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Study of Tensile and Hardness Properties of Al-19Si-3Cu-0.4Sr Alloy in As-Cast And T6 Heat Treated Condition.

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ABSTRACT: Intension of this study is to conduct the mechanical test on the hyper eutectic heat treatable aluminum alloy with the rare earth element such as strontium. Alloy is prepared by conventional casting method and are subjected to solutionizing at 510°C and then T6 heat treatment for different Duration 0f 2hr and 4hr at 210°C, the mechanical test such as tensile and hardness test was performed for as-cast and the cast aged condition of Al-19Si-3.5Cu-0.5Sr alloy. The tensile strength and the BHN values are observed from the test show a great improvement as compared to the as-cast condition, UTS of the alloy improved by 11.5% and 26% for 2hr and 4hr aged alloy respectively as compared to as-cast, and BHN also by 11% as compared to the as-cast condition.

Key words: alloy, T6 heat treatment, UTS, solutionizing, BHN.

I. INTRODUCTION

The Aluminium Association (AA) has classified these alloys based on their chemical composition. The classification differentiates the cast alloys with three digits, and four digits are used to identify the wrought alloys. The first digit (e.g. 1xxx) indicates the purity or the family (second most abundant element) of the alloy. The rest of the elements can be found in the alloys with a range of compositions. For instance, our Al-Si alloy constitutes the 3xx.x family [1]. The most common Al-Si hypoeutectic alloys are the 319, 356 and 357 with 6-7 wt% Si. In the hypereutectic alloys typical compositions are the 390 and 393 containing between 13–18wt% Si and 25–30wt% Si, respectively. The digit after the decimal point is usually 1 or 0 and it is used to identify if the alloy is a cast or an ingot, respectively. Aluminium-Silicon (Al-Si) alloys are the most important among cast alloys and have widespread applications, especially in the aerospace and automotive industries [2, 3]. The dominant group of alloys is the Al-Si foundry alloys which contain between 5 and 25 wt% Si. Other additions include: Mg, Ni, and Cu. MUZAFFER ZEREN and ERDEM K* [4] Have studied the influence of Copper content on metal the hardness and micro structural characteristics of sand cast Al–Si–Cu alloys with 2% and 5% Cu have has been utilized for this purpose. Also the effect of artificial aging (T6 treatment) on mechanical properties studied. Copper is a one of the potent precipitation-strengthening agent in aluminium. Cu additions up to about 5% lead alloys with very high strength and good toughness when subject to natural or artificial aging. By increasing copper content, hardness increases due to precipitation hardening. It is found that increasing copper content from 2 to 5% increases hardness from 55 BHN to 115 BHN[4]**.** Hesham Elzanaty Have investigated the mechanical properties of Al–Si alloys are strongly influenced by the size, shape and distribution of Si phase present in the microstructure. Yield strength, ultimate tensile strength wear characteristics and hardness have increased with the increase of silicon content. But, percent elongation decreases with the increase of silicon content [5]. The development of Aluminium-Silicon

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alloys is very important due to its versatile application due to their good mechanical and tribological properties, such as high wear resistance, high strength to weight ratio, low coefficient of thermal expansion, high thermal conductivity, high corrosion resistance, good cast performance, good weld ability, etc. The improvement in the sliding wear resistance and mechanical properties depends on material related properties like shape, size and size distribution of the second phase particles in the matrix and microstructures in addition to the operating conditions such as sliding speed, sliding distance, temperature, load, etc.

Copper: Copper in Al-Si alloys usually containing 2 to 10% Cu. generally with other additions form important families of alloys. Both cast and wrought aluminum-silicon alloys respond to solution heat treatment and subsequent aging leads to improve in mechanical strength, hardness and machinability of alloys by increasing matrix hardness. The strengthening is maximum between 4 and 6% Cu[4].

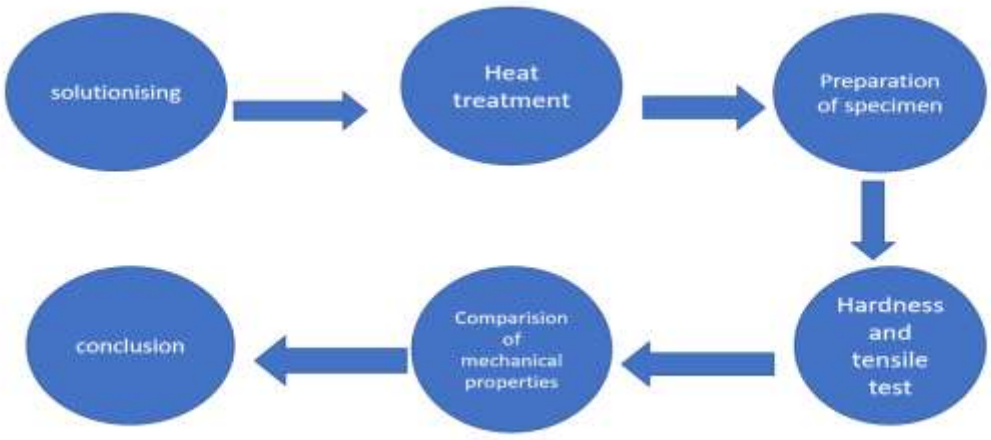
Silicon : The outstanding effect of silicon in aluminium alloys is the improvement of casting characteristics. Additions of silicon to pure aluminum dramatically improve fluidity, hot tear resistance, and feeding characteristics [6]. The most prominently used compositions in all casting processes are those of the Al-Si family.

