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Short Communication

Effect of heat treatment on microstructure and wear behavior of Al–Si alloys with various iron contents

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ABSTRACT

Effect of T6 heat treatment on microstructure and wear behavior of hypoeutectic Al–Si alloys with iron contents of 0.15, 0.7 and 1.2 wt% was studied. Dry sliding wear tests were performed on a pin-on-disk tribometer under normal loads of 20, 30 and 40 N. The alloy with 0.7 wt% iron showed the highest wear resistance before the heat treatment under the loads tested. T6 heat treatment improved the wear resistance of the alloys with different iron contents compared to the non-heat treated 0.7 wt% iron alloy under all applied loads. The improvements in the wear can be attributed to the decrease of length and volume fraction of hard and brittle β-Al_5FeSi iron-rich intermetallics and spherodization of the coarse eutectic silicon particles by diffusion of iron and silicon into the matrix upon solution heat treatment. The change in the morphology of the phase particles reduced the probability of nucleation and propagation of subsurface cracks and increased the wear resistance in the samples.

1. Introduction

The tribological properties of Al–Si alloys are affected by shape and distribution of silicon particles, and addition of alloying elements such as magnesium, copper, nickel, and zinc often combined with a suitable heat treatment [1–4]. The wear resistance of these alloys has been reported to improve when the silicon content is near the eutectic composition [2]. Proper solution treatment results in the modification of the morphology of eutectic silicon particles, solid solution strengthening and precipitation hardening of the matrix in Al–Si alloys. Large flakes of silicon with sharp tips and low bond strength with the matrix may convert to fine spherical shape particles with better bonding strength with the matrix after heat treatment [1,5,6]. This may cause reduction of stress concentration and crack nucleation sites leading to the improvement of tribological behaviors [1,2,5,6].

Addition of elemental iron in Al–Si alloys decreases mechanical and tribological properties due to the formation of long and brittle needle like β-Al_5FeSi intermetallics. These needles have very sharp tips and high aspect ratio and have low bond strength with the aluminum matrix [7,8].

The beneficial effects of heat treatment in controlling the negative effects of Fe-rich intermetallics on mechanical properties have been widely investigated [9–12]. It seems there has not been any systematic work devoted to investigate the effect of heat treatment and iron-rich intermetallics on the wear properties of Al–Si alloys. In view of the above, this study was conducted to investigate the effect of T6 heat treatment on the wear behavior of F332 alloy containing various amount of iron.

2. Experimental procedure

Chemical composition of SAE332 alloy used as the base composition is shown in Table 1. The alloy was melted in a graphite crucible using an electrical resistance furnace. The amount of iron in the base alloy was increased to 0.7 and 1.2 wt% by adding certain amount of Al–75Fe master alloy to the molten alloy at 750 °C. The names allotted to the alloys used in this study are shown in Table 2 in terms of iron content. After the additions were made, the temperature of the melt was raised to 800 °C, held for 15 min to homogenize the liquid, then furnace-cooled to 750 °C. The melt was stirred/degassed for 10 min before pouring to ensure homogeneous distribution of the additions within the melt, and to remove inclusions. Final pouring temperature was always maintained at 720 ± 5 °C. The molten alloy, were cast into a cast iron mold which was preheated to 250 °C. The average cooling rate of the preheated cast iron was 3 °C/s.

The samples were T6 heat treated by solution treatment at 520 °C for 12 h followed by quenching in water at 60 °C, and finally artificial aging at 200 °C for 5 h. This condition resulted in the highest hardness and dissolution of second phase intermetallic in the matrix. H in Table 2 designates the alloy prepared by the heat treatment. The samples were polished and then etched with 0.5%HF and finally were investigated using optical microscopy. An image analysis instrument was used to measure the geometric parameters and the volume fraction of Fe-intermetallics and silicon particles. More than 40 particles were used to determine the

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