Fabrication and Analysis of Aluminum Flyash With Tungsten Carbide By Powder Metallurgy

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Abstract- *The ever-increasing demand for light weight, economy and environmental purpose has leadto the development of advanced materials. MMCs are widely used in industries, as they have excellent mechanical properties and wear resistance.So, in this project introduced Particulate-reinforced hybrid composites because of it is cost less than fiber-reinforced composites owing to the lower cost of fibers and manufacturing cost. In addition to improved physical and mechanical properties, particulate-reinforced hybrid composites are generally isotropic and they can be processed through conventional methods used for metals. Thus, the fly ashes, aluminum AL7075, tungsten carbide reinforced with aluminum composites are increasingly used as substitute materials for high temperature applications.This project deals with the selection of better material for the process of more hardness and temperature resistance, in that Aluminum hybrid composite are produced by AL 7075 as matrix material and fly ash and tungsten carbide as reinforcement in different composition.(Al- 96, tungsten carbide - 2, Fly ash- 2)Different sample are produced by using stir casting methods. Various tests have been conducted to evaluate the different properties of aluminum composites and they are compared with commercial aluminum alloy.*

Keywords- Aluminum alloy (AL-96), Tungsten Carbide, Fly Ash.

I. INTRODUCTION

There have been continuous efforts to develop new manufacturing processes using Aluminum based alloy materials for such as automotive engine components, wear resistance components, and also heavy applications. As the automotive engine components play an important role by transferring the explosive impact from the explosion chamber to the connecting rod, high thermal resistance and great structural strength is required to endure extremely high temperature and pressure. Gravity diecasting, squeeze casting, hot forging, powder forging, stir casting processes have been generally used for the manufacturing of aluminum materials. Among them, application of the stir casting process is dominant enough to occupy over 90% of composites manufacturing in the modern industry. However, as feed materials of the stir casting process are handled at the completely molten state. Its final product undergoes inhomogeneous solidification, which damages the integrity. Moreover, they have dendrite microstructures, which lower the strength of material. Recently, the challenged hot forging process is suitable for high strength products, because the work piece experiences a significant amount of work hardening. However, its requirement for large forming load and the poor generosity on the product geometry could not be overlooked. This project deals with the selection of better material for the process of more hardness and temperature resistance, in that Aluminum hybrid composite are produced by AL 7075 as matrix material and Fly ashand activated carbon as reinforcement in different composition. Different sample are produced by using stir casting methods. Various tests have been conducted to evaluate the different properties of Aluminum composites and they are compared with commercial Aluminum alloy.

1. INTRODUCTION TO COMPOSITES:

Composite materials are engineering materials made from two or more constituent materials that remain separate and distinct on a macroscopic level while forming a single component. There are two categories of constituent materials: matrix and reinforcement. At least one portion of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. A synergism produces material properties unavailable from the individual constituent materials. Due to the wide variety of matrix and reinforcement materials available, the design potentials are incredible.The physical properties of composite materials are generally not isotropic in nature. For instance, the stiffness of a composite panel will often depend upon the directional orientation of the applied forces or moments. In contrast, an isotropic material has the same stiffness regardless of the directional orientation of the applied forces or moments. The relationship between forces/moments and strains/curvatures for an isotropic material can be described with the following material properties like Young's Modulus, the Shear Modulus and Poisson's Ratio.Composite materials are made from two or more constituent materials with significantly different physical or chemical properties. Metal matrix composites (MMCs) are the forerunners amongst different classes of composites. Over the past two decades metal matrix composites (MMCs) have been transformed from a topic of scientific and intellectual interest to a material of broad technological and commercial significance (Miracle,2005) Metal Matrix Composite consists of a metallic matrix combined with a reinforcing material. The matrix materials are Aluminium, Magnesium, and Titanium etc. The reinforcing materials can be Silicon Carbide, Flyash,Alumina, and Graphite. MMCs offer a unique balance of physical and mechanical properties. Aluminium based MMCs have received increasing attention in recent decades as engineering materials with most of them possessing the advantages of high strength, hardness and wear resistance.