Stronitium:

Abundantly employed solution to enhance the hypereutectic aluminium-silicon alloys mechanical properties the modifying rare earth elements such as Sr and Na are added to base alloy in order to modify the morphology of the alloy structure of eutectic silicon phase transform of coarse like structure to dendrites of fine fibers. Strontium is one of the most effective modifiers used in the foundries [7].From the research it was noticed that inclusion of the rare earth metals like strontium leads to the formation of structural defects like cavities and porosity.non binary al-si-mg intermetalic phases of magnesium are modified by the addition of strontium, and also it was noticed the Mg2Si phase are changed predominantly in its morphology with its structure of fragmented to skeletal[8].

II. EXPERIMENTATION

The bellow flow chart will show the experimental work carried out



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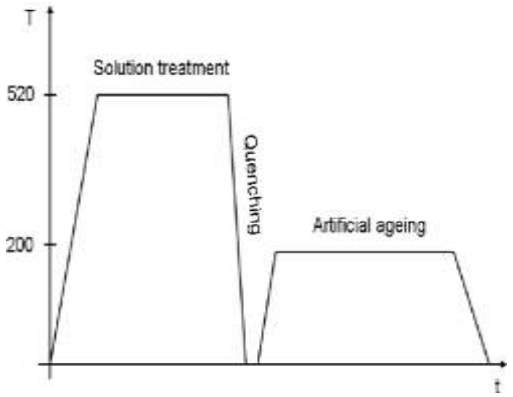
Chemical composition analysis of the Alloy formed by gravity casting in the ingot form is analysed by spectro spark emmision spectrometer(at KMRTC Hubli), the details of composition are listed in the table -1.

Table -1 Chemical composition of the alloy

Element	Al	Si	Cu	Sr
%	77	19	3	0.4

Heat treatment : the heat treatment process of alloy involves two important stages are solution treatment at around 520°C for a shorter duration of time in minutes and are immediately ice cold water quenched and again the specimens are placed in to furnace at 210°C for a duration of 2hr and 4hr and are air cooled. This process is carried out by using muffle furnace having accuracy of ±3ºC . heat treatment process result the homogenization of as-cast structure. Dissolution of certain inter-metallic phases such as Al2Cu and Mg2Si. Change of the morphology of eutectic silicon. Precipitation-hardening(artificial ageing 95°to260°C) results change in solubility, which intern improve the mechanical properties of Al alloys, such as strength and hardness with a corresponding loss in ductility, improved machinability, and reduced residual stresses. Depends upon the of the alloying constituents with temperature.

Figure -1: shows the heat treatment process of precipitation hardening

Steps in Precipitation hardening	Muffle Furnace
	 Muffle furnace

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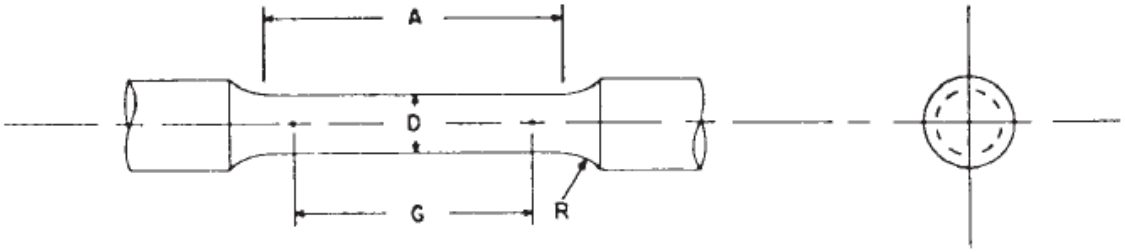
Heat treatment	Quenching

Specimen preparation

The tensile test specimens are prepared as per the ASTM standers as shown in figure-5 bellow. The ingot rods are machined with the help of lath machine and subjected to solution treatment and then artificial aging, the tensile test was performed on universal tensile machine UTM-400KN,



A=60 mm, D=12.60 (+\- .10)mm, R=10R,H=200 mm, S=20 mm.

