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PLASTICITY AND WORKABILITY OF ALUMINIUM ALLOY AT RECOVERY TEMPERATURES

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Abstract: *Importance and extent of aluminium alloys application to drop forgings production is permanently increasing especially in automotive industry. Alloy AlCu4MgI has a particularly significant position because of its low density compared to structural steel. This contribution provides information about mechanical properties of plasticity and workability of aluminium alloy AlCuMg1 at recovery temperatures. Database of measured values is important for future development of warm forming. Warm forging of drop forgings represents a lucrative method of precise forgings production, mainly from the energy savings point of view.*
Key words: *plasticity, workability, warm forming, strain hardening index, numeric simulation*

1. INTRODUCTION

Temperature is an important argument for testing of metals in agreed conditions. Plastic deformation is realized during cold forming of metals by slip and material is strain hardened. Warm forming passes with partial strain hardening of metal above recovery temperature and below temperature of recrystallization (Forejt & Piska, 2006). Recovery removes microscopic and macroscopic stresses while physical and partly plastic properties of metal improve. Values of tensile strength and yield point decrease and formability increases. In this interval of temperatures activated movement of dislocations occurs and their density lowers due to annihilation. Plastic properties of metals are not considered as linear function of temperature, therefore it is necessary to accurately determine an appropriate interval of forming temperatures at warm forming (Pernis, 2007).

2. EXPERIMENTS

The subject of workability research at increased temperatures is aluminium alloy A2024 - STN 424203.61 (natural ageing), chemical specification AlCu4Mg1. This alloy, which belongs to the group “2000” of aluminium alloys, has a main alloying element Copper. Chemical composition of used alloy is in the table 1.

Chemical composition (wt.%)								
Cu	Mg	Mn	Fe	Si	Zn	Ti	Ni	Al
min 3,8 max 4,8	1,2 1,8	0,4 1,1	max 0,5	max 0,5	max 0,2	max 0,2	max 0,1	bal.

Tab. 1. Chemical composition of STN 424203alloy

Alloy AlCu4Mg1 (duralumin) is an age-hardenable alloy determined primarily for hot forming at temperature interval 340-450 °C. This alloy is characterizing by high tensile strength, which comes up to 470 MPa after hardening and it is possible to be increased by forming. Corrosion resistant of this alloy is relatively low. Alloy is widely applicable in automotive and aviation industry in production of various structural elements. Suitability of examined alloy for warm bulk forming was considered by tensile test at higher temperatures. Cylindrical bar tensile test specimens were used. The gage length was 60mm, diameter 8mm. The specimens were tested at room temperature and at temperatures 150, 200, 220, 240, 250 and 260 °C. Higher temperatures represent a temperature interval of warm forming of aluminium alloy.

3. RESULTS

Strength limit Rm, characteristics of plasticity for warm workability (reduction of area Z and index of plasticity according to Kolmogorov λ_R), strain hardness curves and exponent of strain hardness were calculated from measured results at each tested temperatures. Temperature course of tensile strength is in fig. 1, temperature course of percentage reduction of area is in fig.2, temperature course of index of plasticity is in fig.3

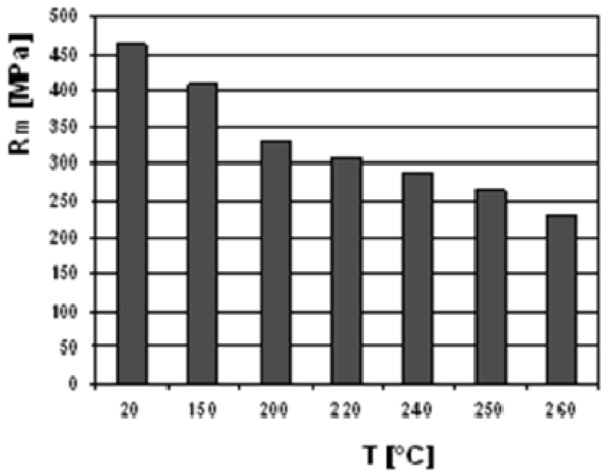

Fig. 1. Temperature course of tensile strength

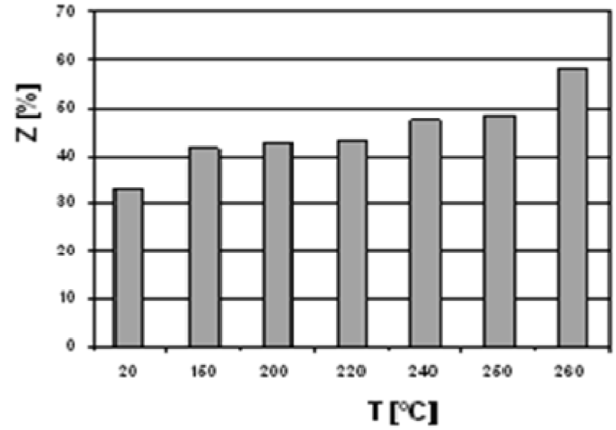

Fig. 2. Temperature course of reduction of area

Based on the results it is obvious that value of percentage reduction of area at temperature 250 °C was 1,5 times higher then the value at room temperature. This fact suggests grow of material plastic properties in warm conditions. Index of plasticity according to Kolmogorov has similar course as reduction of area and it proves increase of plasticity in dependence on temperature as well.

