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Effect of Trace Addition SB and NA in Al-Si alloy

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Abstract – *Aluminium-Silicon alloys are of greater importance to engineering industries as they exhibit high strength to weight ratio, high wear resistance, low density, low coefficient of thermal expansion etc. Silicon imparts high fluidity and low shrinkage, which result in good cast ability and weld ability. The main advantages of Al-Si alloy are Heat treatable, good flow characteristics, medium strength, easily joined, especially by brazing and soldering. The solidification of the alloy continues with formation of Al-Si eutectic mixture. In eutectic solidification two phases of Al and Si precipitate simultaneously from the liquid at constant temperature. Figure presents a phase diagram of the Al-Si system with a eutectic point. The eutectic point is at 12.6 wt. % Si and the eutectic temperature is 577 ℃. Aluminium dissolves a maximum of 1.6 wt. % of Si while the solubility of Al in Si is almost zero. Eutectic alloys provide a natural composite which gives good properties for the alloy. Commercial aluminium alloys often contain other alloying elements such as Cu and Mg in addition to Si. The eutectics of these alloys may be more complex than those observed when looking at the binary system. Formation of Cu- and Mg-bearing intermetallic phases often occurs after eutectic formation. The undercooling depends on the cooling rate, the concentration of the alloying element in the melt and the type of the alloying element. It is well established that the undercooling increases with increasing cooling rate and increasing concentration of the alloying element.*

Key Words: solidification, undercooling, metallographic study, thermal analysis, microstructural characterization, Optical fractography, Guinier-Preston (GP) zones, thermal rate treatment (TRT) etc.

1. INTRODUCTION

A single master alloy (grain refiner cum modifier) that serves the purpose of both grain refinement and modification simultaneously is a better option in converting the micro- structure of elongated α-Al dendrites into fine equiaxed dendrites and needle-like eutectic Si particles (Al-Si alloy) and primary + eutectic Si particles (Al-Si alloy) into fine particles. It is experimentally proved that started improvement in the mechanical properties of Al-Si alloys by combining chips of two different master alloys, i.e., 0.05% of Ti and 0.05% of Sr, to the melt. The advantage of using a single master alloy is that it serves both purposes of grain refinement and modification, thus directly reducing the manufacturing cost and simplifying the foundry operations. Al-alloy belongs to group of hypoeutectic Al–Si alloys and has a wide field of application in the automotive and avionics industries. It is used in the heat-treated condition in which an optimal ratio of physical and mechanical properties is obtained. The alloy solidifies in a broad temperature interval (43℃) and is amenable to treatment in semi-solid state as well as castings. For this reason, it is the subject of rheological investigations, as well as methods of treatment in the semi solid state. By these methods, it is possible to obtain castings with reduced porosity of a non-dendritic structure and with good mechanical properties. Besides this the Al alloy is used as a matrix for obtaining composites, which have an enhanced wear resistance, favourable mechanical properties at room temperature and enhanced mechanical properties at elevated temperatures. Cast aluminium alloy is one of the most well-developed aluminium alloys due to its outstanding properties. It is widely employed in numerous automotive and industrial weight sensitive applications, such as aeronautics and space flight, because of its low density and excellent cast ability. The Al alloy contains about 50 vol% eutectic phases. Al alloy finds wide application in the marine, electrical, automobile and aircraft industries.

2. METHODOLOGY

To modify Al-Si alloy by using Na & Sb in different proportions as describe below, further it is compared the machinability, microstructure, hardness, tensile strength with pure Al-Si alloy for proper improvement of this alloy.

3. REQUIRED MATERIAL

Raw aluminium silicon alloy (LM-6)

Modifier (Sb, NaF and NaCl)

Degasser

4. MODIFICATION PROCEDURE

i) Firstly, put the pure Al-Si alloy to the muffle furnace at 740℃.

ii) Then with this molten metal mixed up 1/3 of NaCl and 2/3 NaF and adding a composition of Sb with this molten metal.

iii) Hold this molten metal for 15 min after adding all this composition for proper mix up.

iv) Poured the whole composition in the die for a desire shape and size.

v) After getting that shape the whole composition in different circumstances and different load conditions are tested.

5. EXPERIMENTAL INVESTIGATION

Al-Si alloy was prepared from commercially pure Al-Si using electric resistance furnace with a graphite crucible, then Na 0.02 wt.% and Sb of 0.2 wt.%, 0.04 wt.% Na and 0.3 wt.% Sb, 0.04 wt.% Na and 0.2 wt.% Sb, 0.02 wt.% Na and 0.3 wt.% Sb were added at 740^{o} C. Those different mixtures are melted for 15 mins inside the furnace, the molten metal was poured into a permanent mould for desire shape and size which will use for further experiment.

5.1 SCANNING OPTICAL IMAGE

Optical image of alloy samples was observed under optical microscope. The cast surface of Al-Si samples with different modification were observed under the microscope to look on the casting effect of different modifier.

5.2 METTALARGICAL STUDIES

Microstructural characterization studies were done to observe the microstructure of sample surface and also the surface after machining. This is done by using scanning electron microscope. The Al-Si samples of different weight composition were 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). The microstructural image of the different specimens is observed.

