Dry Sliding Wear Behavior and Mechanical Properties of Al 5083-Al_2O_3-Gr Hybrid Composite Material

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ABSTRACT

The Al 5083-Al_2O_3-Gr hybrid composite is applicable for replacing the material of pressure vessels body, oil pipeline and water pipeline, etc. The varying weight percentage of Al 5083 (75%, 80% and 85%) and the reinforcement materials like Al_2O_3 (5%, 10% and 15%) and taking Graphite as constant (10%), which are fabricated by using stir casting technique. To analyze the hardness, tensile, impact, wear behavior and microstructural for sample 1, 2 and 3 hybrid composites. Hardness value of sample 3 Hybrid Composite Improved as 95.5 BHN while compared to the sample 1 hybrid composite of 79 BHN and sample 2 Hybrid Composite of 82 BHN. We obtained the better wear rate of sample 3 as 87µm compared to the other composite samples 1 & 2, and microstructural image shows the homogenous mixture of reinforcement particle in the Al 5083- Al_2O_3-Gr.

KEY WORDS: Al 5083, Al_2O_3, Gr, stir casting technique, Wear behavior, Homogenous mixture.

1. INTRODUCTION

Aluminum based metal matrix composite are light weight, high-strength materials used in various application areas such as aerospace, defence, automobile, and other industries. Composites with aluminium alloy matrix materials is been reinforced in order to increase the high strength-to-weight ratio, impact strength, stiffness wear resistance, etc. By adding the reinforcement materials to the base alloy which increase the strength to weight ratio increases since the wear rate of the materials has been improved various reinforcement materials like Al_2O_3, SiC, Graphite, TiO_2 etc. Among the reinforcement materials Al_2O_3 is constructive, since it don't react with the matrix materials at high temperature. Aluminium matrix composites reinforced by Al_2O_3/Gr particles are prepared by conventional stir casting method. The stirring arrangement improves the distribution and wettability of composites. The mechanical behaviour and microstructure of Al-Al_2O_3 composites are investigated. The experimental work has been classified into three parts: a) Development of Al 5083- Al_2O_3-Gr composite, b) Microstructural analyses, c) Characterization of Al 5083- Al_2O_3-Gr composite.

2. EXPERIMENTAL DETAILS

Aluminium 5083 alloy was consider for the research work, alumina (Al_2O_3) and Gr particulates was reinforced with this Al 5083. The chemical composition of Al 5083 was tabulated in Table.1. Al_2O_3 particles being hard in nature to improve the hardness, strength and stiffness of the hybrid composite material. Graphite imparts excellent self-lubricating property of the hybrid composite.

Table.1. Chemical Composition of Al 5083 in Wt%

Mg	Mn	Fe	Si	Zn	Ti	Cr	Al
4.0-4.9	0.4-1.0	0.4	0.4	0.25	0.15	0.05-0.25	Bal

Table.2. Composition of three different samples

Al 5083	**Al_2O_3**	**Gr**
85%	5%	10%
80%	10%	10%
75%	15%	10%

Fig.1. Stir casting setup

Microstructure Analysis: Predicted the optical microstructure image of 5, 10, 15 wt. % Al_2O_3 reinforced with Al metal matrix composites (graphite as constant of 10%). The microstructure of composite shows intermolecular bonding between reinforcements and matrix material. From microstructural analysis, identified the homogeneous distribution of reinforcement particles in Al metal matrix composite and very less amount of cracks. Negligible amount of cluster formation of Al_2O_3 reinforcement particles in the Al metal matrix composite.

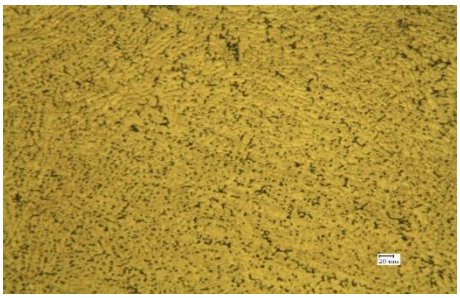

Fig.2. Optical microscopy image sample 3 hybrid composite

3. RESULTS AND DISCUSSIONS

Hardness: The comparison of sample 1, 2 and 3 with base materials (fig.3). The hardness value increased when increase weight percentage of reinforcement material like Al_2O_3 and graphite. The sample 3 having the higher hardness (95 BHN) compared to other sample 1 and 2.

