ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE)
Vol. 1, Issue 4, November 2015

Improved Mechanical Properties and Microstructure of Mechanical Vibration Mold during Solidification

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Abstract: Production is increased now a day'sdemands error free castings. Many researchers are following different methods to improve castings. The mechanical properties of a cast depends on the pouring, solidification of the cast. In the current paper the mechanical properties of aluminum alloy are investigated with attachment of mechanical vibration to the mold during pouring .The properties are then compared with vibration and without vibration. The experimental result shows significantly improvement in mechanical properties with vibration when compared to without vibration.

Keywords: AluminumAlloys, Mechanical Vibration, Mechanical Properties and Microstructure.

1. INTRODUCTION

Aluminum –Copper-Silicon based alloys are the most widely used nonferrous alloys. The properties of this alloy are heat treatable, high strength at room temperature**[1-4].** The alloy whose microstructure have been subjected to grain refinement possesses many advantages such as good mechanical properties thermal stability and high strain rate. The grain refinement can be attained either when external forces are applied to increase the fluid flow during solidification mechanical stirring or electromagnetic stirring of melt. The use of mechanical vibration during pouring and solidification is one of the technique to improve grain refinement [5-13]. Therefore this paper have been investigated by imparting mechanical vibration to the mold and mechanical properties are compared with and without vibration

2. Experimental Procedure

2.1. Experimental Method

The device which converts electrical signals to mechanical vibration with small amplitude is called mechanical vibration table.

The mechanical vibration table consists of mold holding plate, A.C motor, electric mass, four springs, power source, A.C Varying transformer, base plate, sensor, vibration measuring instrument, display unit. the mold is attached to mold holding plate of the vibration table .when the power is on the motor which to attached to the mold holding plate rotates with eccentric mass so that vibration is created which transfers to the mold, then vibration is measured by using vibration measuring instrument. The use of springs is to hold the vibration and reflect it to the mold vibration. The frequency of the vibration is varied by using A.C. varying transformer by cutting the voltage of source or motor.

2.2. Material and Procedure

The chemical composition of the Aluminum Copper alloy was selected as shown in **table 1**. The mold was prepared by using green sand and preheated to 200^{0}C.The melt was produced in an open hearth furnace by heating around 650^{0}C-800^{0}C and the slag was removed by adding NaCl. The mold placed on the vibration table. The vibration table is switched ON before the pouring and switched OFF after 50 seconds of pouring. The specimens are made under different frequency such as 0HZ, 10HZ, 20HZ, 30HZ, 40HZ,and 50HZ. The cylindrical rods of 20mm of diameter is casted for each vibration frequency.

Table1: Chemical Composition of AlCuSi Alloy in Wt.%

Al	Cu	Si	Fe	Mg	Zn	Ti	Ni	Sn	Pb	Mn
91.56	2.39	5	0.39	0.29	0.18	0.04	0.02	0.01	0.03	0.03

2.3. Mechanical Testing's

After casting with and without vibration, the specimens were made according to the ASTM Standards. Three different tests were done for each specimen are Tensile test, Hardness test and Impact test on Universal Testing Machine, Brinell Hardness Testing Machine and Charpy Testing Machine respectively. The results has been tabulated in the **Table 2**.

Table 2:Experimental Values For Various Tests

Frequency (Hz)	Ultimate Tensile Strength (N/mm^2)	Brinell Hardness Number (BHN)	Impact Strength (J/mm^2)
0	130.0699	27.6608	5.4
10	141.1134	32.0356	6
20	148.6202	35.4125	6.2

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30	154.1274	39.3356	6.3
40	151.3214	41.2564	6.4
50	159.5301	42.4832	6.6

2.4. Metallography Test

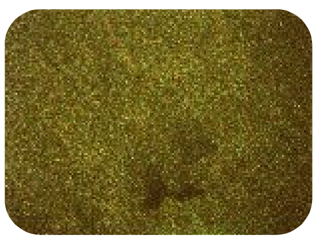
The five specimens under different frequency are first grinded on belt grinding machine. Then the specimens are polished with silicon carbide emery paper under different grades. After polishing, disc polishing is done and cleaned with water and fine polishing was done by surgical cotton.The sample was etched with Keller's reagent (H_20 : 95 ml,HNO $_3$: 2.5 ml, HCl:1.5 ml, HF (48%): 1ml) for 10 seconds than etched samples were cleaned in acetone and dried in hot air. Then these samples were undergone microstructure testing's on optical microscope.

