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Study of Mechanical Properties of Aluminium Based Hybrid Metal Matrix Composites

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Abstract: *The present study deals with the behaviour of aluminium alloy based composites, reinforced with silicon carbide particles and solid lubricants such as graphite. The first one of the composites consists of Al. with Silicon Carbide particles (SiC) and graphite. The other composite is Al with Alumina and solid lubricant, Graphite at solid state. Both composites are fabricated through 'Stir Casting Method'. Mechanical properties of the samples are measured and validated .The tested samples are examined using Scanning Electron microscope (SEM) for the characterization of microstructure on the surface of composites. The results of the research work shows that the proposed Hybrid composites are compared with Al based metal matrix composites at corresponding values of test parameters.*

Keywords: *Hybrid composites, Reinforcement, Mechanical properties, Scanning Electron Microscope.*

I. Introduction

The ever-increasing demand for light weight, economy and environmental purpose has lead to 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 silicon carbide, alumina, graphite reinforced with aluminium composites are increasingly used as substitute materials for high temperature applications.

There have been continuous efforts to develop new manufacturing processes using Aluminium 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 die-casting, squeeze casting, hot forging, powder forging, stir casting processes have been generally used for the manufacturing of aluminium 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 Aluminium hybrid composite are produced by A6061 as matrix material and silicon carbide/alumina/graphite 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 Aluminium composites and they are compared with commercial Aluminium alloy.

II. Literature Review

In 2013**,** M.Mahendra Boopathi,.P. Arulshri and Iyandurai were conducted a study on Evaluation of Mechanical Properties of Aluminium Alloy2024 Reinforced with Silicon Carbide and Fly Ash Hybrid Metal Matrix Composites. Increase in area fraction of reinforcement in matrix result in improved tensile strength, yield strength and hardness. With the addition of SiC and fly ash with higher percentage the rate of elongation of the hybrid MMCs is decreased significantly.

In 2012, V. N. Gaitonde1, S. R. Karnik, M. S. Jayaprakash were conducted Some Studies on Wear and Corrosion Properties of Al/Al2O3/Graphite Hybrid Composites. The effects of reinforcement, time duration and particle size on prepared samples of composites have been studied on slurry erosive wear. The static and accelerated corrosion tests have been performed and the micro hardness of the developed composites was also investigated. The experimental results on Al5083-Al_2O_3-Gr hybrid composites revealed that the addition of reinforcement improves the hardness and reduces corrosion and wear rates.

In 2013, Sharanabasappa, R Patil1, B.S Motgi were conducted A Study on Mechanical Properties of Fly Ash and Alumina Reinforced Aluminium Alloy (LM25) Composites. The mechanical properties of fly ash and Alumina reinforced aluminum alloy (LM25) composites samples, processed by stir casting route were reported in this paper. It was found that the tensile strength & hardness of the aluminium alloy (Lm25) composites increases with the increase in %wt of Al2O3.

In 2012, Daljeet Singh, Harmanjit Singh, Som Kumar and Gurvishal Singh were conducted An Experimental investigation of Mechanical behavior of Aluminum by adding SiC and Alumina. This work was focused to study the change in behavior of aluminum by adding different percentage age amount of 'Sic' and 'Al2O3' composite and it is concluded that as the weight percentage of reinforcement goes on increasing the mechanical properties such as hardness, yield strength, ultimate strength also increases. But at the same time elongation decreases and the behavior of material changes from ductile to brittle.

In 2011, H.C. Anilkumar ,H.S. Hebbar and K.S. Ravishankar were conducted the mechanical properties of fly ash reinforced Aluminium Alloy (Al6061) Composites and found that the tensile strength, compressive strength and hardness of the aluminium alloy (Al 6061) composites decreased with the increase in particle size of reinforced fly ash. Increase in the weight fractions of the fly ash particles increases the ultimate tensile strength, compressive strength, hardness and decreases the ductility of the composite.

