STUDIES ON MICROSTRUCTUREAND MECHANICAL PROPERTIES OFMODIFIED LM25 ALUMINIUM ALLOY

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ABSTRACT

In the present investigation, aluminium alloy LM25 grade is chosen as matrix material with zirconium particles as reinforcement. Modified LM25 alloys are fabricated by stir casting process. Chemical compositions, Rockwell hardness and tensile testing are performed to find the mechanical properties for fabricated modified LM25 alloy. The results revealed that the hardness value increases and the tensile value decreases with Zr addition. Microstructures of the samples were investigated using the optical microscope.

Keywords: Aluminium alloy, LM25, Hardness, Microstructure, Tensile property

I. INTRODUCTION

For the last few decades, the development of materials shifted from monolithic alloy to composite materials to meet the global industrial needs.The properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them. The reinforcements are in the form of flakes, particulates and fibers. Reinforcement enhances the strength, hardness, stiffness, wear resistance, friction coefficient, thermal conductivity and temperature resistance capacity and lowers the density of MMC.

Al–Si–Mg casting alloys are increasingly used in the automotiveand aerospace industries for critical structure applications due totheir excellent casting ability, weldability and corrosion resistance, and particularly good tensile and fatigue properties[1]. A356 alloys naturally have an elastic modulus of about 70 GPa, which is about one-third of the elastic modulus of the majority kinds of steel and steel alloys[2].The yield strength and hardness of these alloys are usually improved by solution treatment and artificial aging through the formation of fine Mg2Si precipitates [3,4]. However, the strength of these alloys degrades quickly above working temperatures of 130–150 ^{0}C because of rapid coarsening of the precipitates. To improve the mechanical properties and thermal stability of Al-based alloys, dispersoid-forming elements such as Zr, Mn and Cr can be added to the alloy. Of these elements[5-7], Zr provides on the one hand an increase of the strength at room temperature and on the other, microstructuralstability at higher temperatures by forming very finestable dispersoids. In the Al–Zr binary system, an ordered Al_3Zr trialuminide may be precipitated from a super saturated solid solutionduring postsolidification aging [6-8]. The hardness of the Zr-containing alloys did increaseby an average of 8% and 15% after solution treatment for8 h and 24 h, respectively. Theaddition of Zr to the alloy had a grain refining effect on the structureand reduced the average grain size to 0.7 mm [9].In the present work, the effect of addition of small amount of lithium and zirconium on microstructure, hardness and tensile property of modified LM25 alloy has been investigated.

II. EXPERIMENTAL WORK

Table 1 Composition of aluminium alloy (LM25)

Elements	**Cu**	**Si**	**Mg**	**Mn**	**Fe**	**Ni**	**Zn**	**Ti**	**Pb**	**Sn**	**Al**
Wt.%	0.07	3.15	0.5	0.17	0.9	0.01	0.04	0.02	0.03	0.002	Balance

The constituent elements of LM25 alloy are presented in Table 1. A weighted quantity of the LM25 Al alloy was melted in clay bonded graphite of 2 Kg capacity using a small electrical furnace. The experimental setup is shown in Fig. 1. The melt was maintained at about 750^{0}C and stirred using a mild steel impeller at a speed of 600 RPM to create the vortex. The reinforcement material, zirconium particles of 100 to 240µm of size were added and the string process was continued for 10 to 15 minutes and then the composite slurry was poured into the mild steel die, which was preheated to about 300^{0}C.

