TO DETERMINE THE MECHANICAL PROPERTIES OF ALUMINIUM 7175 ALLOY IN THE PRESENCE OF STRONTIUM

(PROPERTIES OF AL7175 WITH STRONTIUM ADDITIONS)

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Abstract
The addition of strontium has a beneficial results in mechanical properties of Al7175 Alloy. The strontium modification can improve ductility, and impact properties. Strontium modification of AL7175 alloys has significant role on the presence of porosity in the casting. The addition of 0.02 to 0.05% gives improved compressive stress up to 650 Mpa, however increase in strontium additions over 0.1% decreases its compressive stress.
Keywords: AL7175, Strontium additions, Compressive stress

I. Introduction

Aluminium is the third most abundant material in earth, having low density, relatively soft, durable, lightweight, ductile malleable, better strength and cost effective, still it's properties are comparably lower than Titanium and its Alloys [1].

Aluminium alloys are used extensively in aerospace industries for having the properties such as Corrosion resistance, Low density, High strength to weight ratio, Low modulus of Elasticity, Non-Magnetic, low Thermal Expansion.[2]

Microstructure of alloys can be varied significantly in the processes of plastic working and heat treatment allowing for fitting their mechanical properties including fatigue behavior to the specific requirements.

Function of Alloying elements is to increase the alloy strength (Pure Aluminium has low strength of < 60 MPa) [3]

Alloying elements when added to Aluminum alloys produces effects of precipitation hardening (age hardening), solid solution hardening, dispersion strengthening, grain refining, modifying metallic and inter-metallic phases, suppression of grain growth at elevated temperatures (e.g. during annealing),wear resistance and other tribological properties.[4]

Alloy Al-7175 is typically utilized in applications where improved formability and toughness are desired [5]

The addition of Strontium results in a fine and fibrous silicon structure during solidification and produces several benefits. The Strontium modification may improve the ductility, fracture, and impact properties. Furthermore Strontium modification can effectively be used to reduce the solution treatment time of the alloy. Despite these benefits there is a degree of apprehension associated with modification primarily because of the apparent increase of porosity in the casting. The Sr addition can reduce the rejection rate and improves the casting quality. Approximately 0.02% of Sr will refine platelets into fibrous form. [6]

Under modification and over modification can occur with modification process. The excessive amount of Sr (.12 to .2%) will result in the formation of undesirable compounds such as Sr Si2 and Al2 Si2 Sr. As a general rule slight over modification is preferable if control of the Sr level is not good enough to achieve optimum Sr content.[6]

II. Literature Survey

Light weight is perhaps aluminium's best know characteristic having a density of approx. 2.7 x 103 kilograms per cubic metre at 20'C as compared with 7.9 x 103 for iron and 8.9 x 103 for copper. Commercially pure aluminium has a tensile strength of about 90 mega Pascals. Its usefulness as a structural material in this form is thus somewhat limited. However, by working the metal, as by cold rolling, its strength con be approximately doubled, Much larger increases in strength con be obtained by alloying aluminium with small percentages of one or more other metals such as manganese, silicon, copper, magnesium or zinc. Aluminium has a high resistance to corrosion on surfaces exposed to the atmosphere A thin transparent oxide skin forms immediately and protects the metal from further oxidation.[6]

Tensile strength of the 0.1% Sb and 0.013% Sr modified aluminum A356 alloy in sequence increased 31% and 33%, yield strength around 6% and strain to fracture 84% and 88% relative to the unmodified alloy. Therefore, the most profound effect of the modifier is on the ductility.[7]

Tensile strength and percent elongation increased respectively from 111 Mpa to 165 Mpa and 2.4% to 5.9% for Sr modified. The Sr modified samples contain a significant number of pores compared to the unmodified castings. The chill reduced the porosity in both the modified and unmodified castings. Comparison of modified and unmodified casting shows the Sr modified samples contain higher porosity than the unmodified. The optimum amount of Sr content for achieving a modified fibrous structure in a sand mould is 0.013% Sr (by weight) [7].

It shows that with the addition of Sr, the morphology of the primary silicon crystals has changed from faceted to non-faceted shape. This change is attributed to the adsorption of Sr atoms onto the surface of the primary silicon.

