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A Study On The Characterisation And Preparation Of Aluminium Composite

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ABSTRACT

In this publication, we present the results of a Brinell hardness test and a dry sliding wear behaviour study on AA 5083 aluminium that was strengthened with SiC particles using the stir casting technique. SiC particles with different volume fractions (3, 5, and 7 wt%) were utilised in the synthesis. Using a pin-on-disc testing machine, we analysed the wear behaviour of the aluminium alloy and its composites. Dry sliding wear of metal matrix composites has been investigated in terms of factors such as applied load, sliding speed, sliding distance, and reinforcing percentage (MMCs). A plan of experiments, based on the techniques of Taguchi, was done to obtain data in controlled fashion. An orthogonal array of L9 (34) and signal to noise ratios as smaller the better was selected. Analysis of variance (ANOVA) was employed to investigate the influence of wear parameter on pin of aluminium MMCs. Multiple generalised regressions model was used to determine the correlation. The experimental findings predicted by the aforementioned correlation were then compared to the results of the conformation tests.

Keywords: Wear; Brinell Hardness; Taguchi Method ;Metal Matrix Composites; Orthogonal Array; Analysis of Variance;

1. INTRODUCTION

In order to drastically increase the performance attributes of a polymer, scientists have developed polymer nanocomposites by dispersing nanoscale inorganic particles (usually 10–100 nm in at least one dimension) across a matrix of organic polymer. [1] The physical properties of systems in which the inorganic particles are the layers of a lamellar compound (usually smectite clay or nanocomposites of a polymer (such as nylon) embedded amid layers of silicates) are drastically different. In particular, polymer-silicate nanocomposites with a layer orientation are stiff, strong, and dimensionally stable in two dimensions (rather than one). [4]

The nanoscale length scale is responsible for the low dispersion of light in most nanocomposites. As an alternative to traditional fillers, polymer nanocomposites are on the rise. Because of their nanometer sizes, filler dispersion nanocomposites exhibit significantly improved properties in comparison to the pure polymers or their conventional composites. The modulus, strength, barrier characteristics, solvent resistance, heat tolerance, and flammability have all been enhanced. Polymers with transition metal complexes linked to or incorporated directly into a conjugated backbone [3] are an intriguing and potentially fruitful class of contemporary materials. These macromolecules combine organic polymers with transition metals to form a hybrid structure. It's no secret that -conjugated organic polymers like polyacetylene, polythiophene, and polypyrrole—along with their oligomers and derivatives—have been the subject of substantial research. These materials have been proposed for usage in a variety of applications, such as chemical sensors, electroluminescent devices, electrocatalysis, batteries, smart windows, and memory devices because of their inherent nonlinear optical characteristics, electrical conductivity, and luminescence. [2]

Powders, pellets, and liquids are the most common forms of polymer production. Thermosets require additional polymerization to complete cross-linking processes before finally solidifying into the specified shape, while thermoplastics can be melted and shaped directly after production. Processing is the term for these actions. [6] The processing activities are affected by a wide variety of circumstances. Factors including viscosity, reaction rate, orientation of heterogeneous phases, and volatile production are all in this category. Viscosity is the most important of these parameters since it affects every other aspect of processing. The molecular structure of polymer chains, the temperature, the shear rate, the molecular weight, and the heterogeneity of the materials all play significant roles in determining viscosity. Therefore, rheology, the study of the flow behaviour of polymeric materials, is crucial for comprehending optimal processing conditions. [8]Composites retain the properties of the individual materials that make them up. By combining these elements, new and useful qualities emerge. Tendons, bone, bamboo, rock, and a plethora of other biological and geological elements are all examples of composites found in nature. Our work in composite engineering is limited to synthetic polymer matrices reinforced with natural mineral fillers like silica, mica, and calcium carbonate, as well as synthetic fibres like glass fibres and carbon fibres. In order to create PNC (polymer nanocomposites), a polymer or copolymer is mixed with a nanoparticle or nanofiller. [7] It doesn't matter what form these take (platelets, spheroids, fibres), at least one of their dimensions needs to be between 1 and 50 nm. Multi-phase systems such as these PNCs consume nearly all of the plastics. Compounding procedures for all MPS, including PNC, are similar, necessitating controlled mixing and compounding, stabilisation of the resulting dispersion, and orientation of the dispersed phase. [5]