In 2014, Dinesh Kumar, Jasmeet Singh were done a Comparative Investigation of Mechanical Properties of Aluminium Based Hybrid Metal Matrix Composites.The result indicated that the there is an increase in the value of tensile strength, ultimate tensile strength, hardness value and flexural strength of newly developed composite having SiC and B4C particulates in comparison to the SiC, graphite reinforced composite.

In 2010, G. B. Veeresh Kumar, C. S. P. Rao, N. Selvaraj, M. S. Bhagyashekar were conducted the Studies on Al6061-SiC and Al7075-Al2O3 Metal Matrix Composites and aimed to present the experimental results of the studies conducted regarding hardness, tensile strength and wear resistance properties of Al6061-SiC and Al7075-Al2O3 composites. The SiC and Al2O3 resulted in improving the hardness and density of their respective composites.

In 2011, M. Asif, K. Chandra, P.S. Misra were investigated about the development of Aluminium Based Hybrid Metal Matrix Composites for Heavy Duty Applications and investigated the dry sliding wear behavior of aluminium alloy based composites, reinforced with silicon carbide particles and solid lubricants such as graphite/antimony tri sulphide (Sb2S3). The results revealed that wear rate of hybrid composite are lower than that of binary composite. The wear rate decreased with the increasing load and increased with increasing speed

III. Methodology

The first one of the composites consists of Al. with Silicon Carbide particles (SiC) and graphite. The other composite has Al with Alumina and solid lubricant, Graphite at solid state. Both composites are fabricated through 'Stir Casting Method'. Mechanical properties of the samples are measured by usual methods such as Hardness, Tensile and topography analysis. The tested samples are examined using Scanning Electron microscope (SEM) for the characterization of microstructure on the surface of composites.

IV. Hybrid Composites Compositions

The Matrix material is Aluminium 6061.The reinforcements are, Graphite, Alumina (Al2O3) nd Silicon Carbide (SiC).The first composite consists of A l6061+ Silicon Carbide particles (SiCp) + graphite. [2 Set of combinations].The second composite consists of Al 6061 + Alumina + solid lubricant: Graphite at solid state. [2 Set of combinations]

Table 1: Hybrid Composite Set 1

Specimen	Al 6061 %	SiC %	Gr %
A	70	24	6
B	75	17	8

Table 2: Hybrid Composite Set 2

Specimen	Al 6061 %	Al_2O_3%	Gr %
C	75	17	8
D	70	24	6

V. Experimental Procedure for Stir Casting

Fig 1.Stir Casting setup

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 2.5kg. The maximum operating temperature of the furnace is 1000ºC. The current rating of furnace is single phase 230V AC, 50Hz. The aluminium alloy (A6061) is made in the form of fine scraps using shaping machine. It amounts to about 2.25 kg. The metal scraps are poured into the furnace and heated to a temperature just above its liquidus temperature to make it in the form of semi liquid state (around 600ºC). The mixing of aluminium alloy is done manually for uniformity. Then the reinforcement powder that is preheated to a temperature of 500°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. Mean while 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 150 rpm. The aluminium composite material reaches completely liquid state at the temperature of about 800°C as the melting point of aluminium is 700ºC. Thus the completely melted aluminium metal matrix composite is poured into the permanent moulds.

5.1. Scanning Electron Microscope

Fig 2.Scanning Electron Microscope

A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with electrons in the sample, producing various signals that can be detected and that contain information about the sample's surface topography and composition. The electron beam is generally scanned in a raster scan pattern, and the beam's position is combined with the detected signal to produce an image. SEM can achieve resolution better than 1 nanometer. Specimens can be observed in high vacuum, low vacuum and in environmental SEM specimens can be observed in wet condition.

VI. Results and Discussions

6.1 TENSILE TEST:

Tensile tests were used to assess the mechanical behavior of the composites and matrix alloy. The composite and matrix alloy rods were machined to tensile specimens with a diameter of6mm and gauge length of 30 mm. Ultimate tensile strength (UTS), often shortened to tensile strength (TS) or ultimate strength, is the maximum stress that a material can withstand while being stretched or pulled before necking, which is when the specimen's cross-section starts to significantly contract.The experimental results obtained from tensile test has been tabulated below.

