FABRICATION OF AMMCs BY USING STIR CASTING METHOD FOR HAND LEVER

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Abstract: Aluminum Metal Matrix Composites (AMMCs) are emerging as the most versatile materials for advanced structural, automotive, aviation, aerospace, marine, defense applications and other related sectors because of their excellent combination of properties. In the present investigation, Al6061 T6 composites were fabricated by Stir casting method by varying Weight Percentage (wt. %) of reinforcement from Sample1 (Al80%+Sic20%), Sample2 (Al 80%+SiC10%+FlyAsh10%) & Sample3 (Al80% +SiC10%+ Neem leaf ash10%). The Al6061 T6 alloy composites and its wear and frictional properties of the metal matrix composites was studied by performing dry sliding wear test using a pin-on-disc Friction & wear tester. The sliding wear tests were conducted for various loads, speeds and sliding distances. The result reveals that wear rates of the composite is lower than that of the matrix alloy and friction coefficient was minimum. The incorporation of hybrid ceramic powder with different sized particles as reinforcement material in Al6061 T6 alloy improves („smaller the better") the tribological characteristics of lever not only lever by implementing of this combination we improve the strength & reduce the weight of the component like Chassis & Chain Sprockets Etc....

Keywords: Al6061 – Aluminum 6061 Grade, T6 – Temper Sixth, AMMCs – Aluminum Metal Matrix Composites,

I. INTRODUCTION

The aim involved in designing metal matrix composite materials is to combine the desirable attributes of metals and ceramics. The addition of high strength, high modulus refractory particles to a ductile metal matrix produce a material whose mechanical properties are intermediate between the matrix alloy and the ceramic reinforcement. Aluminium metal matrix composite (AMMCs) refer to the class of light weight high performance aluminium centric material systems. There in for cement in AMMCs could be in the form of continuous/discontinuous fibers, whisker or particulates, in volume fractions ranging from a few percent to 70%. Properties of AMMCs can be tailored to the demands of different industrial applications by suitable combination of matrix, reinforcement and Processing routes. There are various types of AMMCs like Sic, Sic+Fly Ash, Sic+Neem leaf ash, etc. which are commonly used in automotive and defense. These AMMCs have greater demand because of their advanced properties like greater strength, improved stiffness, reduced density, improved high temperature properties, controlled thermal expansion coefficient, enhanced and tailored electrical properties, improved abrasion and wear resistance, control of mass, improved damping capabilities.

II. PROCESSING OF AMMCS

Al 6061 T6 alloy is used in the transportation, construction and engineering industries. It has excellent mechanical properties in addition to good corrosion resistance due to which the alloy finds extensive application in naval vessels manufacturing. Al6061 alloy metal matrix composites with hybrid ceramic powder reinforcement can be a solution for such applications. It can satisfy the requirement of light weight with very good strength. Al6061 T6 alloy composite is a metal matrix composite (AMMCs) that can be manufactured using the stir casting. With hybrid ceramics powder particulate addition the

properties of Al 6061 alloy can be greatly improved. The samples with various compositions produced will be evaluated for their microstructure, wear properties so that the best composition can be recommended for obtaining composites to suit various engineering applications.

Properties and Considerations of Manufacturing by Plaster Mold Casting

When baking the casting mold just the right amount of water should be left in the mold material. Too much moisture in the mold can cause metal casting defects, but if the mold is too dehydrated, it will lack adequate strength. The fluid plaster slurry flows readily over the pattern, making an impression of great detail and surface finish. Also due to the low thermal conductivity of the mold material the casting will solidify slowly creating more uniform grain structure and mitigating casting warping. The qualities of the plaster mold enable the process to manufacture parts with excellent surface finish, thin sections, and produces high geometric accuracy. There is a limit to the casting materials that may be used for this type of manufacturing process, due to the fact that a plaster mold will not withstand temperature above 2200F (1200C). Higher melting point metals cannot be cast in plaster. This process is typically used in industry to manufacture castings made from aluminum, magnesium, zinc, and copper based alloys. Manufacturing production rates for this type of metal casting process are relatively slow, due to the long preparation time of the mold. The plaster mold is not permeable, which severely limits the escape of gases from the casting.