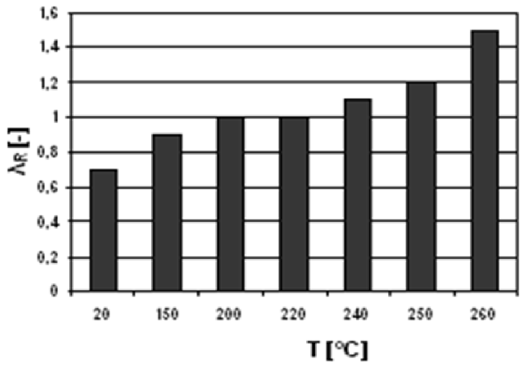

Fig.3. Temperature course of index of plasticity

The strain hardness curves depict course of true stress in dependence on strain, up to the tensile strength point where plastic deformation stability is lost. Strain hardness curves of alloy AlCu4Mg1 are in figure 4. It is evident that material was less resistant with increasing temperature and the area of equilibrium plastic deformation decreased. Great differences between hardness curves at 250°C and 260°C proves that 250°C is limited recrystallization temperature of the alloy, range of plastic deformation rapidly decreased. Table 2 provides calculated values of strain hardening index at examined temperatures. Over 250°C its value rapidly decreased.

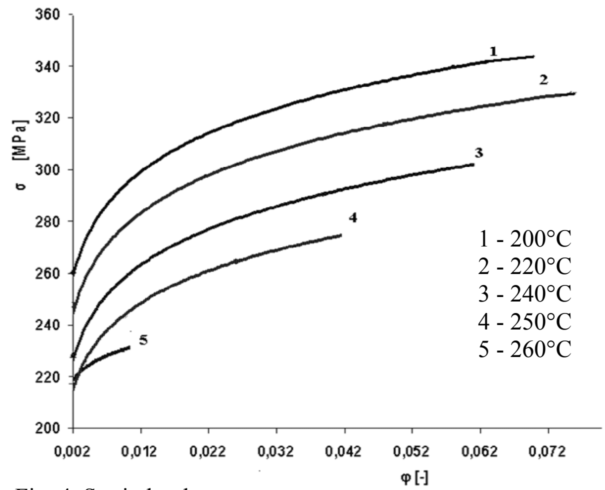

Fig. 4. Strain hardness curves

Temperature [°C]	200	220	240	250	260
Strain hardening index	0,071	0,078	0,062	0,042	0,011

Tab. 2. Values of strain hardening index

3. NUMERIC SIMULATION

Research of workability of alloy AlCu4Mg1 in warm conditions is important for users of simulation software in term of spreading of material databases. Simulation software is necessary for simulation of material flow in forming tool. This software enables arrangement of tools still in preparation stage and thus saves production costs (Spisak, 2000). On the basis of experimental results an optimal warm forging temperature was recommended for the alloy AlCu4Mg1. An example of numeric simulation of plastic flow at temperature 250 °C was applied to forging of drop forging in closed die (Cermak, 2000). Defined input conditions for simulation of forging process of drop forging with ring shape in simulation Programme MSC SuperForge was used. Optimized input data: Crank press LZK 1000 - friction 0.1, die temperature 150˚ C; semiproduct – cylinder Ø40x24 mm, aluminium alloy A2024, workpiece temperature 250°C. Results of forging process simulation are in fig. 5.

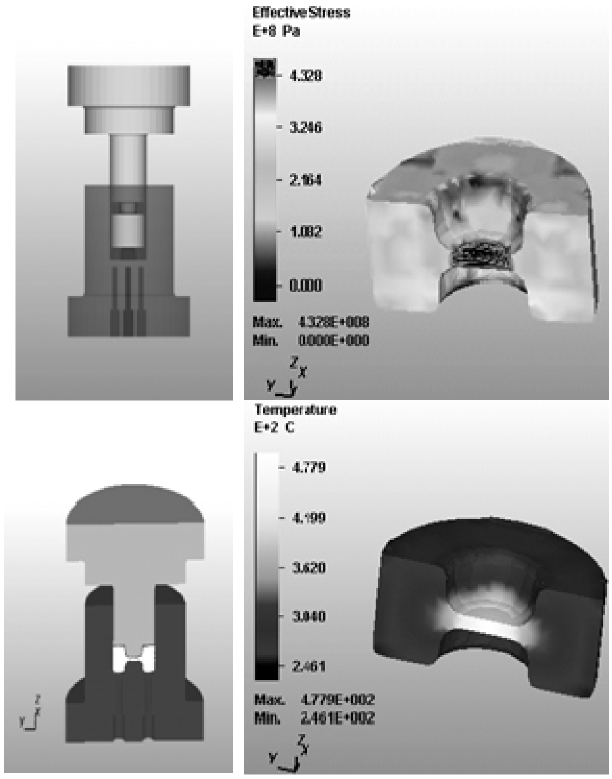

Fig. 5. Results of forging process simulation

4. CONCLUSION

On the basis of mentioned results it is possible to apply the technology of warm forging to small and medium drop forgings with simple and not rugged shapes. Before forging of semiproduct at 250°C it is necessary to heat dies at temperature 150 °C because small drop forgings get cold quickly. Thus this process prevents significant decrease of temperature while heated semi-product is in contact with tool and required higher plastic properties of material are provided It lead to greater lifetime of dies too (Hires at al., 2009).

5. REFERENCES

Cermak, J. (2000). FORM 2000, *Near net-shape closed-die forging,* pp. 43-46, ISBN 80-214-1661-0, Brno, September 19. – 20. 2000, TU Brno, Brno

Forejt, M. & Piska, M. (2006). *Theory of machining, forming and tools,* CERM, ISBN 80-214-2374-9, Brno

Hires, O; Pernis, R. & Kasala, J. (2009). How to solve lifetime of forging dies. *Forging.* No.35, 2009, pp. 7-10, ISSN 1213-9829

Pernis, R. (2007). *Theory of metal forming,* TnUAD, ISBN 978-80-8075-244-6, Trencin

Spisak, E. (2000). *Mathematic modelling and simulation of technological processes*, Typo Press, ISBN 80-7099-530-0, Kosice