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Studies on Dry Sliding Wear Behaviour of Al6061 with Silicon Carbide & Graphite Particulate Composite

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ABSTRACT: This paper presents the wear behaviour of Al6061 reinforced with silicon carbide and Graphite formed Al6061/SiC/Graphite hybrid composites are the combination of the two different hybrid materials one is hard particles of silicon carbide witch increase the hardness and resistance to wear another particles of graphite which improves lubrication and reduce the friction and wear this hybrid composites were produced by stir casting method and then the samples were carried out by hardness test and pin on disc wear test apparatus.

KEYWORDS: Al6061, Silicon carbide & graphite, Hybrid Metal Matrix composite, Stir casting, Wear.

I. INTRODUCTION

Composite materials have achieved success with in a short span despite facing several challenges' during the course of its journey the challenges have only reinforced our abilities to excel in advanced situation to days worldwide the engineers face the several problem likes right selection of materials among all the materials composite materials have the potential to replace widely used steel and aluminium. The present market scenario out of over 1600 engineering materials available in the market today more than 200 are composite Because of the conventional materials have limitation with respect to achievable combination of strength stiffness and density.

In order to overcome these limitations and to meet the ever-increasing engineering demands of modern technology metal matrix composite are gaining importance. Composite materials have become common engineering materials and are designed and manufactured for various application including automotive component, sporting goods, aerospace parts, consumer goods and in many industrially Composite haves been routinely designed and manufactured for application in which help performance and light weight are needed.

Aluminium Matrix

Aluminium is the most abundant metal and the third most abundant chemical element in the earth's crust. Comprising over 8% of its weight Aluminium alloys are broadly used as a main matrix element in composite materials. Aluminium alloys for its light weight has been in the net of researchers for enhancing the technology. The broad use of aluminium alloys is dictated by a very desirable combination of properties, combined with the ease with which they may be produced in a great variety of forms and shapes.



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Al6061-Alloy Selection

The families of aluminium alloys are represented by 1xxx, 2xxx, 3xxx, up to 8xxx. The first digit gives basic information about the principal alloying elements as shown in table 2. The designation system also says something about the hardening of the alloys belonging to a family. Table 3 shows the nominal composition wt% of Al-6061 matrix material. The 1xxx, 3xxx, and 5xxx series are so called non heat treatable alloys; they gain their strength by alloying (increasing the content of Mg) and work hardening. The 1xxx series designation consists unalloyed aluminium materials which are distinguished according to their degree of purity. The 8xxx series designations are for miscellaneous types of alloys which cannot be grouped in the other families. The 2xxx, 6xxx, and 7xxx series are heat treatable alloys, which gain their strength by alloying but make use of precipitation hardening as the main mechanism among several series of aluminium alloys, heat treatable A16061 and A16707 are much explored. Among them A16061 alloy is highly corrosion resistance extricable in nature and exhibits moderate strength. It finds vast applications in the field of construction automotive aerospace marine and other allied fields they have been studied extensively because of their technological importance and their exceptional increase is obtained by precipitation hardening.

Reinforcement

As for the reinforcement the material used are typically ceramics since they provide a very desirable combination of stiffness strength and relatively low density reinforcement material include SiC, Al_2O_3 ., B_4C , Tic cop, TiB₂, graphite and a number of other ceramics the reinforcement is added to provide increased stiffness and strength to the unreinforced matrix ceramic particles with their large elastic modulus and high strength are ideal as the reinforcing particles. Many of the ceramic particles interested are thermo dynamically unstable when they are in contact with pure metals and will react to form reaction compounds at the interface between the particles and the surrounding matrix.

Silicon Carbide (Sic)

Sic can be used as reinforcement in the form of particulates, whiskers are fibres to improve the properties of the composite. When embedded in metal matrix composite Sic certainly improves the overall strength of the composite along with corrections and wear resistance. Aluminium MMCs reinforced with sic particles have up to 20 % improvement in yield strength lower co-efficient of thermal explaition, higher modulus of elasticity and more wear resistance then the corresponding and unreinforced matrix alloy systems . Silicon carbide tools jewellers' automobile parts electronic circuits' structural material's nuclear fuel of particles etc. For those reasons sic carbide particulates reinforced aluminium composites have found many applications such as brake disc bicycles frames, aerospace and automotive industries.