Table 3: Tensile Test Results

Sample Identification	Observed Value		
	Tensile Strength (N/mm^2)	Yield Strength (N/mm^2)	Elongation (%)
Specimen A	245	212	26
Specimen B	214	159	33
Specimen C	265	242	25
Specimen D	202	150	33

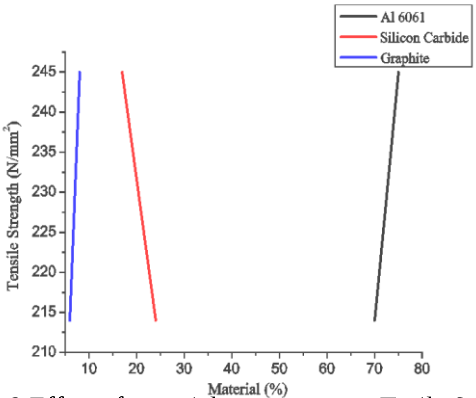

Fig 3.Effect of material percentage on Tesile Strength

Fig.1 shows the ultimate tensile strength of the composite specimens and of the base alloy, along with standard deviations, plotted against the graphite content and SiC. It follows from the graphs that the specimens show an increase in UTS

The increase in strength can attributed to the addition of SiC which impart strength to the matrix alloy, there by enhanced resistance to tensile stresses. There is a reduction in the inter–spatial distance between particulates, which cause an increase in the dislocation pile–up as the particulate content is increased. This leads to restriction to plastic flow due to the random distribution of the particulate in the matrix, thereby providing enhanced strength to the composites. The tensile strength is a function of volume fraction of reinforcement. As volume fraction of reinforcement increases tensile strength of composite increases.

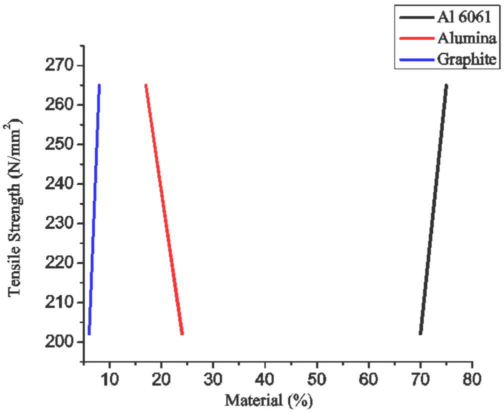

Fig 4.Effect of material percentage on Tesile Strength

It is clear that tensile strength of composites containing 17 wt% of Al2O3 particulates is higher when compared to as cast Al6061, while ductility of composite is lesser that unreinforced alloy Increase in strength is possibly due to the thermal mismatch between the metallic matrix and the reinforcement, which is a major mechanism for increasing the dislocation density of the matrix and therefore, increasing the composite strength. However, the 17 wt% of Al2O3 reinforced composite materials exhibited lower elongation than that of unreinforced specimens.

6.2 Hardness Test:

The Micro-Vickers hardness values of the samples were measured on the polished samples using diamond cone indentor with a load of 100gms and 15 seconds as a holding time. Hardness value reported is the average value of 100 readings taken at different locations on the polished specimen. For tensile results, test was repeated three times to obtain a precise average value.

Table 4: Hardness Test Results (Brinell)

Type of Test	Specimen ID	Value (BHN)
Brinell Test	Specimen A	48.1
	Specimen B	66.0
	Specimen C	58.8
	Specimen D	80.7

