Study of Reinforcement of Silicon powder in Aluminum Matrix and it's Mechanical Properties

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Abstract – *To save the fuel for fuel for future generations and saving the weight of components the aluminium is emerged as an alternative to Iron and Iron alloy the alloys of Aluminium are widely used in automotive industries due to its lower costs and lower density. The alloying elements used are manganese, magnesium, copper, magnesium, silicon, and zinc. Surfaces of aluminim alloys have a brilliant luster in dry environment due to the formation of a shielding layer of aluminium oxide. Aluminium alloys of the 4xxx, 5xxx and 6xxx series, containing major eleental additives of Si and Mg, are now being used to replace steel panels in various automobile indstries. The present work focused on investigating the mechanical properties of aluminium alloy by increasing the percentage of silicon. The results showed that with the increasing of silicon content the solidification time increased, also a decreasing the liquids temperature. The tensile strength of AL alloy is increased with increased Si content up to 6 %.*

Key Words: Silicon, Aluminium, Aluminium Alloy

1. Introduction

An alloy is a material having metallic properties and is formed by combination of two or more chemical element of which at least one is a metal. The metallic atoms must dominate in its chemical composition and the metallic bond in its crystal structure. Generally, alloys have different properties from those of the component elements. An alloy of a metal is made by combining it with one or more other metals or non-metals that often enhances its properties. For example, steel is stronger than iron its primary element. The physical properties, such as density and conductivity, of a alloy may not differ greatly from those of component elements, but engineering properties such as tensile strength and shear strength may be consider different from those of the constituent materials.[1]

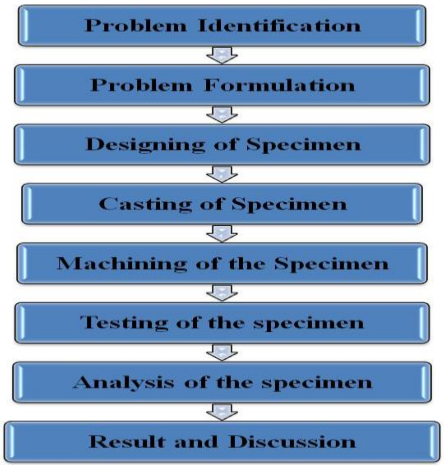
The tribological properties of Al-Si alloy are affected by shape and distribution of silicon particle, and addition of allowing elements such as nickel, Cu, magnesium, and zinc with a suitable heat treatment[1-4]. The excellent tribological properties Al-Si alloys have led to their extension uses in engineering applications, in plain bearings, internal combustion engine pistons, and cylinder liners [4, 5]. Silicon presence as a uniformly distributed fine particle in the matrix. However, when the primary silicon appears as coarse polyhedral particles, the strength properties decrease with increasing silicon content, but the hardness goes on increasing because of the increase in the number of silicon particles [7]. The high-temp. creep resistance of magnesium alloys was discussed, with special reference to Mg-Al and Mg-Y alloys. Mg-Al solid-solution alloys are superior to Al-Mg solid-solution alloys in terms of creep resistance. Manganese is also able to change the morphology of the iron-rich phase from to a more cubic form or to globules. These morphologies improve tensile strength, and ductility [8,9]. If the iron content exceeds 0.45 wt.%, it is reported that the manganese content should not be less than half of the iron [10]. Al alloys with silicon as a major alloying element are a class of alloys, which are the basis of many manufactured castings. This is due to the effects of Si in casting char, combined with other physical properties, such as make properties and corrosion [11]. Silicon is not only the most frequent impurity in pure aluminium, but also the most alloying element [12]. The influence of the Si content of the aluminium alloys on their wear resistance has been well documented and eutectic alloys are shown to have better wear resistance [13]. Forged wheels have been used where the loading conditions are highly extreme and where improvement in properties required. Al alloys have also found application in heat exchangers. Modern, high performance automobiles have many more individual heat exchangers, e.g. engine and transmission cooling system, charge air coolers (CACs), climate control system made up of aluminium alloys [13].

The several methods used for estimating fatigue properties of wrought aluminium alloys from simple tensile data or hardness was discussed. Among them, Park-Song modified.