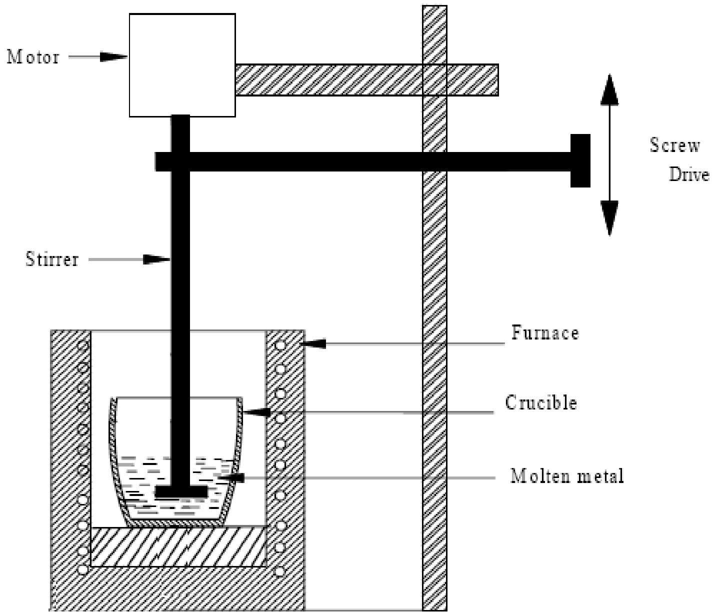


Figure 1 Mechanical stir casting setup and stirring process

Microstructures of the modified LM25 alloy wereanalyzed to verify the reinforcement distribution on composites. The tensile test specimens were made according to ASTM: E8M-13a standard as shown in Fig. 2. Tensile tests were carried out in a computerized testing machine at a strain rate of 1 mm/min. Rockwell hardness test is performed on the samples using digital Rockwell hardness testing machine.

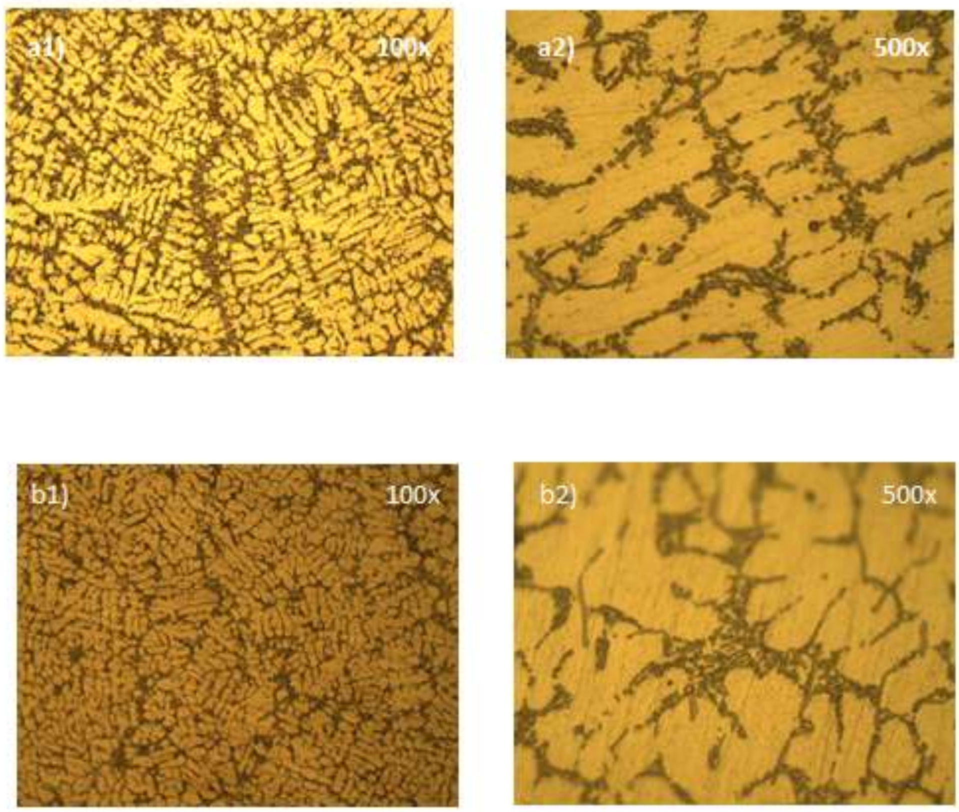
Dimensions	Subsize Specimen
	6 mm [0.250 in.] Wide
	mm [in.]
G—Gage length (Note 1 and Note 2)	25.0 ± 0.1 [1.000 ± 0.003]
W—Width (Note 3 and Note 4)	6.0 ± 0.1 [0.250 ± 0.005]
T—Thickness (Note 5)	
R—Radius of fillet, min (Note 6)	6 [0.250]
L—Overall length, min (Note 2, Note 7, and Note 8)	100 [4]
A—Length of reduced section, min	32 [1.25]
B—Length of grip section, min (Note 9)	30 [1.25]
C—Width of grip section, approximate (Note 4 and Note 9)	10 [0.375]