Problem Identification

Part of a hand lever and as such to satisfy the requirements to brakes,
Mechanism must enable a later fitting the steel cord tension,
Mechanism must enable a later change of the steel cords when necessary.
The procedure of construction of the automatic mechanism for compensating the aeration which satisfies mentioned demands is presented in this paper

Compositions of samples:

	Sample - I	Sample - II	Sample - III
Reinforced with	AA6061-T6 - 80% (83g) SiC- 20% (17g)	AA6061-T6 - 80% (83g) SiC - 10% (8.5g) Fly Ash - 10% (8.5g)	AA6061-T6 - 80% (83g) SiC - 10% (8.5g) Neem leaf ash- 10% (8.5g)

Aluminum Alloy 6061 T6 Properties

General 6061 characteristics and uses: Excellent joining, characteristics, good acceptance of applied coatings and combines relatively high strength, good workability, and high resistance to corrosion. The T8 and T9 tempers offer better chipping characteristics over the T6 temper.

Applications: Aircraft fittings, camera lens mounts, couplings, marines fittings and hardware, electrical fittings and connectors, decorative or misc. hardware, hinge pins, magneto parts, brake pistons, hydraulic pistons, appliance fittings, valve parts and bike frames.

Effect of reinforcement distribution

Apart from the reinforcement level, the reinforcement distribution also influences the ductility and fracture toughness of the AMMCs and hence indirectly the strength. A uniform reinforcement distribution is essential for effective utilization of the load carrying capacity of the reinforcement. Non-uniform distributions of reinforcement in the early stages of processing was observed to persist to the final product in the forms of streaks or clusters of un filtrated reinforcement with their attendant porosity, all of which lowered ductility, strength and toughness of the material.

III. COMPONENTS

Effect of Nano particle size

The deformation and fracture behavior of the composite revealed the importance of particle size. A reduction in particle size is observed to increase the proportional limit, yield stress and the ultimate tensile stress. It is well established that large particles are detrimental to fracture toughness due to their tendency towards fracture. It would be highly desirable to have a composite system where there in forcing particles are relatively fine (4μm or less) so as to get the stiffness benefits of a composite without significantly lowering fracture toughness.

Silicon Carbide, SiC Ceramic Properties:

Silicon Carbide is the only chemical compound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide is an excellent 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.. The material can also be made an electrical conductor and has applications in resistance heating, flame igniters and electronic components. Structural and wear applications are constantly developing.

Fly ash

Fly ash is very much similar to volcanic ashes used in production of the earliest known hydraulic cements about 2,300 years ago. Those cements were made near the small Italian town of Pozzuoli - which later gave its name to the term “pozzolan.. Fly ash is the notorious waste product of coal based electricity generating thermal power plants, known for its ill effects on agricultural land, surface and sub-surface water pollution, soil and air pollution and diseases to mankind. Researchers have proposed few ways of reusing fly ash for variety of application. One of the most common reuse of fly ash is in cement concrete. Fly ash particles are almost totally spherical in shape, allowing them to flow and blend freely in mixtures. That capability is one of the properties making fly ash a desirable admixture for concrete. These materials greatly improve the durability of concrete through control of high thermal gradients, pore refinement, depletion of cement alkalis, resistance to chloride and sulphate penetration, and continued micro structural development through a long-term hydration and pozzolanic reaction

Neem leaf ash

Neem leaf Husk is a by-product obtained during industrial processing of Neem Seed to extract oil and produce fertilizer. In producing Neem based fertilizer, extraction of neem oil is done first, and the resultant cake is used in making organic based fertilizer. Some little quantity of seed husk is crushed and ground into fertilizer formulation but large quantity usually lay waste. Neem leaf Husk ash is obtained by burning the seed husk and the Neem seed itself is from Neem tree. The Neem leaf Ash was dried and burned in an open, after which it was calculated in an oven at temperature of 600^{o}C to produce Neem leaf ash. Locally available river sand was used as fine aggregate was clean, sharp, and free from clay and organic matter and well graded in accordance.

Plaster Mold Casting

Plaster mold casting is a manufacturing process having a similar technique to sand casting. Plaster of Paris is used to form the mold for the casting, instead of sand. In industry parts such as valves, tooling, gears, and lock components may be manufactured by plaster mold casting.

