Production and Characterization of Al- 7%Si-0.3%Mg Alloy

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Abstract - Production of Aluminium-7% Silicon-0.3% Magnesium alloy and the variation of mechanical properties of the alloy on as-received condition, homogenized condition and solution treatment, artificial ageing at 165°C had been studied. Microstructural characterization was done and hardness values were calculated using Rockwell hardness machine. Tensile properties of different heat treated samples were studied using Hounsifield Tensometer. The fractured samples were observed by Scanning Electron Microscope. Corrosive behavior of as-cast samples was studied in sea water environment and sodium carbonate solutions and microstructure characterization was done. It was found that Al-7% Si-0.3% Mg alloy is highly resist to sea water as compared to sodium carbonate solution as evident in the structures.

Key words : Age hardening, microstructure, hardness, corrosion

I. INTRODUCTION

Addition of magnesium to Al-Si alloy increases response to precipitation-hardening to yield higher strengths. LM 8 (Al, 5.5% Si, 0.6% Mg) and LM 25(Al-7% Si- 0.3% Mg) increases strength by precipitation of Mg2Si precipitates in aluminum matrix. Such alloys have good corrosion resistance. Alloys find applications in carburetor parts and pump castings, automotive, aerospace and many electrical industries based on their good electrical conductivity. LM 25 is solution treated at 535°C for 2-6 hours, and aged at 150-180°C for 3-5 hours. Achievement of specified minimum tensile properties is dependent on the magnesium content. In Al-7Si-0.3Mg, Si imparts high fluidity, low shrinkage, good hot cracking resistance and Mg is the major strengthening element by which Mg (0.3) strengthens the alloy by combining with Si to form Mg2Si precipitates. In the ‘as cast condition’ intermetallics appears as coarse precipitates. But after age-hardening treatment, it becomes finer and evenly distributed and this provides maximum strength. The strength and hardness of aluminum alloys can be increased by precipitation hardening heat treatment. Out of many aluminum alloys, Al-Si alloys are very much useful for structural applications. These alloys are age hardenable. Therefore, the mechanical properties can be improved by age hardening process. The main aim of the work is to study the heat treatment behavior of the alloy and its variation in hardness during heat treatment. The tensile properties and response to corrosive environment is also important properties studied in the present work. Structure-property correlation was studied by metallography.

II. EXPERIMENTAL WORK

The experimental work consists of production of Al-7%Si-0.3%Mg, precipitation hardening heat treatment, characterization of mechanical properties and corrosion behavior this alloy in NaCl and Na2CO3 solutions. The cast alloy (Al-7%Si-0.3%Mg) was homogenized in a Muffle furnace at 100°C for 24 hours and air cooled to relieve internal stresses and for homogenization. The homogenized samples were solutionized at 500°C for 3 hours followed by water quenching to get a super saturated single phase region. The solutionized samples were aged at 165°C and hardness values were measured using Rockwell hardness ‘B’ scale at regular intervals to know the peak aged and over aged condition. The tensile properties were characterized by using Hounsfield tensometer. Scanning Electron Microscope was used to study the mode of fracture. Corrosion characteristics of the alloy were studied in sodium chloride and sodium carbonate solutions.

III. Results and Discussion:

3.1. Microstructure:

Fig.1 (a) to (d) shows the microstructures of as cast, homogenized, solutionized, and aged alloy at 100X magnification. Fig. 1 (a) clearly shows a typical dendritic structure. It can be seen from Fig. 1(b) that homogenization has occurred. The microstructure of the aged sample is observed in Fig 1 (d) which clearly depicts that precipitation has occurred.

