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STRUCTURAL AND MECHANICAL CHARACTERISTICS OF COMPOSITES WITH BASE MATRIX OF RAR27 ALLOY REINFORCED WITH Al_2O_3 and SiC PARTICLES

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Abstract
Composites with matrix made of RAR27 alloy with addition of the reinforcing Al_2O_3 particles, size 12 and 250 m and SiC particles of size 15 m, are obtained by the compocasting procedure. The investigations were conducted of the microstructure and pressure tests within the temperature interval from 20°C to 170°C.
The results of structural investigations point to higher tendency for creating the clasters in composites infiltrated by smaller particles relative to larger ones. Results of compression tests have shown that the better resistance to outside loads at elevated temperatures possesses composite materials than the matrix alloy.

KEY WORDS: *compocasting, non-dendritic structure,clusters*

1. INTRODUCTION

Advantages of composite materials with respect to matrices (alloys based on which they are made of) are visible in improvement of mechanical properties, primarily in increase of the specific elasticity modulus (ratio of the elasticity modulus and material density) and higher strength, increased resistance to loads at elevated temperatures, and in general increase of the wear resistance [1-5].

Production and characterization of composites made of zinc alloys started in the eighties of the last century in Round Oaks Laboratories and Aston University in England. As matrix the zinc alloy ZnAl30Cu2 was used, and as reinforcements the short fibers made of Al_2O_3 [2]. The better general properties of composites with the zinc alloy matrix (ZnAl27Cu2 and ZnAl12Cu1), alloys with addition of particles SiC and fibers Al_2O_3, were obtained by the group of researchers from MIT. The composites were obtained by the compocasting procedure (infiltration of particles in the semi-solidified condition with subsequent pressing and rolling of samples) [3]. The contribution to development of the composite materials with the zinc alloys matrix was also provided by the research group from Israel (Israel Institute of metals, Haifa), who determined the significant improvement in the composites' wear resistance of the zinc alloys with 27 mass % of aluminum; and further contribution was by the researchers from Singapore (Department of Mechanical Engineering, Singapore), who introduced new reinforcements into the matrix made of the same alloy (glass, Zr_2O_3 and graphite) [4, 5].

The objective of this work is to obtain the composites with matrix of the RAR27 alloy, perform the basic structural and mechanical investigations, as a basis for investigation of the tribological characteristics.

2. EXPERIMENTAL PROCEDURE

The composite materials with the RAR27 alloy matrix were obtained by the compocasting procedure, which was performed by mixing on the isothermal regime (460°C). The reinforcement infiltration time, as well as the total mixing time, was the same for all the composites, 5 and 45 minutes, respectively. The samples were obtained (rods) of the 36 mm diameter, which were subsequently hot pressed to decrease porosity. From the pressed pieces are then produced samples for metallographic and compression tests. As reinforcements were used powders of Al_2O_3 with particles sizes 12 and 250 mm and SiC powder, 15 μm. The smaller particles (Al_2O_3 and SiC) were infiltrated in the amount of 3 mass %, and larger particles Al_2O_3 (250 μm) were infiltrated in the amounts of 3, 8 and 16 mass %.

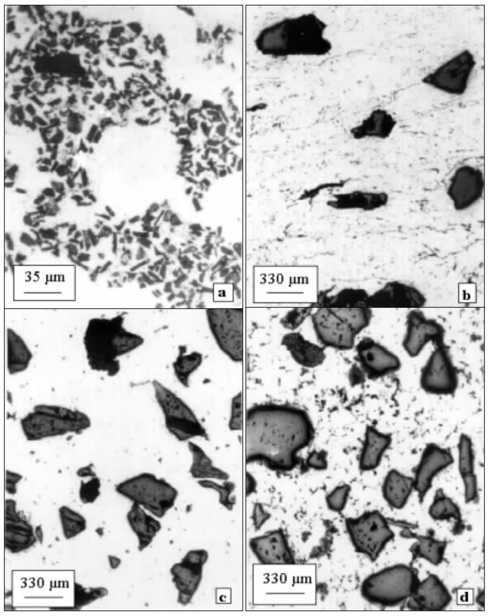

Figure 1: *Composites RAR27 + Al_2O_3, (OM) a) 3 mass %, 12μm, b) 3 mass %, 250μm, c) 8 mass %, 250μm,d) 16 mass %, 250μm*

3. RESULTS AND DISCUSSION

In Figure 1 (OM) is presented the appearance of the polished samples as a basis for estimate of the reinforcement distribution in the metal substrate. It can be seen that the smaller reinforcement particles are prone to forming the clasters, while the distribution of the larger particles is favorable.

In Figure 2, at various magnifications are presented structures of the etched samples of composites RAR27 + 3 mass % Al_2O_3, particles size 12μm. It can be noticed that a transformation of the dendritic structure has occurred, which is characteristic for the conventionally casted pieces made of this alloy, to a non-dendritic one. At small magnification (Figure 2.a) the reinforcement particles are distributed in the form of clasters over the sample surface.

At larger magnification (Figure 2.b) can be seen that the larger portion of the substrate (the part between the clasters) is not filled with particles, what is unfavorable. When the clasters' zone is magnified, it can be seen that they are irregular and not concentrated into the circular forms. The detail, one of such clasters, is shown in Figure 2.d. There are plenty of examples of breaks of the boundary surface matrix-particles (particles touching particles). Those are the spots where the cracks appear, when the material is exposed to outside load.