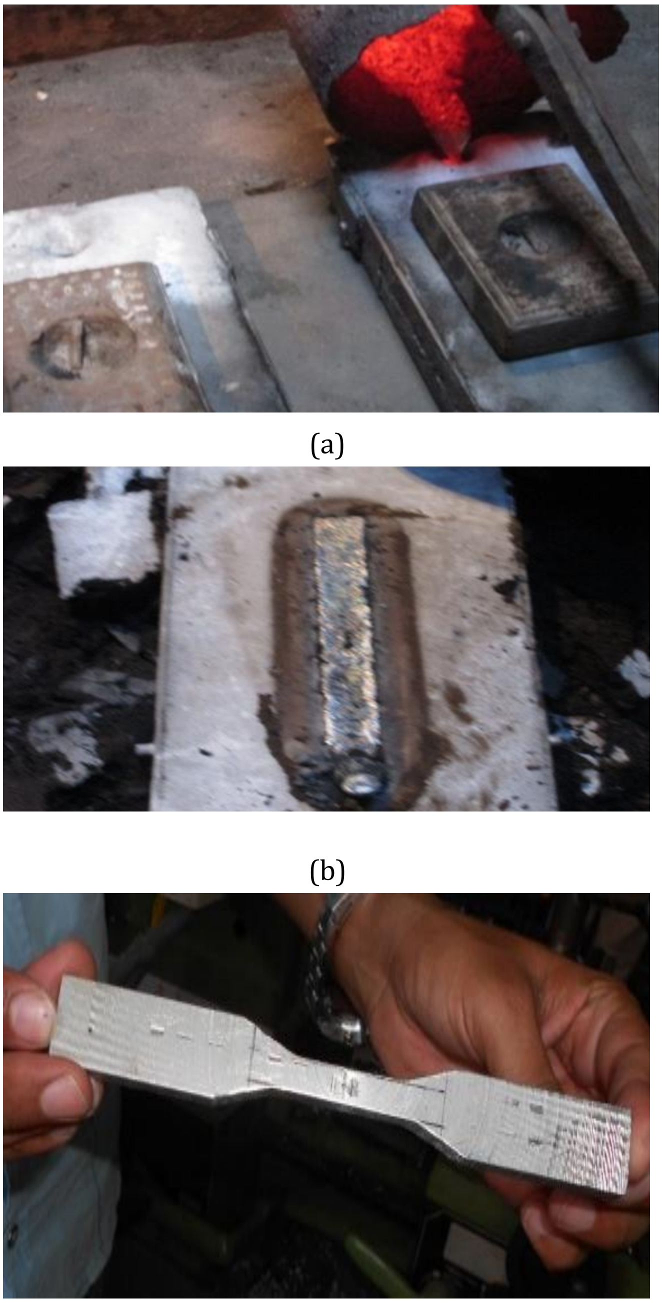
The re heat treatment is performed on Alloy AA 7075-T6 at various temperatures and hold times, and the subsequent aging is performed at 130°C for 12 hours. The microstructure and mechanical prop of the alloy are studied depending on the temp and the hold time of the retrogression heat treatment. Electron microscpic studies are preferred and mechanical char are determined in tensile and impact tests [12].

In this work we investigate the mechanical properties of aluminium alloy to vary the percentage of silicon, using specimens prepared with reference to ASTM D628-02 a [13].

2. Experimental Procedure:



In this process, the metal which has highest melting temperature is firstly poured in the crucible and allowed to melt on the furnace. The metal which posses low melting temperature is allowed to melt in the last because if it will allowed to melt with metal which posses highest temperature then lowest melting temperature metal will burnt.


(a)

(b)

(c)

Figure 1: (a) Pouring of molten metal into mould cavity, (b) Unfinished Product, (c) Finished Product

After pouring molten metal in a mould cavity allows solidifying into the mould cavity. The solidification time of the molten metal is given by Kornicsov's

Criterion.