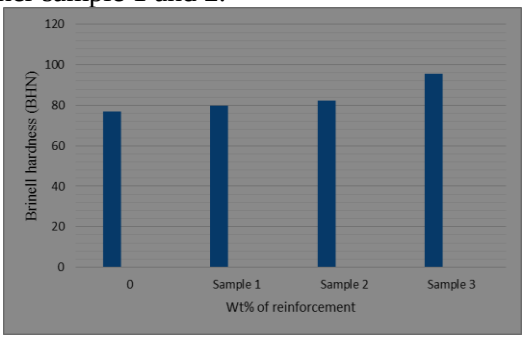

Fig.3. Brinell Hardness value for sample 1, 2 and 3 hybrid composite

The comparison of charpy value shows in fig.4 (sample 1, 2 and 3). The impact value increased when increase weight percentage of reinforcement material like Al_2O_3 and graphite. The sample 3 having the higher Impact value (8 J) compared to other sample 1 and 2.

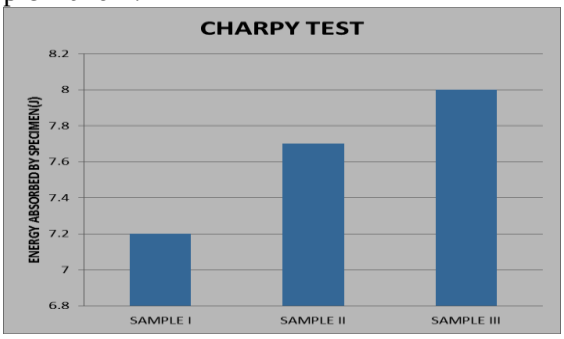

Fig.4. Charpy test value for sample 1, 2 and 3 hybrid composite

Tensile Strength: The comparison of sample 1, 2 and 3 with base materials (fig.5). The tensile strength increased when increase weight percentage of reinforcement material like Al_2O_3 and graphite. Increased the tensile strength with the help of Al_2O_3. So, the sample 3 (15%) of Al_2O_3 material have the better result compared to sample 1 and 2 hybrid composite material.

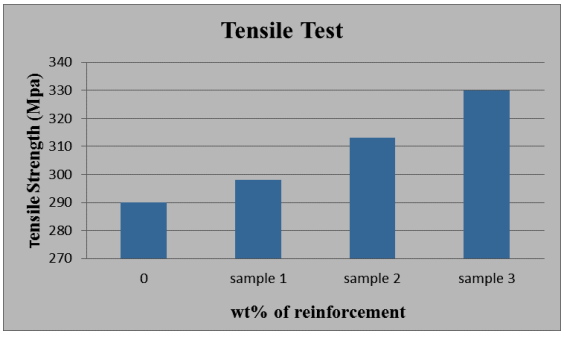

Fig.5. Tensile Test value for sample 1, 2 and 3 hybrid composite

Wear test behavior: At the lower amount of Al_2O_3 (5%) added aluminium 5083 the wear loss of the composite is high. With gradual increase in time the wear of the material gets increased correspondingly.

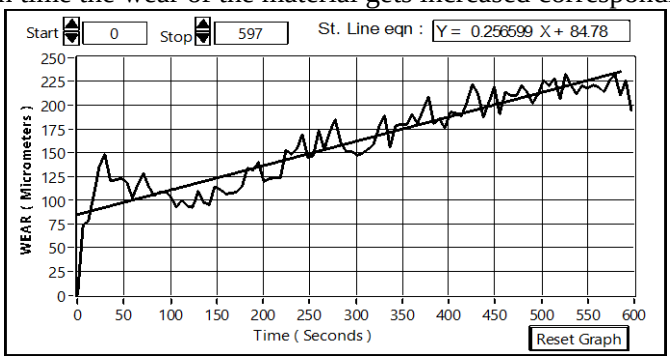

Fig.6. Wear test value for sample 1 hybrid composite

At the lower amount of Al_2O_3 (10%) added aluminium 5083 the wear loss of the composite is high. With gradual increase in time the wear of the material gets increased to some extent and then remain constant.

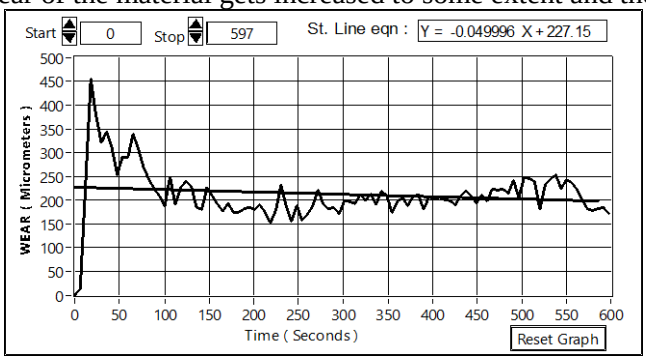

Fig.7. Wear test value for sample 2 hybrid composite

At the higher amount of Al_2O_3 (15%) added aluminium 5083 the wear resistance of the material is high. With gradual increase in time the wear of the material gets increased correspondingly.