2. COMPOSITION OF COMPOSITES

a. **RESINS**

The primary functions of the resin are to transfer stress between the reinforcing fibers, act as a glue to hold the fibers together from the fibers from mechanical and environmental damage. The most common resins used in the production of FRP grating are polyesters.

b. **REINFORCEMENT**

The primary function of fibers or reinforcement is to carry load along the length of the fiber to provide strength and stiffness in one direction.

c. **FILLERS**

Fillers are used to improve performance and reduce the cost of a composite by lowering compound cost of the significantly more expensive resin and importing benefits as shrinkage control, surface smoothness, and crack resistance.

d. **ADDITIVES**

Additives and modifier ingredients expand the usefulness of polymers, enhance their process ability or extend product durability.

3. PROPERTIES ENHANCEMENT BY COMPOSITES

- Strength
- Stiffness
- Fatigue life
- Thermal conductivity
- Density
- Wear resistance

4. **NEED FOR COMPOSITES**

Due to fuel crisis of the world, yet lighter weight material are needed in various field such as aerospace, transportation, automobile and construction sector.

5. TYPES OF COMPOSITES

- Fibrous composites
- Laminated composites
- Particulate composites

✓ **FIBROUS COMPOSITES**

A fiber is characterized by the length being much greater compared to its cross-sectional dimension. The dimensions of the reinforcement determine its capacity of contributing its properties to the composites.

✓ **LAMINATED COMPOSITES**

Laminate composite consists of layers with different anisotropic orientation or of a matrix reinforced with a dispersed phase in form of sheets, when a fibre reinforced composites consists of several layers with different fibre orientation, it is multilayer(angle ply) composite. Laminate composites provide increased mechanical strength in two directions and only in one direction, perpendicular to the preferred orientation of fibres or sheet, mechanical properties of the materials are low.

✓ **PARTICULATE COMPOSITES**

As the name itself indicates, the reinforcement is of a particle in nature(platelets or also include class). It may be spherical cubic, tetragonal, a platelet or of other regular or irregular shape, but it is approximately equated.

6. TYPES OF REINFORCEMENTS USED:

The three different types of reinforcements used in the project are

1. AL7075
2. Tungsten Carbide3. Fly ash (Almond shell)

II. LITERATURE SURVEY

Zhao et.al. studied the “Microstructures and mechanical properties of equal-channel angular pressing (ECAP) processed and naturally aged ultrafine grained (UFG) and coarse grained (CG) Al7075 alloys and their evolutions during heat treatment” in 2004 observed. Their studies established that after the tests, natural aging, tensile yield strength, ultimate strength and micro hardness of UFG samples were higher by 103%, 35% and 48% respectively than those of the CG samples. Their studies show that severe plastic deformation has the potential to significantly improve the mechanical properties of age-hardening Al alloys .The authors have investigated the microstructure and mechanical properties of GTAW and GMAW joints of AA7075 aluminium alloy. Welding of the AA7075 alloy is made using GTAW and GMAW with argon as a shielding gas.

Jothi Sudagar et.al. have investigated “Dry sliding wear properties of a 7075-T6 Al alloy coated with Ni-P (h) in different pretreatment conditions” in 2009 observed. Dry sliding behavior of electroless nickel-phospurous (EN) coating of thickness ~35μm deposited on a 7075-T6 Al alloy was studied. Their results suggested that the wear behavior of EN mostly depended on the pretreatment conditions. Heat treatment at temperature of 400 o C can enhance the wear resistance properties for all types of pretreatment conditioned samples. Ni strike provided better interlocking adhesion between EN and Al and this pretreatment improved the wear, frictional and hardness behavior of the EN coatings on Al7075 substrate. The significance of three important deep drawing process parameters namely blank temperature, die arc radius and punch velocity on the deep drawing characteristics of Al7075 sheet were determined in .The methodology in this paper involved a combination of finite element techniquesalong with Taguchi analysis. Simulations were carried out as per orthogonal array using DEFORM 2D software. The study established that the blank temperature has the greatest influence on the formability of Al material followed bypunch velocity and die arc radius.

