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AlCuAg ALLOY HOT PLASTIC CONSOLIDATED FROM POWDERS - STRUCTURE AND MECHANICAL PROPERTIES

ABSTRACT

The results of microstructural examinations of an AlCuAg alloy fabricated from powder by atomisation were presented. The structure of material hot consolidated by extrusion was evaluated and its mechanical properties and plastic deformability was examined in tensile and compression tests at ambient temperature and at high temperatures.

KEYWORDS: *Al alloys, powder metallurgy, hot plastic consolidation, mechanical properties.*

1. INTRODUCTION

The branch of technology which takes care of manufacture of the ready-for-use elements by means of sintering is called powder metallurgy. At present, by means of this technology are manufactured various parts of machines and mechanisms, including bearing metals and friction elements, also electric contacts, hard-melting metals, cutting plates, and metal matrix ceramic composites.

The process of sintering is basically composed of the three main technological operations, i.e. fabrication of the base component - powder, moulding of metal powder into a prefabricated product by pressing in a die, and sintering which consists in preheating of the moulded prefabricated product in protective atmosphere at a temperature below the melting point of the main component of which this product has been made (occasionally partial melting is admitted as well). The need for wider use of the technology of powder metallurgy results from the following advantages offered by this technology [1]:

a) possibility of moulding near-net-shape elements without further expensive machining (e.g. gears, cams, etc.);
b) low manufacturing cost, providing this is mass production (it is necessary to allow for pay back of the die-making cost),
c) possibility to manufacture materials of the structure and composition never attainable by other methods (e.g. tungsten-silver for contacts, tungsten carbide-cobalt for cutting plates, metal matrix- ceramic reinforced composite materials),
d) possibility of automatisation of the manufacturing process and low consumption of materials and energy.

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Powders of metals, alloys and intermetallic phases are obtained by the following methods: chemical, electrochemical, liquid spraying (e.g. atomisation) and mechanical disintegration[2].

The method of hot plastic consolidation, which is an object of these studies and has been used now for some time worldwide, consists in consolidation of materials manufactured by the process of rapid solidification (e.g. atomisation) in the hot extrusion process. In the hot extrusion process, the temperature, pressure and deformation of material result in consolidation of powders and ribbons to form a material of the density approaching theoretical values. Hot plastic consolidation is used in fabrication of materials which, if produced by traditional process, are not capable of satisfying the imposed requirements, or which cannot be produced by any other means.

2. MATERIAL AND METHODS OF INVESTIGATION

For the process of hot plastic consolidation was selected and processed an aluminium alloy - AlCuAg, its chemical compositions are given in Table 1 below.
This alloy was fabrication in atomisation due to which a powder of 50-150 μm granulation was obtained. The process of atomisation consists in sputtering of liquid metal with an inert gas, followed by screening of the powder to separate the individual grain fractions.

Table 1. Chemical composition of AlCuAg alloy.

Alloy	Fe	Si	Cu	Zn	Ti	Mn	Mg	Ni	Cr	Ag	Zr
AlCuAg	**0,08**	**0,03**	**4,93**	**0,15**	**---**	**---**	**0,56**	**---**	**---**	**0,49**	**0,45**

Investigations of the direct extrusion process were conducted in laboratory on a specially designed and manufactured attachment to a press of maximum 60 T capacity.
The structure of the extruded bars was examined. Further detailed investigations of these materials mainly covered their mechanical properties. To check the homogeneity of the bars, their hardness was measured by Brinell method at the beginning and end. Mechanical properties were determined in the tensile and compression tests carried out on a computer-controlled INSTRON testing machine. The tensile and compression tests were carried out at a room temperature and at range 350-450^{0}C with the initial strain rate of $10^{-3}s^{-1}$.

3. RESULTS AND DISCUSSION

Before the process of plastic consolidation was started, the base product in the form of powder was examined for its structure and chemical composition. Below, photographs of the microstructure (Fig. 1)and chemical composition (Fig. 2) of AlCuAg powder .