The process

Initially plaster of Paris is mixed with water just like in the first step of the formation of any plaster part. In the next step of the manufacture of a plaster casting mold, the plaster of Paris and water are then mixed with various additives such as talc and silica flour. The additives serve to control the setting time of the plaster and improve its strength. The plaster of Paris mixture is then poured over the casting pattern. The slurry must sit for about 20 minutes before it sets enough to remove the pattern. The pattern used for this type of metal casting manufacture should be made from plastic or metal. Since it will experience prolonged exposure to water from the plaster mix, wood casting patterns have a tendency to warp. After striping the pattern, the mold must be baked for several hours, to remove the moisture and become hard enough to pour the metal casting. The two halves of the mold are then assembled for the casting process. When manufacturing a metal casting by the plaster mold casting process one of the biggest problems facing a foundry man is the lack of permeability of the plaster mold. Different techniques may be used in order to overcome this problem. The metal casting may be poured in a vacuum, or pressure may be used to evacuate the mold cavity just before pouring. Another technique would be to produce permeability in the mold material by aerating the plaster slurry before forming the mold for the casting. This "foamed plaster" will allow for the much easier escape of gases from the casting. Sometimes in manufacturing industry a special technique called the Antioch Process may be used to make a permeable plaster metal casting mold.

Pin on Disc Friction & Wear Tester

The following measurements has to be teken from the pin on disc friction & Wear tester

Work pieces	Speed in (RPM)	By load in Kg	By Time in Min	Track Radius	Speed in (RPM)	Frictional Forcein (N)	Wear in (Micron)
Al6061 T6	300	5 Kg	4Min	20mm	500	104.25	243.67
				30mm	600	104.22	338.16
				40mm	700	104.2	519.95
Sample1 (Al80%+Sic20%)	300	5 Kg	4Min	20mm	500	103.86	192.04
				30mm	600	103.84	312.10
				40mm	700	103.82	430.61
Sample2 (Al 80%SiC10%+Fly Ash10%)	300	5 Kg	4Min	20mm	500	104.32	177.71
				30mm	600	104.29	311.59
				40mm	700	104.28	369.13
Sample3 (Al80%+SiC10%+Neem leaf ash10%)	300	5 Kg	4Min	20mm	500	104.41	156.19
				30mm	600	104.4	270.01
				40mm	700	104.37	354.82

A pin-on-disc wear testing tribometer of make was used to investigate the dry sliding wear behavior of the Al 6061 MMC composite specimens. Dry sliding wear tests were conducted as per ASTM G99 standards. Wear specimen of 8 mm diameter and 30 mm length were machined from cast samples and then polished metallo-graphically. The initial weight of the specimen was measured in a single pan electronic weighing machine with a least count of 0.0001g. During the test the pin was pressed against the counterpart rotating against EN-32 (Hardness 65 HRC) steel disc by applying the load at room

temperature as shown in figure-5 The frictional traction experienced by the pin during sliding is measured continuously by PC-based data-logging system. After running through a fixed time period, the specimen were removed, cleaned with acetone, dried and weighed to determine the weight loss due to wear. The difference in the weight measured before and after the test gives the wear of the specimen. The wear rates were determined using the weight loss method.

The wear testing machine was microprocessor controlled, in which height loss and frictional force can be monitored simultaneously by a PC-based data logging system. The height loss data was converted into volumetric loss by multiplying it with area of cross section of the test pin. The wear rate was calculated by dividing volumetric loss with sliding distance. A typical pin is cylindrical in shape with diameter equal to 8mm and length equal to25mm.

A typical disc has diameter of 180 mm and thickness of 12mm. The disc is ground to get a surface roughness of 0.8 micrometer. The disc is made of highly polishedEN-25 steel with surface hardened to about 60 RHN. During wear testing height loss experienced by the pin specimen is measured in microns. Measurement of wear height loss of the pin was used to evaluate the wear loss during the wear test.

Tensile Test Readings

Work pieces	Tensile Stress (N/mm^2)	Tensile Strain %
Base Material Al6061 T6	81.0	14.5
Sample1 (Al80%+Sic20%)	88.0	16.9
Sample2 (Al 80%SiC10%+Fly Ash10%)	83.0	18.3
Sample3 (Al80%+SiC10%+Neem leaf ash10%)	93.0	19.7

IV. STIR CASTING

In this step we have first prepared aluminum based composite material in the Stir Casting furnace as discussed in above section to cast specimen's of various mechanical tests.

