Experimental Analysis In Mechanical Properties of Al-Si Alloy With Mg Addition

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Abstract- *Within the last few decade there has been a rapid growth in the application of aluminum-silicon alloys, particularly in the field of automotive and aerospace industries, due to their high strength to weight ratio, good corrosion resistance, less density, better wear resistance and low coefficient of thermal expansion. Due to this advancements it is mandatory ot study of the mechanical behaviour such as hardness, tensile strength and density are most important. In this current research, Aluminum matrix which containing 12% (weight percentage) of Silicon were synthesized using stir casting method. Chemical composition analysis and mechanical properties of the samples with different composition have shown near uniform dispersion of Silicon in the prepared alloys. The idea behind this work is to see the effect of addition of magnesium for there finement of microstructure.*

Keywords- Al-Si Alloy, microstructure, grain refinement, casting.

I. INTRODUCTION

Aluminium is a one of predominant metal having atomic number 13 with the FCC crystal structure. Due to the superior properties of aluminium which is extensively used as an engineering material and its low density with the competitive tensile strength when it is used in the form of alloy. Meanwhile its density is only around one third of steel its alloys are widely used in automobile, construction and aerospace engineering. The combination of suitable alloying with better heat-treatment can produce alloys which, suitable for wide range of engineering applications.

II. METHODOLOGY

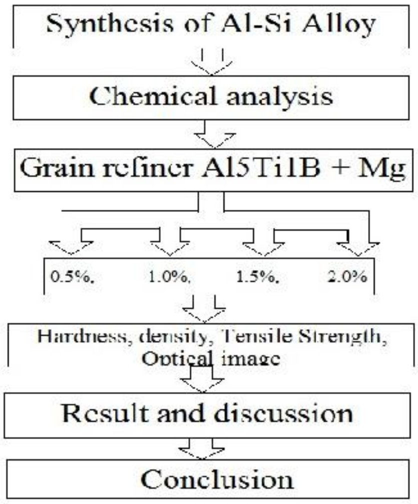
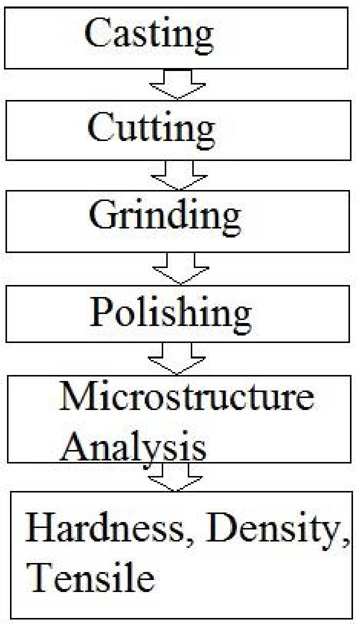


Fig 2.1 flow chart

III. EXPERIMENTAL METHODS



3.1 preparation of al-si, master alloys

Grain refiners were prepared with two different compositions (Al-3Ti-1B &Al-5Ti-1B) using halide salt route in a stir cast furnace. Then the grain refiners were added to the aluminium- silicon alloy (eutectic) at different compositions. Spectroscopic analysis has done on the sample for chemical composition of alloys. Samples of different dimensions were cut for different tests. Optical microscope was used for microstructural analysis. Scanning electron microscope (SEM) was used for higher magnification microstructure. The hardness was measured with the Vickers hardness testing machine. The tensile properties were obtained by conducting tensile test on tensometer. Effectiveness of grain refiners with different compositions on the mechanical properties of eutectic Al-Si alloy studied.

3.2 Preparation Grain Refiner (Al-Ti-B)

Materials and equipment required

1. Commercially pure Al (99.7% Al)
2. Halide salts **:**
   a. Potassium hexafluorotitanate (K2TiF6), &
   b. Potassium tetra fluoroborate (KBF4)
3. Resistance furnace
4. Stir – zirconia coated iron
5. Etchant- Keller’s reagent
6. Poulton’s reagent
7. SEM analysis
8. Degassing agent – Hexachloroethane
9. Flux- 45%NaCl+45%KCl+10%NaF

While the simultaneous addition of both the salts results a synergic reaction with molten aluminium and also both $TiAl_3$ and TiB_2 particles forms, which the most favorable condition for grain refinement.

