence upon these features are: the pressure of deformation (or the force of deformation F_d), the temperature of processing (T_P), the vibrations frequency (f) and the die's preheating temperature (T_{OM}).

For the study of these influences of the main parameters upon the mechanical characteristics, I effectuate some experiments that consist in obtain of a cylindrical full pieces from aluminum alloy (AlSi7Mg0.38), in various processing conditions.

Before of the casting, the alloy temperature is between 630…650^{0}C. The die and the press die are lubricated with a lubricating mixture's layer.

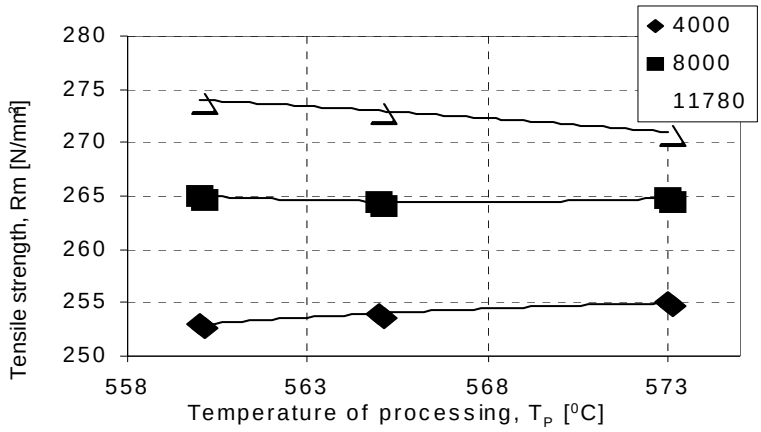
For the resulted pieces, I determine the following mechanical characteristics: the tensile strength R_m [N/mm^2], the elongation A [%] and the Brinell hardness HBS. The results are presented in the diagrams (figure 3).

The influences of the deformation's forces and the processing temperature upon the main mechanical characteristics in the diagrams of the figure 3 are presented.

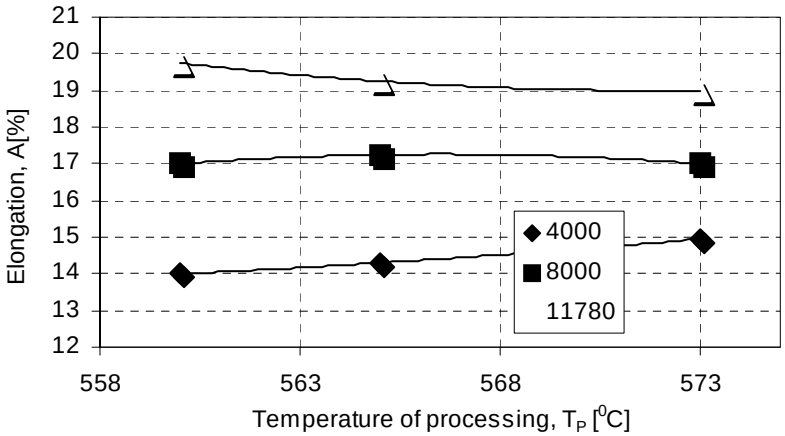
Such as observed in figure 3, a, the tensile strength increase significant with increases of the forces of deformation. The increase of the temperature of processing cause next behavior of tensile strength: in the domain of low forces of deformation (<4000 daN) an easy-increase of the tensile strength, in the domain of

medium forces (8000 daN) influence is negligible, and in the domain of great forces (>11780 daN) an easy decrease of this characteristics.

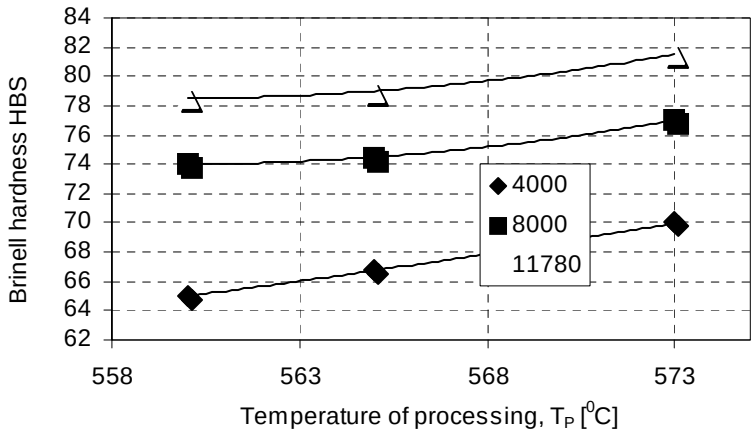
The elongation (fig. 3, b) presents same behavior as the tensile strength, and the hardness (fig. 3, c) increase with increasing temperature of processing and force of deformation.



a).



b).



c).

FIGURE 3. The processing temperature's influence upon the mechanical characteristics (in the conditions: f=500 s^{-1})

In figure 4 are presented the mechanical characteristics of pieces obtained to different preheating temperature of the die, in the next conditions of processing: Fd=

4000 daN, T_P=565 ^{0}C, f=500 s^{-1}. The influence of the die's preheating temperature upon the mechanical characteristics is insignificant.

Thus, in condition of the duplicated values of the deformation's forces, depending on the processing temperature and the vibration's frequency, the tensile strength scale up by 3.5…5 %, the hardness HBS scale up by 4…10%, and elongation with 15…20%.