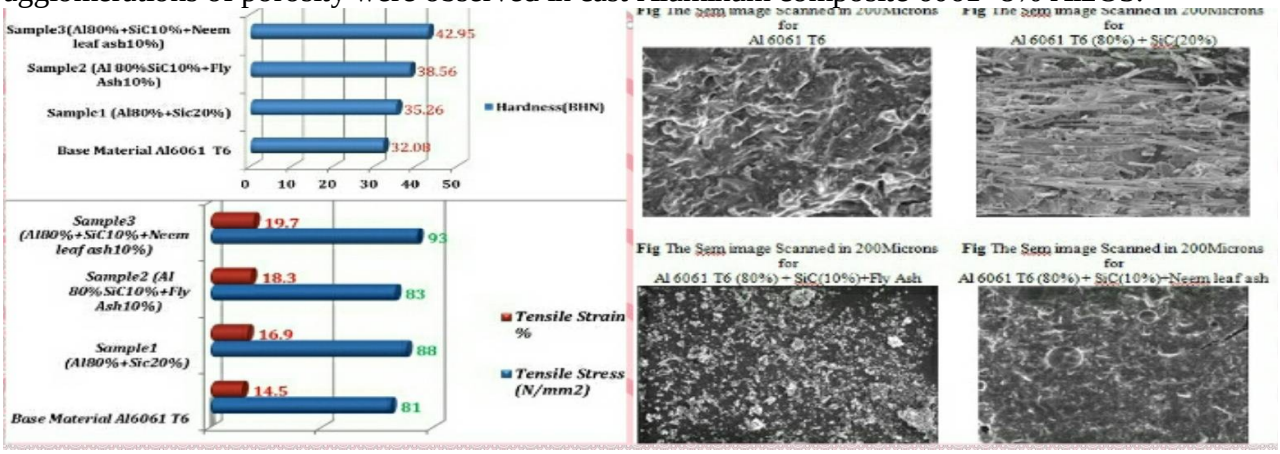
Work pieces	Furnace Temp in ^oC	Metal Melting Temp in ^oC	Stirrer Speed in RPM	Stirrer Timing in mins	Reinforcement Pre heating Temp in ^oC
Sample 1	800 - 820	780 - 790	750	5	562 - 570
Sample 2	800 - 820	775 - 790	750	5	616 – 627
Sample 3	800 - 820	778 - 794	750	5	623 - 640

V. MICRO STRUCTURE & HARDNESS TEST

Microstructure Test (SEM Test)

After the Sample 3(AA+SiC+Neem leaf ash) fabricated by stir casting, the SEM micrographs were taken at Annamalai University, Chidambaram. Al6061 alloy, Al6061 Metal matrix alloy composites shown in figure - 4 reveal that there is fairly uniform distribution of Al2O3 & graphite particulates throughout the matrix alloy and good interface bonding between reinforcements& base metal. It is reported that higher hardness is always associated with lower porosity of the MMCs. Also, it can be

observed that there is good bonding between the matrix and the reinforcement particulates resulting in better load transfer from the matrix to reinforcement materials. The Particle clustering and agglomerations of porosity were observed in cast Aluminum composite 6061 -8% Al2O3.



VI. RESULT & DISCUSSION

The results confirmed that stir formed Al alloy 6061 with Sic + Neem leaf ash reinforced composites is clearly superior to base Al alloy 6061 in the well Hardness.

Dispersion of Sic particles in aluminum matrix improves the hardness of the matrix material.

The results confirmed that stir formed Al alloy 6061 with Sic + Neem leaf ash reinforced composites we can reduce weight of the component

VII. CONCLUSION

Aluminium Silicon carbide alloy composite materials are widely used for a many number of applications like engineering structures, aerospace and marine application, automotive bumpers, sporting goods and so on. Based on our work we have found that the weight to strength ratio for Al alloy 6061 with Sic + Neem leaf ash is about three times that of mild steel during tensile test. Al alloy 6061 with Sic + Neem leaf ash composite material is two times less in weight than the aluminium of the same dimensions. The maximum tensile strength has been obtained at 10% SiC ratio. This indicates that the Aluminium silicon carbide composite material is having less weight and more strength; it is very much useful in practical automobile & aerospace applications.

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