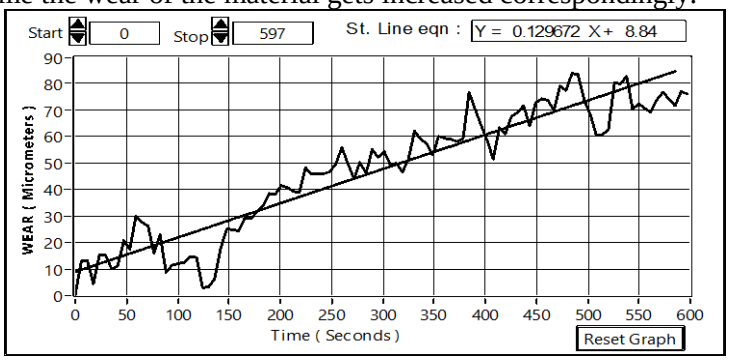

Fig.8. Wear test value for sample 3 hybrid composite

Comparison: At the lower amount of Al_2O_3 (5%) added aluminium 5083 the wear loss of the composite is high. At the lower amount of Al_2O_3 (10%) added aluminium 5083 the wear loss of the composite is low when the comparison of Al_2O_3 (5%). At the higher amount of Al_2O_3 (15%) added aluminium 5083 the wear loss of the composite is low when the comparison of 5% and 10% of Al_2O_3.

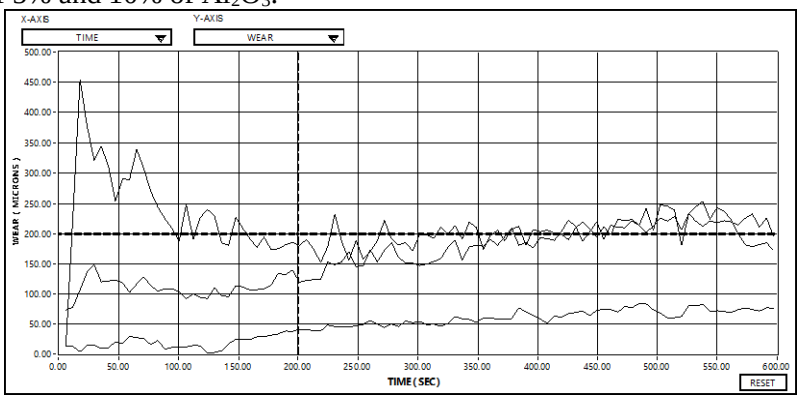

Fig.9. Wear test value comparison sample 1, 2 and 3 hybrid composite

4. CONCLUSION

From that investigation, we have concluded as follows:-

- The mechanical properties improved in sample 3 compared to other sample 1, 2 like harness, impact value.
- Tensile test result gives better value while adding the Al_2O_3 into the Al 5083 matrix alloy.
- Hardness value of sample 3 Hybrid Composite Improved as 95.5 BHN while compared to the sample 1 hybrid composite of 79 BHN and sample 2 Hybrid Composite of 82 BHN.
- The tribological test shows the wear resistance is high. The sample 3 have high wear resistant because of Al_2O_3 and graphite have higher hardness and dry lubricant. Microstructural image shows the homogenous mixture of reinforcement particle in the Al 5083-Al_2O_3-Gr. This kind of material is application for vehicle bodies.

REFERENCES

Ashjari M, Mostafapour A, Rouh S, Experimental investigation on the effect of process environment on the mechanical properties of AA5083/Al_2O_3 Nano composite fabricated via friction stir processing, Original Research Article Materials Science and Engineering: A, 645, 2015, 40-46.

Athijayamani A, Manickam C, Kumar J, Natesan Diwahar, Mechanical and wear behaviors of untreated and alkali treated roselle fiber-reinforced vinyl ester composite, Journal of Engineering Research, 3 (3), 2015.

Chandrasekar M, Rajkumar S, Valavan D, A review on the thermal regulation techniques for nonintegrated flat PV modules mounted on building top, Energy and Buildings 2015, 86, 2015, 692–697.

Gali O.A, Riahi A.R, A.T. Alpas A.T, The effect of surface conditions on the elevated temperature sliding contact deformation of AA5083 alloy, Original Research Article Wear, 330–331, 2015, 309-319.