Test specimen befor and after the tensile test

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BHN Test setup

BHN test specimens

The cylindrical test specimens are prepared by machining the ingot rods and are subjected to T6 heat treatment process and are polished and are used for the test the results are listed in table-2

III. RESULTS AND DISCUSSION

Table -2: Result of UTS and BHN

Sl no	Alloy Condition	UTS trial 1	UTS trial-2	Average UTS in Mpa	BHN trial-1	BHN trial-2	Average BHN
1	As-cast	132	137	134.5	73	88	80.5
2	2hr heat treated	152	148	150	77	86	81.5
3	4hr heat treated	167	170	169	90	89	89.5

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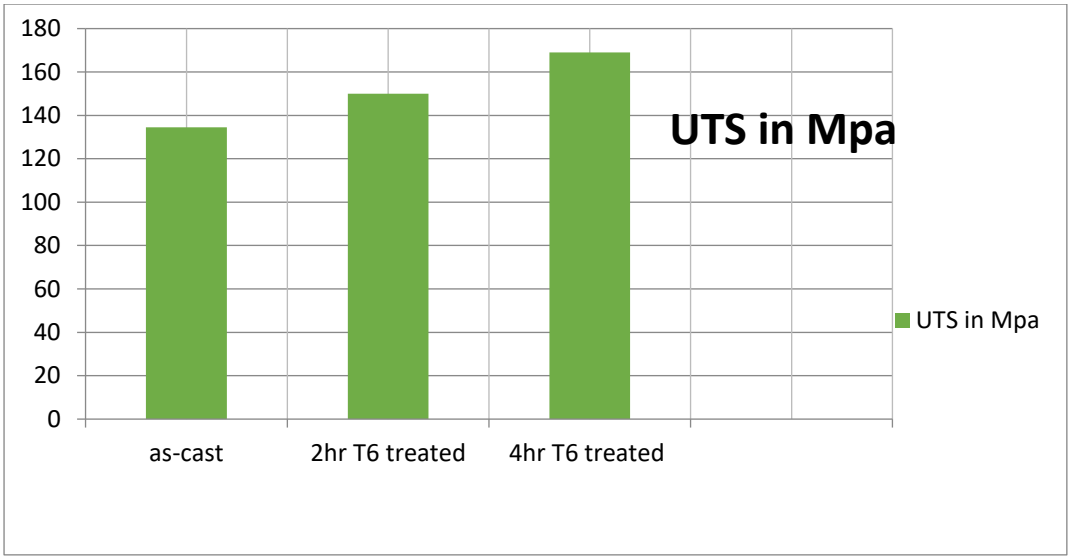
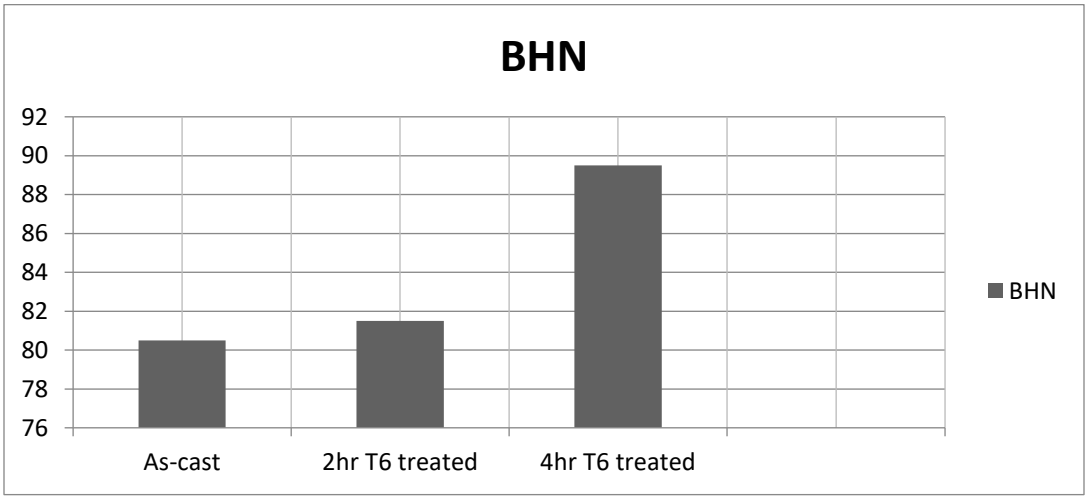
Figure-2: Ultimate tensile strength of alloy at different condition.



From the test results it is observed that the artificial aging in the presence of copper in the alloy will improve the percentage of elongation and the ultimate tensile strength of the alloy, from the table-2 the ultimate tensile strength of the ally at 2hr and 4hr heat treatment will result a better improvement as compared to that of as-cast. Test was carried out twice and the average values are listed

Figure-3: BHN values of as-cast and T6 heat treated Al-19-Si-3.5 Cu-0.4Sr



The hardness test results shown in table-2, the as-cast and 2hr heat treated samples will show the closer values of BHN, but the 4hr aged samples given better results of 11% improvement in its hardness as compared to as cast and the 2hr heat treated samples.

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IV. CONCLUSIONS

1. Artificial ageing of the alloy results improvement in its percentage of elongation and the Ultimate tensile strength. For 4hr T6 heat treated samples the UTS is improved by 26% as compaired to as-cast alloy.

2. Brinell hardness test results good hardness for 4hr aged alloy samples ie 89.5BHN which is 11% greater than the as-cast(80.5)

3. Due to higher presence of copper (3.5%) presence in the alloy will improve the tensile properties but simultaneously the harness will decrease.

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