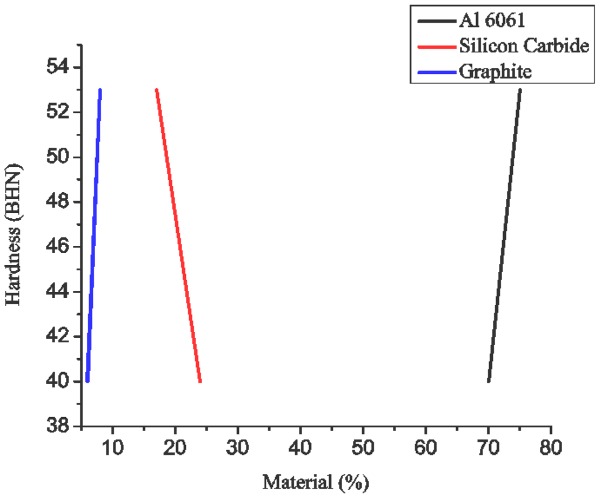

Fig 5.Effect of material percentage on Hardness

The increase in hardness of Al6061-SiC composite with increasing SiC content could be due to the fact that the reinforcement material is much harder than that of the matrix material for SiC and also could be due to better wettability of SiC by 6061 matrix which leads to good bonding between the matrix and reinforcement.

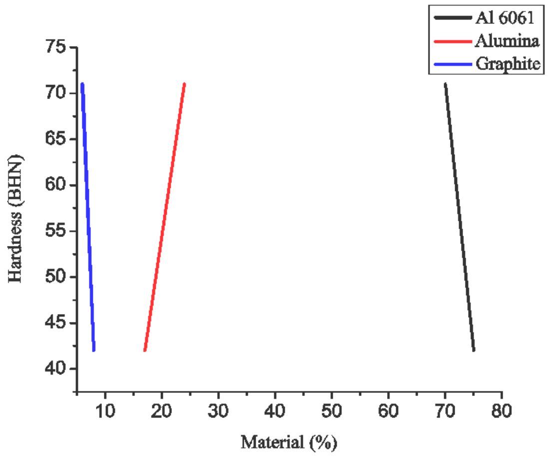

Fig 6.Effect of material percentage on Hardness

The hardness tests conducted on a Al6061 composite containing of Al2O3 and varying Graphite particles are prepared and the results are represented in Figure 6. A significant increase in hardness of the alloy matrix can be seen with addition of Al_2O_3 particles. A hardness reading showed a higher value of hardness indicating that the existence particulates in the matrix have improved the overall hardness of the composites. This is true due to the fact that aluminum is a soft material and the reinforced particle especially ceramics material being hard, contributes positively to the hardness of the composites. The presence of stiffer and harder

Al_2O_3 reinforcement leads to the increase in constraint to plastic deformation of the matrix during the hardness test. Thus increase of hardness of composites could be attributed to the relatively high hardness of Al_2O_3 itself. Though adding Graphite makes material ductile but the hardness does not decrease below the base material.

6.3. Sem Test Results (Surface Structure):

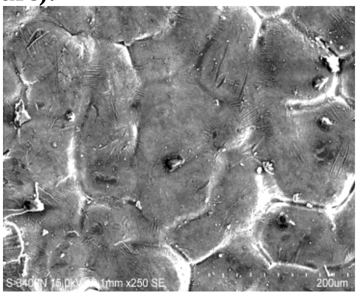

Fig 7.Specimen a Zoom-X250

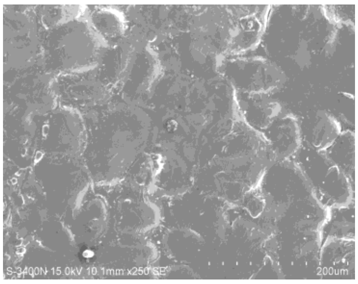

Fig 8.Specimen B Zoom-X250

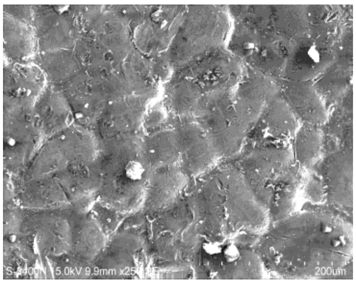

Fig 9.Specimen C Zoom-X250

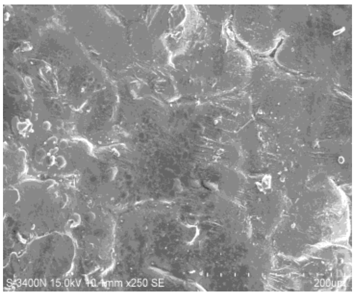

Fig 10.Specimen D Zoom-X250

Figures 7-10 reveals the microphotographs of Al6061 reinforced with Graphite and SiC particulates. From figure it is clear that, the distribution of reinforcing particulates in both the composites is fairly uniform