Characteristics of Silicon Carbide:- The following are characteristics of silicon carbide Low density, High strength of thermal conductivity, Low thermal expansion, High hardness

Table [.]	- 2 Particle	sizes of	silicon	carbide an	d graphite
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Reinforcement	Practical size range (µm)
Silicon carbide (SiC)	30-50
Graphite	30-40

The table show the particle size of silicon carbide and graphite the importance of practical size is uniformly distributed in the base metal Al6061 and improves the wetablity.



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Different Methods Used To Manufacture Particulate Reinforced MMC's

MMC manufacturing can be of two type; solid and liquid.

Solid –phase fabrication methods;

- Powder blending and consolidation; powdered metal and discontinuous reinforcements are mixed and then bonded through a process of compaction, degassing and thermo mechanical treatment.
- Foil diffusion bonding; layers of metal foil are sandwiched with long fibers, and then pressed through to form a matrix

Liquid - phase fabrication methods;

Liquid –phase fabrication method is more efficient than the solid phase fabrication methods because solid – phase processing requires a longer time.

- Electroplating/electroforming; a solution containing metal ions loaded with reinforcing particles is codeposited forming a composite material.
- Stir casting; discontinuous reinforcement is stirred into molten metal's which is allowed to solidify.
- Squeeze casting; molten metal is injected into a form with fibers preplaced inside it
- > Spray deposition; molten metal is sprayed onto a continuous fibers substrate.

Methodology

In this process studies related to hybrid composites of Al6061 was reviewed Specimen were prepared using stir casting method. In this work composites of Al6061/SiC/Gr was prepared Initially only Al6061 was melted to required temperature i.e. 700^oc and poured in to the metallic mould In preparing the composite a known quantity of Al6061 as matrix SiC in varying proportions as primary reinforcement i.e. 2%, 4%, 6%, 8% by weight and fixed quantity of Graphite as secondary reinforcement i.e. 4% by weight was used. Further machining of the composites to ASTM standards to conduct dry sliding wear test on pin-on-disc apparatus, by applying parameters like load, speed, distance and microstructures studied under SEM.

II. EXIPERMENTALS SETUP

Composite preparations by liquid stir casting route

As shown in the figure the stir casting setup it consist of the induction furnace; stirrer assembly. The stirrer assembly consist of the mild steel stirrer which was connected to the radial drilling machine with varying speed 80-800 rpm by means of steel shaft. The stirrer consist of nine blades in curved shape as shown in the fig crucible made up of mild steel coated with graphite and the capacity of 5kg was placed inside the Furnace. The graphical representation of stir casting is shown in figure 1

A known quality of (3kg) of Al alloys in soiled ingots was melted in the induction Furnace complete up to liquid form and slag is removed by the adding the scum powder and gas in removed by the adding hexachloro ethane tablets. After Al6061 in completely in the molten state next the reinforcement is pre heated on the surface of the Furnace to remove the moisture and to achieve good wet ability of the reinforcements the stir setup was readily available for next process. The stirrer will be immersed to ¼ of the depth of molten metal stirrer will be started and stirred up to 500 rpm and the vortex will be created inside the crucible. The mixture of reinforcement like SiC and Graphite by 2% & 4 %(fixed) were added at the rate of 10-20gr/min in to the metal. The speed is controlled with the speedometer and temperature is closely monitored at this stage of reinforcement adding in the molten metal After complete addition of the reinforcement remove the stir and degassing will be done and melt poured in to the preheated mould and allowed to solidified in the atmospheric air. This will be repeated for 4%, 6%, & 8% Silicon carbide



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Figure;-1 the graphical representation of stir casting

Hardness's Test:- The below table show the mean hardness no of different samples with variation of reinforcement

Sample no	Sample name (Al6061+)	Mean hardness no(VHN)
1	Pure(base Alloy)	52.0
2	2%SiC+44%Graphite	56.20
3	4%SiC+Graphite	65.79
4	6%SiC+Graphite	83.5
5	8%SiC+Graphite	93.71

Table no 3: hardness measurement

A hardness tester model no FV 700 is used for the hardness measurement. The surface being tested generally requires a metallographic finish and it was done with the help of 100,200,400,600 and 1000 grit size emery paper the load used on Vickers hardness tester was 1kg, 3kg and 5kg at 10x optical zoom with the dwell time 10 second for each sample The result of Vickers hardness tester for alloy Al6061 without reinforcement (sample no1) and variation of different reinforcement such as SiC and Graphite in alloy Al6061 MM'C (sample NO 1-5) as shown in table below

Results and Discussion:-

5.1.9 Graphs Showing the Wear Performance of Al6061, SiC, Graphite Sliding Distance 500, 1000, 1500m with Constant Speed1m/s, 2m/s& 3m/S

The pin on disc apparatus was used to perform the wear experiment the wear track alloy and composite specimens cleaned through with acetone prior to each test after that the specimen is mounted on the pin holder of the trybometre reedy for wear test, For all the experiment track diameter is 60mm and load 1kg 2kg 3kg &4kg speed 1m/s, 2m/s, &3m/s sliding distance 500m, 1000m, &1500m.



