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Microstructure and Mechanical Properties of Al-Si Alloy in As-cast and Heat Treated Condition

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ABSTRACT: *In the present research, the microstructure and mechanical properties of LM 25 Alloy under as-cast and T6 heat treatment conditions produced by liquid metallurgical route were studied. The outcomes showed that, eutectic silicon, α-Al primary and Mg_2Si are the main phases in the microstructure of LM 25 alloy produced by liquid metallurgical route. The hardness, ultimate tensile strength, yield strength and Elongation of LM 25 alloy under T6 heat treatment improved by 14.8%, 49%, 73% and 18% respectively as compared to as-cast conditions.*

Key words: *Hardness, LM 25 alloy, microstructure, T6 heat treatment, tensile test*

I. INTRODUCTION

A356 is a general cast Al-Si alloy used in the automotive industries and aircraft especially for pistons, cylinder heads, cylinder blocks, and valve lifters, Because of its high wear resistance, better fluidity during casting, good corrosion resistance, high strength to weight ratio, low thermal expansion coefficient, heat treatability and improved mechanical properties in different temperatures [1-10]. On the other hand, Microstructural features such as secondary dendrite arm spacing (SDAS) [11,12], eutectic silicon particles [13,14], intermetallics [15], microporosity [16-17] and heat treatments [18,19] significantly affect the mechanical properties of A356. The as-cast microstructure of A356 is generally characterized by a nonuniformly distributed Si particles, coarse dendritic structure and porosity [11-12, 16-17, 20−23]. These microstructural features bound the mechanical properties of cast alloys especially in terms of fatigue resistance and toughness.

As-cast A356 alloys are made up of coarse primary α-Al dendrites and acicular-shaped eutectic silicon, which decreases the mechanical properties and limits its industrial applications. The mechanical properties can determine by controlling the microstructures of the alloys [24-25].Heat treatment are defining the casting mechanical and microstructure properties [26-28]. Heat treatment is generally carried out to obtain an optimum combination of ductility and strength in Al-Si-Cu-Mg alloys. The step of heat treatment consist of solution treatment, quenching and artificial aging [29]. In this study, the effect of T-6 heat treatment on the microstructure and mechanical properties of LM 25 Alloy (Al-Si alloy) was studied.

II. EXPERIMENTAL

2.1 Materials

Aluminium-Silicon alloy (BS: LM25) is taken as matrix alloys for synthesis of AMCs. The chemical compositions of LM 25 alloy was studied by Optical Emission Spectrometer (model: SPECTRO MAXx LMF05, SPECTRO, Germany) and the chemical compositions are presented in the Table (1).

Table 1 Chemical Compositions of LM 25 Alloys (in wt. %)

Element	*Si*	*Fe*	*Mg*	*Mn*	*Ti*	*Cu*	*Al*
LM 25	7.46	0.387	0.326	0.0470	0.0396	0.0707	Rest

2.2 Heat treatment

The matrix alloy was heat-treated following steps consisting of solutionizing at 495˚C for 8 hours, quenched in oil (at 35˚C) followed by tempering at 175˚C for 6 h and finally cooled in ambient air.

2.3 Microstructural Study

The samples of LM 25 alloy in as-cast and heat-treated conditions, of dimensions 15mm thick and 20 mm diameter were cut and cold mounted, for microstructural analysis. The polishing of these samples was done using standard metallographic procedure and they were etched with Keller's reagent (2.5% HNO_3, 1.5% HCl, 1% HF and remaining water). After that the microstructural observations were done by Optical Microscopy (Model: JEOL, JSM-6390).

2.4 Hardness

The hardness of as-cast and heat-treated LM 25 alloy was measured in Hv scale using a Vikers hardness tester at an applied load of 2.5 kg. The metallographic polishing of the specimens was done and before the hardness measurement opposite sides were made perfectly parallel. The hardness readings (ten) were noted on each sample and the average value was taken.

