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Optimization and Analysis of Improved Material for Windmill Blades

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***Abstract* - In recent years the wind turbine blade has been the subject of comprehensive study and research amongst all other components of the wind turbine. Our appetite for renewable energy from the wind turbine continues to increase; companies now focus on rotor blades which can go up to 80m in length. The blade material not only have to face large aerodynamic, inertial and fatigue loads but are now being designed to endure environmental effects such as Ultraviolet degradation of surface, accumulation of dust particles at sandy locations, ice accretion on blades in cold countries, insect collision on blades and moisture ingress. All this is considered to ensure that the blades complete its designated life span. Furthermore exponential increase in composite blade manufacturing is causing a substantial amount of unrecyclable material. All these issues raise challenges for wind blade material use, its capacity to solve above mentioned problems and also maintain its structural integrity. Properties and corrosion resistance have been achieved. Under optimum conditions, a maximum Young's modulus of over 80 GPa, a maximum hardness of 1.39 GPa, and maximum wear resistance have been achieved. Due to the resistance of WO3 particles to corrosion in terms of electrochemical behavior, optimal composites have the lowest thermodynamic corrosion propensity and show higher pitting corrosion resistance. In addition, if the amount of TiO and WO_3 is large, the formation of a continuous protective layer on the surface will be delayed and the corrosion resistance will decrease.**

Keywords: Casting, metal matrix, Composite material Reinforcement, Corrosion resistance, Wind blades.

I. INTRODUCTION

Comparative study of numerous composite materials, their properties useful for wind energy application and cost. Now we move on to environmental degradation and surface engineering problems faced by the blade material. Sand dust and dirt accumulation on wind blades airfoils continue to be an ignored problem, which has serious effect on the power curve of a wind turbine and can cause losses up to 50% at its rated power in a span of 1 year.

Dust particles accumulated on the surface of most materials (airfoils) cause an increase in surface roughness and a corresponding change in a boundary layer, a fall in lift and an increase in drag of the airfoil. These eroded blades now have lesser life expectancy. In cold countries icing on blades adversely affects the aerodynamic performance, durability (strength of the material) and fatigue life of wind turbine blades but also possess safety concerns as the rotating blades throw rocks of ice to substantial distances which can put life and property at risk.

Metal matrix composite is gaining a large momentum in attaining light weight and huge utilization in various engineering applications. Monolithic metals and their alloys cannot always meet the demands of today's modern engineering requirements. With addition of more than one material it is possible to achieve tailor made properties and meet the performance requirements for specific application. Materials are mainly added to change their properties in order to fulfill the requirements of design.

Few researchers have incorporated fly ash in AA7075 to provide a better wear resistant, strength and hardness composite. Micro structural characteristics of AA7075 and its composite were compared and analyzed using Optical Microscope (OM) and SEM. It has been noticed that the fly ash particles have been dispersed uniformly in the composite. The composite has been prepared by liquid metallurgy technique. The hardness has been increased due to good union between flyash and Al7075 alloy and homogenous dispersion of fly ash.

Review on various combinations with Al7075 being the matrix and various components like SiC, TiO2, TiB2, B4C, fly ash etc. being the reinforcements have contributed in improved mechanical characteristics. This paper emphasises on the composite prepared by liquid state processing techniques like stir casting methods. This process appears to be relatively simple and cost effective and can be made semi continuous or continuous by stirring.

The coefficient of thermal expansion of hybrid composites decreased with increase in the content of TiO_2 and Titanium. On the other hand, thermal conductivity of

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composites decreases with hybrid reinforcements when evaluated with Al7075 alloy.

Aluminium based hybrid metal matrix composites with low cost reinforcements like w and tio by stir casting. W and tio were chosen as hybrid reinforcements owing to their superior mechanical, Tribological and physical properties. From the extensive review of literature, it is clear that tungsten and Titanium oxide can be considered as efficient reinforcements with multiple benefits for synthesis of hybrid metal matrix composites. Further, very limited information exists with reference to mechanical properties with the combination of titanium dioxide and tungsten reinforced Al7075 based metal matrix composites. In the light of the above, this work focuses on synthesis of Al7075-TIO-WO_3 hybrid metal matrix composites by liquid metallurgy technique and characterization of its mechanical properties.

1.1 Background of analysis

Among the various manufacturing processes mentioned MMC, agitation casting or vortex casting is more suitable for professionals produce an almost shaped final product. Therefore, it forms a view Vortex, the point of industrial application and academic research Casting is attracting attention for producing various MMCs Parts with unique structure and mechanical properties. Traditionally, the agitation casting process has been considered one Flexible, simple and inexpensive to manufacture MMC. However, this method has the following limitations: B. Possibility of reaction between the second phase and the melt, or the tendency to settle during casting to form aggregates of the strengthened phase.

