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Investigation of Tribo- Mechanical Properties of Fly ash with E-Glass Fiber Reinforced AL MMC's.

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Abstract: *Many of the engineering applications in the world today require materials with unusual combination of properties that cannot be met by the conventional metal alloys, ceramics or polymers. Composite materials have been increasingly used in aerospace and automotive applications over the last three decades and even usage increase in non-aerospace products in the recent few years. Hybrid composite materials having outstanding strength, stiffness, and lightweight properties and the ability to tailor the stiffness and strength to specific design load among the various aluminum series. Here the base alloy as Al2024 shows low strength and corrosion resistance as compared with other alloy series. AMC's specimen made by liquid stir casting technique, by addition of fixed 3% E-glass fibers and fly ash particles in different proportions (4, 6 and 8 wt.%) prepared the matrix phase.*

The test specimens are prepared as per ASTM standard size by turning and facing operations to conduct mechanical testing like hardness and tensile & compression tests. From these test the composites shows better improvement in hardness, tensile and compression strength. The composite shows better mechanical properties than the base alloy. Dry

sliding wear behavior of the aluminum alloy and the composites has been studied and tested using a pin-on-disc wear and friction monitor. The testing carried out on sliding velocity of 1.5, 2.5 and 3.5 m/s and load ranges from 1, 2 and 3kgf. Abrasive wear resistance improves by addition of fly ash reinforcement. By E-Glass and Fly ash reinforced into base alloy showed a much lower rate of wear when compare to unreinforced matrix alloys for loads.

Using Taguchi method, an Orthogonal Array (OA) is considered to reduce the number of experiments required to determine the optical wear for Al/EG/Fly ash Metal matrix composites. Results shows the signal to noise ratio for wear rate shows the better wear resistance with increase in fly ash contents. Analysis of variance shows small error i.e. % contribution factor of error is smaller. Confirmation test is verified for optimal level.

Keywords: ASTM standard

I. INTRODUCTION

A composite material is a structural material created synthetically or artificially, by combining two or more materials having dissimilar characteristics. . Reinforcing phase is embedded in the matrix phase to give the desired characteristics, to develop new composite materials with improved physical and mechanical properties. These new materials include high performance composites such as Polymer matrix composites, Ceramic matrix composites and Metal matrix composites etc.

Aluminum based Metal Matrix Composites(AMCs) have greater utilization in various fields like aerospace, automobile, construction equipment, owing to their versatile mechanical properties and tribological behavior and that are being used for varieties of applications owing to their good strength to weight ratio, excellent thermal conductivity properties. There is increasing demands for low cost reinforcement and low density material for manufacturing purpose. So fly ash a waste by product of thermal power plant and good tensile strength, corrosion resistant E glass fiber used as reinforcement in Al matrix.

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II. LITERATURE SUMMARY

Rohathgi P.K (2006) has made AL/Fly ash composites shows the hardness and wear resistance increases whereas density and thermal expansion decreases with increase in % Fly ash. *P. Shanmughsundram, et al (*2011) successfully fabricated Al –fly ash composites using stir casting, showing better improvements in physical and mechanical properties upto 15% FA. *Deepak Singla, and S R Mediratta* (2013)state that, with increase in value of fly ash, toughness, hardness and tensile strength was increased compared to the base metal and the density got decreased, so these composites can be used in automobile and space industries due to their light weight. *Deepti kushwaha, Gaurav Saxena (2014)* shows the achievement of weight reduction of the drive shaft with adequate improvement of mechanical properties has made composite a very good replacement material for conventional steel drive shaft. For manufacturing composites, in fibers, E- glass fiber was found appropriate, as it is high quality glass, which is used as standard reinforcement fiber for all the present systems well complying with mechanical property requirements.

K. Punith Gowda et al, (2015), his study revealed that as the tungsten carbide particle content in AL 2024 was increased, there were significant increases in the ultimate tensile strength, hardness and young's modulus, compressive strength, accompanied by a reduction in its ductility. *S. Rajesh et al* gives the optimal combination of the testing parameters was determined for WVL and COF by implementing Taguchi method for the experimental studies. Finally Analysis of Variance (ANOVA) was performed to know the impact of individual factors on the WVL and COF. The results indicated that the sliding distance for WVL, sliding distance and reinforcement percentage for COF was found to be most effective factor among the other control parameters on dry sliding wear. *Satpal Kundu et al.* (2013) shows the regression equations for wear rate and coefficient of friction, where found that wear rate of composite is directly proportional to applied load and inversely proportional to speed and distance and Coefficient of friction is directly proportional to applied load and sliding speed. *Hemanth Kumar. T. R. et al.* (2011) study is carried out to simultaneously optimize the tribological properties. Signal to noise ratio analysis has been carried out to determine optimal parametric condition, which yields minimum wear rate and frictional force.