3.3 Process parameter

Table 3.2 process parameters for the preparation of grain refiner

Alloy	Melting temp(⁰c)	Holding time (min)	Stirring(sec)
Al-5Ti-1B	800	30	30

3.3.1 CASTING:

It is the process of producing metal parts by pouring metal into the mould cavity of the required shape and allowing the metal to solidify. The solidified metal piece is called as “casting”.

Fig 3.2 Electric furnace

Fig 3.3 molten metal pouring to the die

3.3.2 DIE CASTING:

The process of producing near net shape casting by pouring molten metal in metallic cavities.

3.3.3 PROCESS PARAMETERS:

Table 3.3 Process parameter for casting of samples

Temperature	700⁰C
Holding time	20 -30 min
Degassing agent	Hexachloroethane (1%wt)
Stirring	30 sec
Die dimension	Length -14 mm Diameter- 35 mm
Temperature	1000°C
Voltage	230 V
Power	6 KW(3-Phase)

Fig 3.4 showing grinded sample

The sample was then polished on a fine polishing machine usi ng Alumina/diamond polishes.

3.4 CHARACTERIZATION:

3.4.1 MICRO STRUCTURAL ANALYSIS

The wellpolished samples were thenobserved under a n optical microscope.Micrographswere taken with the help of CCD camera attached tothe optical microscope and are further viewed on computerwith opticalimageanalyzer softwareat mag nification of 200X and400X for allthe different samples.

3.4.2 OPTICAL MICROSCOPY

Microstructures of the alloy samples were observed under computerized optical microscope. The Al-Si samples of different composition of grain refiner mechanically polished using standard metallographic techniques before the examination. Characterization is done in etched conditions. Etching was done using the Keller's reagent (1 volume part of hydrofluoric acid (48%), 1.5 volume part of hydrochloric acid, 2.5 volume parts of nitric acid and 95 volume parts of water).

Fig 3.4.1 Optical microscope for microstructural analysis

Table 3.4 Specifications of microscope

Experiment set up data	
Magnification	400x
Objective magnification	40x
Resolution	0.0005
Measuring distance	0.23 mm
Objective specification distance	0.9 mm

3.5.3 VICKERS HARDNESS TEST

The micro hardness tests of all the samples have been done using a Vickers's hardness testing machine. The applied load during the testing was 0 .3 kg, with a dwell time of 30 s. It has a square-base diamond pyramid indenter. The Vickers hardness number (VHN) is calculated from the following equation:

$$\mathbf{VHN = 1.854\ P/D^2}$$

Where,
P- Applied load, kg
D-Average length of diagonals, mm

Fig 3.5.2 Vickers hardness testing machine (Zwick 3212 hardness test)

3.5.4 DENSITY MEASUREMENT

Density of sample measured in density measuring instrument (HT/HTR 220E). It worked on the tuning fork technology. Weight of samples has taken in air and water respectively in the instrument (VIBRA-HT/HTR 220E) and the density has calculated for every samples.

Fig.3.5.3 Density measuring instrument

3.5.4TENSILE TEST

Tensile properties of the alloys were analyzed by carrying out test on the tensometer. Tensile tests were carried out with a load of 20 KN and cross-sectional area of 63.23mm^2, gauge length was 36 mm and gauge diameter was 9 mm.During the tests, the load elongation data is captured in a digital screen, whose data is used for further analysis.

Table 3.5 Specifications of tensile samples and motor specification of tensometer

Standard specimen specification	
Gauge length- 36 mm	
Gauge diameter- 9 mm	
Load	20 KN
Cross-sectional area	63.23 cm2
Motor specification	
Speed	1440 RPM
HP	¼ KW
Frequency	50 cycles
Current	2 Amp
Voltage	220 V

Fig 3.5.4 Tensometer (TIMER3) for tensile test

IV. RESULT AND DISSCUSION

4.1 MICROSTRUCTURE

Microstructural investigation of different sample will be analyses in this section at different magnification captured by optical microscope.

4.1.1 MICROSTRUCTURE OF BASE ALLOY

Microstructure obtained from optical microscope for Al-Si alloy containing 12.6%Wt Si in fig.4.1 for different magnification.