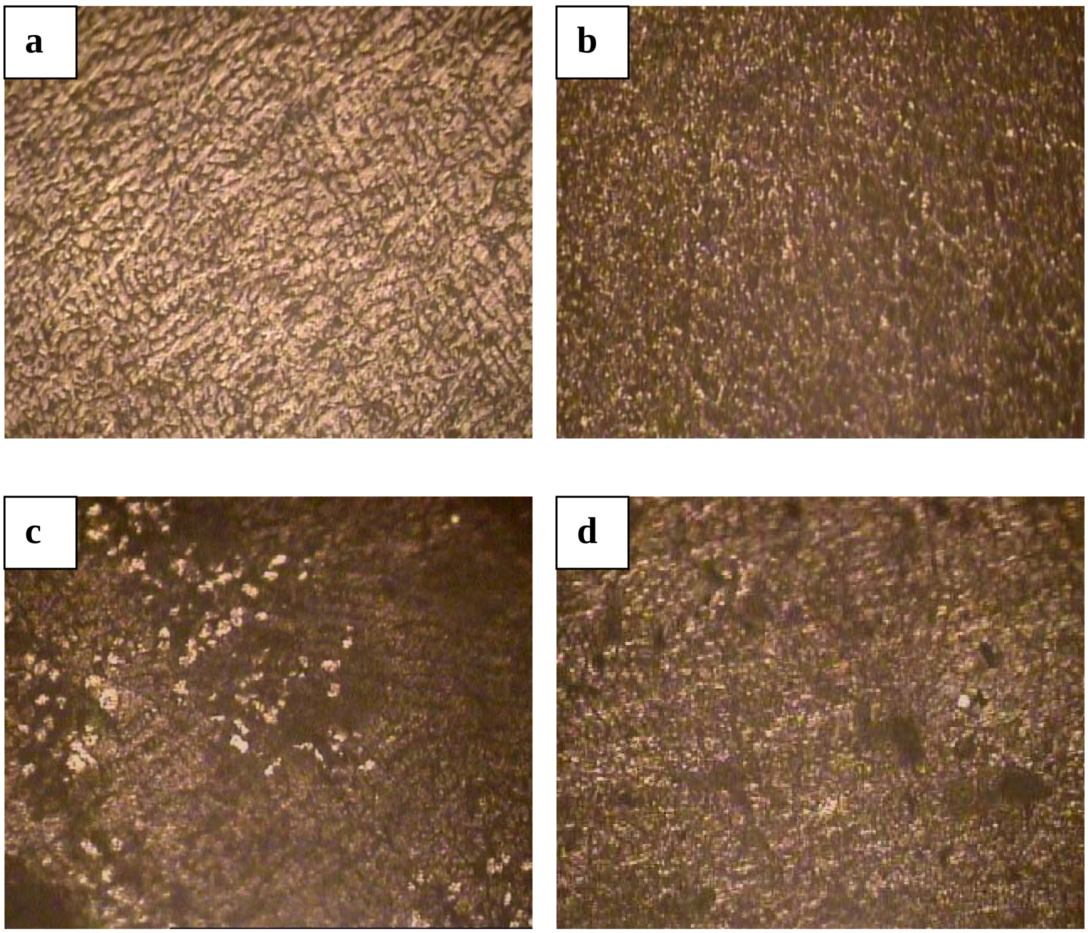

Fig. 1: Microstructures of (a) As-cast sample (b) Homogenized sample (c) Solutionized sample (d) Aged sample