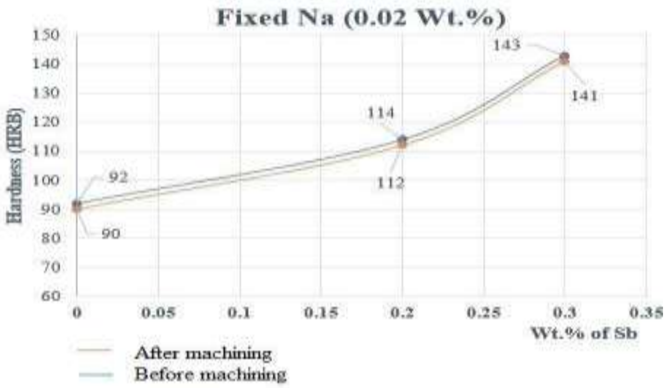
The hardness tests of all the samples have been done by using a Rockwell hardness testing machine. The applied load during the testing was 100 kgf, with dwell time 30s. It has a steel, ball type indenter with a diameter 1/16". From the B-Scale of the setup we get the HRB of that particular specimen.

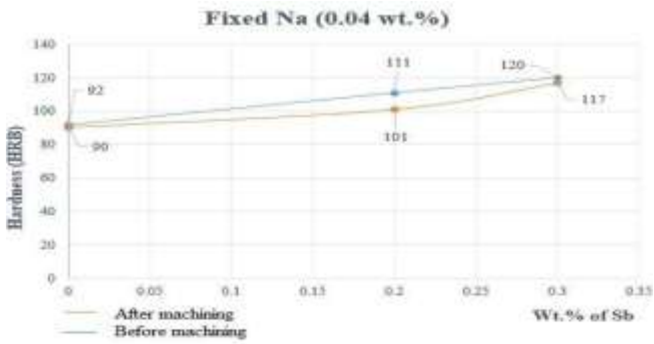
5.2.1 SURFACE ROUGHNESS

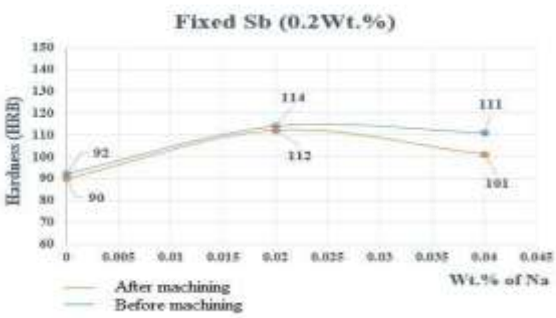
With the more precise demands of modern engineering products, the control of surface texture together with dimensional accuracy has become more important. It has been investigated that the surface texture greatly influences the functioning of the machined parts. The properties such as appearance, corrosion resistance, wear resistance, fatigue resistance, lubrication, initial tolerance, ability 'to hold pressure, load carrying capacity, noise reduction in case of gears are influenced by the surface texture.

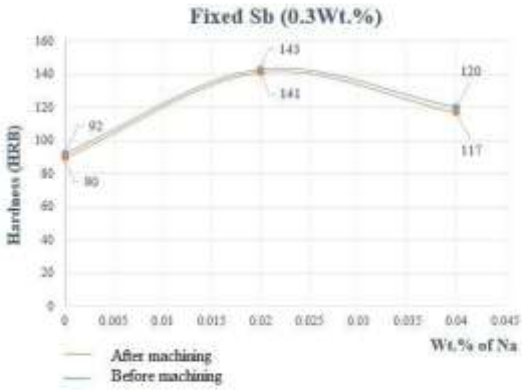
Specimen no.	Wt. of pure Al-Si alloy (in gm.)	Total Wt. of Na (in gm.)	Nacl (in gm.)	NaF (in gm.)	Sb (in gm.)
1.	308	6.10	2.00	4.10	61.6
2.	282	11.30	3.80	7.50	84.6
3.	298	11.90	3.90	7.90	59.6
4.	289	5.70	1.90	3.80	86.7

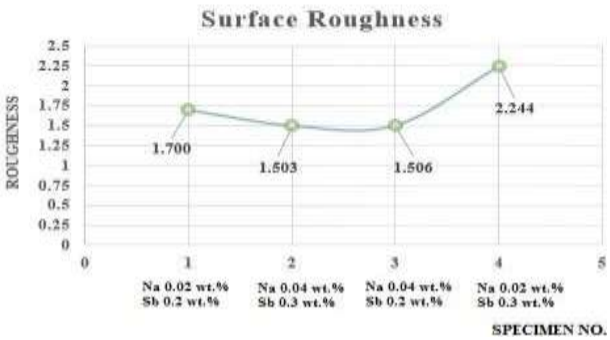
Table: Weight of different modifier present in the modified Al-Si sample.











5.3 MICROSTRUCTURE ANALYSIS

Fig. 1

Fig. 1 Microstructure of non-modified Al-Si alloy which shows the needle type Si particles which cause high stress concentration in this alloy, due to this mechanical property reduce significantly.

