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Tribological Behaviour Of Aluminium Metal Matrix Composite Reinforced With Boron Nitride And Carbon Fibre

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Abstract- The increasing need for low weight alloys and composites for engineering and structural applications motivates researchers to investigate the prospect of developing novel processes to generate high-performance materials. The current study addresses the manufacturing of metal matrix composites (MMCs) employing Stir casting procedures with aluminium as the base metal and carbon fibre and boron nitride as reinforcements. The primary goal of incorporating reinforcement into a metal matrix is to improve thermal, structural, and tribological qualities by increasing yield strength, tensile strength, and hardness at ambient temperatures. A hardness test will be performed to investigate the tribological and mechanical properties of the AMMCs, and a SEM image will be captured to investigate the microstructure.

***Keywords*- Metal matrix composite, Stir casting, Aluminium 7075.**

I. INTRODUCTION

The use of aluminium metal matrix composites has increased in the recent years replacing many conventional metals like steel, iron etc. in the fields of aerospace, automobile, marine, high speed trains etc. because of their good properties such as low density, high wear resistance, stiffness, reliability, toughness, good combination of strength to weight ratio. Aluminium's mechanical qualities can be improved by reinforcing it with appropriate materials and forming composite materials[1-5]. The most effective way to increase these qualities is to make a hybrid composite with two reinforcements. When boron nitride is added, the mechanical characteristics of the matrix change, resulting in machinability issues. Carbon fibre has been added to improve machinability[6-10].

R.Elayaraja investigate the mechanical behaviour of the aluminium foams and the thermal effects on them were studied. Different processing methods to improve the foamability and strengths are also discussed. This paper overviews the physical, mechanical and thermal behaviour of the aluminium foams, their processing methods, their applications, testing and validation of properties for specific requirements[16].

Elayaraja.R studied the "Research on the development of composites has been going on long. But growing concerns about global warming, waste generation & management, increasing environmental awareness, increasing pressure on fossil fuel resources have led to the development of green composites. Even, there are some natural fibers where the properties can be good compared to the synthetic fibers which have contributed to this development. The work aims to develop a polymer composite with Prosopis juliflora and mango tree as reinforcements of a natural composite epoxyresin matrix. Composite plates were produced using a compression mold method with a composition ratio of 60:40,65:35 and 70:30. The resin and hardener proportions were 10:1 respectively[17].

Subramaniam D investigate the "FEA And Wear Rate Analysis Of Nano Coated HSS Tools For Industrial Application" by The life of the tool depends primarily on the wear rate of the tool, which in effect depends very much on the prevailing wear mechanism. We plan to do our project work on the machining tool (HSS) to boost their performance here. The HSS method is to render nano coating with Zirconia and Chromium materials. Using the FEA method (ANSYS software), the material strength and wear rate of the proposed HSS device is analysed. Through suggesting this nano-coated tools it helps in enhancing the life of the machining machine. Via this present project research we may also propose the latest and most sophisticated machining method[18].

Elayaraja R conducted "Experimental Investigation Of E-Glass and Kenaf Fibre with Epoxy Resin". hybrid composite isprepared with Bisphenol unsaturated polyester resin polymer matrix using untreated Kenaf fiber and E-glass fiber reinforcement. Kenaf / fiber glass hybrid composites were manufactured using a mixture of hand-laying techniques. Prepared composites were evaluated for compression, flexural and impact strength (Izod test) as per ASTM D3410, ASTM D790 and ASTM D256, respectively. Harness (Brinell) and water absorption tests were also carried out. Water absorption tests were conducted in two environmental conditions including sea water and distilled water. Results stated that the mechanical characteristics of kenaf fiber were reduced after the moisture had penetrated the composite[19].

II. EXPERIMENTAL DETAILS

1. Materials

A. Aluminium 7075:- In metal matrix composites, Al 7075 matrix material is employed. Al 7075 is utilised in applications that require a high strength-to-weight ratio, superior electrical and thermal conductivity, fatigue resistance, and low density, among other things. The density of Al 7075 is 2.70g/cm3, and the thermal conductivity is 151-202W/mK. This alloy's composition is shown below.

Table -1: Chemical composition of the Al 7075 matrix alloy (wt. %).to maintain the quality of the blind review process.

Element	Al	Si	Fe	Cu	Mu	Mg	Cr	Zn	ti
% weight	Base	0.8	0.7	0.4	0.15	1.2	0.35	0.25	0.15

B. Boron Nitride (BN):- Boron nitride has exceptional hardness and excellent thermal and chemical stability. The practical size of boron nitride is 5-11 microns. Boron nitride powder has a density of 2.1g/cm^3 and a thermal conductivity of 600 W/mK. BN acquired from Mumbai-based Parshwamani Metals.

