# Abstract

The effects of the microstructural features on the wear and mechanical behavior of some hypoeutectic Al-Si alloys have been investigated. For this purpose, Al-7Si and LM25 alloys were subjected to several melt treatments such as grain refinement (refinement of α-Al dendrites), modification (refinement of eutectic silicon) and combined treatment with grain refiner and modifier (for refinement of α-Al dendrites and refinement of eutectic silicon).

In order to reveal the role of grain refinement on the mechanical and wear behaviour of Al-Si alloys of Al-Si alloys, initially a commercially pure Al (CPAL) was grain refined to produce varied grain sizes, The effects of grain size on the mechanical and wear properties of CPAL were first investigated. It is interesting to note that a decrease in the grain size not only improved the mechanical properties of CPAL as expected, but also improved the wear behaviour, the load bearing capacity in particular. The wear resistance has shown a straight-line relation with (grain size)$^{-1/2}$ similar to Hall-Petch relationship.

Molten Al-7Si and LM25 alloy at 720°C have been inoculated with Al-3B, Al-1Ti-3B, Al-5Ti-2C grain refiners in order to refine the α-Al dendrites. It has been found that grain refinement treatment leads to decrease of secondary dendritic arm spacing (SDAS). The mechanical and wear properties of grain refined hypoeutectic Al-Si alloys have been investigated, it has been shown that the decrease in the SDAS results in the improvement in the wear resistance of Al-7Si and LM25 alloy in the steady state regime (sliding distance = 500-1500m). It is also demonstrated that the refinement of SDAS results in the improvement on the load bearing capacity of the grain refined hypoeutectic Al-Si alloys, as was the observation in case of CPAL, which has been attributed to the improved strain-hardening tendency due to fine SDAS. Detail studies of the sub-surface of the worn Al-7Si specimens revealed that there is significant amount of diffusion of Fe along the dendritic boundaries. It is also seen that in Al-7Si alloy, grain refinement treatment leads to enhanced diffusion (because of presence of eutectic silicon) of Fe along the dendritic boundaries due to the increased boundary area. Following the observations, wear mechanisms have been proposed which involve several mechanisms such as plastic deformation, delamination, mechanical alloying and three-body abrasion. However in case of commercial pure aluminum, delamination and adhesive wear are found to be dominating, while mechanical alloying and ploughing (abrasion) are predominant in case of Al-7Si alloy.

In order to alter the morphology of the eutectic silicon, hypoeutectic Al-Si alloys have been treated with various elements such as Sr, Sb or Cd for different holding times as done in the case of grain refinement. The role of each of the modifying elements on the morphology of the eutectic silicon has been analyzed. It has been shown that melt holding time and addition level of the modifier element, have significant influence on the morphology of the eutectic silicon. Sr modifies eutectic silicon to fine fibrous morphology, by impurity induced twinning mechanism, and shows better modification effect for 5min holding than at 120min holding, which has been accounted for the loss of Sr. On the other Sb modifies eutectic silicon by forming AlSb particles, which act as heterogeneous nucleants for eutectic silicon. Thus resulting in Si with fine lamellar morphology. It has been found that Cd refines the size of the eutectic silicon by increasing the viscosity of the eutectic liquid during solidification, which increases the viscous friction between the growing silicon and the Cd rich liquid. In addition to these studies, a number of mechanical and wear studies were conducted by varying the dry-sliding parameters, in order to understand the effect of modification of the eutectic silicon on the wear behavior of Al-7Si and LM25 alloy. A wear mechanism has been proposed to explain the wear behavior of modified Al-7Si and LM25 alloy for different holding times. It has been found that modified Al-Si alloys result in higher wear resistance and improved load bearing capacity due to reduced abrasion due to fine eutectic silicon particles when compared to that of un-modified Al-7Si alloy containing coarser silicon needles.

Two methods are followed in order to obtain combined grain refinement and modification to ensure fine α-Al dendrites along with fine eutectic silicon particles in Al-7Si alloy. Both the conventional method and the Al-Ti-C-Sr master alloy addition methods result in good modification of eutectic silicon and fine SDAS. It has been found that the grain refined and modified hypoeutectic Al-Si alloys exhibit better mechanical and wear properties compared that of un-treated, grain refined or modified ones.

While the modification of eutectic Si particles results in reduced abrasion the grain refinement cause a decrease in the SDAS and a consequential increase in the load bearing capacity of hypoeutectic Al-Si alloys.

***Key words:*** *Grain refinement, Modification, WEAR, Al-Si alloys*