RESEARCH GAP

- Need to develop simple, economical and portable non-destructive kits to quantify undesirable defects in AMCs
- Utilization of inexpensive and low density reinforcement materials.
- To produce high quality and low cost composites using reinforcements from industrial wastes and by-products.
- With Al 2024 as low strength aluminium, one has to reinforce the glass fibre and fly ash as low cost material in combination to find mechanical and tribological properties.

OBJECTIVES: -

The objectives of this experimental work are as follows,

- To study the various mechanical properties like Tension, Compression, and Hardness property.
- To study the effect of wear test parameters like normal load, velocity of counter disc on friction and wear behavior of Al MMC's composites.
- To study the relationship between normal loads, velocity of counter disc, wear rate and wear resistance.
- To find improvement in wear resistance due to combination of different fly ash into Al 2024 alloy.
- To find optimum combination of composites for improving the wear resistance of it.

III. MATERIAL AND METHODOLOGY:

Aluminum alloy 2024 is a copper alloy, with reinforcing element as E glass fiber having excellent fiber forming capabilities and fly ash produced during combustion of coal as a low cost byproduct as waste.

They all are mixed and prepared with the liquid vortex stir casting method in the different proportion. Keeping the 3% E glass constant and changing wt % of fly ash (4, 6, and 8 %) in Aluminum metal matrix named as A3E4F, A3E6F, and A3E8F respectively. With the help of DOE and Taguchi method we plan for experimental work making L9 orthogonal

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array. To study of wear behavior of Al composites, the control parameters chosen are weight % of reinforcement (wt.), applied load (L), and sliding speed (S).

IV. RESULT AND DISCUSSION

The fabricated and machined specimen are undergone through the mechanical testing such as tensile, compression and hardness test at FAN services Nasik as per the ASTM standards. Also tribological testing done using pin on disc wear and friction monitor for studying the wear properties at various combinations.

Mechanical Test: Mechanical testing shows the hardness strength of the sample specimen was increased w. r. t. the base alloy by 44.05 – 48.35%. The tensile strength gradually increased by the increase in wt. % of the reinforcement added to the metal matrix. The compressive strength of the hybrid composites increases monotonically as the reinforcement contents are increased. The increase in wt.% of fly ash in Al alloy tends to rise of compressive strength by 48%.

Wear Test: Dry sliding wear tests were carried out on computerized pin-on-disc "Wear and Friction monitor" in order to investigate the wear resistance of the A3E4F, A3E6F and A3E8F. Sliding wear tests were performed according to ASTM G99-05 standard. Testing pin of 8 mm diameter and 30mm length was used. Load 1 kg, 2 and 3 kg will be applied while test and sliding speeds of 1.5 m/s 2.5 m/s and 3.5 m/s set to study wear. Wear rate (in mm3/km) of the composites reduced with the increase in reinforcement content. The reduction in wear rate by as much as 28 to 40% as the content of E-Glass fibers (3%) and Fly ash (4-6- 8%) varied. Load variation causes more changes in wear rates. At high loads however, due to fracture composites lose their ability to support the load. Sliding velocity increases the wear rate shows significant changes of decreasing the wear rate. With increase in wt. % of reinforcement, the specific wear rate also decreases.

DOE with Taguchi and ANNOVA for optimization: Taguchi design of experiment is a powerful analysis tool for modeling and analyzing the influence of control factors on performance output. The influence of control parameters such as load, sliding speed and fly ash content on wear rate has been evaluated using S/N ratio response analysis. From the main effect plots for Mean and S/N ratio based on smaller the better, wear rate are studied shows that, higher the S/N ratio gives optimum or better combinations for getting best result for wear rate.

Results of analysis of variance (ANOVA) for wear rate is found that, load applied (%P = 59.89%) is most contributing and significant factor, whereas the sliding speed as 6.77% and wt.% reinforcement as 32.01% towards minimizing the wear rate of the composites. Total error associated in this analysis is approximately about 1.33%. Here we get optimal condition as L-9,81N, S-2.5m/s and R- 8% fly ash. The confirmation experiment is conducted to verify that, the optimal setting, in which how close the respective predictions with the real ones are validate. The error is calculated as the difference between actual and predicted values of S/N ratio

V. CONCLUSION

After conducting the experimental work, following conclusions can be drawn from the results-

1. The wear volume, wear rate (WR) increases linearly with increasing normal load for all type of samples, whereas coefficient of friction increases with increase in normal load.
2. At higher velocities the wear rate is enhanced. Nonetheless, the coefficient of friction did not change with sliding speed.
3. The composite showed better wear resistance for the applied load of 3 kg.
4. The wear was extensive in Al-fly ash composite for higher loads and longer sliding distances, might be due to the presence of dislodged and fractured fly ash particles in the alloy matrix.
5. The analysis of variance for Sliding wear rate of the Al/EG/Fly ash composite material shows that, that Load applied on the pin is the most significant influencing factor, whereas sliding speed has little contribution towards the Quality characteristic under study.
6. Confirmation experiment was conducted to show the define models are correct. This method can be adopted for simultaneous optimization of tribological parameters.

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