M.Marini and V.Fontanari have investigated “The effect of surface hardening by Shot Peening on fatigue properties of high strength Al7075-T651 alloy” in 2017 is observed. The authors show an increase of fatigue strength after Shot Peening treatment due to the compressive residual stressability to influence fatigue crack nucleation. Machinability is considered as a system property that includes both the process and the material. Various factors such as hardness, ductility, surface tensions, alloying elements within the structure and heat treatment to which the material is exposed have influence on the machinability of a material. Hasan Kaya et.al. in have analyzed the effect of aging on the machinability of AL7075 aluminium alloy using the single point turning method. In their analysis, the alloy samples were aged at 180 o C for 1, 6, 12 and 24 hours. The machinability tests were conducted at various cutting speeds and the resulting sample surface roughness, cutting forces and thermal changes occurring on the cutting tool were analyzed according to the cutting speed. The tests also involved unaged samples. Their results showed that depending on the aging time, the hardness measurement taken from the aged samples increased the hardness between the intervalsof 102 to 211 (HV). The temperature of different types of chips which were observed with thermal camera during machining of the unaged and aged samples were found to vary between 52 o C to 92 o C.

H.B.Bhaskar and Abdul Sharief in have investigated “The Tribological properties of Al 2024 alloy. Al2024-beryl composites were fabricated by liquid metallurgy route by varying the weight percentage of reinforcement from 0 to 10 wt.% in steps of 2 wt.% ” 2012 is observed. Dry sliding wear tests were conducted to test the wear behavior of Al2024 alloy its composites. Their results indicated that the wear rates of the composite was lower than half of the matrix alloy and friction coefficient was minimum when compared to monolithic alloy. Further beryl particles as reinforcement improved Tribological characteristics. The process of factorial design of elements have been demonstrated in to predict the hardness behavior of forged composites. The components produced by stir casting and forging of Al7075/Al 2 O 3 composites are shown to possess almost two times the average hardness as compared to those obtained by their monolithic matrix based on counter parts. Their study shows that parts possessing maximum micro hardness of 140VHN can be produced using 15% by weight of 60μm diameter Al 2 O 3 at forging temperature of 425 C and a reduction in area of 55% after forging. The model proposed in this paper can be used to produce Al7075/Al 2 O 3 composites of desired micro hardness and to predict the hardness of composites.

Karthigeyan et.al. “Al7075 alloy composites containing different volume fraction of short basalt fiber are developed using the stir casting process” in 2012 observed. The experimental strength values of the composites are compared with the theoretical values in this paper. The results suggested that the experimental values best suited the theoretical values owing to the random distribution of basalt fibers in the Al7075 matrix. The effects of load and sliding speed on the friction coefficient and wear properties of pin of Al7075-Fly Ash composite material on Pin on Disc apparatus was investigated by Deepak Singla and Mediratta. Their experiments indicated that composites with fly ash as reinforcement in Al7075 optimizes the different physical and mechanical properties of the composite.The mechanical properties of TiB 2 reinforced

Al7075 MMC material was studied Aluminium MMC's containing Titanium-boride are developed using liquid metallurgy technique. The composites were prepared with Al10%Ti and Al-3%B master alloys as reinforcement. Microstructure test and grain size tests were conducted to find uniform distribution of TiB 2 particles in the matrix material. Micro hardness test confirmed the fact that this composite is much harder than the matrix alloy. Tensile strength increased in the MMC but the ductility of the MMC decreased in respect of the ductility of the matrix material. TiB 2 particle peaks were observed in the X-ray diffraction test, Grain size test indicated the initiation of heterogeneous nucleation in the composite mixture, homogeneous distribution of TiB 2 particles were observed in the Optical micrographs and the presence of TiB 2 particles indicated a grain refinement.

