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Investigation on the Effect of FGM Alloy on Cylinder Liner using Centrifugal Casting Technique

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***Abstract*— In modern scenario due to rapid growth in the automotive sector there is huge demand for materials which are light in eight and display suitable mechanical properties and tribological characteristics. Conventional alloys and composites do not meet demands. Chief aim of research is to produce FGM by horizontal centrifugal casting under 600, 800 and 1000 rpm. The objective is to manufacture FGM cylinder liner by centrifugal casting technique through varying the speed of the mould. Later the specimens are prepared and are subjected for various tests like tensile test, wear test, hardness and microstructure study. It is observed that of liner prepared by 1000 rpm has been showing better properties.**

Keywords—Cylinder liner; FGM; Centrifugal casting:Mould speed, Al-10wt%Sil

INTRODUCTION

Aluminium is one of the most abundant metals available in natural earth crust. Pure aluminium is soft and ductile to overcome this issue aluminium is alloyed with other elements. Aluminium alloy is one of the widely used alloy in which aluminium is the dominant metal. The most commonly used are copper, manganese, silicon, tin and zinc. Aluminium are light in weight, resistant to corrosion and high strength to weight ratio, high thermal conductivity and low coefficient of thermal expansion because of the high thermal conductivity and low coefficient of thermal expansion properties, this is widely used to reduce the weight and boost fuel mileage.. Al-Si is most commonly used alloy because addition of silicon results in good casting and it reduces the melting point, increases the fluidity of the alloy and increases the hardness of the alloy. Al-10wt%Si is melted in the blast furnace and keeping the rpm of the centrifugal mould at 600, 800 and 1000 three engine cylinder liners are manufactured and during centrifugal casting parameters like pouring temperature, die wall temperature are taken into considerations.

FGM

FGM stands for functionally graded material and in which by vaying the composition and structure there is simultaneous change in properties of the material without having any effect on mechanical properties. These are advanced material and unique merit of this FGM is many properties can be attained in a single entity because of this sole reason FGM become very famous and because of their efficacy they are widely used in many industries like automotive, aircraft and space technology.

CENTRIFUGAL CASTING

Centrifugal casting is used to manufacture cylindrical shape objects. Mould is connected to electric motor in which hot molten metal is poured into the rotating mould and due the centrifugal force the metal is thrown into the walls of the mould . Parameters like rpm of the mould of horizontal casting are taken into considerations.

CYLINDER LINER

Cylinder liner is a cylindrical object which is fitted along inner side the walls of combustion chamber and it act as a sliding surface for piston and piston rings, absorbs heat and transfer it to coolant, doesn't let gases to escape and mitigates wear and tear of the combustion walls. When cylinder liners are worn out they are replaced with new one either have high thermal conductivity and low coefficient of thermal expansion

METHODOLOGY AND EXPERIMENTAL SETUP

Figure:1. Show the centrifugal casting machine, which has die made up of mild steel and driven by DC motor. Molten Al-10wt%Si poured into the mould for manufacture of cylinder liner keeping mould rpm to 600, 800, 1000.

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Figure: 1 Centrifugal casting Machine

Figure: 2 Al-10wt%Si at 600 rpm, 800 rpm and 1000 rpm

Microstructure is developed and observed the distribution of size and shape of Si particles in the alloying element through inverted microscope.

Tensile test is carried using electronic tensometer which is connected to computer and it calculates the elongation, ultimate tensile strength and breaking load and plots graph of load versus displacement with aid of PC2000 tensometer software.

Hardness test is carried out by Rockwell hardness machine and resistance to indentation is being measured. Scale F is employed which has 1/16" diamond indenter is used for indentation.

Wear test was carried out by using Ducom pin on disc type machine and parameters like track diameter, load, speed of the disc are considered. Wear test machine is connected to the computer and displays coefficient of friction, friction force and weight loss.