VII. CONCLUSION

Aluminium based hybrid metal matrix composites have been successfully fabricated by melt stir method by three step addition of reinforcement combined with preheating of particulates.Based on the experimental results,the following conclusions were drawn.From the study, it can be concluded that an increase in the percentage of graphite & SiC reinforcements in aluminium alloy increases the ultimate tensile strength. Addition of 17wt% Al_2O_3 increases the tensile strength considerably with respect to base matrix Al6061.

Whereas the addition of Graphite particulates doesn't vary the tensile strength much with respect to Al_2O_3 added composition.. The microstructural studies revealed the fairly uniform distribution of the particles in both Al6061-SiC and Al6061-Graphite composites.

REFERENCES

[1] Evaluation Of Mechanical Properties Of Aluminium Alloy2024 Reinforced With Silicon Carbide And Fly Ash Hybrid Metal Matrix Composites by Mahendra Boopathi, M., K.P. Arulshri and N. Iyandurai ,Department of Mechanical Engineering, CMS College of Engineering and Technology, American Journal of Applied Sciences, 10 (3): 219-229, 2013.

[2] Some Studies on Wear and Corrosion Properties of Al5083/Al2O3/Graphite Hybrid Composites by V. N. Gaitonde1, S. R. Karnik, M. S. Jayaprakash, Department of Industrial and Production Engineering, B. V. B. College of Engineering and Technology, Hubli, India, Journal of Minerals and Materials Characterization and Engineering, 2012, 11, 695-703.

[3] A Study on Mechanical Properties of Fly Ash and Alumina Reinforced Aluminium Alloy (LM25) Composites, Sharanabasappa R Patil1, Prof B.S Motgi, Department of Mechanical Engineering,PDA College of Engineering, Gulbarga, IOSR Journal of Mechanical and Civil Engineering, Volume 7, Issue 6 (Jul. - Aug. 2013).

[4] An Experimental investigation of Mechanical behavior of Aluminum by adding SiC and Alumina, Daljeet Singh, Harmanjit Singh, Som Kumar and Gurvishal Singh, Department of Mechanical Engineering, Amritsar College of Engg. & Technology,Manawala, (PB) India, International Journal on Emerging Technologies 3(1): 178-184(2012).

[5] Mechanical Properties Of Fly Ash Reinforced Aluminium Alloy (Al6061) Composites, H.C. Anilkumar , H.S. Hebbar and K.S. Ravishankar Dept. of Mechanical Engineering, Anjuman Engineering College, Bhatkal-581 320, India, International Journal of Mechanical and Materials Engineering (IJMME), Vol.6 (2011).

[6] Comparative Investigation of Mechanical Properties of Aluminium Based Hybrid MetalMatrix Composites, Dinesh Kuma, Jasmeet Singh, Department of Mechanical engineering, Punjab technical University, Jalandhar, International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622.

[7] Studies on Al6061-SiC and Al7075-Al2O3 Metal Matrix Composites, G. B. Veeresh Kumar, C. S. P. Rao, N. Selvaraj, M. S. Bhagyashekar, 2Department of Mechanical Engineering, National Institute of Technology, Warangal, (A.P),India, Journal of Minerals & Materials Characterization & Engineering, Vol. 9, No.1, 2010.

[8] Development of Aluminium Based Hybrid Metal Matrix Composites for Heavy Duty Applications, M. Asif*, K. Chandra, P.S. Misra, Department of Metallurgical and Materials Engineering, Indian Institute of Technology, Roorkee, Journal of Minerals & Materials Characterization & Engineering, Vol. 10, No.14, 2011.