Material characterization on Functionally Graded Al-Cu alloy Fabricated using Centrifugal Technique

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Abstract - *Aluminum 2014 (Al-Cu) is one among the strongest aluminum alloy and it is the functionally graded material which has its application in the field of Aerospace and Automotive Industries. An intensive study of this Cast Aluminum family has been found in many literatures for increasing the mechanical properties and grain refinement of the aluminum alloys. The main objective of this work is to study the properties of Al 2014 produced by Horizontal Centrifugal Casting process at different rotating speeds (400rpm 600rpm and 800rpm) wit fixed pouring temperature (650°C). The mechanical properties such as tensile strength and hardness were studied using Electronic Tensometer and Brinell Hardness Tester. It was observed that the tensile strength and hardness are increased with the increase in rotary speed of the mold. Also, the microstructure of the sample had very fine grain refinement enhancing good property at higher Rotational speeds of the mold.*

***Key Words*: Al-Cu alloy, Tensile strength, Grain size, Microstructure, Hardness.**

1. INTRODUCTION

Functionally Graded Materials (FGMs) are the class of engineering materials characterized by their spatial variation of composition and microstructure aiming at controlling corresponding functional properties (i.e. mechanical, thermal, electrical, etc.). This material exhibits steady progress in the microstructure as well as the composition in a definite way, the presence of FGMs, which prompts variety in useful execution inside the part through micro structural control. [2] In castings inhomogeneous distribution in composition, is a typical defect although microsegregation usually between 10 and 100 μm can be minimized/eliminated by heat treatments but macrosegregation (cm to m) is essentially unaffected and this may influence the effects of heat treatment, result in property variations and damage the quality of the final product. [1]

Centrifugal casting is one of the promising processes taking major role in the production of functionally graded material. It is a process of producing hollow castings by causing molten metal to solidify in rotating mould. The operations include in centrifugal casting are rotation of mold at a known speed, pouring the molten metal and extraction of the casting from the mold. The solidification is quite rapid and hence good metallurgical quality is achieved as solidification starts from the inner surface of the mold corresponding to casting outer surface, so low melting point impurities are carried by the solidification front to the casting inner surface and gas porosity is also forced at the casting inner surface because of its low density and also fine grain structures are formed.[5] On Centrifugal casting the first melt that reaches the wall surface of the mold will backing the income fresh metal and hence forms nucleation sites hence promoted for fast solidification fine grains[6]

The centrifugal process eliminates the mid wall effects because the inner surface will completely be in the liquid state during the solidification process which results in a continuous feed of metal in the areas of contraction, thereby ensuring the absence of trapped porosity.

2. EXPERIMENTAL PROCEDURE:

2.1 Material Selection: The increase in the demand for the aluminum and its alloys in Aerospace and Automobile industrial applications due to its favorable properties such as high specific toughness, good strength, good machinability and good wear properties. In this alloys aluminum is the base and other materials such as Si, Mg, Cu, Mn, Fe, Zn are the alloying elements. In this study Al 2014 (Al-Cu) has been taken because of its popularity which is remarked as the strongest alloying elements.

Elements	Cr	Cu	Fe	Mg	Mn	Si	Ti	Zn	Al
Percentage	0.1	5	0.7	0.8	1.2	0.5	0.15	0.25	Remaining

Chart-2.1 The chemical composition of Al 2014 (Al-Cu)

2.2 Methodology: The hollow cylindrical casting of outer diameter 72mm and length 84mm with wall thickness of 8mm were produced by using Horizontal centrifugal casting process which is shown in the fig . As mold rotational speed is one of the process parameter which influences the rate of solidification. The centrifugal casting were produced at their rotational speed of the mold such has 400rpm, 600rpm and 800rpm.The pouring temperature is kept constant as 650°C, Due to the centrifugal force which is acting away from the central axis the denser metals in the alloy will be towards the wall of the mold and lesser denser metals towards the central axis thus influencing the property of the metal. The casting specimens are cut to prepare the specimen to conduct various tests like Brinell Hardness Test, tensile test are performed.

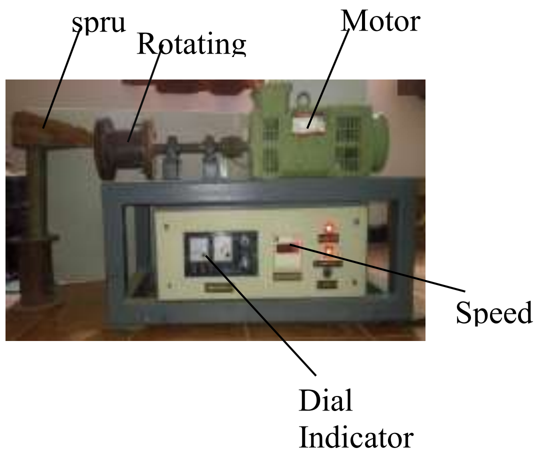

Fig-2.1 Experimental setup of horizontal centrifugal casting

Fig-2.2 Mold formed after centrifugal casting

3. RESULTS AND DISCUSSION:

3.1 Microstructural Analysis: The figure shows the microstructure obtained from the castings Produced at different Rotational speeds of the mold.

