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Characterization of Aluminium Alloy (8011) Reinforced with Silicon Carbide Using Design of Experiments

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ABSTRACT: Aluminium metal matrix composite is a relatively modern material that hasestablished its position in various engineering applications including aerospace due to its light weight and high strength. Need for improved performance has led to the design and election of newer variants of the composite Material. This Experiment deals with the comparison of wear behaviour of Al-Sic metal matrix composite for fluctuating reinforcement content with the 8011-aluminium alloy. Metal matrix composites are prepared by a stir casting method using 8011 aluminium alloy, silicon carbide particles by varying the weight fraction of Sic in the range of 2%and 4% and 6%. The material is symphonized by a stir casting process in an electric melting furnace. The wear and frictional properties of the casted hybrid metal matrix composites were investigated by performing dry sliding wear test using a pin-on disc wear tester. It is observed that wear resistance of metal matrix composites was increased compared to the 8011-aluminium alloy. The investigation was done to find the influence of applied load, sliding speed, and sliding distance on wear rate, as well as the coefficient of friction during wearing process. From the investigation, itis evident that wear resistance of Al-8011 is increased while adding the Sic reinforcement content. The results were compared with the existing liner material. From this comparative study the Al-8011 and Sic composite can be the considered as an alternative material for existing cylinder material.

KEYWORDS: wear resistance, coefficient of friction, surface roughness.

I. INTRODUCTION:

Metal Matrix Composites (MMCs) are engineering materials that refers to metal-based materials reinforced with particulates, whisker, or fibre, which can produce appreciable mutation in the physical and mechanical properties of the base alloy. MMCs are the necessary class of materials with the possible to replace several traditional materials being used in aerospace, automotive, defence and other industries where the requirement of light weight and high strength elements are increasing and especially aluminium alloys are used in engineering design chiefly for their light weight, gesturing-to-weight ratio, corrosion resistance, and relatively below cost. They also apply for their high electrical and thermal conductivities, ease of fabrication, and ready availability. Aeronautical Components require lightweight materials that provide processing flexibility, curtail manufacturing costs, and provide durability in harsh environments.

Metal Matrix Composites (MMCs) are suitable for applications requiring combined strength, thermal conductivity, damping properties and a low coefficient of thermal expansion with lower density. These properties of MMCs enhance their exercise in automotive and tribological applications. In the field of automobile, MMCs are used for pistons, brake drum and cylinder block because of better corrosion resistance and fatigue resistance. Fabrication of MMCs has several challenges like porosity formation, poor wet ability and improper distribution of support. Achieving uniform distribution of reinforcement is the foremost important work. In this, all the cloths are set in graphite powder and heated in an inert atmosphere until the matrix alloy is melted and followed by stirring action to obtain uniform distribution of reinforcement.

The fabrication techniques of MMCs play a major part in the improvement of mechanical and

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tribological properties. The performance characteristics of Al 8011 alloy reinforced with 2% sic containing 2%, 4% and 6% of the volume are to be fabricated through stir casting processes. It has been set up that the stir casting specimen has higher intensity compared to powder metallurgy specimen. The size and type of reinforcement also have a significant role in determining the mechanical and Tribological properties of the composites. The issue of type of reinforcements, such as fly ash, is to increase the hardness and tensile strength of the fabric. Graphite acts as the solid lubricant of material and reduces the wear of the material. It was found that there lived a substantial dependence on the kind of reinforcement and its mass fraction. The answers revealed that particulate reinforcement is most beneficial for improving the wear resistance of MMCs

MMC have successfully displaced metals and other plastics in a growing number of aeronautical applications because they're exceptionally strong, light, and wear resistant, and can be easily fabricated into tight tolerance parts. metal matrix Composites generally acquire superior hardness when compared to the unreinforced aluminium alloy. Wear behaviour of materials depends on the many factors such as properties of material combinations, experimental condition, and types of testers. The result analysis shows that the wear resistance of Al-Sic metal matrix composite increased when compared to the Al- alloy 8011.Studied the wear behaviour of SicAl8011 Metal Matrix Composite and Al-8011alloy and reported that wear resistance of MMCs increased because of the content of the Sic. The presence of particles in the Sic improves the wear resistance.