Also, at the duplicated values of the vibration's frequency, the tensile strength scale up by 1…2%, the hardness HBS scale up by 2.1…3% and elongation with 8…10%.

Based on these results I can conclude that the technological parameters have an influence upon the mechanical characteristics of the pieces in the follow ascending order: the deformation's force, the vibration's frequency, the processing temperature and the preheating temperature of the die.

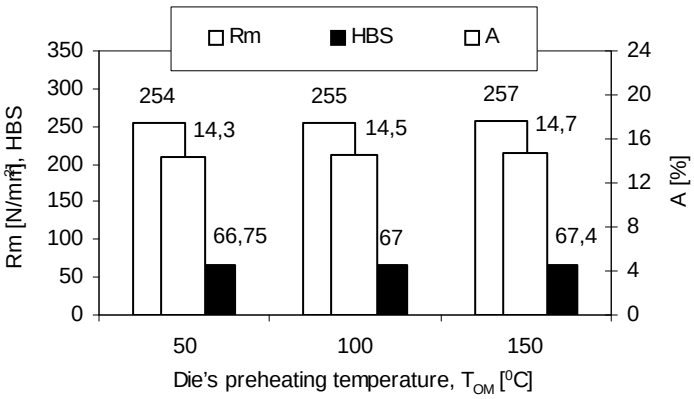


FIGURE 4. The influence of the die's preheating temperature upon the mechanical characteristics (Fd=4000daN, T_P=565^{0}C, f=500s^{-1})

In the comparing with casting in the metallic die, the pieces have, in the all the situations, better mechanical characteristics (figure 5).

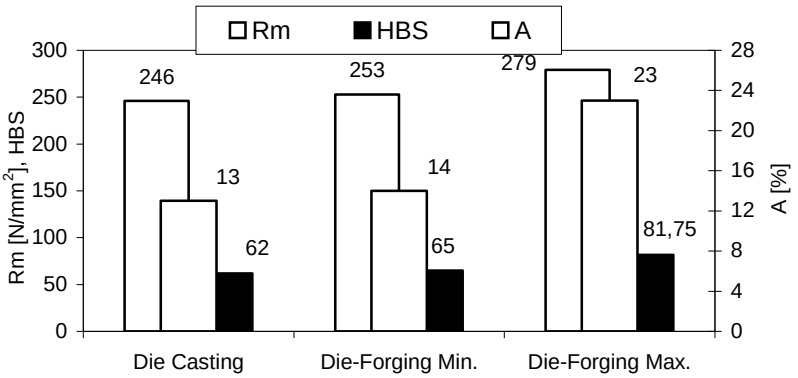
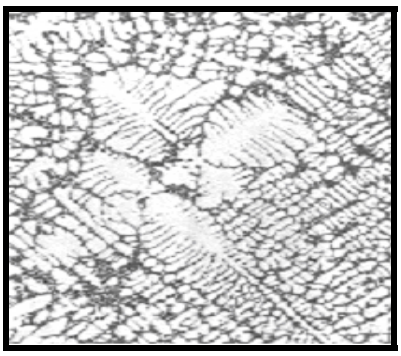
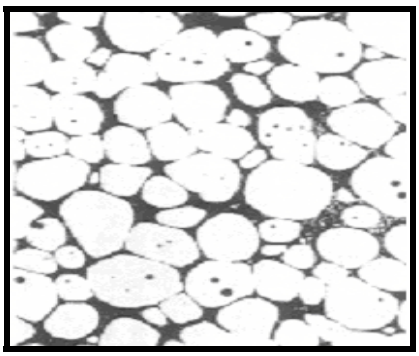


FIGURE 5. The improvement of the mechanical characteristics of pieces obtained through die-forging in semi-liquid state, comparison with the pieces obtained through casting in the metallic die:
DIE-FORGING min. - PROCESSING IN THE CONDITIONS: T_P=560^{0}C, F_D=4000daN, F=500s^{-1}
DIE-FORGING max. - PROCESSING IN THE CONDITIONS: T_P=560^{0}C, F_D=11780daN, F=2500s^{-1}

The improvement of the mechanical characteristics of pieces obtained through die-forging in semi-liquid state is explained with the microstructures presented in figure 6. Thus, I observe as through die-forging in semi-liquid state obtained the microstructures with a spheroid solid solution a covered in eutectic, dense and compact (figure 6, b), that determine the better mechanical characteristics, in compare with the dendrite microstructure obtained through casting in the metallic die (figure 6, a).



a).



b).

FIGURE 6. Microstructures of the AlSi7Mg0.38 alloy:
a - through casting in metallic die; b - through die-forging in the semi-liquid state

4. CONCLUSIONS

The experimental researches concerning the mechanical characteristics of pieces obtained through die-forging in the semi-liquid state permit to drawn the following conclusion: the mechanical characteristics of pieces increase sensitive with increase the force of deformation and frequency of the vibrations. This thing is explained through obtaining the structures extremely fine and improvement the toughness of wall of the piece, therefore increase density and the defects absence of structure, that form discontinuities in metallic mass or primers for propagate the fissures.

The pieces, obtained from aluminium alloy AlSi7Mg0.38 through die-forging in the semi-liquid state, presented, comparing with similar pieces obtained through casting in the metallic die, a tensile strength with 2.8…13.4% elder, a Brinell hardness with 4.8…30% elder and an elongation with 7.6…50% elder.

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