Edwin A. González Segura (2018)Titanium dioxide (TiO_2) nanoparticles were incorporated into polymer composite materials made from polylactic acid (PLA). This study was conducted to learn more about the possible applications of TiO_2 in the food and agro-alimentary industries by looking into its antibacterial action against a strain of E. coli (DH5). The two-step technique used to prepare the PLA/TiO_2 systems involves hot pressing after a solvent casting stage. The particles were characterised according to their size (21 nm and 100 nm) and their concentration (0%, 1%, 5%, 10%, and 20%, wt%). Neither X-ray diffraction (XRD) nor Fourier transformed infrared spectroscopy (FTIR) revealed any major alterations to the polymer structure as a result of the incorporation of TiO_2 nanoparticles. Thermogravimetric analysis (TGA) found a modest increase in the temperature of degradation with particle concentration, but differential scanning calorimetry (DSC) showed that thermal transitions did not vary, regardless of size or content. Biofilm development and bacterial growth on the surface of composites in the presence of DH5 Escherichia coli were investigated. Bacterial growth is inhibited by TiO_2 nanoparticles by reducing the production of extracellular polymeric substances (EPS). When TiO_2 nanoparticles (NPs) were injected into PLA at a concentration of 1%, the inhibition distances measured using the Kirby-Bauer method were doubled. However, no significant differences were observed for greater concentrations of TiO_2 NPs. [8]

2.MATERIALS AND METHODS

The Al-Mg matrix alloy AA 5083 from the Aluminium Association was chosen as the DRAMMC material for this study. This matrix alloy has the lowest density of all Al alloys at only 2.6 gm/cm3, and it offers a remarkable mix of properties, including high corrosion resistance to seawater, high tensile strength, exceptional toughness, and good machinability and weldability. It reveals the chemical composition of AA 5083 as determined via Spectro analysis. The particle size range of the SiC particles used to make the composite is between 1 and 25 microns.

The Composite Preparation

The composite specimens utilised in this investigation were prepared using the liquid metallurgy stir casting process for the fabrication of the particulate metal matrix composites (MMCs) employed in this research. This technology is the cheapest way to produce composite particles. Initially, the matrix alloy (AA5083) was superheated in an electric furnace to a temperature of 760 °C, which is higher than the material's melting point. The slurry was degassed and slag powder was sprinkled to eliminate any slag content. A slow decrease brought the temperature down to below the liquidus point, which is 720 C. It was at this point that the SiC particles, which had been warmed at 800 °C to generate a coating of SiO_2 on their surface to increase their wettability with molten metal, were mixed into the slurry by weight. There was an increase in slurry temperature, and the automatic stirring was kept going for 10 minutes at a speed of 450 to 500 revolutions per minute. The melt was then superheated past the liquidus temperature before being put into cast iron (CI) permanent moulds measuring 20 mm in diameter and 210 mm in height. Three, five, and seven wt% SiC reinforcements were used. Both the permanent CI moulds and the melting and stirring process are depicted in Figure 1.

Experimental Setup and Procedure

Wear

Dry sliding wear parameters of composite were studied using a pin-on-disc model (model type, TR-201CL of Ducom, India) in accordance with ASTM G99-95 standards. Machined from as-cast samples, the wear specimen (pin) is 8 mm in diameter and 25 mm in height. An accurate digital microbalance weighing machine was used to record the initial weight of the specimen at 0.1 mg. During the test, the pin was forced against the counterpart, rotating against an EN32 steel disc with a hardness of 65 HRC. Wear was quantified by taking specimens out of the test run after they had slid a predetermined distance. The difference in the weight measured before and after the test gives the sliding wear of the composite specimen and then volume loss is estimated.

Hardness

Composite specimens were tested using a Brinell hardness test in accordance with ASTM E-10. From the as cast condition, 20 mm 20 mm specimens were cut, and the surfaces of the specimens were polished. Tests of Brinell hardness are performed on soft materials like aluminium and aluminium alloys using a load of 500 kgf. A 10 mm hardened steel ball was used as the penetrator.

Plan of Experiment

Wear Test

Taguchi's orthogonal array was followed for all of the trials. The selection of the orthogonal array was based on the condition that the degrees of freedom for the orthogonal array should be greater than or equal to the sum of those wear parameters. To conduct the current study, the 94 L9 (34) orthogonal array was chosen. In the present inquiry, the wear parameters chosen for the trials were 1) sliding speed, 2) load, 3) sliding distance, and 4) weight percentage of SiC. Table 3 displays the factors and their levels. The experiment comprises of 9 tests (each row in the L9 orthogonal array), and the columns were assigned with parameters. In the fourth column, the weight percentage of SiC is recorded, with sliding speed in the first, load in the second, sliding distance in the third, and sliding distance in the fourth. The wear was the response, and the smaller the objective, the better the S/N ratio.

3.RESULTS

Table 1 shows the percentage by weight composition of AA 5083.

Al	Balance
Si	0.0960
Fe	0.161
Cu	0.0270
Mn	0.600
Mg	3.92
Cr	0.0790
Ni	0.0008
Zn	0.0270
Ti	0.0660
Sb	0.002
Sn	0.001

Table 2. Orthogonal array L9 (34) of Taguchi.