According the Kornichsov's criterion, the solidification time of the molten metal in the mould cavity is directly proportional to the square of the ratio of volume to the surface area of the cavity.

$$T_s \alpha [v/S.A]^2 \quad (1)$$

$$T_s = k [v/S.A]^2 \quad (2)$$

T_s = Solidification Time
k = Constant of proportionality V = Volume of the cavity
S.A. = Surface area of the mould cavity

Dimension (mm)	Thickness 7mm or less		Over 7mm to 14mm
	Type –I	Type – II	Type – III
W-width	15	8	18
L-length	54	54	57
WO-width overall	18	18	28
LO-length overall	165	183	250
G-Gage length	50	50	50
D-grip distance	113	137	117

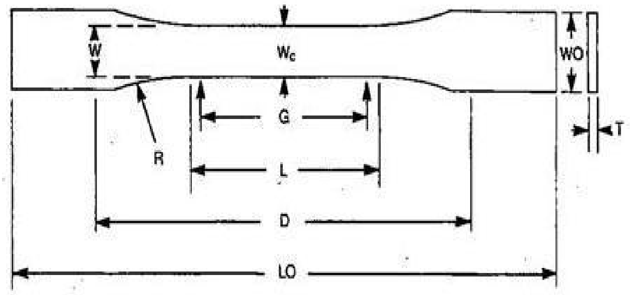


Figure 2:- Drawing of Test Specimen

The specimens 1 and, 2 are made with the help of ASTM code D638-02 a [21] and have the characteristics. Specimen 1 made of Type-I Specimen 2 made of Type-II.

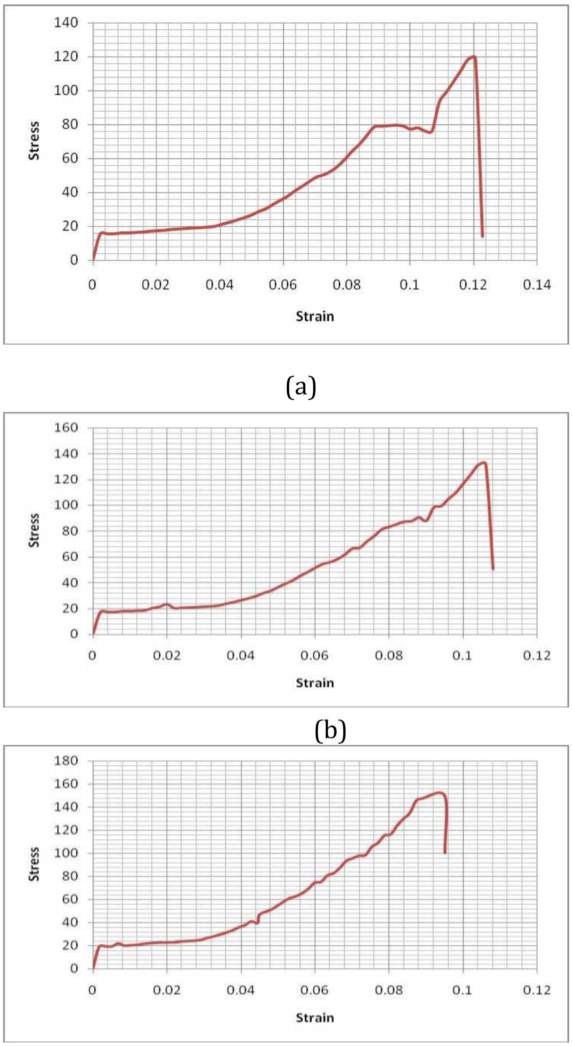
Alloying components	Al-Alloy Si-1.5%	Al-Alloy Si-3%	Al-Alloy Si-4.5%	Al-Alloy Si-6%
Silicon	1.5	3	4.5	6
Aluminium	92.9	91.4	89.9	88.4
Copper	3	3	3	3
Iron	0.8	0.8	0.8	0.8
Manganese	0.4	0.4	0.4	0.4
Nickel	0.3	0.3	0.3	0.3
Zinc	0.5	0.5	0.5	0.5
Lead	0.1	0.1	0.1	0.1
Tin	0.1	0.1	0.1	0.1
Titanium	0.2	0.2	0.2	0.2
Magnesium	0.2	0.2	0.2	0.2

Table 2:- Composition of Aluminium Alloy

3. Result and Discussions:

Silicon is the important single alloying element used in majority of aluminum casting alloys. Its primarily responsible for high fluidity, low shrinkage, low density which may be advantage in reducing total weight of cast component and has very low solubility in Aluminum therefore precipitates as virtually pure Si which is hard and improve the abrasion resistance. Si reduces thermal expansion coefficient of Al-Si alloys