3. RESULTS AND DISCUSSION

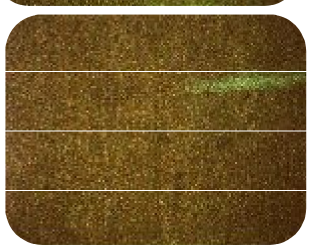
3.1. Microstructure Analysis

Microstructure of an Al-Cu-Si alloy is shown in **fig.1**. By observing the microstructure of specimen without vibration in fig.1 (f). Having coarse grain due to the presence of silicon flakes and intermetallic compounds of copper and aluminum. But while observing the microstructure of the specimens with vibration in fig.1 (a-e). Having fine grains due to the refinement of silicon flakes and due to the decrease of intermetallic compounds of aluminum and copper.

Fig(a): With frequency 50 Hz



Fig(b): With frequency 40 Hz



Fig(c): With frequency 30 Hz

Fig(d): With frequency 20 Hz

Fig(f): Without frequency

Fig(e): With frequency 10 Hz

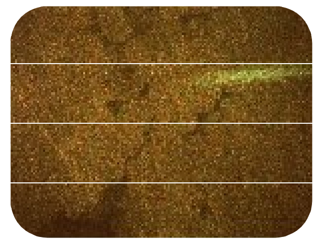


Fig.1. (a, b, c, d, e, f) Optical Microstructure with 300X magnification

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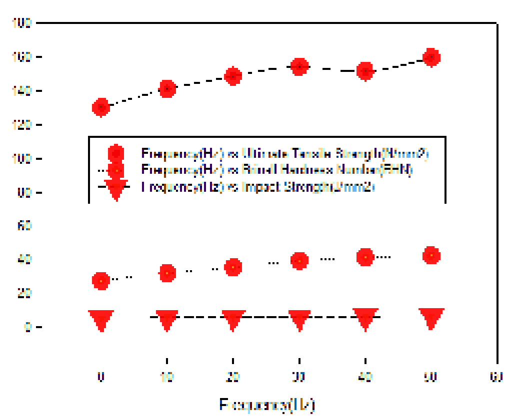

Fig.2. plotting of variation of properties with and without frequency.

3.2. Analysis of Mechanical Properties

The values obtained in **table 2**was plotted Graphs versus frequency and without frequency shown in **fig.2.** By observing the curve of frequency vs ultimate tensile strength, the ultimate tensile strength is increased with mechanical vibration when compared to ultimate tensile strength without mechanical vibration and increases with increase in frequency of mechanical vibration.

Similarly, the impact strength and hardness also improved with mechanical vibration.

CONCLUSIONS

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The mechanical properties and microstructure with mechanical vibration and without mechanical vibration during pouring has been investigated and the major conclusions are as follows:

1. The microstructure of the specimen without mechanical vibration looks like coarse grain structure such that there is no grain refinement and hence the ultimate tensile strength, hardness and impact strength values are less.
2. After imposing mechanical vibration to the mold, the specimens having fine microstructure and hence there is a grain refinement.Therefore the properties are improved when compared with specimens without vibration.
3. The final conclusion is that if the casting is done with mechanical vibration will have improved mechanical properties and high strength.
4. Establishment of mechanical vibration is very cheap and easy to install in foundry shops and easy to handle when compared to other methods.

ACKNOWLEDGMENTS

This work was fully and completely supported by Dr. I.Satyanarayana, B.E, M.E, PGDAS, FIE, FIIP, MISTE, (ENGG), born in west Godavari district andhrapradesh, INDIA. He is also a council member of IEI. He has 35 years of industrial experience and 11 years teaching experience as professor in mechanical engineering department in Chaitanya engineering college, Visakhapatnam.

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