2.5 Tensile Test

Yield strength, ultimate tensile strength, Young's modulus and ductility of the LM25 alloy as-cast and heat treated condition were measured in an Instron universal testing (Model 8801, UK) machine using standard test samples(as shown in Fig 1) at room temperature under tensile loading at a strain rate of 10^{-2}/s.[30]

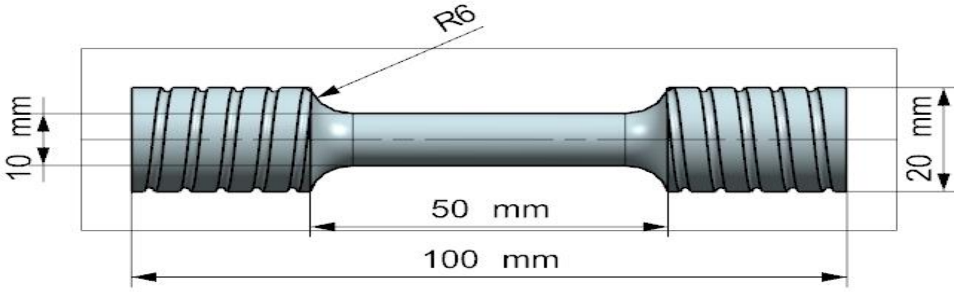


Fig 1 Dimension of tensile specimen (in mm)

III. RESULT AND DISCUSSION

3.1 Microstructure

Fig 2 shows the optical microstructures of LM 25 alloy with as-cast and T6 heat treatment produced by liquid metallurgical route. Figure 1 indicates three phases in the microstructure are α-Al primary, eutectic silicon and Mg_2Si. Eutectic was the combination of Al and Si phase microstructure that resulted from nucleation during solidification. Eutectic Silicon particles are spheroidized and homogeneously distributed in the grain boundary after T6 heat treatment.

3.2 Hardness

Fig 3 shows the Vickers hardness of the samples. The values of hardness of LM 25 Alloy in as-cast condition and heat treated condition were 57.44 Hv and 65.98Hv (improved by 14.8 %) respectively. It is clearly shows that the hardness of heat treated sample increased because harder and stronger interfacial bonding strength of eutectic phase after T6 heat treatment.

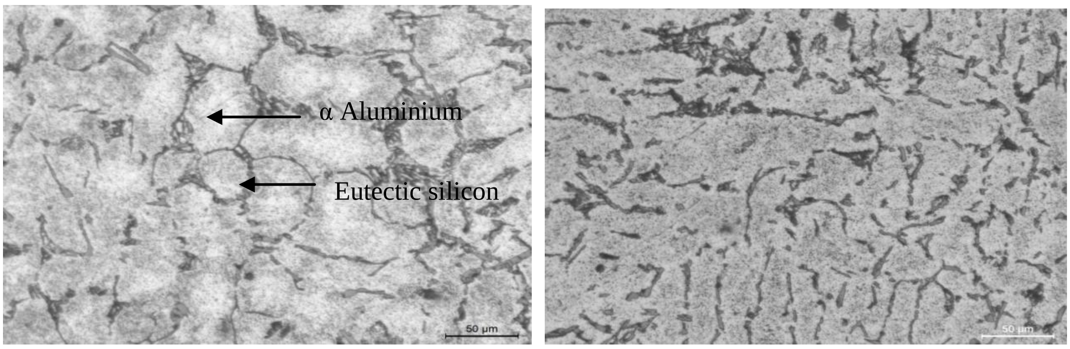


Fig 2 Optical micrograph of LM 25 alloy in (a) As-cast condition (b) heat treated condition

