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Short Communication

Mechanical and wear behaviors of Al–12Si–XMg composites reinforced with in situ Mg_2Si particles

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ABSTRACT

A study has been conducted to investigate the mechanical and wear behaviors of the Al–12Si–XMg alloys (where Mg contents were 5%, 10% and 20%) cast by adding modifiers such as Sr, red phosphorous and salt mixtures. Mechanical properties were determined by hardness measurements, compression and wear tests. Reciprocating wear tests were conducted by rubbing ceramic (Al_2O_3) and steel (AISI 52100) balls on the unlubricated surfaces by applying the normal load of 2 N. The microstructure of the Al–12Si–XMg alloys consisted of the Si needles and Mg_2Si precipitates (two morphologies of which are polyhedral shape dark particles and grey colored components of Chinese script) in the Al matrix. Results demonstrated that volume fraction and size of the primary Mg_2Si particles increased with increasing the Mg content. Mg containing alloys exhibited higher hardness and better wear resistance than the Mg free alloy.

1. Introduction

Among the materials of the tribological importance, hypereutectic Al–Si alloys preferentially have received considerable attention to wear related applications such as internal combustion engines, pistons, liners, pulleys, rockers and pivots. Reduction in density and thermal expansion coefficient, improvement in hardness, ambient temperature mechanical properties (modulus and strength) and wear resistance along with an excellent castability can be achieved with addition of Si to Al matrix [1–7].

In situ composites are multiphase materials where the reinforcing phase is synthesized within the matrix during composite fabrication. This conflicts with ex situ composites where the reinforcing phase is synthesized separately and then inserted into the matrix during a secondary process such as infiltration or powder processing. In situ processes can create a variety of reinforcement morphologies, ranging from discontinuous to continuous, and the reinforcement may be either ductile or ceramic phases [8].

Al–Mg_2Si in situ composite offers attractive advantages, as a candidate material, in future industrial applications. These advantages include (a) weight reduction due to the low density of Mg_2Si; (b) better mechanical properties compared with Al–Si_{12}–Cu–Mg–Ni alloy at the medium high temperature and (c) low cost by using Al, Mg, Si as starting materials [9–15]. However, the mechanical properties of the as-cast alloys containing Mg_2Si phases were not satisfactory due to the brittle matrix and large Mg_2Si phase [11,14]. For further improvement of the mechanical properties, rapid solidification and mechanical alloying have been used to produce the material with very fine matrix structure and in situ Mg_2Si particles. Unfortunately, such techniques are too expensive and too complex to be accepted by the engineering community for general applications. Therefore, preparing the in situ composite by simple casting process seems to be the most hopeful route when facing further commercial demands. Based on this understanding, most of our previous studies were focused on the improvement of microstructure and mechanical properties of the as-cast composites [16–18].

A great number of researches are available in the literature [13,18–22], in relation to the preparation and processing of the in situ composites containing Mg_2Si particles as the reinforcement materials. However, reports on the wear behavior of the in situ composites appear rarely. Therefore, this study deals with the mechanical and wear behaviors of the hot extruded in situ Mg_2Si reinforced Al–12Si alloy matrix composites.

2. Experimental details

Commercially pure 12 wt.% Si containing Al ingot alloy and pure Mg were used as starting materials to prepare the Al–12Si–XMg alloys. The Mg contents varied between 0 wt.% and 20 wt.% in the Al matrix. The Mg was added to the Al–12Si alloy melt at 800 °C along with 0.05% of Sr, 0.20% of red phosphorous and 0.30% of NaCl + 30$MgCl_2$ + 10KCl mixtures necessary for the refinement and modification of precipitations which were all preheated at

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