Thus, it prevents the TPRE growth mode and introduces an impurity-induced twinning growth mode. The needle-shaped eutectic silicon of LM30 alloy turns into a coral-like fibrous structure on addition of Sr. The qualitative analyses show that with the addition of Sr, the eutectic silicon is modified to a greater extent. Liu et al.[8] studied the effect of Sr on Al-20 % Si and concluded that the addition of 0.04 % Sr modifies the eutectic silicon, and found that there was a considerable decrease in the eutectic temperature with Sr addition.[9].

III. Experimental procedure

In the present study, experiments are conducted in order to make castings of Aluminium Alloy 7175 with varying percentage of Strontium

Strontium additions in the order of 0.02%, 0.05% 0.10%, 0.20% and 0.30% to Al-7175 is taken, stir casted and poured into a mould cavity. This obtained mould is used to test the mechanical properties.

Fig. 1 MELTING FURNACE

A. *Calculation of Mass % of Strontium*

The Required amount of Strontium additions to Aluminium Alloy 7175 is calculated as shown in the sample calculation shown below.

<u>Sample Calculation for 0.2% weight of Sr</u>

- Weight of Al 7175 alloy – 830 gm
- Coverall Flux – 1% of Al 7175 alloy – 8.3 gm
- Strontium Addition - 0.2% weight of Strontium
- = 830 x 0.2/100 = 1.66 gm
- Weight of Al – 10% Sr = 1.66 * 10 = 16.6 gm

Al-10%Sr Master Alloy is weighed and taken as per Table 1

TABLE I. WEIGHT OF AL-10%SR MASTER ALLOY

SL No	Percentage of Strontium in Grams		
	Weight of AL7175	***% of Sr***	***Required Al-10% Sr Master Alloy***
1	***ASCAST***	–	–
2	***893***	***0.02***	***1.8***
3	***880***	***0.05***	***4.4***
4	***877***	***0.10***	***8.8***
5	***831***	***0.20***	***16.6***
6	***819***	***0.30***	***24.5***

B. Stir Casting

Aluminium 7175 alloy ingot and Al-10%Sr master alloy in weight is taken in a crucible as per the calculation shown and heated in electrically operated pit furnace.

Coverall Flux and Degasser is added to the crucible while charging the Alloy. The purpose of adding the flux is to prevent the melt surface from oxidation and contamination.

The addition of degasser is to drive away the dissolved hydrogen, which will otherwise be present in the solidified ingot as porosities. The heat is transferred to the metal through convection and radiation. The charge is heated up to 750^{0}c and stirred; meanwhile the moulds are preheated to a temperature of 250^{0}c.

The molten metal is poured into the preheated moulds at 720^{0}c. Then the moulds are allowed to solidify. The drying of the mould is shown in the figure. After solidification, the casting is removed from the mould.

Fig. 2 AL7175- Sr Alloy poured into the Mould Cavity

C. Standard Sample Dimensions

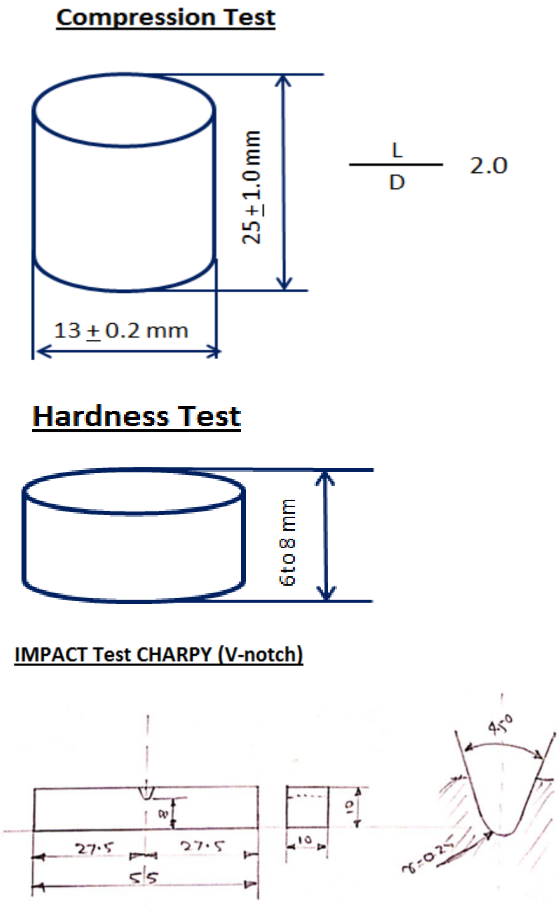

Fig. 3 Compression , Hardness, Impact Test Samples

D. Sample preparations

Samples are cut from random portions of each casting and are machined to get the standard size for testing, such as Hardness Test, Impact Test and mechanical compression testing. The drawing of the samples are given in Section C.

