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EFFECT OF DIFFERENT SI CONTENT ON THE MECHANICAL PROPERTIES IN AL-BASED ALLOY

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ABSTRACT

The aim of this work was to determine the effect of Si content on the mechanical properties of near eutectic and hypereutectic Al–Si alloys with high Si content. The alloys of different content of Si–namely, 2, 4, 6, 8, 11.6, 12.5, 15, 17 and 20 wt.% are produced by stir casting route in an induction heating furnace. The mechanical properties namely Tensile strength and Hardness were investigated according to standard procedure. Tensile tests were carried out with universal testing machine. Yield strength and ultimate tensile strength has increased with increase in silicon content. But, percent elongation decreases with the increase of silicon content. The hardness tests of all the samples were conducted using a Vicker's hardness testing machine. The hardness of the samples increases with the increase in silicon content.

KEYWORDS: Al–Based Alloy, Tensile Strength, Percent Elongation and Hardness

INTRODUCTION

At the original equipment level, the use of aluminum in main and rod bearings is growing for a variety of reasons. One among them is, aluminum bearings are less expensive to manufacturer and it also gets rid of lead which is an environmental concern for manufacturers. Aluminum alloys and other lightweight materials have growing applications in the automotive industry, with respect to reducing the fuel utilization and shielding the environment, where they can successfully reinstate steel and cast iron parts. These alloys are extensively used in buildings and constructions, containers and packaging, marine, aviation, aerospace and electrical industries because of their lightweight, corrosion resistance in most environments, or combination of these properties [2]. Aluminum based alloy provides good combination of strength, corrosion resistance, along with fluidity and freedom from hot shortness [4].

Aluminum alloys are distinguished according to their major alloying elements. Silicon is good in metallic alloys. This is because it increases the fluidity of the melt, reduces the melting temperature, decreases the shrinkage during solidification and is very inexpensive as a raw material. Silicon also has a low density, which may be an advantage in reducing the total weight of the cast component. Silicon has a very low solubility in aluminum; it therefore precipitates as virtually pure silicon, which is hard and hence improves the abrasion resistance.

Within the last few years there has been a rapid increase in the utilization of aluminum-silicon alloys, particularly in the automobile industries, due to their high strength to weight ratio, high wear resistance, low density and low coefficient of thermal expansion. The advancements in the field of application make the study of their wear and tensile behavior of utmost importance.

Mechanical properties are principally controlled by the cast structure. Microstructure evolution of hypoeutectic Al–Si alloys during solidification is in two stages: primary dendrite Al–phase formation (α–matrix), and the subsequent eutectic transformation (eutectic Si particles in α–matrix). The mechanical properties of Al–Si alloys depend, more on the distribution and the shape of the silicon particles [1, 2]. Aluminum–silicon alloys are divided into three groups:

- Hypoeutectic containing 5–10% silicon
- Eutectic containing 10–13% silicon
- Hypereutectic containing 13–25% silicon

MATERIALS AND METHODS

Al–Si alloys with varying Si contents were prepared by melting commercially pure aluminum (99.7%) and commercially pure silicon (99.5%) in a graphite crucible in a high frequency induction furnace and the melt was held at 720 °C in order to attain homogeneous composition. After degassing with 1% solid hexachloroethane, 0.1% Al–Ti master alloy was added to the melt for modification of microstructure. Each melt was stirred for 30 seconds after the addition of the modifier, held for 5 min and then poured into a cubical graphite mould surrounded by fireclay bricks. The cast samples were of 100 mm length, 30 mm wide and 20 mm height.

Tensile properties of the alloys were analyzed by carrying out test on the universal testing machine. The hardness tests of all the samples have been done using a Vicker's hardness testing machine. The applied load during the testing was 5 kgf, with a dwell time of 15 s. For each composition, five indentations were taken and average value is reported.

RESULTS AND DISCUSSIONS

Different tests like tensile test and hardness test on Al-Si alloys were carried out. The results obtained from these tests are analyzed and discussed. Mechanical properties of Al–Si casting alloys depend not only on their chemical composition but are also significantly dependent on microstructural features such as the morphologies of the Al-rich α-phase and of the eutectic Si particles.

