HARDENED ALUMINUM WITH DISCONTINUOUS COPPER THREADS

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ABSTRACT

The paper presents the influence of the quantity of discontinuous reinforced threads on the mechanical characteristics of some samples obtained through deformation from composite material with metallic matrix.

As a raw material for obtaining the matrix it was used aluminum powder and as a reinforcing phase, short and long copper threads with different volumetric percentages. The products have been plastically deformed at a final diameter of 3mm.

The presence of the copper threads dispersed in the aluminum matrix in quantities of up to 16% copper (volumetric percentages), determines the hardening of the composite material. Above this limit the increase in the quantity of copper is no longer justified as it begins fragilizing the aluminum matrix.

KEYWORDS: aluminum, matrix, reinforcement, copper, threads.

1. Introduction

The aluminum powder used for experimentations was obtained in laboratory on a spraying installation with air-jet. After granulometric rating it was chosen for pressing the powder with grain size (0.1 – 0.2) mm having an apparent density of 1.14 g/cm^3. After mixing and homogenization of the two components, six series of composite materials were made through compressing, armed with different volumetric contents of copper threads (table 1).

The reinforcing component was made of copper threads with the diameter of ϕ = 0.4 mm and length of l_1 = 7 mm.

Table 1

Composite material	**Series I**	**Series II**	**Series III**	**Series IV**	**Series V**	**Series VI**
Copper [%]	10	12	14	16	18	20

The influence of the discontinuous thread quantity of copper used for reinforcing the aluminum powder on the mechanical characteristics (mechanical resistance, elongation) of the composite material obtained through extrusion is shown in graphics.

As blank test it was used extruded aluminum (without addition of copper threads) from the same range of powder and under the same deformation conditions. The mechanical characteristics calculated for tensile breaking test had for the blank tests values of 7 daN/mm^2 for mechanical resistance and of 31 % for elongation.

2. Experimental conditions

The container used for obtaining the comprimats, had a diameter of ϕ = 20 mm and the height of 92 mm and it was executed in strapped structure of steel Cr 120 as well as the bottom die and the punches for compression. The average specific pressure necessary for compressing the tests was of p_m = 90 daN/mm^2.

Tests were obtained with dimensions of ϕ 20 x 30 mm. Out of these comprimats, samples of composite materials were obtained, through direct extrusion and then through drawing.

Extrusion was made at hot conditions, with a diameter reduction from ϕ 20 mm to ϕ 4 mm. The tests were heated at 400^{0}C. At extrusion the average specific pressure was of p_m = 95 daN/mm^2. After extrusion samples were obtained with the diameter of 4 mm and a length of approximately 600 mm.

After the extrusion operation, to cold-hardened tests a annealing thermal treatment of recrystallization was applied, in order to give them back the plasticity necessary for an afterwards deformation.

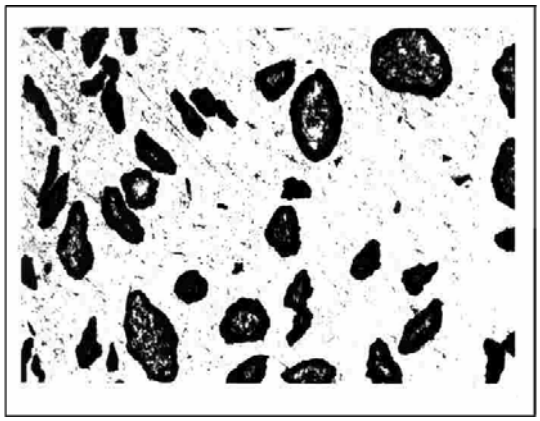

Fig. 1. *Distribution of copper threads dispersed in aluminum matrix; transversal section (200:1).*

The diameter reduction, from ϕ 4 mm to ϕ 3 mm, was realized by consecutive passes, using four auger dies in the following steps: ϕ 4 mm ↦ ϕ 3.9 mm ↦ϕ 3.5 mm ↦ ϕ 3.3 mm ↦ ϕ 3 mm. The last operation was the thermal treatment of recrystallization applied at 400^{0}C, with a period of 30 minutes.