Benachour et.al. "Investigated fatigue crack initiation 7075 T6 and 7075 T71 aluminium alloys under constant amplitude loading" in 2013 is observed. The investigation involved local strain approach at the notch and a single edge notch tensile specimen with semi-circular notch was used. Their results indicated that fatigue life initiation was affected by notch geometry and mean stress. Fabrication and characterization of Al7075 alloy reinforced with SiC particulates is studied by the authors Rajesh Kumar Bhushan, Sudhir Kumar and S. Das. The investigation involves fabrication using stir cast method of the alloys AA7075 and AA7075/SiCp (20-40 μm). The characterizations of composites of different weight fractions of reinforcement materials (10% and 15%) were carried out by SEM, EDAX, XRD, DTA and EMPA analysis. It was observed that alloying of Al matrix with 2.52 wt% Mg and its segregation at the interfaces was effective in restricting the formation of Al 4 C 3 at the interfaces during casting. Oxidation of SiC has prevented or restricted chemical reaction at interfaces. Enhancement of wetting between the molten alloy and reinforcement was observed due to the well stirred matrix and reinforcement. SEM examination showed that the distribution of reinforcement particles is homogeneous. The XRD pattern indicated no peaks of Al 4 C 3. EPMA analysis indicated aluminium as the main constituent and the coarse particles contained the alloying element of Zn, Mg and Cu and microstructures of Al7075 alloy, AA7075-10 wt%SiCp (20-40 μm) and AA7075-15 wt% SiCp (20-40μm).

In Yazdian et.al. have investigated "The fabrication and precipitation hardening characterization of nanostructure Al7075 alloy" in 2014 is observed. In their experiment, the Al7075 alloy is milled up to 15 h and then hot pressed. The milled and hot pressed samples are characterized by XRD, TEM, SEM and DTA. Their results indicated that after 15 h of milling, the alloying elements are dissolved in the Al matrix and a supersaturated solid solution with average crystallite size of 30±5 nm is obtained. Hot pressing the powder samples at 500 o C under 400 MPa resulted in a fully dense bulk nanostructure Al7075alloy. The hardness value of the consolidated sample increased from 165 HV to 240 HV after appropriate hardening.

EzhilVannan and Paul Vizhian. "Corrosion Characteristics of Basalt Short Fiber Reinforced with Al-7075 Metal Matrix Composites" in 2014 is observed .The effects of short basalt fiber reinforcement on the mechanical properties of case Al7075 alloy composites containing short basalt fiber of content ranging from 2.5% to 10% by weight in steps of 2.5% and fabricated using compocasting technique. The study revealed that as the short basalt fiber content was increased, there were significant increases in the ultimate tensile strength, hardness, compressive strength and Young's modulus accompanied by a reduction in its ductility. The microstructure and facture studies using OM and SEM carried out were used to establish the relationships between the quality of the fiber/aluminium interface bond and the mechanical properties of composites.Fabrication, Surface ,Morphology and Corrosion investigation of Al7075/Al 2 O 3 matrix composite in sea water and industrial environment was presented by VigneshShanbagh et.al. The corrosion behavior of base Al7075 alloy and Al7075 reinforced with 10% wt and 15% wt of Al 2 O 3 fabricated by stir casting method is studied. Metallographic study of composite was carried out using optical microscope, XRD, SEM with EDX. The results showed that Al7075/Al 2 O 3 corroded more in sea water environment than in industrial environment. By correlating density measurement, Tafel plots, SEM Micrograph, the authors concluded that as reinforcement increases, interface bond between matrix and reinforcement reduces. Consequently, porosity increases and corrosion rate increases.