Fig. 2

Fig. 2 In this case 0.04 wt.% of Na and 0.3 wt.% of Sb used as modifiers, due to this modification the effect of Si particles reduce more significantly than the previous one, and it's also improve mechanical properties compare to specimen 1.

Fig. 3

Fig. 3 This fig shows the optical micrograph of Al- Si alloy with 0.04 wt.% of Na and 0.2 wt.% of Sb. This microstructure also shows the refinement of eutectic silicon particles, but the effect of the modifiers is bit less as lesser amount of Sb is used than the previous one.

Fig. 4

Fig. 4 This microstructural morphology shows the refinement of Si particles increases as the wt.% of Sb increases and Na wt.% decreases, in this case 0.02 wt.% of Na and 0.3 wt.% of Sb decreases, the increasing amount of Sb make the Si particles more refine which also improve the mechanical strength.

6. CONCLUSIONS

The conclusions drawn from the conducted investigations are as follows:

The hardness of the Al-Si alloy is increased with the higher wt.% of Sb as well as with lower wt.% of Na, it is also observed that the stress due to machining caused a decrement of hardness no for all compositions of Al-Si alloy.

From the microstructure analysis, we observed that with 0.02 wt.% Na & 0.3 wt.% Sb, in Al- Si alloy the eutectic particle size is smaller and uniformly distributed in the microstructure and with 0.04 wt.% Na & 0.2 wt.% Sb caused the large and more amount of Si grains in microstructure.

The higher amount of Sb & lower amount of Na caused rougher cast surface and lower amount of Sb and higher amount of Na caused less rough cast surface.

7. REFERENCES

1. S. A. Kori, B. S. Murty, and M. Chakraborty, Mater. Sci. Eng. A 283, 94 (2000).
2. P. Moldovan, G. Popescu, C.A. Popescu, I. Apostolescu, and A. Buzaianu, Advanced Materials Research 23, 295 (2007)
3. Conley JG, Huang J, Asada J, Akiba K Mater Sci Eng A285:49 (2000)
4. M. Makhlouf, H. Guthy, Journal of Light Metals, 1 199-218; (2001)
5. M. Djurdjevic, H. Jiang, J. Sokolowski, Materials characterization, 46 31-38; (2001)
6. Yang X, Jing Y, Liu J J Mater Process Technol: 130–131:569 (2002)
7. D.M. Stefanescu, Science and Engineering of Casting Solidification, Kluwer Academic/Plenum Publishers, New York, (2002)
8. H. Ye, Journal on “An overview on the development of Al-Si alloy based material for engine application; ASM International; Vol 12; PP 288-296 (2003)
9. Freitas de ED, Ferracini Junior EG, Piffer VP, Ferrante M Mater Res 7(4):595 (2004)
10. Pacs M, Zoqui EJ Mater Sci Eng A 406(1–2):63 (2005)
11. S.P. Nikanorov, M.P. Volkov, V.N. Guri, L.I. Derkachenko; Structural & Mechanical properties of Al-Si alloy; Material Science and Engineering A390; PP 63-69 (2005)
12. P. Feng, J. Tang, X. Jin, S. Li, and D. Zeng, Mater. Sci. Technol. 22, 50 (2006).
13. B. Su�ez -Pe� and J. Asensio -Lozano, Material Charac- terization 57, 218 (2006).
14. Natarajan N, Vijayarangan S, Rajendran I Wear 261:812 (2006)
15. H. Fredriksson, U. �kerlind, Materials Processing during Casting, John Wiley & Sons Ltd, Chichester, (2006)
16. H. Liao, M. Zhang, Q. Wu, H. Wang, and G. Sun, Scr. Mater. 57 1121 (2007).
17. M. Faraji and L. Katgerman, Inter. J. Cast Metals Research22, 1 (2009).
18. O. Uzun, F. Yilmaz, U. Kolemen, and N. Basman, J. Alloys Compd. 509, 21 (2011).
19. H. Fredriksson, U. �kerlind, Solidification and Crystallization Processing in Metals and Alloys, John Wiley & Sons Ltd., Chichester, (2012)
20. M. Javidani, D. Larouche; “Application of Cast Al-Si Alloys in Internal Combustion Engine Components”; Institute of Materials, Minerals and Mining and ASM International; Vol 01; PP-1-27 (2014)
21. G. Kalhapure, P. M. Dighe, “Impact of silicon content on mechanical properties of Aluminium alloy”; International Journal of Science and Research (IJSR), PP 38-40 (2015)
22. J. A. Lozano & G. V. Voort on a “Al- Si phase diagram”; Buehler, A division of Illinois Tool Works; Vol 5; Issue 1; PP 1-4.
23. H. Torabian, J.P. Pathak. and S.N. Tiwai.; Wear Characteristics of Al-Si alloys, Wear; An International Journal on the Science and Technology of Friction; Vol. 172 ;(1994)
24. M.G Kalhapure1, P.M Dighe; Impact of Silicon Content on Mechanical Properties of Aluminium Alloys; International Journal of Science and Research (IJSR) ISSN; Volume 4; (2015)