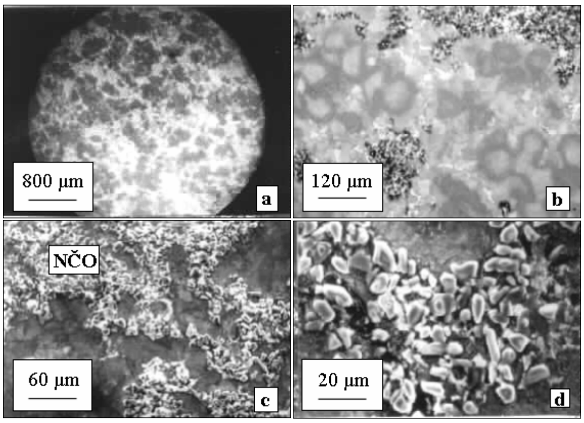

Figure 2: *Composites RAR27 +3 mass % Al_2O_3, μm, etched by 6 % nital*

a) General structure appearance, b) Appearance of the metal matrix portion, c) Appearance of clasters of the reinforcement particles, d) Detail, one of the clasters.

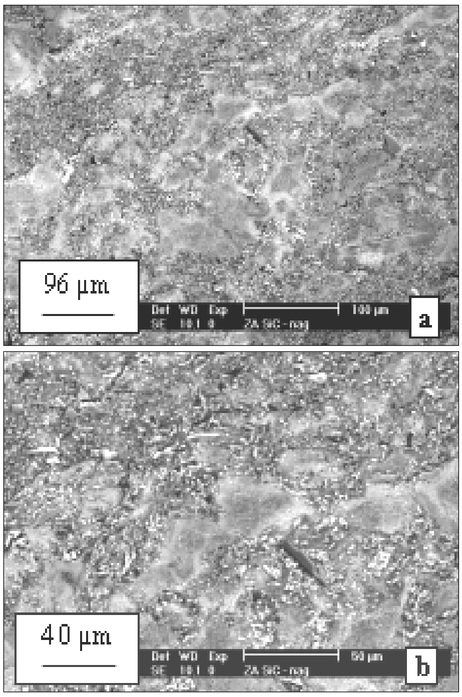

Figure 3: *Composite of RAR27 + 3 mass % of SiC, 15 µm (SEM)*

In Figure 3. is presented the appearance of the composite of the RAR27 alloy reinforced with 3 % SiC with particles size 15µm, under smaller (a) and higher magnification (b). The shape of clasters and their relation to the matrix zone which is not filled with particles is significantly more favorable when compared to structure of the composites infiltrated with smaller particles Al_2O_3.

Considering the fact that both materials are produced under the same procedure parameters, the most probable cause for this phenomenon (in any case favorable for mechanical properties of composites is the higher abrasiveness of the SiC particles and their lower affinity to mutual bonding.

Results of the compression tests of composite material samples at the room temperature [6] (in the temperature interval from 20 to 170°C), are presented by the diagram in Figure 4, as a function of the yield strength ($R_{p0.2}$) and temperature. For the sake of comparison, in diagram are included the corresponding values of the mentioned indicators for the cast iron and Rh-10* state of RAR27 alloy.

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* *Rheologically processed RAR alloy for the period of 10 minutes – without the reinforcement particles infiltration.*

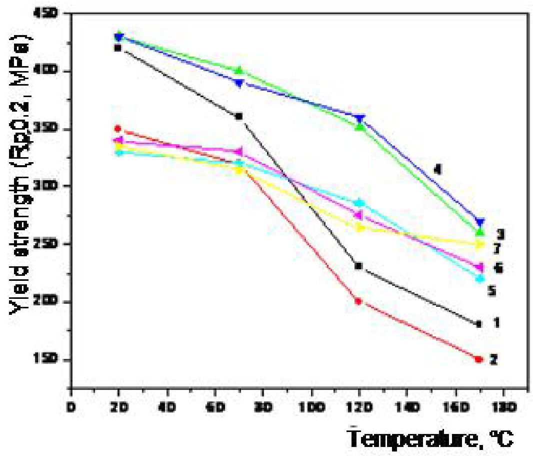

Figure 4: *Variation of the yield strength ($R_{p0.2}$) with temperature, for the compression tests [6].*

By reviewing the diagram one can notice that the mechanical properties of the composite materials, reinforced by the smaller particles (curves 3 and 4), measured by the value of the yield strength, are superior relative to properties of composites reinforced by larger particles (curves 5, 6 and 7). Also, those properties are superior relative to cast samples, as well as relative to samples in the Rh-10 condition (curves 1 and 2). Besides that, mechanical properties of composites with smaller particles are superior relative to cast and Rh-10 condition at elevated temperatures, with very important change in behavior, which is manifested in significantly slower decrease of the yield strength values with temperature increase.

it is interesting that up to temperature of 90°C samples of cast and Rh-10 condition of the alloy have higher values of the yield strength, relative to composites with matrix made of the RAR27 alloy, reinforced with larger Al_2O_3 particles. With further test temperature rising, the change occurs, so all the way to the end of the applied working interval, composite materials (regardless of the value of the mass share of reinforcement) these alloys exhibit better mechanical properties.

4. CONCLUSION

1. As a consequence of application of the compocasting procedure, the transformation occurred of the dendritic to non-dendritic structure of the matrix RAR27 alloy.

2. The better mechanical properties, both at the room and elevated temperatures, possess

samples of composites with smaller and better distributed particles.

3. At temperatures over 250°C composite samples, regardless of the type of particles and their mass share, exhibit better mechanical properties than the matrix alloy.

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