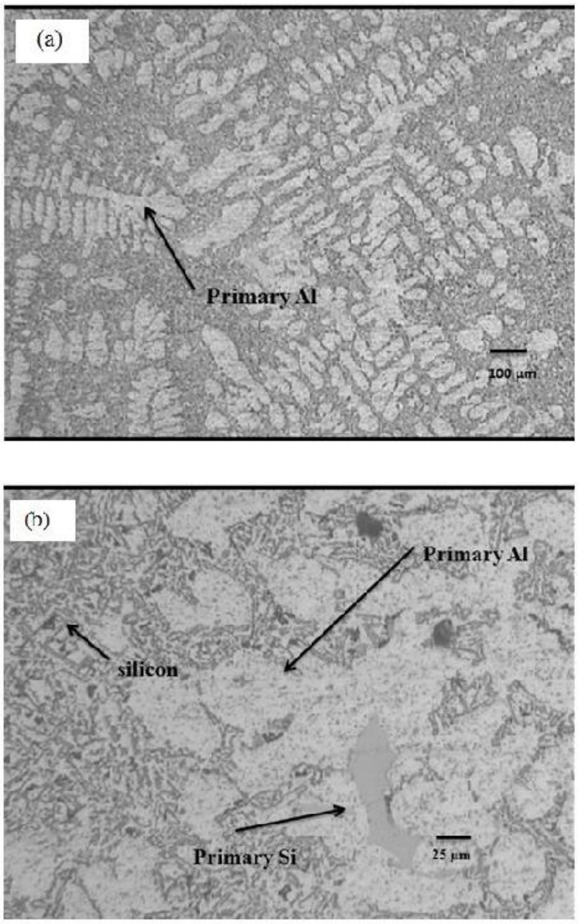


Fig 4.1 Microstructure of Al-Si alloy a) at 100x, b) at 400x

Microstructure of hypo-eutectic Al-Si captured in optical microscope gives information about the presence of α-Al, primary silicon and eutectic silicon in the alloy.

4.2 HARDNESS:

It embraces many different properties such as resistance to wear, scratching, deformation and machine ability etc.Hardness can be defined as the resistance of a metal to attempts to deform it.

Table 4.1 showing foe Vickers hardness number for different samples.

Sample No	Aluminium-silicon in(gms)	Magnesium (wt %)	Master alloy (wt %)	Hardness VHN
1	250	0.5	0.5	95.32
2	250	0.5	1.0	101.3
3	250	0.5	1.5	91.83
4	250	0.5	2.0	117.38
5	250	1.0	0.5	115.4
6	250	1.0	1.0	119.87
7	250	1.0	1.5	102.54
8	250	1.0	2.0	118.28
9	250	1.5	0.5	108.27
10	250	1.5	1.0	124.57
11	250	1.5	1.5	117.57
12	250	1.5	2.0	119.57
13	250	2.0	0.5	129.29
14	250	2.0	1.0	111.81
15	250	2.0	1.5	113.43
16	250	2.0	2.0	106.7

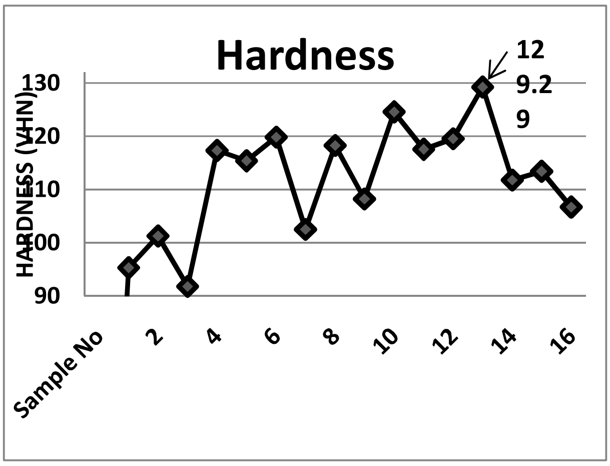


Fig 4.4 samples Vs Hardness

6.3 DENSITY:

The mass density of the material is the mass per unit volume. Unit-kg/m^3.

Table 4.2 showing for Density for different samples.