While improving the properties of metal-based composites need to be appropriate Distribution of ceramic particles in the metal matrix Performance is good physical coupling between re Reinforcement and matrix. Melting temperature, stirring speed, stirring time, supply The speed of the ceramic particles and the temperature of the mold Considered an essential parameter for agitation casting Processes for reducing clustering, gas inclusions, and interfacial reactions Appropriate distribution of reinforcements.

Nonetheless, the interface reinforcement matrix uses a variety of complementary approaches such as preheating the reinforcement particles, incorporating surfactants such as Mg, etching and coating the particle surface, and using neat materials as raw materials. Ensure proper wetting and distribution. Degassing of melt Aluminum Metal Matrix Composite (AMMC) is one of the most important MMCs due to its unique properties such as low density, excellent combination of strength and ductility, formability and high corrosion resistance. Various types of ceramic reinforcements can be used to manufacture AMMCs such as Al_2O_3, SiC, B_4C, TiO and WO_3. A common feature of these reinforcements is the improved mechanical properties and wears resistance of the material. Aluminum matrix however, biocompatibility is a feature the properties of W (tungsten) distinguish it from other composites.

Therefore, in this study Al7075 & WO_3 with TiO MMC with different volume fractions Reinforcement is done using cheap agitation casting Industrial application process. Also, Mike Structural, mechanical properties and electrochemical let's take a closer look at their behavior.

II. LITERATURE SURVEY

C Marin, A. Barroso, F. Paris presents in his Study of damage and repair of 300KW wind turbine – e Journal of Energy (2008), said that The core foam sandwich used is a PVC type with cross linking polymers named as the G-PET-115™. Surface issues can be solved to a great extent by using Gel coat and specialized coating but to further improve surface engineering issues Nanocoatings will be implemented.

Dattatraya N et.al, presents a study on stir casing process and process parameter having Al alloy as a matrix phase and alumina (Al2O3) as a reinforcement. In their study, they have concluded the following points: (i) Stir casing process can successfully be used for manufacturing of AMMC's having low density and enhanced mechanical properties. 2) Stir casting process is cost effective and conventional route for manufacturing of composite material. 3) Material having isotropic nature can be manufactured successfully. 4) Preheating of mould reduces porosity and enhances mechanical properties. 5) Addition of Magnesium is important to increase wettability. 6) Design of stirrer decides the flow pattern of melt. 7) Stirrer speed, stirring time decides quality of casting.

Manikandan. C, noticed in his experimental study, that the 12% of SiC and 450°C preheat temperature of the reinforcement improves the hardness and impact strength of the composite. At 6% of SiC, 200 rpm of stirrer speed and 500°C reinforcement pre heat temperature attains the improved level of tensile strength. The hardness and impact strength to values are directly proportional to the SiC composition rate. The minimal percentage of elongation is obtained in the 9% of SiC, 250 RPM and 500°C pre heating temperature of reinforcement.

Hariharan. R et. al, carried out the research work by fabricating Al6061 – TiB_2 MMC by stir casting method. The addition of the TiB particles into Al-6061 is a good route to improve the mechanical properties of materials. The resulting

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composite showed the increase in tensile strength when compared to the unreinforced alloy. SEM and XRD analysis of the composite confirms the presence of TiB particle and its volume fraction. The increased volume fraction of the TiB particles contributed to increase the strength of composites. The dry sliding at room temperature shows that there is a definite increase in the wear resistance of Al6061 alloy by the addition of TiB_2 particles.

Pradeep R et.al observed the study of mechanical properties of Al- Red Mud and Silicon Carbide Metal Matrix Composite (MMC) of Aluminium alloy of grade 7075 with addition of varying weight percentage composition such as SiC8%+Al7075, SiC6%+Red mud2%+ Al7075, SiC4%+Red mud 4%+Al7075, SiC2%+Red mud 6%+Al7075, Red mud 8%+Al7075ed mud and Silicon Carbide particles by stir casting technique. The experimental result reveals that the combination of a matrix material with reinforcement such as SiC and Red mud particles, improves mechanical properties like tensile strength, compressive strength, hardness and yield strength.

Ravichandran Met.al carried out the research work by fabricating aluminium metal matrix composites through liquid powder metallurgy route. The aluminium matrix composite containing TiO_2 reinforcement particle was produced to study the mechanical properties such as tensile strength and hardness. The characterization studies are also carried out to evident the phase presence in the composite and the results are discussed for the reinforcement addition with the mechanical properties. Results show that, the addition of 5 weight percentage of TiO_2 to the pure aluminium improves the mechanical properties.

