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Investigation of Mechanical Properties of Aluminum Nano Composite

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Abstract— The application of aluminum composites in automobile industry has gained significant attention of researchers over the last few years. The main reason for this is aluminum composites provides better mechanical and wear properties. The nano composites provide better thermal stability, wear resistance and weight reduction in automotive industry. The main objective of this study is to investigate the aluminum nano composite performance of piston rings. In this study, nano composites are prepared by alloying of Aluminum with other transition elements, which will produce a dispersion of Magnesium mixture a reinforcement particle within a nano structured aluminum matrix, at room temperature. Aluminum, Magnesium particles mixtures were mechanically alloyed during casting with different quantities mixed in the Al-Si mold and cooling in annealed atmosphere by using a cast iron die. The powder mixtures were produced with nominal composition of extra 5gm of Si, and 10 gm of Mg to Al-Si alloy, using powders of pure particles of Mg-Si. The performance of these nano composites was studied under various mechanical properties such as wear resistance, frictional force and hardness. It was found from results that al-mg nano composites provide better mechanical performance.

Indexed Terms— Nano composites, piston rings, wear resistance and Aluminum composites

I. INTRODUCTION

In general piston ring is a metallic ring that is attached to the outer diameter of a piston in an internal combustion engine. The main purpose of ring for sealing the combustion chamber so that there is minimal loss of gases to the crank case. Improving the heat transfer from the piston cylinder wall and maintaining the proper quantity of the oil between the piston and the cylinder wall. Most of the piston ring are made of cast iron and aluminum alloy.

In this paper we are going to add material mixture which consists of high strength and hardness properties with organic reaction of condensation. By adding the mg and si mixture to aluminum piston ring alloy we can get the more wear resistance and hardness which increase the life cycle of the ring. The melting of piston rings doesn’t loss its mechanical properties, after melting we need to make them into a cylindrical rods with the required dimensions. The hot ring metallic liquidous were pour into a die cast which gives exact dimension which is useful to done the various test. In this we are using eutectic Al-12% Si and 1% of Cu ,Ni & Mg The aluminum is such a composition increase the thermal conductivity without increasing the coefficient of thermal expansion , improves resistance against the wear, and improve the fatigue strength of the piston reciprocating under condition of high temperature and high speed. When the aluminum alloy containing more % Si and Mg is used to form a piston through a convention method of casting , a desired shape of piston is hard to made due to poor ease of casting. With the present invention however, the piston may be formed by forging or casting by making rapidly cooled and solidified powder from the aluminum alloy containing the Si and Mg. As a result, The piston is provided with restricted deformation at high temperatures, a good thermal conductivity, and a high strength and wear resistance .Here, to disperse the Si and Mg in fine grains in the aluminum alloy,it may also be arranged that the aluminum is rapidly cooled and solidified to produce the grain diameter of 1-15 cm are mixed by an amount that produces aluminum alloy of the present invention, and formed directly to a required size by pressing and heating at a temperature below 700 degree celsius. This results in Si & Mg of average grain Diameter smaller than 15 cm dispersed in the boundary area of aluminum. Aluminum is a Non ferrous alloys containing at least 5% by weight but less than 50% by weight of oxides, carbides, borides, nitrides or other metal compounds eg sulfides whether added as such or formed in situ with carbides , nitrides , borides as the main non-metallic constituents only carbides based on Sic. By using Mg Cast composites designed as based on a magnesium matrix and reinforced with silicon carbide particles constitute a new group of materials that feature the desired set of properties. The use of magnesium for the matrix of composites allows a low weight of the final element to be obtained, while assuring the proper level of properties; the introduction of SiC particles, on the other hand, enables the tribological properties, Young's modulus, tensile strength and hardness of the composite to be enhanced. It should be noted that the Mg-SiC system is characterized by

a) A very good wettability of SiC by molten Mg.
b) A very high stability of SiC in liquid Mg.

Investigations carried out so far have determined the possibility of obtaining adhesive bonding between components and high volumetric fractions of SiC particles with their uniform distribution within the matrix.The focus of this research is to investigate on wear resistance and hardness test of process parameter on casting of composite material i.e addition of Mg and Si in piston ring Al alloy and comparing with pure Al-Si alloy to improve mechanical properties. The basic steps for achieving the above target are summarized below.

a) Selection of process parameter and quality characteristics of the process.
b) Pouring the mould in casting and cooling it to Annealed Atmosphere.
c) Performing the machining operation on the specimens as per the ASTM standard to perform wear and hardness tests.
d) Make the decisions based on the result obtained by performing the test.
e) Researchers worked on tribology and found the properties of various materials by using ANOVA and pin on disc experimental set up [1-4].