Sample No	Aluminium-silicon in(gms)	Magnesium (wt %)	Master alloy (wt %)	Density (gm/cc)
1	250	0.5	0.5	2.6948
2	250	0.5	1.0	2.6863
3	250	0.5	1.5	2.6876
4	250	0.5	2.0	2.7014
5	250	1.0	0.5	2.7008
6	250	1.0	1.0	2.7171
7	250	1.0	1.5	2.7106
8	250	1.0	2.0	2.7162
9	250	1.5	0.5	2.7498
10	250	1.5	1.0	2.7355
11	250	1.5	1.5	2.7200
12	250	1.5	2.0	2.6865
13	250	2.0	0.5	2.7210
14	250	2.0	1.0	2.6895
15	250	2.0	1.5	2.7112
16	250	2.0	2.0	2.6371

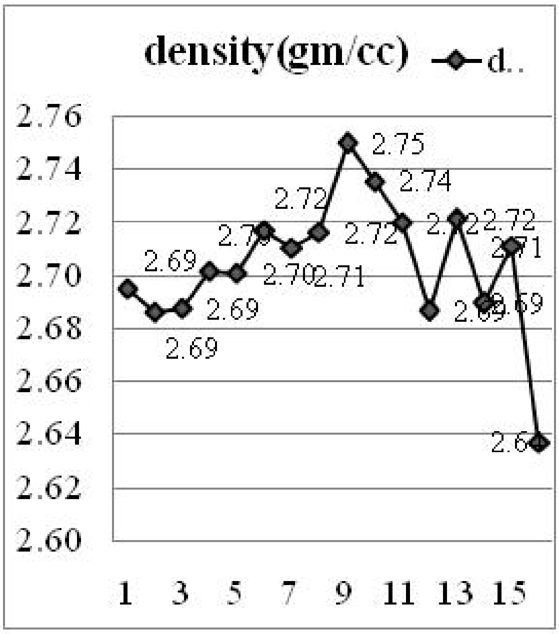


Fig 4.5 samples Vs density

4.4 TENSILE STRENGTH:

Table 4.3 showing for tensile strength for different samples.

Sample No	Aluminium-silicon in(gms)	Magnesium (wt %)	Master alloy (wt %)	TS (N/mm$^{2)}$
1	250	0.5	0.5	335.1
2	250	0.5	1.0	356.75
3	250	0.5	1.5	323.31
4	250	0.5	2.0	415.35
5	250	1.0	0.5	409.07
6	250	1.0	1.0	421.43
7	250	1.0	1.5	361.4
8	250	1.0	2.0	417.61
9	250	1.5	0.5	382.39
10	250	1.5	1.0	438.99
11	250	1.5	1.5	415.45
12	250	1.5	2.0	420.74
13	250	2.0	0.5	458.71
14	250	2.0	1.0	395.04
15	250	2.0	1.5	400.34
16	250	2.0	2.0	376.21

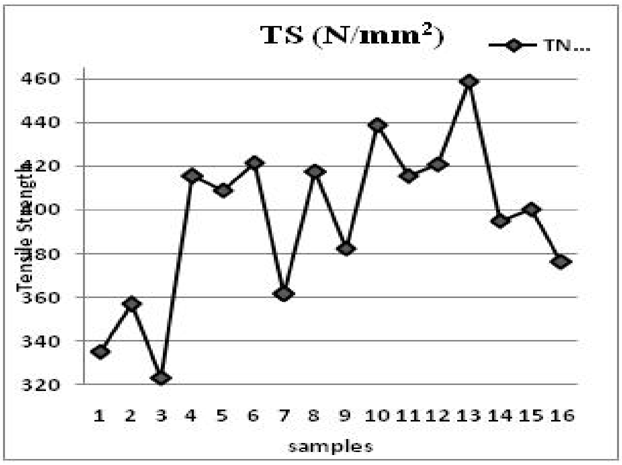


Fig 4.6 samples Vs Tensile Strength

V. CONCLUSIONS

- Eutectic aluminium silicon alloys were Synthesized .
- Al5Ti1B Master alloy was prepared viz Induction furnace(Reaction of K2TiF6+ KBF4 with CP Al).
- The hardness, tensile property of Before and after Grain refinement of Eutectic Al-Si alloy with different addition level of Mg were studied.
- Mechanical properties are increased and best combination of alloys were noted that sample number 13 such as Eutectic Al-Si + 2.0 % Mg+ 0.5% Al5Ti1B.

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