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Figure:-2 Variation of volume wear rate against load (a) At sliding distance of 500m

From the fig2 (a) show that the wear rate is increased with increasing in load the maximum wear rate is at 8% reinforcement of Silicon carbide and minimum wear rate is 6% reinforcement of Silicon carbide irrespective of load applied due to increasing contact between disc and pin leads



Figure:-2 Variation of volume wear rate against load b) At sliding distance of 1000m

From the figure 2 (b) show that with an increasing load on SiC/Graphite oxides coexisted with inter metallic phase that volume wear rate wear mild low loads and increased gradually until they material experienced transient from mild to severe load.



(c) Figure:-2 Variation of volume wear rate against load (c) At sliding distance of 1500



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From the figure 3(c) it is evident from the experiment that at low applied load and 2m/s speed the warm pin surface predominantly raises fine and shoal groves in the slide rate

Graphs Showing the Wear Performance of Different Sliding Speed with Constant Sliding Distance 500m,1000m&1500m



Figure:-4 Variation of volume wear rate against speed a) At load 1kg b) at load 2kg c) at load 3kg

From the graph plotted on volumetric loss vs. speed and volumetric loss vs load it is found that at 4 kg load, speed 3m/sec and 6% Silicon carbide and 4% Graphite as reinforcement wear loss is found to be optimum. As observed from the microstructure it is because uniform distribution of Silicon carbide and Graphite particles



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SEM analysis

The specimen will be prepared by the etching different grits size of emery paper like 400, 600, 800 and 1000 the surface will be nearly mirror image the specimen will be mounted on specially designed holder after that specimen with holder kept in to the machine HICATHI S-3400N under 20kv voltage figures shows that the SEM micro graphs of the different aluminium matrix composite at different magnification 500x, 1000x, 1500x.



Figure ;-5 SEM of MMC'S with 2% of Sic & 4% graphite at a) 1500



Figure:-7 SEM of MMC'S with 6% SiC &4% Graphite at c) 1500x



Figure;- 6 SEM of MMC'S with 4% of Sic & 4% graphite at b) 1500x



Figure:-8 SEM of MMC'S with 8% SiC 4% Graphite d) 1500x

Figure 8 shows the homogenous distribution of SiC and Graphite reinforced particle in alloy matrix homogenous distribution of particle is desired for achieving better wear behaviour and mechanical properties homogenous distribution of particle in a molten alloy is achieved due to the higher shear rate caused by stirring which also minimize the particle setting. However agglomeration of particle in some regions is clearly visible in all cases there is due to the presence of porosity associated to it presence of entrapped air and moisture in the reinforcement particle result in the void/porosity after casting. Poor bonding between the Al6061 alloy matrixes.

Micro structure observations of worn surfaces

The worn out surface of some selected /typical specimen (6% and 8% of reinforcement) after the wear test were observed under SEM at 250x, 500 xs.

Figure:-9 micrographs shows that a) 6% of SiC, b) 8% of SiC in Al6061





(b)



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The structure of the worn surface generally depends on load, speed, sliding distance and hardness of particle. Comparing their figure it can be visualized that one of the common features observed in all this MMC'S i.e. the formation of groves and roughness running parallel to the sliding distance on further analysis it has been found that grooves are fine on the worn surface of Al6061 with 8% SiC.

III. CONCLUSIONS

The conclusion given from the present investigation is as follows

- ➢ Al based metal matrix composite have been successfully fabricated by stir casting technique with fairly uniform distribution of Al6061 with Silicon carbide and Graphite particulates.
- For synthesizing of composite by stir casting process stirrer design, stirrer position, stirrer speed and time particles preheating temperature are the important process parameters
- > The results confirmed that in the base alloy the hardness increases with increasing the reinforcement
- > The SEM images revealed that Silicon carbide particulates are fairly distribution in aluminium alloy matrix.
- And it is also revealed from the SEM images that at some places void has been occurred before wearing after wear grooves running slide marks observed

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