Tribology is also applied on metal matrix composites and proposed the experimental results [6]. Scientists also worked on hetero structured steel and found the properties [7]. Wear strengthening properties on aluminium alloys, nano composites and metal matrix composites are proposed experimentally [8-14]. In this article wear properties are studied experimentally.

II. METHODOLOGY

In this research, the design of specimens for the experiment has been prepared using the cast iron dies, which gives the main stage in the experiment to perform various test accurately and it is based on mainly researcher’s previous investigations into optimization of the die casting process. Thus based on previous experimentation, this researcher as selected mainly three process parameters. Melting the metal, adding the mixture of Mg and Si mixture to aluminum piston ring alloy by roading at 450ºC-700ºC temperature, and die temperature at atmospheric pressure, recognizing them as the most critical parameter in the experimental design. The other parameters are involved in experimental purpose kept constantly they are designated as process parameters for the present investigaton on Al-Si Al-Mg and Al-Si-Mg compounds. Experimental designs for the fabrication of casting samples at different levels and weight percentages of parameters. Piston parameters are • Bike Variant: Bajaj pulsar 180 ENGINE,•Type: 4-stroke, 2-valve, Twin spark BSIV Complaint DTS-I Engine displacement (cc): 178.6,•Max power (PS @RPM) : 17.02 @ 8500 rpm Max torque(Nm @ Rpm) :14.52@6500 rpm Bore : 63mm.•Stroke : 56mm

Fig.1 Piston and Piston rings

The details of the materials and processing methods that are used to fabricate the composite materials are discussed below. Fig.1 shows the piston and piston rings. The used process parameters and properties of materials is shown in Table 1 and Table.2

Table 1: Process parameters and their levels used in the experiments

Parameter designation	Input Parameters	Parameter Range
A	Molten metal temperature	450º C - 700º C
B	Al-Si	0.0 – 5.0 gms
C	Al-Mg	0.1 – 10.0 gms
D	Al-Si-Mg	0.1 – 2.5 – 5.0 gms

Table 2: Properties Of Material:

Properties	Al-Si Alloy	Magnesium
Density (kg/m³)	2770	1740
Melting Temperature Deg	750	650º
Young's Modulus(Mpa)	71*10³	44.4*10³
Poission Ratio	0.33	0.28
Ultimate Strength(Mpa)	310	515
Thermal Conductivity	174	150
Hardness (H/V)	124.7	72

III. RESULTS AND DISCUSSION

a. Rock well hardness test: the Rockwell hardness tester is an essentially a machine that measures hardness by determining the depth of penetration of a penetrator into the specimen under the certain fixed condition of tests. The penetrator may be either steel ball or a diamond spheroconical penetrator. A minor load of 10 kgf is first applied, causing an initial penetration. The dial is set at zero on the black figure scale, and the major load is applied. This major load is customarily 60 kgf or 100 kgf when a steel ball is used as a penetrator, but other loads may be used when necessary. The ball penetrator is 1/16" in diameter normally, but other penetrators of larger diameter, such as 1/8", may be employed for soft metals. When a diamond spheroconical penetrator is employed, the load is usually 150 kgf. Experience decides the best combination of load and penetrator for use. After the major load is applied and removed, according to standard procedure, the reading is taken while the minor load is still applied.

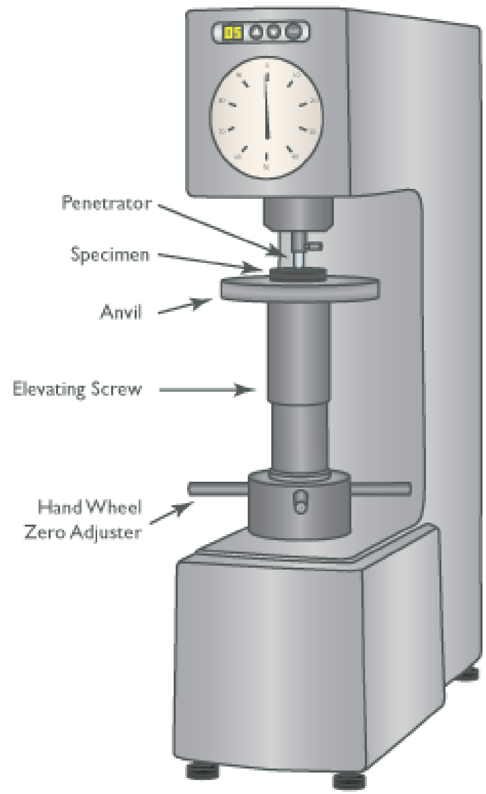

Fig.2 Hardness test rig

Fig.2 shows the hardness test rig, used for finding hardness of the materials. In this experiment we have done the hardness test on different aluminum alloy piston ring. The four types of piston rings are pure aluminum and silicon nano composites alloy ring (12% of si) , aluminum and magnesium nano composites alloy (10gms of mg) aluminum and more quantity of silicon nano composites(10gms of si) and aluminum silicon and magnesium nano composites piston ring alloy.