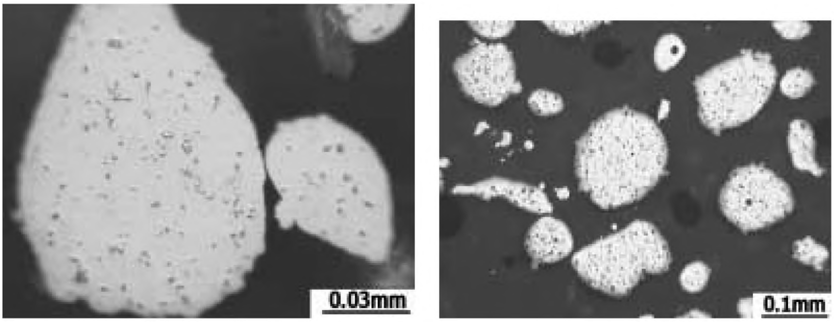

Fig. 1. Microstructure of powdered AlCuAg alloy.

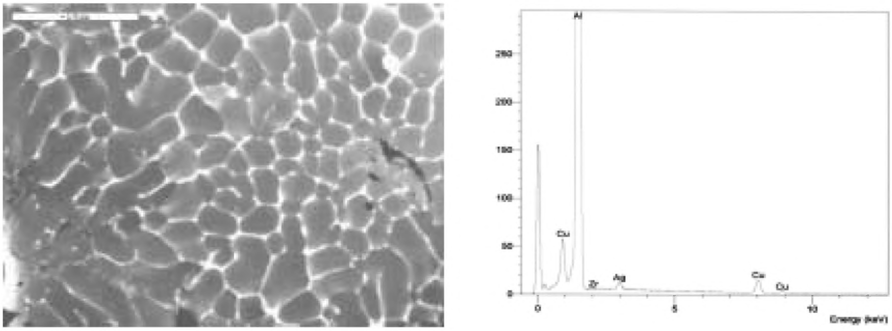

Fig. 2. Microstructure and chemical composition analyze of powdered AlCuAg alloy.

On the extruded bars the examinations of structure were made and specimens for mechanical tests were prepared. Figures 4-6 show microstructures and results of chemical composition analyses from X-ray microanalyser of the extruded bars.

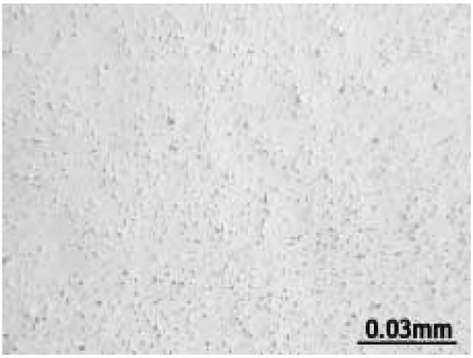

Fig. 4. Microstructure of ϕ8mm bar extruded from powder AlCuAg alloy.

Fig. 5. Microstructure of ϕ8mm bar extruded from powder AlCuAg alloy from X-ray *microanalyser. Secondary electrons, mag. 2000x*

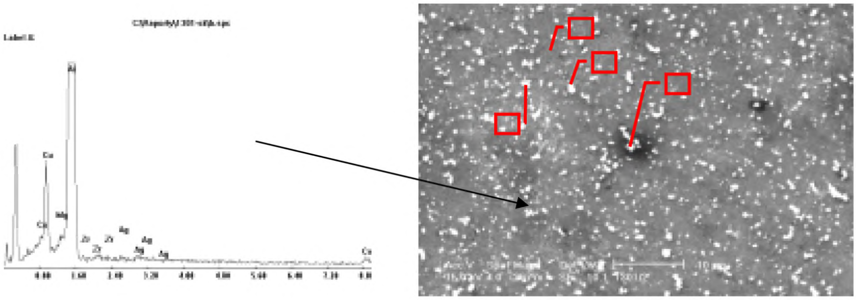

Fig. 6. Microstructure and chemical composition of bar extruded from powder AlCuAg alloy from X-ray *microanalyser.*

The above shown microstructures prove the correct run of the consolidation process and good compaction of the material - no discontinuities, like cracks or large pores have been observed. The results of hardness measurements and of testing the mechanical properties (tensile test) are given in Table 2. Tests were carried out at room temperature (20^0C) with the strain rate of $10^{-3}s^{-1}$.