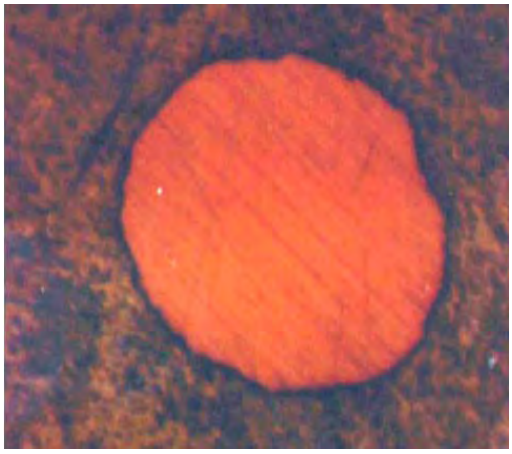

Fig.2. *The aspect of including a copper thread in the aluminum matrix in transversal section (1000 :1).*

Eventually, tests with ϕ=3 mm were obtained from Al-Cu composite material, having different volumetric percentages of copper: 10%, 12%, 14%, 16%, 18%, 20%.

The copper threads dispersed in the aluminum matrix and deformed along with this have different aspects (circular, oval) depending on the way they had been divided when making the assays (fig.1).

3. Experimental results

On samples, in annealed condition with length l = 160 mm made from the series of composite materials presented in table 1, it was determined at the tensile breaking test the resistance R_m [daN/mm^2] and the elongation A [%].

In figure 2 it is presented the graphic on the influence of the copper quantity on the mechanical resistance at the tensile breaking test for the series of composite materials presented in table 1.

In figure 3 it is presented the variation graphic of the mechanical resistance at the tensile breaking test for the series of composite materials presented in table 1 depending on the volumetric content of copper, when reinforcing with discontinuous copper threads. One can notice that the hardening effect through thread dispersions manifest itself up to a volumetric content of 16% copper.

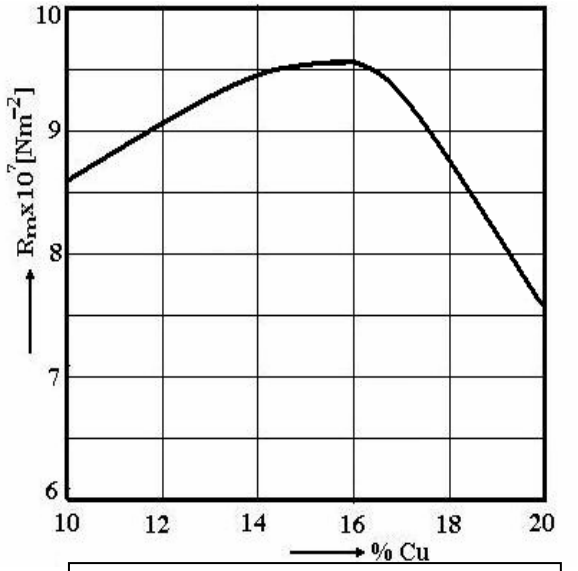

Fig. 3. *The influence of the quantity of copper threads on the mechanical resistance of the composite material.*

An enhanced quantity of reinforced phase in the aluminum matrix has no longer the desired effect, and therefore at over 16% copper, the values of mechanical resistance decrease, which suggests that the hardening effect is obtained up to around this quantity (16%), after which it begins appearing a fragilizing effect of the composite matrix. Apart from

the resistance, the plasticity characteristics (elongation) decrease continuously as the quantity of copper increases, the decrease being slower up to 16%, after which the fragilizing effect becomes more emphasized (fig. 4).

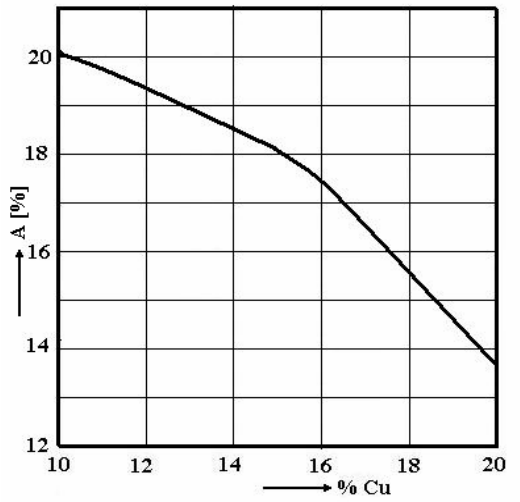

Fig.4. *The influence of the quantity of copper threads on the elongation of the extruded samples of composite material.*

4. Conclusions

The experiments realized confirmed the hardening role of the reinforcing phase up to a percentage of ~ 16% copper.

Over the quantity of ~ 16% copper used as reinforcing phase threaded-shape, one can notice that it begins appearing fragilizing of the metallic matrix.

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