Rajesha et.al. studied "Recast layers and surface roughness on Al7075 MMC during EDM machining" in 2014 is observed. Optimization of process parameters to minimize surface roughness of the rapidly resolidified layer of Al7075 MMC which machining using EDM process is carried out using Taguchi techniques. Corrosion studies on friction welded dissimilar aluminium alloys of AA7075 and AA6061-T6 were carried out by Satish and Sheshagiri Rao. Their experiments indicated that the parental metal wrought aluminium alloy corroded at a higher rate than the corresponding friction welded region of joints. The corrosion current and corrosion rate was found to be higher for the AA7075-T6 side compared to the AA- 6061-T6 side. The minimum and maximum corrosion rate varied from 1.91 to 5.74 mm/year in different regions. The results were validated by a microstructure study by optical microscopy of the weld joints.

In Song et.al. studied “The temperature induced work softening in Be/Al composites”in 2000 is observerd. The Be/Al composites exhibited a normal work hardening behavior at room temperature but flow softening occurred at 232°C and above. Work softening behavior was observed in Be/Al composites at elevated temperatures. Alloy 562 exhibited a pronounced softening behavior after yielding, while alloy 162 was work hardened slightly in the early stage of deformation and its stress/strain curve was leveled off later. Reinforcement particle size plays an important part in the observed work softening. The smaller the particle size, the more pronounced is the softening behavior. Particle rearrangement and interfacial sliding are the primary causes for the observed work softening of the Be/Al composites. Increasing temperature and decreasing particle size intensify work-softening behavior. The synthesis of Al-TiN(10, 20, 30 wt. %) composites by using microwave radiation was studied by Venkateswarlu et.al. During analysis, Al and TiN powders were sintered for various times. The results showed that an optimum microwave sintering time of 2 min was essential for synthesis of Al-TiN MMC’s. Moreover, microwave sintering is more economical than other conventional sintering methods. SiCsusceptor was used during microwave sintering which was responsible for an efficient way of supply of heat to the samples. Increasing TiN content in Al- TiN MMC’s from 10 to 30 wt. % showed superior hardness and wear resistance properties as compared to Al-TiN composites prepared by hot pressingSoon-Jik Hong et.al. synthesized “Al 2024 –SiC MMC by centrifugal atomization, hot extruded to investigate the effect of clustering on the mechanical properties” in 2017 is observed. Fracture toughness and tension tests were conducted on specimens reinforced with different volume fractions of SiC. Their results show that by optimizing the volume fraction of the reinforcement and the clusters, high strength and reasonablygood fracture toughness values could be obtained. For the Al 2024-SiC system, the optimum values appear to be 5-7 vol. % SiC, with a cluster volume of about 15-20%. Processing methods that produce microstructures with a more uniform distribution of reinforcements could potentially result in composites with improved mechanical properties.

III. METHODOLOGY

Methodology

In this work of Aluminium metal matrix composites, Al 7075 is used as the matrix metal , fly ash particulates as the reinforced material. The metal matrix composite was prepared using a furnace. The pure Al 7075 was fed into the furnace crucible of the preheated furnace and was allowed to melt at 950C. The reinforcement powder of fly ash and Tungsten carbide heated separately at 200C and was added to the molten metal and was stirred well at 60 rpm for 15 minutes. After well mixed, the crucible is taken out and the molten metal is poured into the cylindrical metallic molds and then subjected to squeeze casting. Thus, the required cylindrical shaped sample work pieces are obtained. The fabricated metal matrix composite was subjected to various testing procedures for mechanical properties such as hardness, tensile strength, impact strength, density and microstructure. Finally, the results are obtained from the test as report.