H. Izadiet.al investigated through FSP and has observed improvement in the micro hardness of Al–SiC composites produced by traditional powder metallurgy and sintering methods. The material flow in the stir zone during FSP was successful in uniformly distributing the SiC particles. However, when samples with 16% SiC (by volume) were processed, there were residual pores and lack of consolidation. An increase in hardness of all samples was observed after friction stir processing which was attributed to the improvement in particle distribution and elimination of porosity.

Keshavamurthy Ret.al studied about Al7075-TiB_2 insitu composite, processed by stir casting technique using commercially available Al-10%Ti and Al- 3% Br master alloys. Both matrix alloy and composite were subjected to microstructure analysis, micro hardness test, grain size studies and tensile test. Microstructure shows fairly uniform distribution of TiB_2 particles in matrix alloy. Average grain size of the composite was lower than unreinforced alloy. Micro hardness, yield strength and ultimate tensile strength of Al7075-TiB_2 composite, were considerably higher when compared with unreinforced alloy. Uvarajaet.al observed that Hybridization is commonly used for improving the properties and for lowering the cost of conventional composites. Hybrid MMCs are made by dispersing two or more reinforcing materials into a metal matrix. They have received considerable research and trials by Toyota Motor Inc., in the early 1980s. Hybrid metal matrix composites are a relatively new class of materials characterized by lighter weight, greater strength, high wear resistance, good fatigue properties and dimensional stability at elevated temperatures than those of conventional composites.

Y. Reda, H.M. Yehia, et al. have studied to dry sliding wear characteristics of aluminum 7075Tm, magnesium az31 and rock dust composite. In this work, the reinforcing materials, magnesium AZ31 and rock dust are used within al7075 –t6 to find the wear characteristics. The mg rock dusts are varied from 1% to 3% and with al7075 –t6 during stir casting process. The addition of magnesium AZ31 will increase the ultimate tensile strength. The reinforcement of rock dust will decrease the density. The rock dust is produced less wear by using L9 orthoganalarrey.

D Valavan and R Balasundaram, et al. studied the experimental design and analysis of carbon fiber reinforced composite drive shafts. In this work, we will investigate the mechanical properties of carbon fiber composites such as torsional strength, tensile strength, bending strength, impact strength, and hardness strength. This task replaces the drive shaft with the proposed composite material. Various mechanical tests are performed according to ASTM standards to evaluate the suitability of carbon fiber reinforced polymer composites.

Naher et al. performed Scaled-up stirring experiments with liquids having similar characteristics of aluminum melt and used SiC particles as reinforcements. The experiment was carried out in a transparent crucible and established photographing flow patterns.

Ravi et al. investigated effect of mixing parameters through a water model for the fabrication of Al-SiC composite through stir casting. Impeller blade angle, stirring speed, direction of impeller rotation was taken as stirring parameters. Lu and Lu used finite element method to simulate the flow pattern and to find effects of stirring parameters like blade angle, stirring speed, impeller size, and the stirrer geometry over the flow characteristic. Sahu and Sahu used computational fluid dynamics to simulate the fluid flow and optimized stirring parameters like blade angle, impeller size

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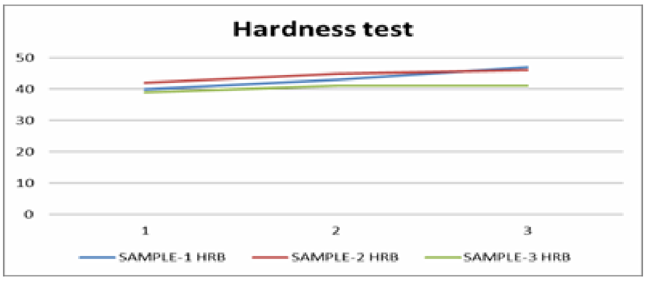
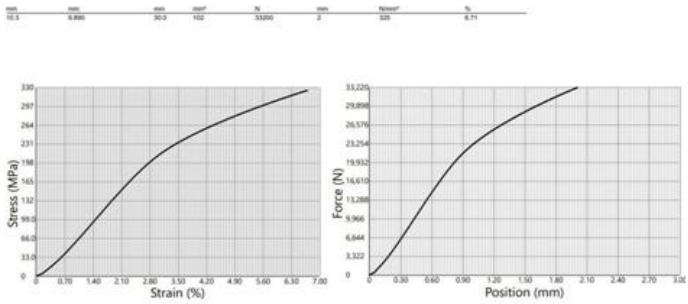
and stirring speed using Grey Taguchi method. This chapter attempt to review the studies conducted on the effect of stirring parameters and optimization of stirring parameters for the fabrication of AMCs and HAMCs through stir casting method.

