Impact of Silicon Content on Mechanical Properties of Aluminum Alloys

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Abstract: ***Mechanical testing plays an important role in evaluating fundamental properties of engineering materials as well as in developing new materials and in controlling the quality of materials for use in design and construction. If a material is to be used as part of an engineering structure that will be subjected to a load, it is important to know that the material is strong enough and rigid enough to withstand the loads that it will experience in service. As a result engineers have developed a number of experimental techniques for mechanical testing of engineering materials subjected to tension, compression, bending or torsion loading. In present work we have studied the influence of silicon on mechanical properties such as ductility, hardness, toughness, yield strength of Aluminum alloy. The silicon content is varied from 5, 7, 9, 12.5 and 14% in five different aluminum alloys. The mechanical properties were measured using the tension test. It was found that the ductility has been decreased after increase in silicon percentage. Also there is a significant change in ultimate tensile strength and hardness due to silicon.***

Keywords: Aluminum alloys, Tensile strength, Ductility, Hardness

1. Introduction

Every Engineer is vitally concerned with the materials and their properties. Whether he has to manufacture a bridge, a machine or an automobile part, he must have an intimate knowledge to select suitable material for his products according to the requirements. In selecting a particular material, properties such as machinability, mechanical stability, chemical durability, electrical resistivity and thermal conductivity as well as cost of the material should be considered.

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 [5].

Mechanical properties are 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].

2. Materials and Composition

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 exachloroethane, 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 110 mm length and 16 mm diameter.

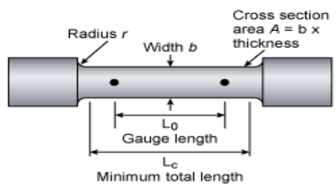

Figure : Geometry of specimen

3. Testing System

The testing system consists of a tensile testing machine, a load cell, a power supply and an X-Y recorder. Testing Machine is of hydraulic type (Alsa Universal Testing Machine). It is a load-controlled machine. Load Cell provides an electrical circuit for measuring the instantaneous load along the loading axis. Power Supply is connected to load cell. It feeds the load cell, amplifies the output signal and displays the load. Recorder plots the variation of load against time. The hardness tests of all the samples have been done using a Vickers hardness testing machine. For each composition, six indentations were taken and average value is reported**.**

4. Results and Discussions

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 test is the most common procedure; hence it is an easy way to get information about the materials strength and deformation properties in 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 tensile stress) of Al–Si alloys also increase to maximum value 175MPa at 14 wt % of silicon. However, the percent elongation decreases continuously with increasing silicon content.

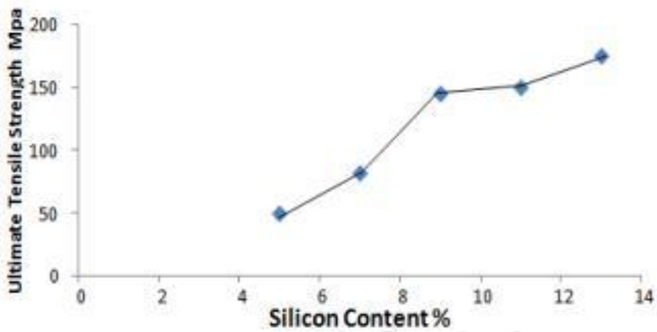

Figure 1: Effect of Si Content on the Ultimate Tensile Strength of Al–Based Alloy

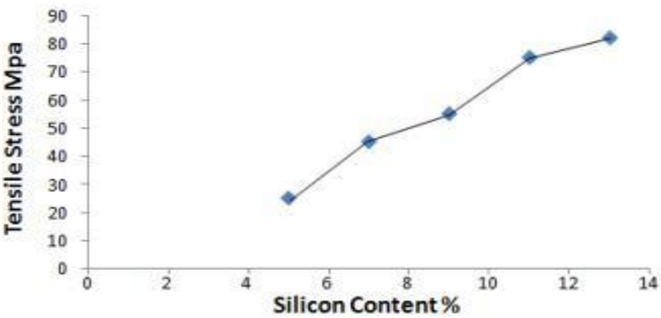

Figure 2: Effect of Si Content on the Tensile Stress of Al–Based Alloy

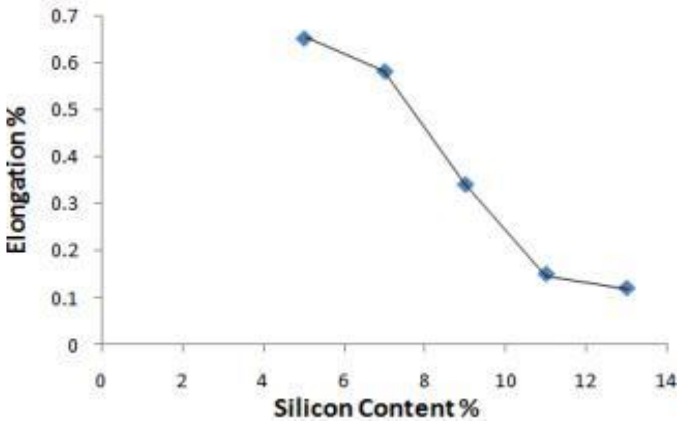

Figure 3: Effect of Si Content on the Percent Elongation of Al–Based Alloy

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.

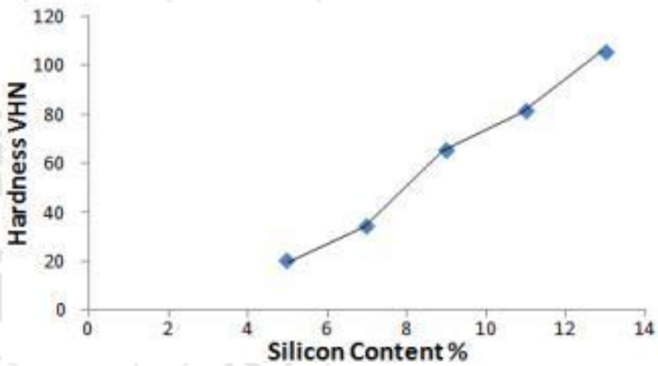

Figure 4: Effect of Si Content on the Hardness of Al–Based Alloys

5. 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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