3.2. Hardness :

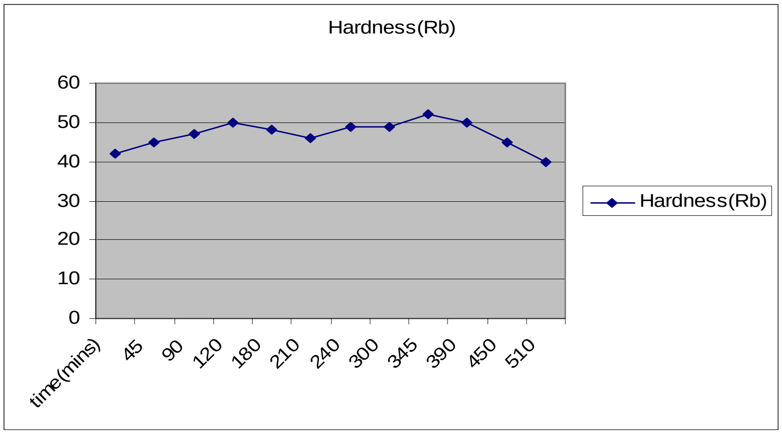

Fig. 2 : Relation between ageing time and hardness

Fig. 2 shows the variation of hardness with ageing time. The graph clearly reveals the increase in hardness with ageing time until attaining of peak age i.e., 6 hrs. Then the graph shows the decrease in hardness values from 52RB to 40RB.due to over ageing.

3.3 Tensile properties :

The effect of heat treatment on strength and ductile properties of the specimen in terms of ultimate tensile strength and % of elongation are observed in Table 1. It is seen from the Table that the elongation has decreased from homogenized to solutionized to aged samples. This may be due to the formation of intermetallic compounds. The SEM micrographs of the fractured samples are shown in the Fig. 3. The fractographs revealed the ductile mode of fracture which can be correlated to the values of the % elongation obtained.

Table 1 : Tensile properties of heat-treated sample

Condition of the Sample	Ultimate Tensile Strength (Kg/mm^2)	% of Elongation
Homogenized	11.49	28
Solutionized	17.45	26
Aged	16.27	20

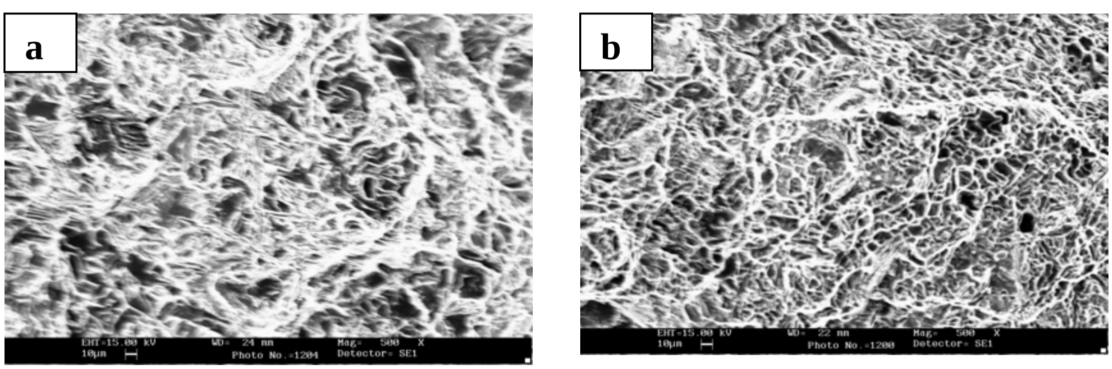

Fig.3 : SEM fractographs of (a) Homogenized Sample (b) Aged Sample

3.4 Corrosion:

The samples were found be corrosive resistant to sea water atmosphere and severely attacked by sodium carbonate solutions. Fig. 4 (a) and (b) shows the microstructures of corroded samples in 3% NaCl solution for 24 hrs and 48 hrs respectively. From the Fig. 4 (a) and (b) it can be clearly seen that no changes have occurred when compared to the as cast sample Fig. 1 (a). Fig. 4 (c) and (d) shows the microstructures of corroded samples in 3% Na2CO3 solution for 4 hrs and 6 hrs respectively. It can be clearly seen that there is transformation of as cast dendritic structures in the Fig. 4 (c) and (d) indicating that the alloy has undergone corrosive attack.