III. RESULTS AND DISCUSSIONS

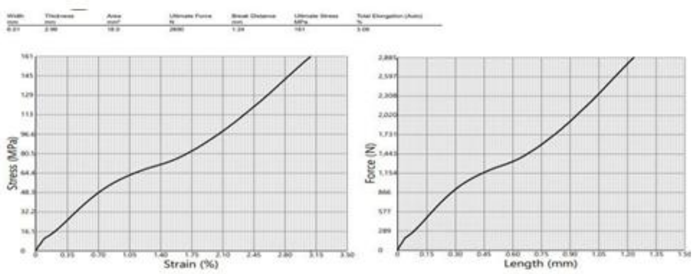
Hardness Test



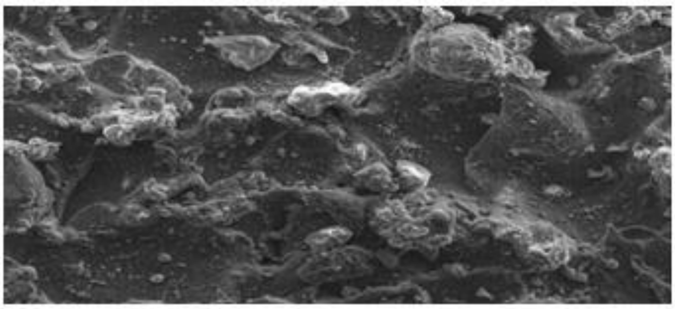
Compression Test

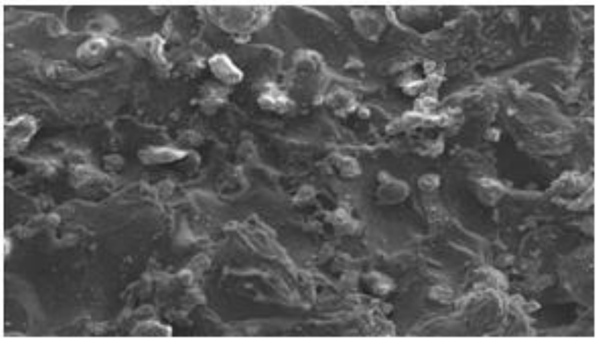


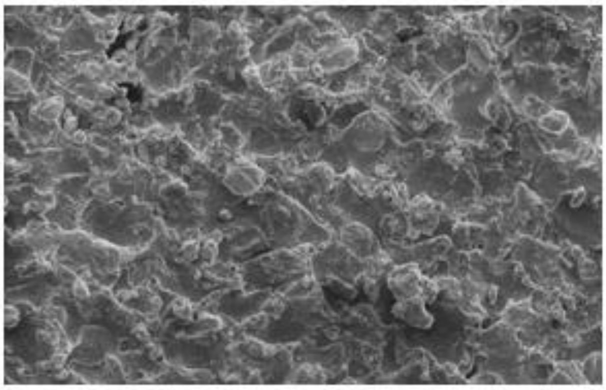
Tensile Test

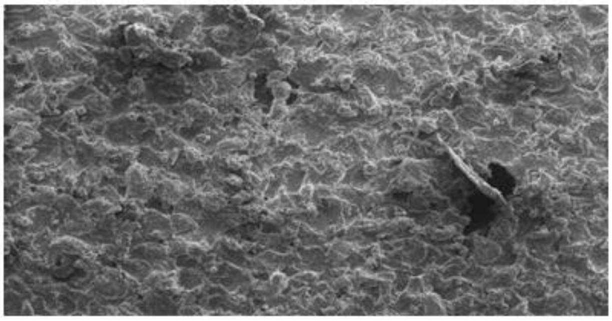


Sem Test









IV. CONCLUSION

In the present work, AA7075/TiO & W, AMMCs were prepared by the stir casting process and the effect of TiO & WO_3 particulate content on mechanical and tribological properties of the prepared AMMCs were investigated both as cast and heat treated conditions.

The results can be summarized as follows:

- The composites at cast condition exhibits less hardness, tensile strength and wear resistance than heat treated (T6) condition, due to failure to form good hardening.
- The mechanical (hardness, tensile strength and percentage of elongation) properties for the TiO, WO_3 reinforced composite specimens are better than AL7075 matrix material in both conditions.
- The high content of TiO& WO_3 particles in AMMCs lead to high wear resistance up to 8 wt.%.
- The wear rate of AL7075/8 wt.% TiO & WO_3 composite at T6 condition was found to be optimal wear rate

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compare to the cast conditions and AL7075 matrix material.

- Wear rate and coefficient of friction decreases with increase of wt. % of TiO & WO_3 reinforced particle.

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