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Structural, mechanical and tribological properties of A356 aluminium alloy reinforced with Al_2O_3, SiC and SiC + graphite particles

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ABSTRACT

Particulate composites with A356 aluminium alloy as a matrix were produced by compocasting process using ceramic particles (Al_2O_3, SiC) and graphite particles. The matrix alloy and the composites were thermally processed applying the T6 heat treatment regime. Structural, mechanical and tribological properties of heat treated matrix alloy and the composites were examined and compared. It was shown that heat treatment affected microstructure of the composites matrix. The fracture of the composites matrix was ductile, while transition from ductile to brittle fracture occurred in the zone of reinforcing particles. The values of elasticity modulus of all the composites were higher in relation to the matrix alloy. It was also established that wear resistance and coefficient of friction were better at the SiC particulate composites than at the Al_2O_3 particulate composite, while the addition of graphite particles improved tribological properties further.

1. Introduction

A356 aluminium alloy is a casting alloy consisting of aluminium, silicon and magnesium. It is distinguished by good mechanical characteristics and high ductility, as well as excellent casting characteristics and high corrosion resistance. Mechanical properties of this alloy can be significantly improved by suitable heat treatment and especially using T6 heat treatment regime [1]. The alloy has been widely applied in the machinery, aircraft and defence industries and particularly in the automotive industry to replace steel components [2]. A356 aluminium alloy has been also used as the basis for obtaining composites with ceramic reinforcing particles and fibres such as SiC, Al_2O_3 etc. [3–5] aiming to improve the alloy wear resistance.

Starting from the first experiments [6] until today [7] the process of obtaining composites named compocasting is an object of interest for many researchers from the whole world. Belonging to the SST (semi-solid technology) procedures for composites production this process is based on the infiltration (with mixing) of reinforcing particles and/or fibres in the semi-solid melt of an alloy. Compocasting shows some advantages in relation to other processes for producing composites, when the composite matrix is in liquid state. This process is performed at considerably lower temperatures and an extended life of tools can be achieved [8] as well as energy savings. Accordingly, the process is of lower cost [9] compared to other procedures of composites production.

Particulate reinforced composites cost less than fibre reinforced composites, owing to the lower costs of the particles. In addition, mechanical and physical properties of particulate composites are generally isotropic. Cast metal matrix particulate composites represent the lowest cost composites, and they find the most tribological applications [10].

Reinforcing particles are relatively easy to infiltrate during compocasting process and so the problem of wettability [11] is not necessary to solve. It is possible to infiltrate various reinforcing particles (SiC, Al_2O_3, TiB_2 etc.) in the metal matrix (aluminium alloys [3], magnesium alloys [12], zinc–aluminium alloys etc.). The particles of ash [13], graphite [14] or some other solid lubricant have been also used in order to improve tribological characteristics of base alloys. With suitable combination of process parameters it is possible to achieve a very good distribution of reinforcing particles in the composite matrix and thus affect mechanical properties of the composite. During compocasting process composite materials can be produced in the form of so-called thixo ingots, which can be

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