C. Carbon fibre powder:-

Carbon fibre (also known as graphite fibre or carbon fibre) is a type of fibre that is 5-10 micrometres in diameter and is largely made up of carbon atoms. Carbon fibres provide a number of benefits, including high stiffness, high tensile strength, low weight, good chemical resistance, high temperature tolerance, and minimal thermal expansion. Carbon fiber's qualities have made it particularly popular in aircraft, civil engineering, military, and motorsports, as well as other competitive sports. However, when compared to equivalent materials like as glass or plastic, they are quite pricey.

2. Experimental setup and procedure

Stir casting method is used for the preparation of composite. In this process the Al7075 bars are cut into small chips using lathe machine. These chips are placed in a clay graphite crucible and the crucible is kept in the electrical resistance furnace. The ingots are melted at a temperature of 800 ºC. The BN particles are pre -heated at a temperature of 400 ºC for to increase the surface reaction along with the carbon fibre powder are preheated at a temperature of 100 ºC. These pre-heated particles are then added into the melt and stirred continuously in order to achieve uniform distribution of particles in the matrix. After the mixing of the reinforcements with the matrix, the crucible is taken out of the furnace and the molten metal is poured into the metal mould and allowed to solidify.

3. Testing of composites

Brinell hardness test was conducted to determine the hardness of the composites and base metal. The tensile test was conducted on a Universal Testing Machine (UTM) to determine the tensile strength and the percentage elongation. For micro structural study, Scanning Electron Microscope was used.

III. RESULTS AND DISCUSSION

1. Hardness Results

Hardness is a characteristic of a material, not a fundamental physical property and it is defined as the resistance to indentation. The Rockwell test is carried out for the aluminium 7075 specimen reinforced with boron nitride and carbon fibre.

For aluminium alloy

- Scale : B
- Indentor : 1/16" ball
- Load (kgs) : 100
- Dial : Red

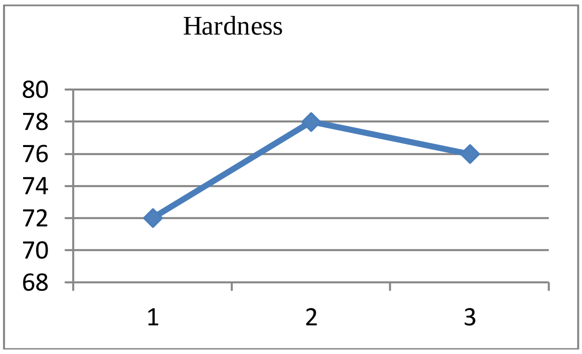

Figure 1: Rockwell hardness test results for varying percentage of boron nitride and carbon fibre.

Hardness Test Results (shows that above 9% of carbon fibre addition decreases the mechanical properties of the alloy.)

2. Tensile Results

The tensile tests are conducted on Universal Testing Machine. The ultimate tensile strength (UTS) was found to increase compared to that of the base metal because of the presence of reinforcements which take up the load. Figure 6 shows the ultimate tensile strength of the aluminium 7075 rod of 1cm diameter reinforced with boron nitride and carbon fibre. The ultimate strength of the aluminium alloy above 9% of carbon fibre addition decreases the mechanical properties of the alloy.

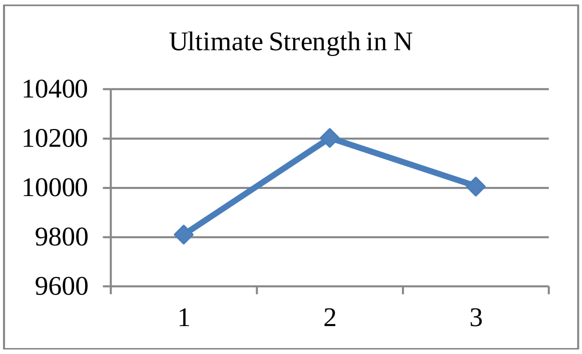

Figure 2: Tensile test results for Al 7075reinforced with BN and Carbon fibre.

IV. CONCLUSION

1. Al 7075/hBN composite have been successfully manufactured by stir casting method up to 9% hB reinforcement. Al 7075/hBN composite is found light weight than pure Al 7075.
2. Increase in the Hardness of the composite and it is found to be 78 HBN and carbon fibre for 9%of Reinforcement. The micro structural study shows that there was uniform distribution of the hBN in Al7075 matrix.
3. Tests conducted to determine the hardness shows very encouraging results as the reinforced composite was able to take higher loads of indentations due to presence of Boron Nitride and Carbon Fibre, the hardness is increased.
4. Similarly with increasing the wt. % of reinforcement, increase in the Ultimate Tensile Strength (UTS). The Maximum UTS was found to be 10200 at 9% of reinforcements.
5. Metal matrix composites of Al 7075 reinforced with Boron Nitride and Carbon fibre particulates is found to have improved tensile strength when compared to Al 7075 alloy alone.
6. Above 9% of carbon fibre addition, decreases the mechanical properties of the alloy.