Figure 2 Sizeof tensile Specimen

III. RESULTS AND DISCUSSION

3.1. Microstructure

Microstructural examination of the modified LM25 alloy was carried out to confirm the dispersion of Zr particles. Cross sectional of the samples revealed the presence ofinterdendriticnetwork of eutectic silicon, Zirconium particles (mostly rounded, less angular) and Mg_2Si particles distributed in a matrix of aluminum solid solution throughout structure as shown in Fig. 3.



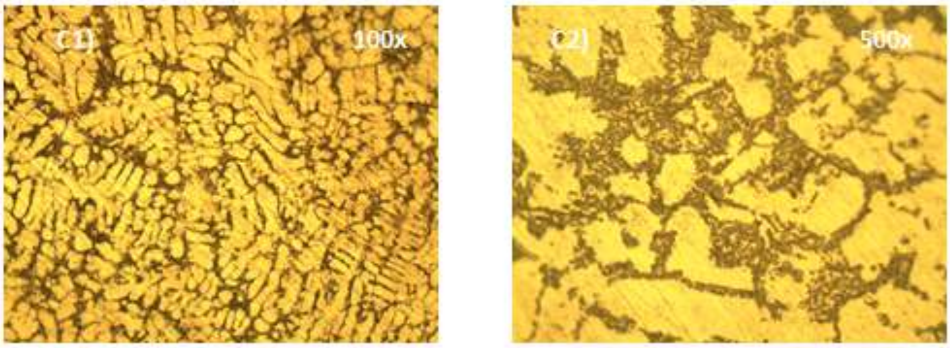


Figure 3 Microstructures of the modified LM25 alloys,
(a) 0.25 wt% Zr, (b) 0.5 wt% Zr and (c) Zr-free

3.2. Hardness

The results of hardness tests are shown in Table 2. It can be seen that the initial hardness of the unmodified alloy was 60HRB that decreased to48 HRB and increases with the addition of Zr. According to the micro structural modification so fβ inter metallic, hardness should increase with the addition of Zr , but the results indicate that hardness obviously declines initially. Because of porosity in the composites the hardness value is decreased and the hardness is very sensitive to the porosity volume fraction.The hardness of the fabricated composite can be enhanced by age hardening process.

Table 2 Rockwell hardness of modified LM25 alloy

Sample No.	Composition of samples	Hardness value (HRB)
1	Al + 0%Zr	60
2	Al + 0.75%Zr	48
3	Al + 1.00%Zr	53

3.3. Tensile Property

The average ultimate tensile strength (UTS) and elongation values of composites with and without Zr are illustrated in Table 3. It is evident that the addition of Zr decreases the tensile property. UTS is decreased form 230 to 165MPa and elongation percentage is reduced from 6% to 3.8%. Further increase of Zr decreases the tensile property. The tensile properties of composites can be increased with the age hardening process.

Table 3 Ultimate tensile strength and elongation of modified LM25 alloy

Sample No.	Composition of samples	UTS (Mpa)	Elongation (%)
1	Al + 0%Zr	230	6.0
2	Al + 0. 75%Zr	165	3.7
3	Al + 1.00%Zr	162	3.9

IV. CONCLUSION

The effect of Zr and Li on the microstructure and mechanical properties of modified LM25 alloys were investigated. The following conclusions were drawn:

1. Presence of less porosity is confirmed with the microstructure analysis.
2. Addition of Zr to the LM25 alloy decreased the hardness values initially and then increases with the rise ofZr. Further the hardness of the modified LM25 alloy can be enhanced with age hardening process.
3. The ultimate tensile strength and elongation percentage of the modified LM25 alloy decreases with the addition of Zr.

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