The effects of silicon on the mechanical properties of Al-Si alloys are well studied. The mechanical properties of the Al-Si alloy are dependent on the size, shape and distribution of eutectic and primary silicon particles. Small, Spherical, uniformly distributed silicon particles enhance the strength properties of Al-Si alloys.

Tensile Properties

Tensile test is the most common procedure; hence it is an easy way to get information about the materials strength and deformation properties in a single tests. Some of the results from the tensile test are ultimate tensile strength, yield strength and percent elongation.

From figures (1) to (3), It may be observed that as the silicon content in the alloy increases, the strength properties (ultimate tensile strength and 0.2% tensile stress) of Al–Si alloys also increase to maximum value 189 MPa at 12.5 wt% of silicon, after which they show a decline with further increase in the silicon content. However, the percent elongation decreases continuously with increasing silicon content.

This may be largely attributed to the size, shape and distribution of silicon particles in the cast structures up to the eutectic composition. Silicon is present as fine particles and is uniformly distributed in the structure, and hence the strength properties increase. However, when the primary silicon appears as coarse polyhedral particles, the strength properties decrease with increasing silicon content.

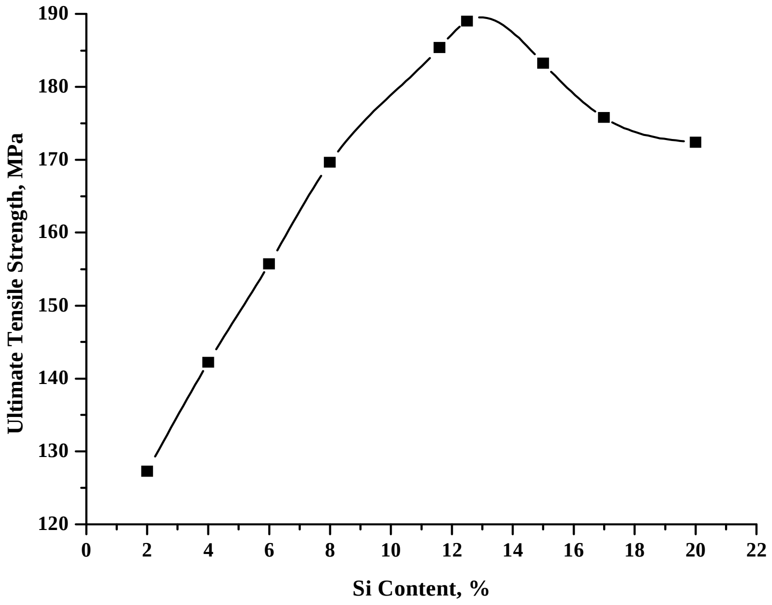

Figure 1: Effect of Si Content on the Ultimate Tensile Strength of Al–Based Alloy