Table 2. Mechanical properties and hardness HB of specimens made from AlCuAg alloy.

ALLOY	TEMPER	HB	MECHANICAL PROPERTIES		
			$R_{p0,2}$ [MPa]	R_m [MPa]	A_5[%]
AlCuAg	F	100	269	379	15
	T6	157	474	532	6,3

The mechanical characteristics of the specimens (temper F – extruded) undergoing deformation in a σ–ε system (tensile and compression test) are shown Figure 7-9.

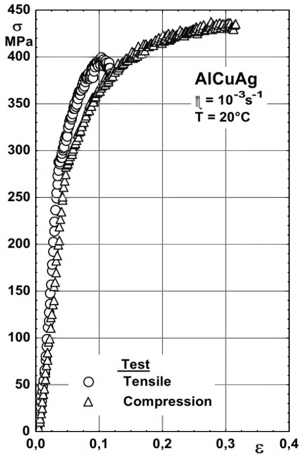

Fig. 7. Mechanical characteristics of deformation in a σ–ε system (tensile and compression test) in room temperature, strain rate $10^{-3}s^{-1}$.

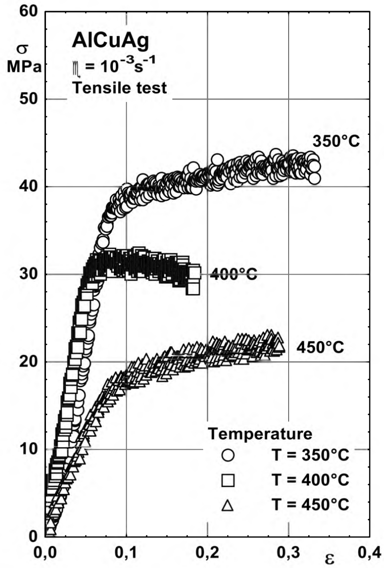

Fig. 8. Mechanical characteristics of deformation in a σ–ε system (tensile test) in temperature range 350-450°C, strain rate $10^{-3}s^{-1}$.

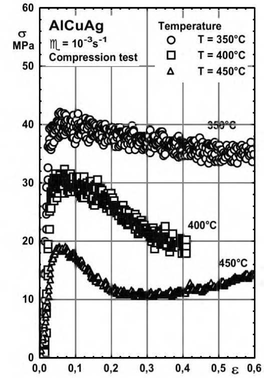

Fig. 9. Mechanical characteristics of deformation in a σ–ε system (Compression test) in temperature range 350-450°C, strain rate $10^{-3}s^{-1}$.

The specimens deformed at room temperature (20°C) were characterized by high strength during both tensile and compressions tests however in the compressions tests this material obtained the high plastic deformability (over 0,3 of true strain). In higher temperatures in the range 350-450°C yield stress it is significantly lower for this material and this alloy also obtained the high plastic deformability, which is very important for further moulding of material during the process of plastic working, e.g. die forging.

4. CONCLUSIONS

- The use of powders of 50-150 μm granulation made by Rapid Soldification and subjected to hot consolidation enabled making extruded bars of ultra-fine grain microstructure.
- The results of hardness measurements and of testing the mechanical properties prove that the material consolidated from powders is of definitely superior quality.
- The mechanical properties of the extruded bars indicate that it is possible to raise these properties above a standard level during the process of final shaping of the ready products and heat treatment.
- Introducing of Zr in an amount of ~0,45% to the solid solution creates possibilities for the process of plastic working of these materials to be conducted at high temperatures but with the stable structure maintained.

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