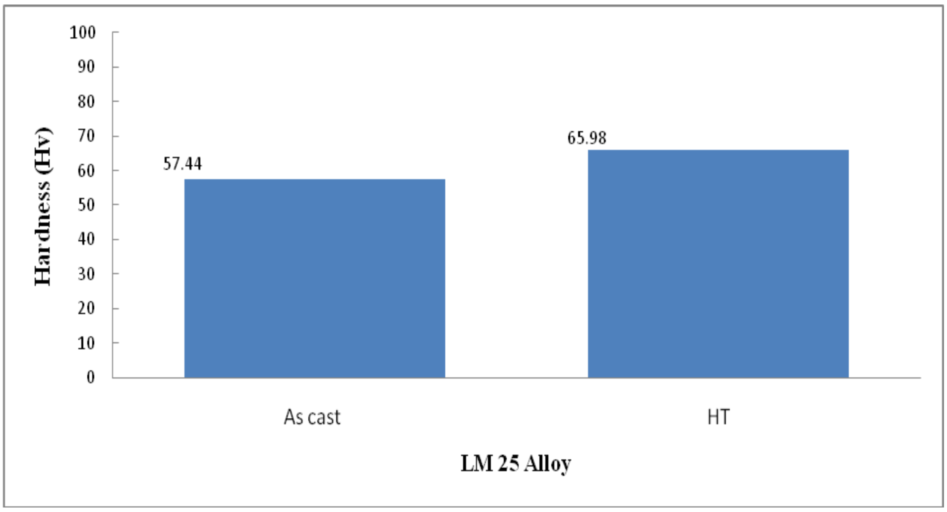


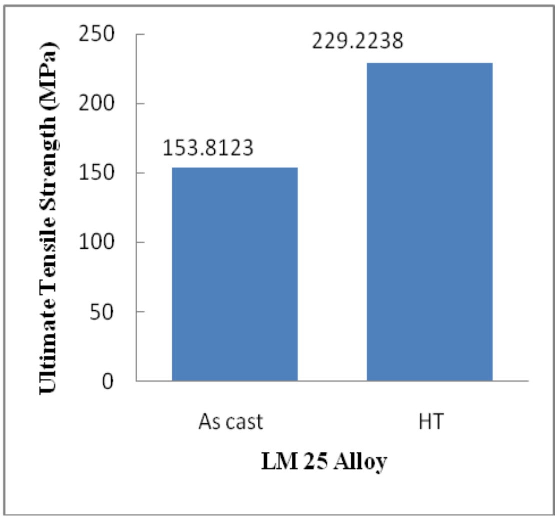
Fig 3 Vickers hardness of the sample

Tensile properties

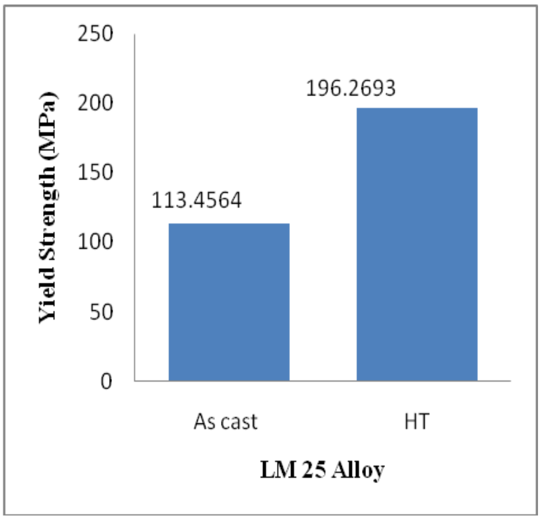
Fig 4 shows the tensile properties of samples, including the ultimate tensile strength (UTS), Yield strength (YS) and elongation (EL). After T6 heat treatment, the average UTS, YS and EL of LM 25 Alloy in heat treated condition were 229.2238MPa (improved by 49%), 196.269335 MPa(improved by 73%) and 2.26965 %(improved by 18%), respectively. It is clear that tensile properties of LM 25 alloy can be improved by T-6 heat treatment process. Harder and stronger interfacial bonding strength of Al-Si eutectic phase are responsible for improved tensile properties.

IV. CONCLUSION

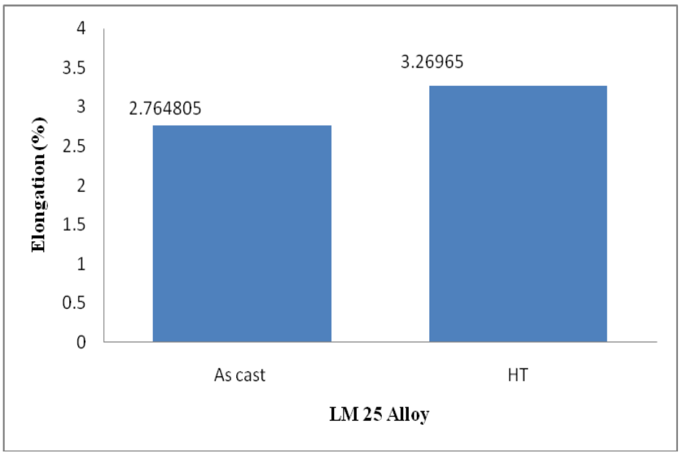
1. Mainly three phases in the microstructure of LM 25 alloy are α-Al primary, eutectic silicon and Mg_2Si produced by liquid metallurgical route. Eutectic Silicon particles are spheroidized and homogeneously distributed in the grain boundary after T6 heat treatment. After heat treatment interfacial bonding strength of Al-Si eutectic phase are stronger and harder as compared to as-cast condition.
2. The hardness of LM25 alloy withT6 heat treatment condition reach 65.98 Hv and they increase compared to as-cast condition and is 14.8% higher than those of as-cast condition.
3. The ultimate tensile strength, yield strength and elongation of LM25 alloy in T6 heat treatment condition reaches 229.2238MPa, 196.269335 MPa and 3.26965 respectively and they are 49%, 73% and 18% improved respectively as compared to as-cast condition.



(a)



(b)



(c)

Fig 4 Ultimate tensile strength, Yield strength and Elongation of samples in the tensile test

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