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Experimental Investigation of Microstructural Characteristics and Tribological Properties of Al-Si Alloys Modified under the Influence of Mechanical Mold Vibration.

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Dry sliding wear behavior of Al-Si alloys depends on the size, shape of the silicon particles and size and distribution of the α-Al grains in the interdendritic region. This paper highlights the effect of mechanical mold vibration during solidification on the microstructure and tribological properties of Al-12% Si alloy. The size of eutectic silicon, grain size and wear resistance were investigated.

Keywords- Mechanical mold vibration, dry sliding wear test.

1. Introduction

Aluminum-Silicon alloys are the most commonly used foundry alloys because of their good thermal conductivity, excellent cast ability, high strength to weight ratio, wear and corrosion resistance etc. Therefore they are well suited for automotive and air craft components. The mechanical properties of Aluminum-Silicon alloys are related to the size and shape of eutectic silicon which in turns depends on the solidification process.

In the present work, mold material (A), mechanical mold vibration (B) and pouring temperature (C) were considered as variables during the solidification process.

Imposition of mechanical vibration on liquid Al-Si alloy during solidification has shown improvements like grain refinement [1], reduction in shrinkage pipe [2], fragmentation of dendrites and transition of eutectic structures from flakes to fibrous [3], reduction in average size of silicon needle [4] resulting in improved properties.

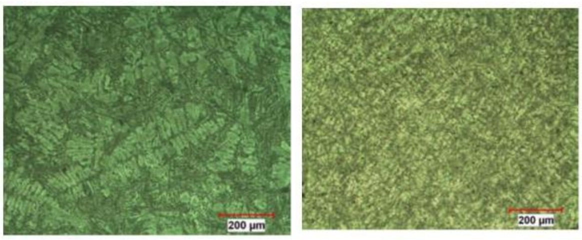
2. Experimental

A simple mechanical vibrator set up was used to subject the mold to vibration. Molten commercial grade LM6 alloy was solidified under the influence of vibration with frequency and amplitude maintained at 25 Hz and 0.05 mm respectively. The vibration was maintained until the melt was completely solidified. After solidification the cast specimen were prepared for testing.

Experiments were conducted as per the design matrix [5] of full factorial design as shown in Table 1. The notations are as follows: For mold material, cast iron mold is designated as -1 and graphite mold as 1, absence of vibration as -1 and presence of vibration as 1 and pouring temperature of 700°C as -1 and 800°C as 1.

3. Results and Discussion

The results of microstructure examination as per ASTM-E407 standard of samples cast as per Table 1 are shown in Fig 1. The microstructure for cast specimen in static mold shows presence of dendritic growth but for the cast specimen in vibrated mold the aluminum dendrites have broken. Inducing vibration fragments the dendrites thereby resulting in less dendritic growth.



(a) (b)

Fig.1 Microstructure of cast specimen poured in graphite mold at 800°C under (a) static condition (b) vibrated condition at 100x magnification.

Fig. 2 and Fig. 3 shows the variation of average silicon size and grain size and it is observed that the average size of silicon needles and average grain size for cast specimen designated as *abc* i.e vibrated graphite mold with alloy poured at 800°C is least.

Table 1 Design Matrix

Experiment Number	Label	Factors A	B	C
1	(1)	-1	-1	-1
2	a	1	-1	-1
3	b	-1	1	-1
4	c	-1	-1	1
5	ab	1	1	-1
6	bc	-1	1	1
7	ac	1	-1	1
8	abc	1	1	1

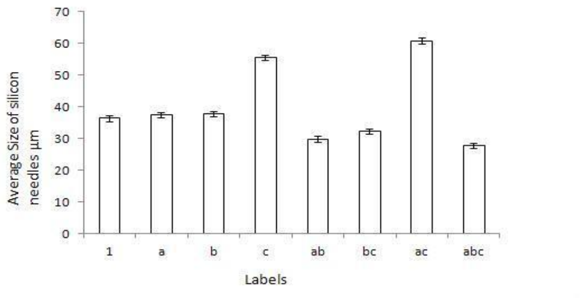


Fig. 2 Average size of silicon needles of the cast specimen designated with labels as per the design matrix table 1.

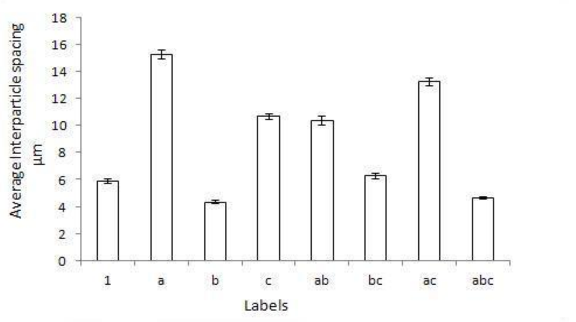


Fig. 3 Average grain size number v/s Label as designated in design matrix table 1.

The energy of mechanical vibrations promotes microstructure refinement during solidification. Also vibration induces a higher heat transfer along the mold walls due to the alternated movement of liquid molten metal. This could be the reason for change in the silicon particle size and grain size.

Fig. 4 shows the variation of volume loss with normal load at a constant sliding speed of 5.495 m/s and a sliding distance of 9891 m. It is observed that there is an improvement in the wear behavior of the cast specimen in vibrated mold as compared to the wear behavior of cast specimen in static mold.

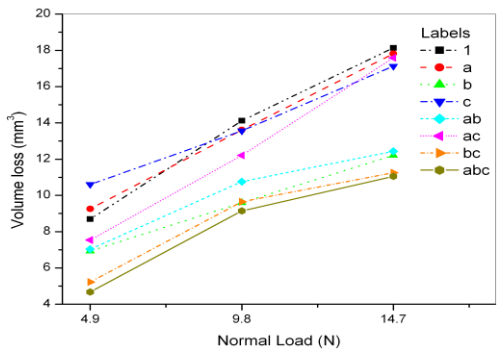


Fig. 4 Volume loss vs. normal load

4. Conclusion

Applying vibration to the solidifying LM6 alloy leads to microstructural changes to both the dendritic structure and eutectic silicon which results in improved properties. The technique currently in use is addition of grain refiners like master alloys of Al-Ti or Al-Ti-B and modifiers like Sodium to the melt, but efficiency is limited due to fading effect and is not environment friendly. Hence the technique studied in this paper is hoped to be beneficial to the industries producing Al-Si alloy casting.

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