THE EFFECT OF MAGNESIUM ON THE MICROSTRUCTURE OF AK7- SiC<sub>p</sub> COMPOSITES

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SUMMARY

The article presents the results of the microstructural investigations of aluminium composites reinforced with silicon carbide particles. The addition of magnesium applied to the matrix alloy has enabled durable and adhesive bonds between the components to be obtained. The studies have also revealed the effect of magnesium on the microstructure of the matrix alloy itself, the occurrence of Mg<sub>2</sub>Si precipitates, and changes in the composition of the eutectics.

1. INTRODUCTION

The main feature of composites, being a very important one for material engineering at the same time, is a potentiality for designing specific sets of properties by means of selecting components and the process for the production of these materials [1,2]. The microstructure of cast composites reinforced with ceramic particles is determined, on one hand, by the disequilibrium solidification of metal suspension, while, on the other hand, by reactions occurring at the interfaces between the matrix and the reinforcing phase during the production process. Reactions occurring in many metal-ceramics systems may either change significantly the phase composition of the matrix, or cause the formation of transitional layers at the component interfaces, which have been described in numerous publications [3-7]. In the case of composites reinforced with particles these layers, although enabling a bond to be obtained between the particle and the matrix, are not tough enough so as to carry loads between the components and thus they often contribute to lowering the properties of composites.

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2. EXPERIMENTAL MATERIAL

The experimental materials were aluminium alloy-based composites reinforced with SiC particles. As the basic matrix alloy, the normalized AK7 casting alloy was used. To improve the wettability of the components and prevent reactions from occurring at the particle-matrix interface, 4% of magnesium was added to the alloy. As a reinforcing phase, $\alpha$-SiC particles of 6H type were used, with an average diameter of 40µm. The weight fraction of silicon carbide particles in the composite was 20%.

The composites were produced by a casting method, involving the introduction of particles to the molten matrix alloy, while mechanically mixing the composite suspension. Then, the composites were cast into metal moulds.

3. MICROSTRUCTURE OF AL-SIC$_p$ COMPOSITES

Figure 1 shows a typical microstructure of the produced aluminium composite reinforced with SiC particles, featuring a uniform distribution of ceramic particles within the matrix volume. Obtaining such a structure was made possible, above all, by the addition of magnesium to the matrix alloy, but also by proper selecting the parameters of the technological process. In the composites examined, no effects of unfavourable phenomena were observed, which frequently form the structures of cast composites, such as the sedimentation or flowing out of the reinforcing phase, as well as the formation of particle agglomerates or gas blisters. The composite matrix alloy had a dendritic structure, typical of gravity cast materials.

![Microstructure of the Al-SiC$_p$ composite](image)

Fig.1. Microstructure of the Al-SiC$_p$ composite.
Rys.1. Mikrostruktura kompozytu Al-SiC$_p$

The microstructure the hypo-eutectoid matrix alloy (AK7) was underwent, however, significant changes under the influence of introduced magnesium. It caused, above all,
The microscopic examinations revealed also the presence of additional precipitates of fairly large size in the composites examined, which are visible in Fig. 1b. Analyzes carried out using the SEM+EDX technique made it possible to determine the distributions of the surface X-ray characteristic radiation of elements for the precipitates found. Fig. 3 shows a surface distribution of elements, determined for the materials under consideration. A distinctly marked concentration of Mn and Fe (and Si), with a depletion in Al, is visible for the precipitate situated on the left-hand side of the micrograph in Fig. 3. The presence of this type precipitates was confirmed by the results of X-ray phase analysis. Owing to this method, the presence of the Mg2Si compound and a complex compound of AlFeMnSi type was found, besides the aluminium solid solution and SiC particles (Fig. 4). The presence of this complex compound was confirmed also by results obtained from transmission electron microscopy (TEM). Figure 5 shows the electron microstructure of the composite depicting precipitates with an eutectic morphology, in the form of the so called Chinese band, identified as the Al19Fe4MnSi2 compound. This type of degenerate eutectics forms in the event where one of the eutectic phase (namely the α phase) crystallizes selectively on the existing surfaces of the same phase, while the other (Al19Fe4MnSi2) only fills the inter-dendritic spaces in the form of continuous or semi-continuous precipitates. Occurring without the participation of magnesium, however, this compound is frequently one of the components of the matrix alloy (AK7) itself.

Tests carried out using electron transmission microscopy enabled also making the analysis of the interfaces between SiC particles and the matrix. Figure 7 shows a typical electron microstructure of the component interface identified in the composites.
examined. The presence of the considerable amount of magnesium in the matrix alloy assured the formation of the required bonds between the components of the composite examined. Interfaces between the particles and the matrix, as free from intermediary phases and any precipitates, had an adhesive character of component bonding. Moreover, they were characterized by a high cohesion (without microcracks) and strength of bonding.

![Fig.3. Surface distribution of elements in the Al-SiC<sub>e</sub> composite.](image)

Rys.3. Powierzchnia rozkładu składników w kompozycie Al-SiC<sub>e</sub>
Fig. 4. X-ray photograph obtained for Al-SiC<sub>p</sub> composites.

Rys. 4 Rendgenogram kompozytu Al-SiC<sub>p</sub>.

Fig. 5. Electron microstructure depicting Al<sub>19</sub>Fe<sub>4</sub>MnSi<sub>2</sub> precipitates.

Rys. 5. Wydzielenie Al<sub>19</sub>Fe<sub>4</sub>MnSi<sub>2</sub>.

Fig. 6. TEM microstructure of the interface in Al-SiC<sub>p</sub> composites.

Rys. 6 Mikrostruktura pow. międzyfazowej w kompozycie Al-SiC<sub>p</sub>.
4. SUMMARY

The presented results of the investigations of cast aluminium composites with silicon carbide particles enable one to determine the role of magnesium in the formation of the microstructure of composites. Magnesium assures mainly the wettability of silicon carbide particles by the liquid matrix and permits the formation of cohesive bonds of an adhesive character between the components. This causes, however, the formation of the Mg$_2$Si intermetallic compound and changes in the composition of the eutectics. In the primary structure, this compound contributes generally to the brittleness of the material, but its effect on the strength properties can be changed through heat treatment (solutioning and ageing).

REFERENCES