RESULTS AND DISCUSSION

Hardness Test: Al-10wt%Si has been casted by horizontal centrifugal casting under the rpm 600, 800 and 1000. It is observed that hardness values at surface of the casting is more for high rpm low for low rpm and moderate for medium rpm. Since density of the Si is more than the Al naturally due to centrifugal action more heavy particles collected near to the outer surface. Therefore hardness values are varied with the percentage of collected Si particles at the outer surface.

Table: 1 Hardness value comparison

Composition	RPM	Average Rc
Al-10wt%Si	600	64
Al-10wt%Si	800	66
Al-10wt%Si	1000	73

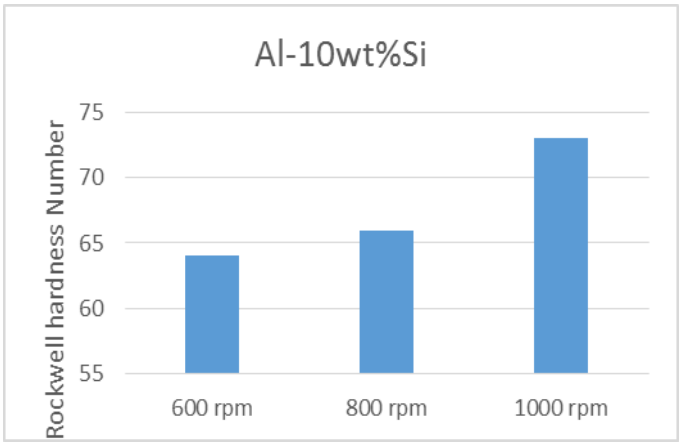

Figure: 3 Hardness value comparison

Tensile Test: Tensile test have been carried out for all the three specimen . It is observed that higher UTS is observed for 1000 rpm and low tensile strength is observed for low rpm and moderate tensile strength is observed for medium rpm. Under high rpm due to more centrifugal force rpm of the heavy particles pushed outer surface of the casting and low density material collected at inner surface of the cylinder hence more blow holes escape from the inner surface a thin cylinder hence more the rpm higher the density and least the blow holes defect observed hence higher UTS is observed for high rpm and low UTS is observed for least rpm and moderate rpm for medium rpm.

From the below Table:2 and Figure:4 it clearly manifests that Al-10wt%Si manufactured at each 600 rpm, 800 rpm and 1000 rpm the Al-10wtt%Si which is manufactured by keeping the mould speed to 1000 rpm shows highest value

Table: 2 Tensile Test value comparisons

RPM	Composition	UTS MPa
600	Al-10wt%Si	88
800	Al-10wt%Si	92
1000	Al-10wt%Si	99,9

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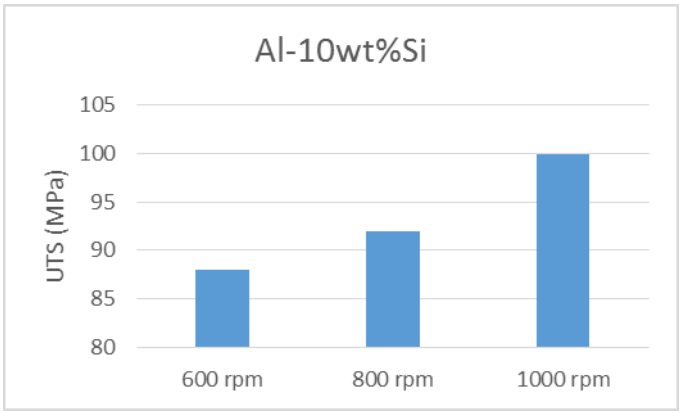

Figure: 4 tensile value comparison

Wear Test: Wear phenomenon is one of the common occurring phenomenon found . Test was carried by using ducom pin on disc. Track diameter was adjusted to 110 mm and normal load of 2 Kg is applied with use of string and pulley arrangements and rpm is set to 695 and is carried out for 20 Minutes and computer displays the wear rate, coefficient of time and friction force.