IV. EXPERIMENTAL WORK

EXPERIMENTAL PROCEDURE FOR STIR CASTING:

The conventional experimental setup of stir casting essentially consists of an electric furnace and a mechanical stirrer. The electric furnace carries a crucible of capacity 2kg. The maximum operating temperature of the furnace is 1900ºC. The current rating of furnace is single phase 230V AC, 50Hz. The aluminium alloy (7075) is made in the form of fine scraps using shaping machine. It amounts to about 1150 gm. The metal scraps are poured into the furnace and heated to a temperature just above its liquidus temperature to make it in theform of semi liquid state (around 650ºC). The mixing of aluminium alloy is done manually for uniformity. Then the reinforcement powder that is preheated to a temperature of 600°C is added to semi liquid aluminium alloy in the furnace. Again reheating of the aluminum matrix composite is done until it reaches complete liquid state. argon gas is introduced into the furnace through a provision in it for few minutes. During this reheating process stirring is done by means of a mechanical stirrer which rotates at a speed of 60 rpm. The aluminium composite material reaches completely liquid state at the temperature of about 950°C as the melting point of aluminium is 700ºC.the completely melted aluminium metal matrix composite is poured into the permanent moulds and subjected to compaction to produce the required specimen.

V. ANALYSIS AND TESTING

The following test are analysed in the composite materials

- TENSILE TEST
- HARDNESS TEST

TENSILE TEST

Tensile testing, also known as tension testing,is a fundamental materials sciencetest in which a sample is subjected to a controlled tension until failure. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under other types of forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined: Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics. Uniaxial tensile testing is the most commonly used for obtaining the mechanical characteristics of isotropic materials. For anisotropic materials, such as composite materials and textiles, biaxial tensile testing is required.

TENSILE TEST TABULAR ANALYSIS

Sample Identificatio	Ultimat Tensi Strength	Yield Strengt (Mp)
Sample	55	32
Sample	55	32
Sample	55	32

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HARDNESS TEST

The Brinell hardness test was developed in England is 1925 and was formally known as the Diamond Pyramid Hardness (DPH) test. The briwell test has two distinct force ranges, micro (10g to 1000g).The indenter is the same for both ranges therefore Vickers hardness values are continuous over the total range of hardness for metals (typically HV100 to HV1000). . With the exception of test forces below 200g, Vickers values are generally considered test force independent. In other words, if the material tested is uniform, the Vickers values will be the same if tested using a 500g force or a 50kg force. Below 200g, caution must be used when trying to compare results.

HARDNESS TEST

Type of Test	Sample ID	Observed Value
Hardness Test (Bhn)	Sample 1	210
	Sample 2	208
	Sample 3	208

MATERIAL REQUIREMENT FINDING METHOD

FOR SAMPLE 1
98% AL + 1% TC + 1% MS
<u>(Density of AL* % of AL*vol of AL) +(Density of TC* % of TC*vol of TC) +(Density of MS* % of MS*vol of MS) + 346.47 gms Al+ 1.37gms TC + 1.63gms MS</u>

FOR SAMPLE 2
98% AL + 1% TC + 1% MS
342.92 gms Al+ 2.77gms TC + 3.306gms Fly ash

FOR SAMPLE 3
97% AL + 1.5%TC + 1.5% MS
<u>339.47 gms Al+ 4.209 gms TC + 4.82 gms MS</u>

VI. CONCLUSIONS

The flowing conclusion may be drawn from the present work: From the study it is concluded that we can use fly ash for the production of composites and can turn industrial waste into industrial wealth. This can also solve the problem of storage and disposal of fly ash. Fly ash up-to 0.5% by weight can be successfully added to commercially pure aluminum by stir casting route to produce composites. Addition of Tungsten carbide and Fly ash improves the wet ability of fly ash with aluminum melt and thus increases the retention of the fly ash in the composite. Hardness of commercially pure aluminum is increased from 208BHN to 210BHN with addition of fly ash and Tungsten carbide. The Ultimate tensile strength has improved with increase in Aluminum content. Whereas ductility has decreased with increase in Tungsten carbide content. The effect of increased reinforcement on the wear behavior of the MMCs is to increase the wear resistance and reduce the coefficient of friction. The MMCs exhibited better wear resistance due to its superior load bearing capacity. Increased normal load and sliding velocity increases magnitude of wear and frictional force.

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