Material	Specimen	Ultimate Tensile Strength (N/mm^2)	Mean Ultimate Tensile Strength (N/mm^2)
Al-Alloy (1.5 % Si)	1	119.21	120.87
	2	122.54	
Al-Alloy (3.0 % Si)	1	129.12	130.88
	2	132.65	
Al-Alloy (4.5 % Si)	1	138.24	139.74
	2	141.25	
Al-Alloy (6.0 % Si)	1	148.74	148.99
	2	149.25	



(a)

(b)

(c)

Figure 3:- Stress Strain Diagram for Aluminium Alloy (a) Si-1.5%, (b) Si-3%, (c) Si-4.5%

The stress-strain curve for Al specimens with an enlarged scale, now showing strains from zero up to specimen fracture. Here it is appears that the rate of strain hardening diminishes up to UTS (Ultimate Tensile Strength). Beyond the point, the material appears to strain soften as it, so that each increment of an additional strain requires a smaller stress.

A Study on Mechanical Properties of Aluminium Alloy with variation of Silicon element, tensile test is carried out at room temperature using UTM.

The variation of the silicon particles in aluminium alloy as shown in table -2. It can be seen that the ultimate tensile strength of aluminium alloy is increases with increase in silicon content as shown in table 3. The density & due to density weight of alloys decreases with the silicon content increased. The maximum tensile strength is found in Aluminium alloy (6% of silicon) 149.97 MPa, when we decrease the silicon content then the tensile strength will be decreases, the minimum tensile strength was found in Aluminium alloy (1.5% of silicon) 122.87 MPa.

Conclusion:

The mechanical properties of aluminium alloy was calculated with variation of silicon content, the following conclusion are

- As the silicon content increases the melting point of aluminium alloy is decreases & the fluidity will increases.
- With increase in silicon content the ultimate tensile strength of alloy will increase.
- The maximum ultimate tensile strength was 149.97 Mpa in 6% of silicon content in aluminum alloy.
- The minimum ultimate tensile strength was 122.87 Mpa in1.5% silicon content in al alloy.

REFERENCES

[1] Yang C.Y., Lee S.L., Lee G.K., Lin J.G., Effect of Sr and Sb modifiers on the sliding behaviour of A357 alloy under varying pressure and speed conditions, Wear, 2006, 261, p. 1348-1358.

[2] Harun M., Talib I.A., Daud A.R., Effect of element additions on wear property of eutectic aluminium-Silicon alloys, Wear, 1996, 194, p.54-59.

[3] Dwivedi D.K., Wear behaviour of cast hypereutectic aluminium silicon alloys, Mater Des., 2006, 27(7), p. 610-616.

[4] Davis F.A., Eyre T.S., The effect of silicon content and morphology on the wear of aluminium-silicon alloys under dry and lubricated sliding conditions, Tribology International, 1994, 27(1), p. 171-181.

[5] Torabian H., Pathak J.P., Tiwari S.N., *On wear characteristics of leaded aluminium silicon alloys*,Wear,1994, 177(1), p.47-54.

[6] Torabian H., Pathak J.P., Tiwari S.N., Wear Characteristics of Al-Si Alloys, Wear, 1994,172(1), p. 49-58.

[7] Kouichi Maruyama, Mayumi Suzuki, and Hiroyuki Sato, Creep strength of magnesium-based alloys, vol. 42, 2008.

[8] S.G. Shabestari, M. Mahmudi, M. Emami, J. Campbell, Inter. J. Cast Metals Res. 15 (2002) 7–24.

[9] Miller W.S., Zhuang L., Recent development in aluminium alloys for the automotive industry, Materials Science and Engineering: A, Volume 280, Issue 1, Pages 37-49

[10] Jing li, Zhong-ping zhang, Qing sun, Chun-Wang li, and Rong-sui li a modified method to estimate fatigue parameters of wrought aluminium alloys, july 31, 2010).

[11] Kouichi Maruyama, Mayumi Suzuki, and Hiroyuki Sato, Creep strength of magnesium-based alloys, vol. 42, 2008.

[12] Das, S., Mondal, D. P., Sawla, S. & Ramakrishnan, N.(2008). Synergic effect of reinforcement and heat treatment on the two body abrasive wear of an Al-Si alloy under varying loads and abrasive sizes. Wear. Volume264, Issues 1-2. Pages 47-59.

[13] The jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.10 on Mechanical Properties. Current edition approved November 10, 2002.

BIOGRAPHIES

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