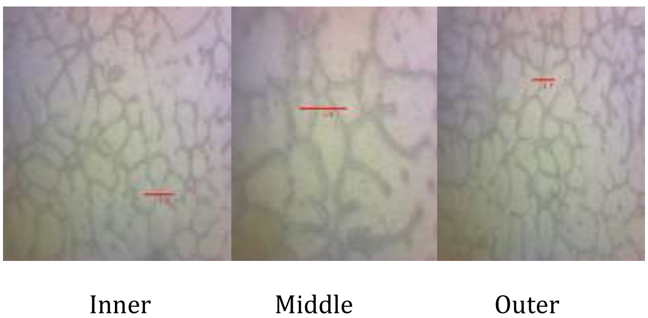

Fig-3.1a Microstructure of Al-Cu Specimen-1 (650°C temperature at 400rpm speed)

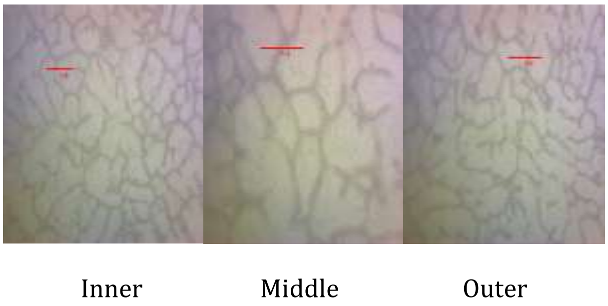

Fig-3.1b Microstructure of Al-Cu Specimen-2 (650°C temperature at 600rpm speed)

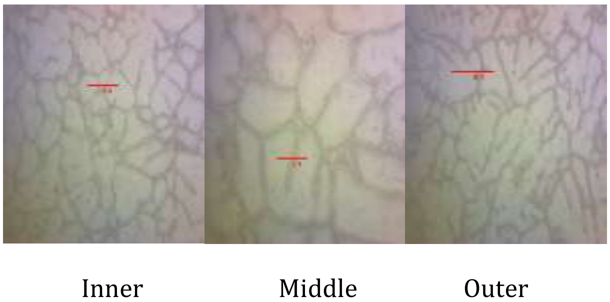

Fig-3.1c Microstructure of Al-Cu Specimen-3 (650°C temperature at 800rpm speed)

3.2 Hardness test:

The graph shows the variation of hardness along the radial direction among three specimens which was experimented at different rotary speeds.

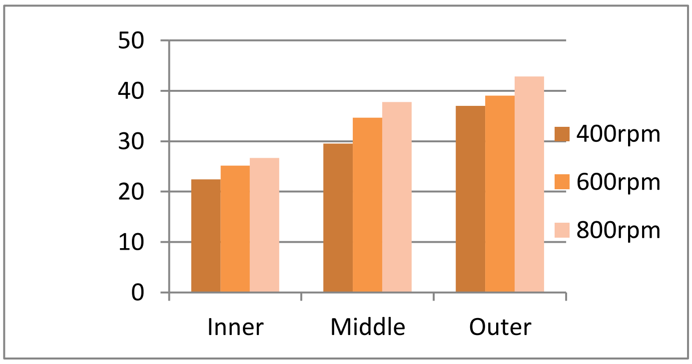

Chart-3.2 Variation of Brinell Hardnesss number from inner to outer region

It shows similar variation in rate of solidification of the casting along the radial direction. The cast shows higher hardness number at the outer and inner region due to the rapid solidification of the casts. The outer surface is harder due to the chilling effect where the molten metal is contacted to the mold surface. The lower hardness number at the middle region indicates that the metal takes more time to solidify compared to inner and outer radius.

3.3 Tensile test:

The pictures show the tensile specimen before and after fracture

Fig-3.3 Tensile specimen before and after breaking

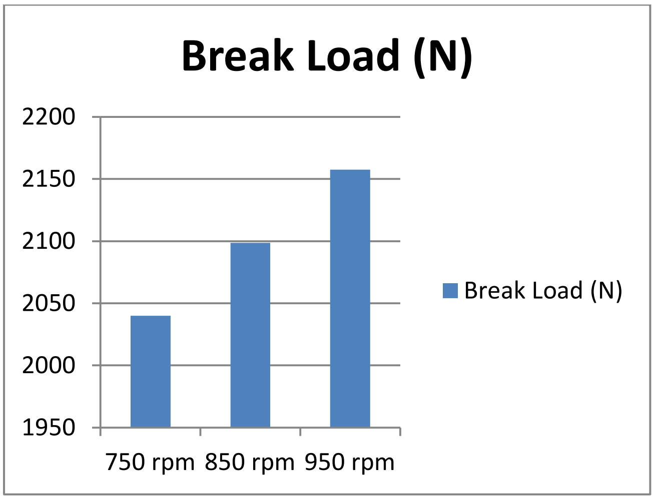

Chart-3.3 Variation of Break Load at different speeds

The tensile test specimen of the Indian standards was tested using Electronic Tensometer with the uniform load applied to the specimen to undergo fracture; The Fig. shows the tensile strength of centrifugally cast specimen at three different rotational speeds of the mold. It shows higher tensile strength for casting produced at the higher rotational speed compared to the casting produced at lower rotational speed.

4. CONCLUSIONS:

The main Conclusions of this work are:

- The Centrifugal casting is one of the methods to produce functionally graded materials with variation in hardness along the radial direction in the casting.
- At higher rotational speeds of the mold fine grains will be formed with improved mechanical properties and at lower rotational speeds coarse grains will be formed with lower mechanical properties.
- The results show the variation in hardness along the radial direction with slightly higher hardness values at inner and outer radii.
- The tensile strength is also observed higher for the casting produced at the 800rpm compared to that of 400rpm.

5. REFERENCE:

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