Aluminium 8011 is currently the next most widely used metal in the world? This is due to the fact thatAl-8011 has a unique combination of alluring properties. Al-8011 has special Properties such as its corrosion resistance, low weight, and easy maintenance of final component, have ensured that this metal and its alloys will be in use for a very long time. Aluminium 8011 alloy, which contains iron and silicon as major constituent, which is used matrix material and is composition is givenSic

Silicon Carbide is the only chemical compound of carbon and silicon. It was originally composed by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide is an attractive abrasive and has been produced and made into grinding wheels and other abrasive products for over one hundred years. Today the material has been developed into a high-quality technical grade ceramic with very good mechanical properties It is pre-owned in abrasives, refractories, ceramics, and numerous great-performance applications. The material can also be built as an electrical conductor and has applications in retardation heating, flame igniters and electronic components. Structural and wear applications are steadily developing. Properties of Si-Cd are below density, High strength, below thermal expansion, High thermal conductivity, large hardness, High elastic modulus, outstanding thermal shock resistance, exclusive chemical inertness.

Silicon carbide is composed of tetrahedral of carbon and silicon atoms with strong bonds in the crystal lattice. This produces a very compact and strong material. Silicon carbide is not assailed by any acids or alkaline or molten salts up to 800°C.in air sic forms a protective silicon oxide coating at 1200°C and is able to be used up to 1600°C. The high thermal conductivity coupled with low thermal expansion and high strength give this material exceptional thermal shock resistant qualities. Silicon carbide ceramics with scant or no grain boundary impurities maintain their strength to very high temperatures, approaching 1600°c with no strength loss.

II. BOTTOM POURING TYPE STIR CASTING AND CUTTING MACHINE

STIR Casting:

The casting method used in this process is stir casting. The casting was done by adding Aluminium8011, Silicon Carbide. Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (short fibres, ceramic particles) is blended with a molten matrix metal by means of mechanical stirring. The liquid Al 8011 and sic composite material is then cast by conventional casting methods and may also be treated by conventional Metal forming technologies

Machining:

Machining is any of various processes in which a piece of raw material is cut into a desired final shape and size by a controlled material-removal process. The various machining processes used are cutting and facing. Metal Cutting: Metal cutting, or machining is the process of by removing unwanted material from a block of metal in the Form of chips. Cutting processes work by causing fracture of the material that is processed. Usually, the portion that is fractured Away is in small sized pieces, called chips. Common cutting processes include sawing, shaping (or planning), broaching, drilling, Grinding, turning and milling. Although the actual machines, tools and processes for cutting look very different from each other, The basic mechanism for causing the fracture can be understood by just a simple model called for orthogonal cutting.

III. EXPERIMENTATION

Wear test:

Wear test was conducted using pin on disc method at 100m temperature and dry sliding condition. a cast iron disc of diameter 9 cm and Rockwell hardness HRC -47 were used as counter discs. The diameter of the specimen was 10mm and 5mm respectively of wear and test samples.

A pin on disc equipment consists of a stationary "pin" under an applied load in contact with a rotating disc. The pin can have any pattern to imitate a specific contact, but spherical tips are often applied to simplify the contact geometry. Coefficient of friction is defined by the ratio of the frictional force to the loading force on the pin. To investigate the dry sliding wear behaviour of the composite, a pin on disc wear testing machine is used. The size of the pin was 10 mm in diameter and 50 mm in length and HMMC composite was used as the test material. The twin disc with 100 mm in external diameter and10 mm in thickness was fabricated using hardened chromium steel. The test pins were loaded against the disc with a dead weight. The stick and the disc were washed with acetone to ensure that the trials were held out under nominally dry sliding condition.

The weight of the pin is measured before and after to calculate the mass on each test. The wear rate was estimated from the weight-loss measurements. The frictional torque was recorded during the experiment and friction coefficient was estimated. The trials were held out at different loads of 2,4 and 6 kg. The sliding speed under 200, 300 and 400 RPM were used. The time is varying under 10,20 and 30 minutes. And the sliding distance was fixed at 100mmDIA. The trials were conducted at ambient temperature without lubrication. To investigate the wear mechanisms of Al 8011

All The wear tests were conducted at 200,300,400 rpm of rotating counter disc and applying a load of 2,4,6 kgs in test samples. During

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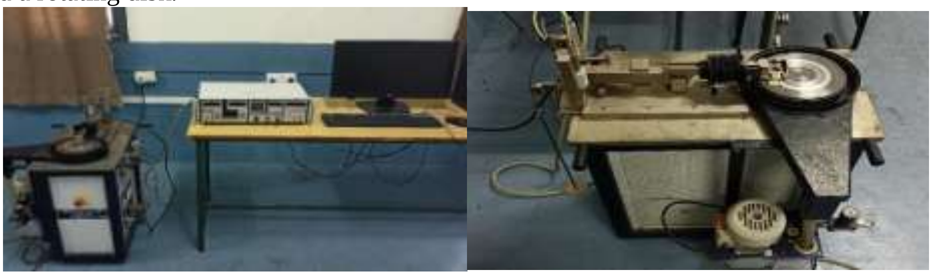
wear test weight loss from the worm surface were increased at 10,20,30 mins external with 3 hours for each sample.