REFERENCES

1. Anandha Moorthy A, Uvaraja V C, Natarajan N, Palani P K, Dhanendran N, Anantha Kumar M, Satheesh K S, “Tribological Behavior of Aluminium based MMC Subjected to Various Temperature”, International Journal of Applied Engineering Research, Volume 9, Number 22 (2014) pp. 14207-14215.
2. Mr. Rushikesh A. Khatavkar, Prof. Abhijeet K. Mandave, Prof. Devakant D. Baviskar, Prof. Samir L. shinde,Influence of “Hexagonal Boron Nitride on Tribological Properties of AA2024-hBN Metal Matrix Composite”, International Research Journal of Engineering and Technology (IRJET) Volu me: 05 Issue: 05 | May-2018.
3. Essa Zitoun and A. Chennakesava Reddy, “Microstructure-Property Relationship of AA3003/Boron Nitride Particle-Reinforced Metal Matrix Composites Cast by Bottom-Up Pouring”, 6th National Conference on Materials and Manufacturing Processes.
4. Yathiraj K, Chandraiah M T, Mohan Kumar A R, “Evaluation of Mechanical Properties of Aluminium 6061 Reinforced with Boron Nitride MMC’s using OM”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 9, September 2016.
5. Risheng Pei, Guoqin Chen, Yaping Wang, Ming Zhao, Gaohui Wu, “Effect of interfacial microstructure on the thermal-mechanical properties of mesophase pitch-based carbon fibre reinforced aluminum composites”, Journal of Alloys and Compounds 756 (2018) 8e18.
6. M. Sánchez, J. Rams, A. Urena,”Fabrication of aluminium composites reinforced with carbon fibre by a centrifugal infiltration process”, Composites: Part A 41 (2010) 1605–1611.
7. Prof.(Mrs)Madhuri Deshpande, Mr. Ramesh Gondil, Dr.Rahul Waikar, Dr.S.V.S.Narayan Murty, Dr.T. S. Mahata, “Processing and Characterization of Carbon Fibre Reinforced Aluminium7075”, Materials Today: Proceedings 5 (2018) 7115–7122.
8. Ashok Kumar.M.S, Mohana Kumar.K.C, Ajit Prasad.S.L, “Experimental Investigations on Mechanical and Tribological Properties of Extruded Aluminium A356 - AL2O3 Stir Cast MMC”, Materials Today: Proceedings 5 (2018) 3044–3051.
9. N. Radhika, R. Raghu, “Dry Sliding Wear Behaviour of Aluminium Al–Si12Cu/TiB2 Metal Matrix Composite Using Response Surface Methodology”, Tribol Lett (2015) 59:2.
10. T.S.A.Suryakumari, S.Ranganathan, “Preparation and Study the Wear Behaviour of Aluminium Hybrid Composite”, Materials Today: Proceedings 5 (2018) 8104–8111.
11. B. Bhav Singha, M. Balasubramanian, “Processing and properties of copper-coated carbon fibre reinforced aluminium alloy composites”, journal of materials processing technology 2 0 9 (2 0 0 9) 2104–2110.
12. S. Rajesh, A. Gopala Krishna, P. Rama Murty Raju, M. Duraiselvam,“Statistical Analysis of Dry Sliding Wear Behavior of Graphite Reinforced Aluminum MMCs”, 3rd International Conference on Materials Processing and Characterisation (ICMPC 2014).
13. Matthews F.L., Ralwlings R.D,“Composite materials engineering and science”, Glasgow, UK, Champaman and hall, 1994.
14. Chawla K.K, “On the applicability of the "Rule-of-Mixtures" to the strength properties of metal-matrix composites”, Revista Brasileira de Física, 4(1974): pp 411-418.

15. Gangatharan T, Anandha Moorthy A,“Enhancing the ribological Properties of Composite Materials for Centrifugal Pump Application”, (IRJET) e-ISSN: 2395 - 0056 Issue:03 2016p-ISSN: 2395-0072.
16. J. Dineshkumar, T. Jesudas, R. Elayaraja, Characteristics, applications and processing of aluminium foams – A Review, Mater. Today: Proc. (2021).
17. R Elayaraja et al 2020 IOP Conf. Ser.: Mater. Sci. Eng. 923 012050.
18. Subramaniam D, Ajithkumar M, Elayaraja R, “FEA And Wear Rate Analysis Of Nano Coated HSS Tools For Industrial Application”,International Journal of Engineering Development and Research, Vol 8,Issue 2,2020.
19. Elayaraja.R, Dr.Saravanan.P, Gokul.M, Gowrisankar.T,” Experimental Investigation af E-Glass and Kenaf fibre with Epoxy Resin”, International Research Journal of Engineering and Technology,Vol 6, Issue 11,2019.