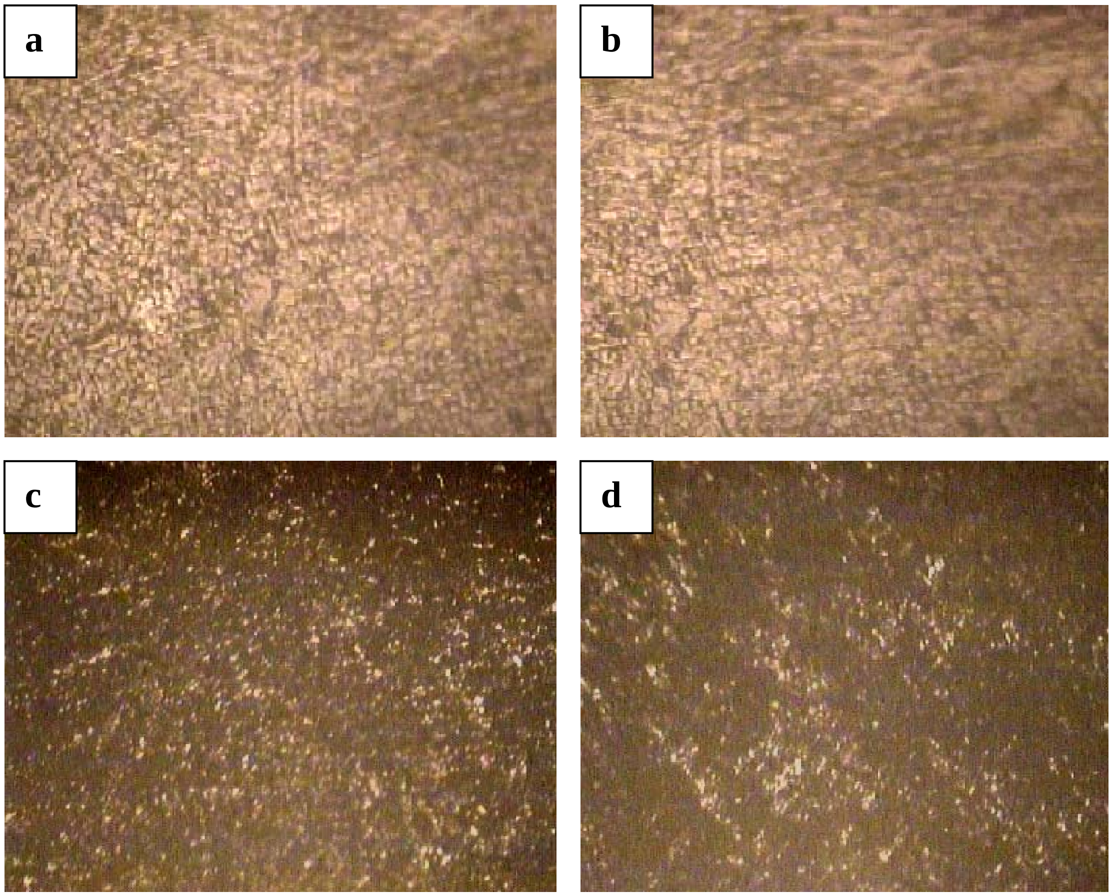

Fig. 4: Microstructures of corroded sample at 100x in
(a) 3% NaCl solution for 24 hrs (b) 3% NaCl solution 48 hrs
(c) 3% Na2CO3 solution for 4 hrs (d) 3% Na2CO3 solution for 6hrs

IV. CONCLUSIONS

The present study concluded that the microstructure of Al-7%Si-0.3%Mg alloy is refined in homogenized condition and there is decrease in hardness values from homogenized condition to over ageing from 52RB to 40RB respectively. The UTS values were found to increase from the homogenized (11.5 kg/mm²) to solutionized specimen (17.45 kg/mm²) but later on were decreased in over aged specimen (16.27 kg/mm²) and the % elongation was decreased from homogenized to aged specimen. The fractured surface of the specimens revealed the ductile mode of fracture. Corrosion resistance of the as-cast alloy in sea environment was high and the alloy showed a poor response to corrosion resistance in sodium carbonate solution.

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