Jagesvar Verma, Anil Kumar, Rituraj Chandrakar, Rajesh Kumar, Processing of 5083 Aluminum Alloy Reinforced with Alumina through Microwave Sintering, Journal of Minerals and Materials Characterization and Engineering, 11, 2012, 1126-1131.

Karthe M, Tamilarasan M, Prasanna S.C, Manikandan A, Experimental Investigation on Reduction of NOX Emission Using Zeolite Coated Converter in CI Engine, Applied Mechanics and Materials, 854, 2017, 72-77.

Krishnan M, Karthikeyan T, Chinnusamy TR, Venkatesh Raja K, A novel hybrid metaheuristic scatter search-simulated annealing algorithm for solving flexible manufacturing system layout, Eur J Sci Res, 2012, 52-61.

Manickam C, Kumar J, Athijayamani A, Karthik K, Modeling and multi response optimization of the mechanical properties of Roselle fiber-reinforced vinyl ester composite, Polymer-Plastics Technology and Engineering, 54(16), 2015, 1694-1703.

Manojkumar M, Shanmuga Prakash R, Wear Characteristics of Hybrid Al 6063 Matrix Composites Reinforced with Graphite and Fly Ash Particulates, Applied Mechanics and Materials, 854, 2016, 1-9.

Megavarnan R, Rajamurugan G, Shanmuga Prakash R, Comparative Study on Mechanical Properties of GMA Welded IRSM41 Mild Steel Plate Based on Grain Flow Direction, Applied Mechanics and Materials, 854, 2017, 38-44.

Prabhu T, Ramesh C, Kumar J, Sivakuma S, Hybrid Solar PVT System based on Neural Network Models to track optimal Thermal and electrical power, International Journal of Applied Engineering Research, 10 (28), 2015, 22075-22081.

Prasanna S.C, Ramesh C, Manivel R, Manikandan A, Preparation of Al6061-SiC with Neem Leaf Ash in AMMC's by Using Stir Casting Method and Evaluation of Mechanical, Wear Properties and Investigation on Microstructures, Applied Mechanics and Materials, 854, 2017, 115-120.

Prasanna S.C, Ramesh C, Property Evaluation of Aluminium Metal Matrix Composites Fabricated Using Stir Casting Method for Hand Lever In Automobile Applications, International Journal of Applied Engineering Research, 10 (85), 2015.

Rajakumar S, Balasubramanian V, Balakrishnan M, Friction surfacing for enhanced surface protection of marine engineering components: erosion-corrosion study, Journal of the Mechanical Behavior of Materials, 25 (3-4), 2016, 111–119.

Ramesh C, Manickam C, Prasanna S.C, Lean Six Sigma Approach to Improve Overall Equipment Effectiveness Performance: A Case Study in the Indian Small Manufacturing Firm, Asian Journal of Research in Social Sciences and Humanities, 6 (12), 2016.

Ramesh C, Valliappan M, Prasanna S.C, Fabrication of Ammcs by using Stir Casting Method for Hand Lever, International Journal of New Technologies in Science and Engineering, 2 (1), 2015.

Ramesh M, Karthic K.S, Karthikeyan T, Kumaravel A, Construction materials from industrial wastes—a review of current practices, International journal of environmental research and development, 2014, 317-324.

Ramesh M, Karthikeyan T, Effect of Reinforcement of Natural Residue (Quarry Dust) to Enhance the Properties of Aluminium Metal, Journal of Industrial Pollution Control, 2013.

Ramesh R, Ramesh C, Design, analysis and fabrication of canard wing configuration, International Journal of Research and Innovation in Engineering Technology, 2 (09), 2016.

Sethusundaram P.P, Arulshri K.P, Mylsamy K, Biodiesel blend, fuel properties and its emission characteristics Sterculia oil in diesel engine, International Review of Mechanical Engineering, 7 (5), 2013.

Shanmuga Prakash R, Sivakumar M, Jeevaraja M, Saravanan G, Review on Wire Electrical Discharge Machining of Die and Tool Grade Steels, International Journal of Applied Engineering Research, 10 (85), 2015, 521-527.

Sivakumar M, Sivakumar K, Shanmuga Prakash R, and Vignesh S, Parameters Optimisation of Wire Electrical Discharge Machining on AISI D3 Steel with Different Thickness, International Journal of Applied Engineering Research, 10 (62), 2015, 185–191.

Vijayan V, Karthikeyan T, Design and Analysis of Compliant Mechanism for Active Vibration Isolation Using FEA Technique, International Journal of Recent Trends in Engineering, 1 (5), 2009.