By the resultant graph we have come to know that aluminum and magnesium piston ring have more hardness compare to the other three piston ring alloys. it ranges R1 at 67kgf and R2 at 71kgf by considering both the readings the resultant hardness value 69kgf .

Fig.3 represents the hardness numbers of four samples is shown in bar chart for comparing and interpreting.

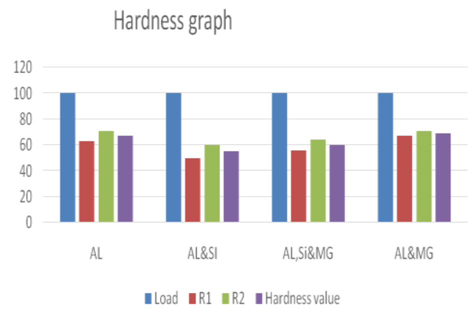

Fig.3 Hardness of four samples

Wear Resistance:

- Pin-on-disc measurement involves engaging an indenter or pin (usually flat or sphere shaped) on to a test sample. The engagement mechanism applies a precise force to the indenter as the test sample is rotated. The resulting friction forces are measured using a strain gage sensor.
- In this study, wear performance of Al-Si alloys are evaluated. Al-Si alloys have excellent castability and are widely used in automotive industries. The presence of Si in Al alloys increases its castability but also offers reasonable wear resistance. In hypoeutectic Al-Si alloys, Si is distributed as eutectic phase in interdendritic regions; whereas in hypereutectic Al-Si alloys, Si exists both as primary and eutectic phases. In general, the abrasive wear resistance of Al-Si alloy increases with the increase in Si content. This is because Si is hard phase and it offers resistance to abrasion. However, in many challenging applications, the abrasive wear resistance of Al-Si alloys (irrespective of its composition) is inadequate

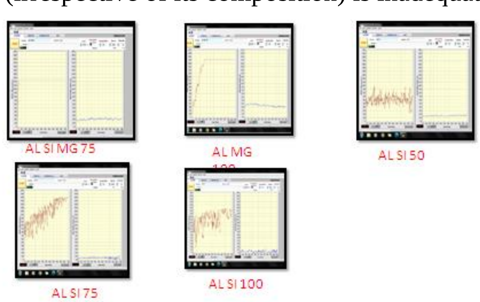

Fig.4. Experimental Wear Resistance values

The wear resistance frictional force and hardness with silicon and magnesium mixtures at various weight percentage have been studied which is shown in Fig.4. The crystalline lattice of Al-si alloy die castings with/ without hard metallic particles (SI-MG) increment. Based on these die casting cylindrical formation of pattern it is observed regarding Al-si cast alloy with increasing the hardness of metallic particles (SI-MG) has coarse structure . After addition of SI-MG particles, the size grain is further decreased in α-AL-SI piston rings , and it has been noticed that the commercial particle size of Al-Si alloy with the increment of 2.5 wt.% of MG particles, as represented, is found substantially harder in nominee to the alloy with increment of 02.0wt.% MG particles . The sum of total size of the α-Al in the Al-si alloy with addition of 2 . 5 wt.% MG-SI particles is decreased to 27± 3 μ m from 91± 3 μ m. MG-SI particles acta as to develop good wear resistance strength and frictional force for AL&SI piston rings. Hence by conducting multi metallic UTM testing improves the life cycle of AL-SI piston rings

CONCLUSION

The wear resistance frictional force and hardness of Al-SI piston ring alloys behaviour & Commercial Mechanical characteristic of AL-SI casting effected by MG&SI and alloying increments has been carried out.The following in brief result are achieved based on the experimental investigations:The following conclusions can be derived based on the above-mentioned values. Upon increment of MG-SI at 2.5 & 1.0 % wt it leads to change in total particle size and increase the moderate strengths high corrosion resistance of the α-Al in the Al-Si alloy with increment of 2.5 wt.% MG. The Mechanical Properties of material upon addition of 1.0% Wt where the tensile stress were reduced by approx. 28% and Hardness value is increased by 16.5% which results in Brittleness value of the material, Whereas the upon addition of 2.5% Wt the tensile stress was increased to 11% and hardness value remains same which is accepted and recommended to industries.

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