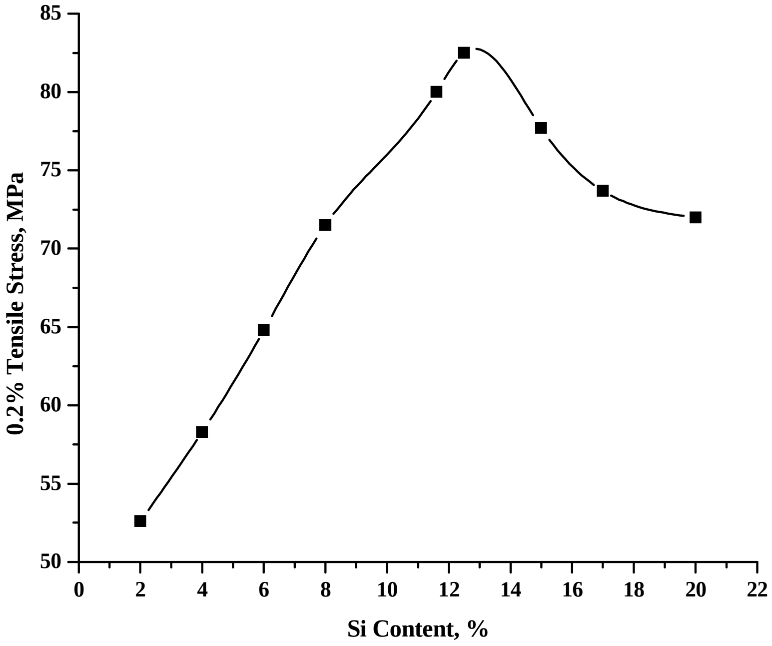

Figure 2: Effect of Si Content on the 0.2% Tensile Stress of Al–Based Alloy

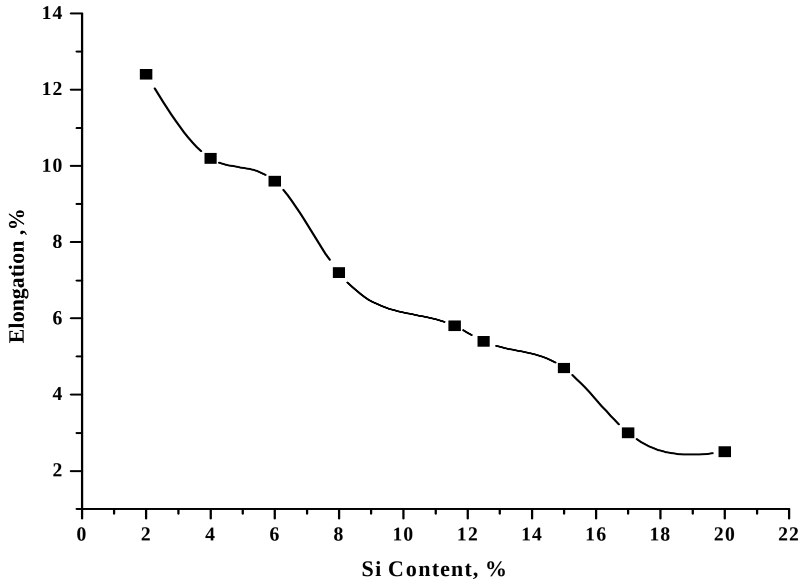

Figure 3: Effect of Si Content on the Percent Elongation of Al–Based Alloy

Hardness

The figure (4) shows that hardness of the Al–Si alloy increases with the increase in the silicon content. This may be due to the increment of silicon amount, which is harder. However, when the primary silicon appears as coarse polyhedral particles with increasing silicon content, the hardness goes on increasing because of the increase in the number of silicon particles.

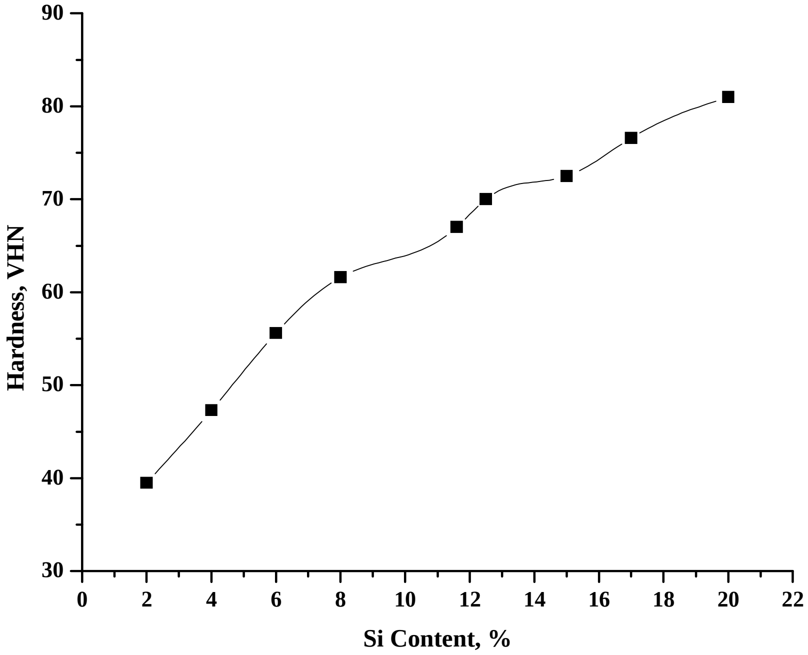

Figure 4: Effect of Si Content on the Hardness of Al–Based Alloys

CONCLUSIONS

- The prepared Al–Si alloys have homogenous distribution of silicon throughout the cast.

- The amount of primary silicon increases with the increase in silicon content in the cast.
- Yield strength and ultimate tensile strength increases with the increase in silicon content.
- Total elongation decreases with the increase in silicon content.
- Hardness of the Al–Si composite increases with the increase in silicon content.

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