Compression testing was carried out using computer controlled UTM. The required dimensions of the specimen were measured and noted. Then the specimen is loaded onto the UTM.

Ultimate compressive strength, is obtained directly from the computer interface with the machine. Similarly Impact Test is carried out in Chary Impact Test and Hardness Test in Rockwell-C scale Hardness Tester.

Fig. 4 Compression Test Samples

Fig. 5 IMPACT Test Samples

IV. Results and Discussion

Addition of strontium increases ultimate stress of AL7175 alloy from 588MPa to 650 MPa (0.65 KN/sq mm) up to 0.05% from Compression Test as shown in the graph below. Thereafter the reduction in compressive stress is observed and hence a detailed microstructure test would provide a better understanding in morphology of the alloy.

A. *Compression Test results*

Compression test results shows there is increase in ultimate stress of the test samples up to 0.05% of strontium additions there after there is a reduction in stress values which shows the optimum value of strontium addition is 0.05%.

For 0.05% Sr additions 0.650 KN/sq mm is the Ultimate stress.

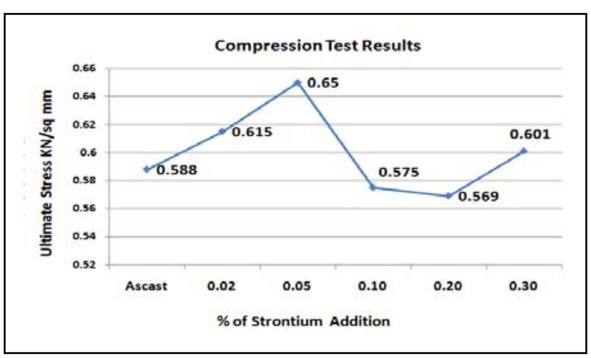

Fig. 4 Compression Test Results

However, the effects of varying Strontium % in AL7175 needs further investigations as the tensile properties and microstructural analysis would give good assessment of the alloy.

B. *Impact & Hardness Test*

Impact Energy of 4.4 Kg.m was observed for all the samples. Similarly Hardness Number of 50 to 55 HRC was observed for all the samples and hence found comparatively there is no change in amount of energy absorbed by the samples.

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References

[1] ASM, Specialty Hand BOOK, Aluminum and Aluminum Alloys edited by Joseph R. Davis

[2] Mohan Raju S, Dr. S Krishna and Dr.C.M.Ramesh, “A Comparative Study Of Aluminium Alloy And Titanium Alloy“ , IJRMEE ISSN2349-7947

[3] A Text Book of “Aluminum: Properties and Physical Metallurgy” edited by John E. Hatch, Constitution of Alloys Page 48.

[4] A Text Book of “Casting Aluminum Alloys” By Michael V Glazoff, Vadim S Zolotorevsky, Nikolai A Belov

[5] "Titanium-6-4". Retrieved 2009-02-19.ASM_METAL HANDBOOK

[6] Gautam Krishnan.R, Dr E. M. Somasekharan Nair R. Nicole, “Study of Strontium modification in Aluminium Alloy.

[7] S.A.jenabalijahromi, a. Dehghan** and s. Malekjani ”Effects of optimum amount of sr and sb modifiers on tensile, impact and fatigue properties of a356 aluminum alloy ”.

[8] Liu, G., Li, G., Cai, A., and Chen, Z., “The Influence of Strontium Addition on Wear Properties of Al–20 wt. % Si Alloys Under Dry Reciprocating Sliding Condition,” Mater. Design, Vol. 32, 2011, pp. 121–126.

[9] V. Vijeesh, M. Ravi, and K. Narayan Prabhu “The Effect of the Addition of Strontium and Cerium Modifiers on Microstructure and Mechanical Properties of Hypereutectic Al-Si (LM30) Alloy“.