The Pin-On-Disc machine is a versatile unit designed to evaluate the wear and friction characteristics on a variety of materials exposed to sliding contacts in dry or lubricated environments. The sliding friction test occurs between a stationary pin stylus and a rotating disk.

Normal load, rotational speed, and wear track diameter can be varied. Electronic sensors monitor wear and the tangential force of friction as a function of load, speed, lubrication, or environmental condition. These parameters as well as the acoustic emissions at the contact are measured and displayed graphically utilizing the WINDCOM DATA software package.



Wear machinepin on disc apparatus

SURFACE ROUGHNESS:

Surface Roughness plays an Important role as it influences the fatigue strength, wear rate, coefficient of friction and corrosion resistance of the machined components. In actual practice there are many factors which effect the surface roughness i.e., tool variables, workpiece variables and cutting conditions. Tool variables include tool material, noise radius, rake angle, cutting edge, geometry, tool vibration, tool overhang, tool point angle, etc. Work piece variables include material, hardness, and other mechanical properties. Cutting conditions include speed, feed, and depth of cut. As the hard turning process involves large number of parameters, the process control becomes complex, and it would be difficult to select the appropriate cutting condition and tool geometry for achieving the required surface quality

Surface roughness also affects several functional attributes of parts, such as friction, wear and tear, light reflection, heat transformation, ability of distributing and holding a lubricant, coating etc. Therefore, the desired surface finish is usually specified, and appropriate processes are required to maintain the quality. Hence the inspection of surface roughness of the work piece is very important to assess the quality of a component.

Various researchers have developed the surface roughness predictive models for the conventional turning, tool but these models may not be useful for hard turning because hard turning differs from that of the conventional turning process. So, it would be necessary to study the effects of speed, feed, effective rake angle and nose radius on the for hard turning

surface roughness measurement

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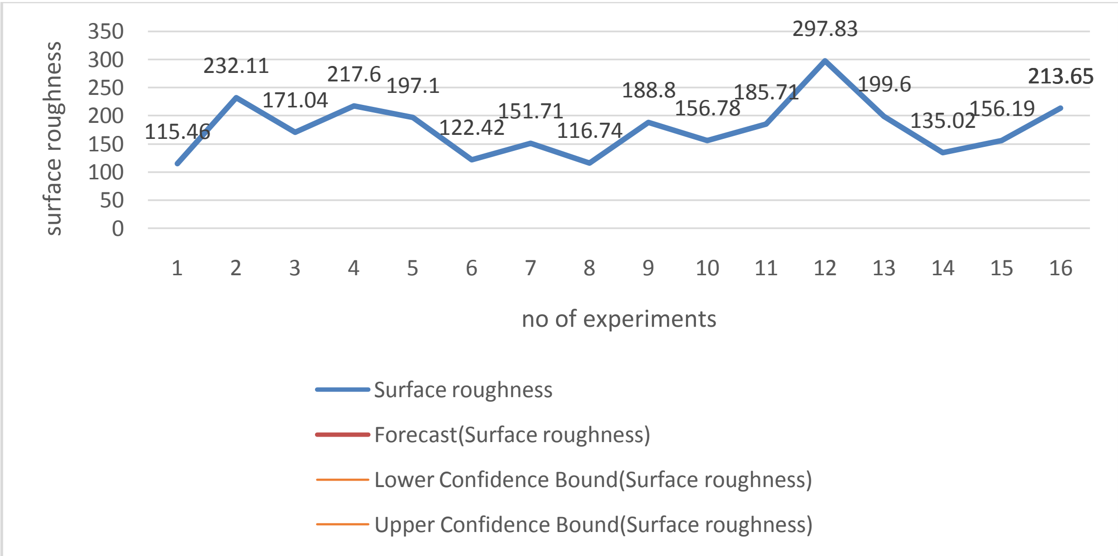
IV. PLAN OF EXPERIMENTS AND RESULTS:

SL.NO	Load	Speed	Time	%Sic	Wear	friction	Surface roughness
1	2	200	10	2	99	6	136.04
2	2	200	10	6	157	7	243.57
3	2	200	30	2	460	9	175.37
4	2	200	30	6	518	10.7	217.47
5	2	400	10	2	87	6.6	191.28
6	2	400	10	6	145	7.4	136.72
7	2	400	30	2	582	12.75	162.4
8	2	400	30	6	640	8.95	133.99
9	6	200	10	2	280	21.75	170.02
10	6	200	10	6	338	25	212.19
11	6	200	30	2	461	21	140.01
12	6	200	30	6	529	23	233.83
13	6	400	10	2	368	21.6	197.39
14	6	400	10	6	425	23.9	152.75
15	6	400	30	2	375	22.5	139.44
16	6	400	30	6	433	23.5	193.87
17	2	300	20	4	351	10.9	84.65
18	6	300	20	4	698	16.35	98.62
19	4	200	20	4	180	14.7	143.69
20	4	400	20	4	480	23.5	192.75
21	4	300	10	4	430	17.0	140.51
22	4	300	30	4	751	18.0	148.9
23	4	300	20	2	309	12.4	176.75
24	4	300	20	6	228	9.8	196.54
25	4	300	20	4	595	21.3	90.61
26	4	300	20	4	428	16.5	123.47
27	4	300	20	4	726	19	85.19



No. of experiments 16 vs/ surface roughness

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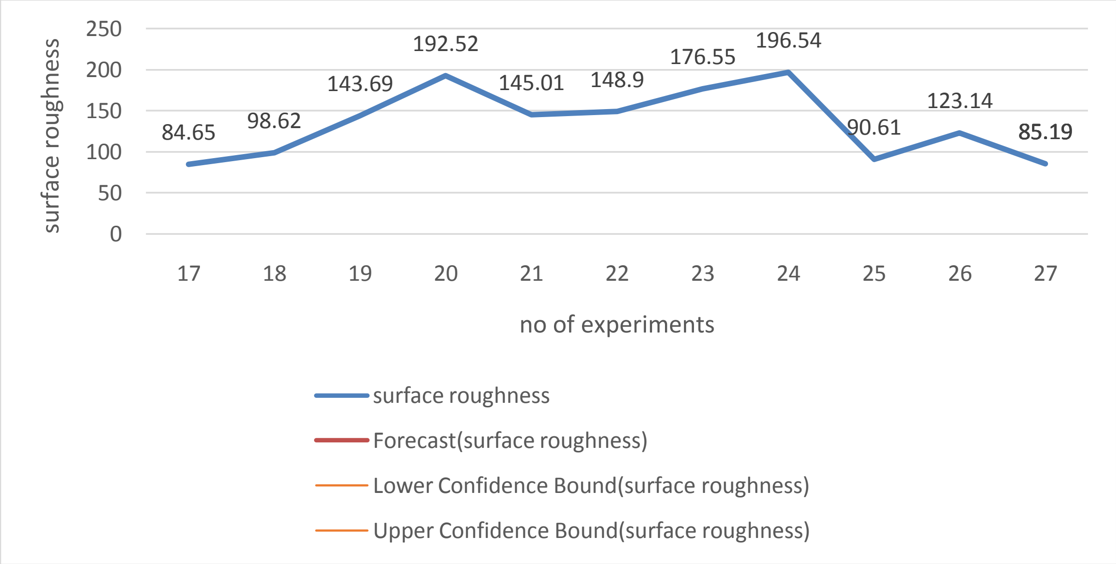

No. of experiments 27 vs/ surface roughness

The above graph shows the results of surface roughness and sl.no. The surface roughness has the highest point at 16thexperiment, and it will be decreased in 27thexperiment.
so, the surface roughness is best at the 6% sic is reinforced with al 8011 by using this design of experiment.
The 94% of aluminium is reinforced with 6% sic is good for casting and surface roughness, coefficient of friction

V. CONCLUSION

Aluminium 8011 /silicon carbide with three various amounts of combination have been successfully fabricated by stir casting method. Aluminium is tested by wear resistance, friction force and surface roughness
. It observes the maximum surface roughness is 516.715 microns (µm). Hence all results are shows AL 8011(94%) + SIC (6%) is best composition to give low weight, high speed, and less time. The wear resistance rate increases with the increase in normal load. However, the composite has shown as lower rate of wear (up to 6% SIC) as compared to that observed in 2% and 4% sic. The average coefficient of friction
decreases with increasing load in both pure aluminium and composites. However, the composites show a lower coefficient of friction than that observed.

Advantages from the above results
1. It's sliding velocity is high
2. Very light weight and High strength-to-weight ratio.
3. Highly corrosion resistance
4. Easy to use in aerospace industries and recyclable
5. It has the Non-toxic, Heat conducting, Reflective, electrically conducting, Non-magnetic nature

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