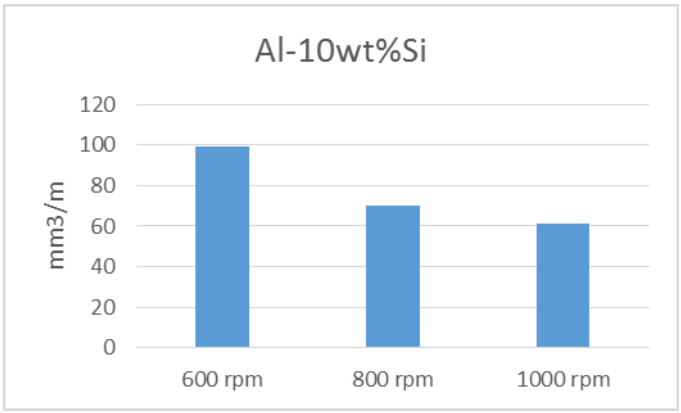

Figure: 5 Wear results

From the above Figure:5 it is observed that volumetric wear rate is least for 1000 rpm casted specimen because it is more hard and almost defect free specimen. As per Archard's equation hardness is inversly proportional to volume loss load hence specimen casted by 1000 rpm has shown minimum wear rate.

Microstructure Study: Samples are studied to find the distribution, size and shape of the grain. Presence of primary silicon influences the strength of the alloy.

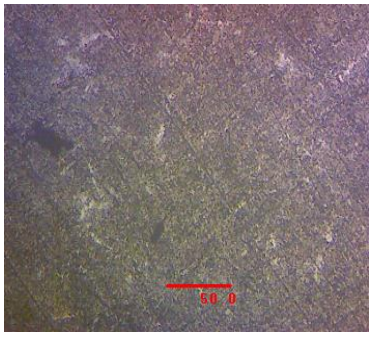

Figure: 6 Al-10%Si Microstructure at 600 rpm

From the above Figure: 6 it can be clearly seen that silicon grains are not distributed uniformly throughout the sample and due to the low speed of the mould coarse silicon particles are formed. Presence of coarse silicon reduces the strength and hardness of the sample whereas presence of fine silicon enhances the strength and hardness of the sample.

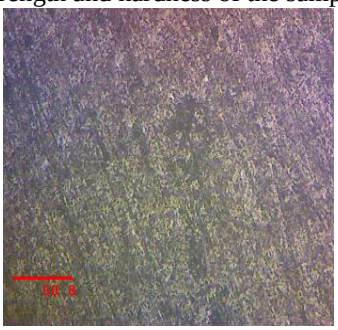

Figure: 7 Al-10%Si Microstructure at 800 rpm

Figure:7 it depicts that due to the moderate speed of the mould the grain refinemnet is slightly improved and needle like silicon particles are seen and surrounded by grey aluminiun particles

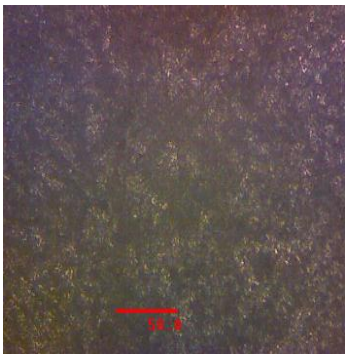

Figure: 8 Al-10%Si Microstructure at 1000 rpm

From the above Figure:8 it is seen that due to the high speed of the mould rate of solidification is fast and as a result the grains are distributed throughout the sample and aluminium particles are surrounded by fine primary silicon and this enhances the mechanical as well as the tribological charasteristics.

CONCLUSION

The mechanical properties depend upon the microstructure of the specimen. From the microstructure data it is observed that, high hardness and strength due to its more surface to volume ratio in the material. Therefore under high rpm, specimen has fine particles and almost defects free. Therefore more surface hardness, higher UTS and least volumetric wear rate is observed.

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