L_9 (3^4) test	1	2	3	4
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

Table 3. Process parameters with their values at three levels

Level	Sliding speed m/s	Load N	Sliding distance M	SiC/wt pct
1	0.314	9.81	500	3
2	0.942	29.43	1000	5
3	1.570	49.05	1500	7

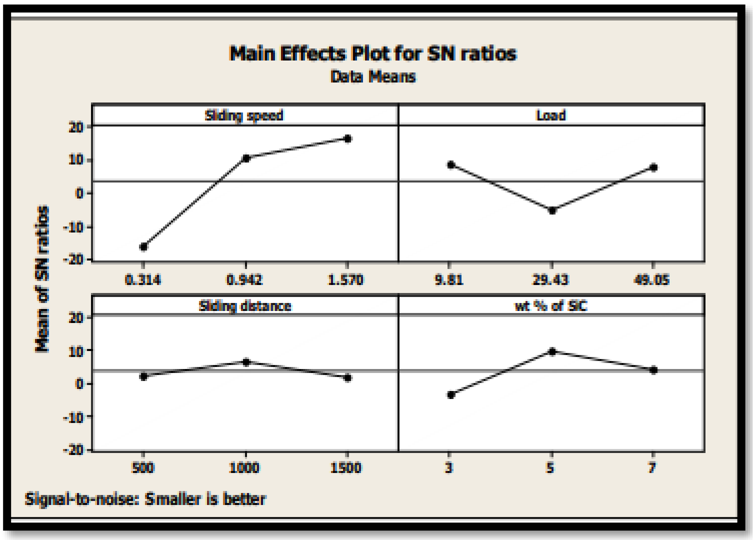

Fig 1. Main effects plot for S/N ratios.

4.DISCUSSIONS

The Brinell hardness of Al-5083 that has been strengthened with 3, 5, and 7 wt pct of SiC is higher than that of the unreinforced metal. [22] As the SiC reinforcement percentage has grown, so too has the Brinell hardness value. Tests were designed to determine how factors like sliding speed, load, sliding distance, and reinforcing percentage relate to dry sliding wear on a composite material. An S/N ratio with a higher value is preferred over one with a lower value because it reduces the amount of variation in the final product relative to the desired value. As was noted before, [24] "Smaller is better" was the quality criterion employed in this investigation. The inclusion of SiC particles, which operate as load-supporting elements, is responsible for the high wear resistance of composite materials. If the coefficient of sliding wear is positive , this means that sliding wear rises with those variables. However, if the coefficient has a negative value, it indicates that the sliding wear of the material will decrease as the linked variables rise. The relative importance of the factors is reflected in the sizes of the variabless. [29]

5.CONCLUSIONS

The following inferences can be taken from the study's examination of the findings of dry sliding wear of the SiC particle reinforced MMCs and the results of hardness of material obtained[26]. Optimizing wear factors with the help of a Taguchi orthogonal array, signal-to-noise (S/N) ratio, analysis of variance (ANOVA), and a general regression model proved fruitful. The ideal combination of parameters and their levels for attaining a minimum wear rate is $A_3B_1C_2D_2$, i.e., sliding speed at level 3 (1.57 m/s), load at level 1 (9.81 N), sliding distance at level 2 (1000 m), and wt pct of SiC at level 2 (5 wt%). [28] This is based on the major effects of S/N ratios. Wear rate was shown to be significantly affected by sliding speed (p =

84.46), somewhat affected by load (p = 4.65) and weight percentage of SiC (p = 8.31), and unaffected by sliding distance (p = 2.39), according to the ANOVA analysis. The components have a pooled error of 2%, and the regression coefficient is 0.82, indicating a strong association [23]. The wear rate of an AA5083-SiC particle composite can be accurately predicted using a general regression mathematical model. The created model can estimate the wear rate of a composite with 95% confidence within the scope of the experiment. The verification test revealed an inaccuracy of 8.1% in predicting dry sliding wear of the composite using the ideal combination of parameters $A_3B_1C_2D_2$. The wear rate was found to decrease by increasing the proportion of SiC particles used in the reinforcement. Al-5083 reinforced with 3, 5, and 7 weight percent has a lower wear rate than pure Al-5083 alloy. An increase in SiC particle weight up to 7 wt% significantly boosted Al-5083's hardness . [30]

REFERENCES

1. Langer, R. "Physical and mechanical properties of PLA, and their functions in widespread applications—A comprehensive review". Adv. Drug Deliv. Rev. Vol 107,issue (1), Page 367–392,2016.
2. Dubois, P. "PLA composites: From production to properties". Adv. Drug Deliv. Rev. Vol 107, issue (1), Page 17–46,2016.
3. Kumar, M.N.V.R. "Poly(lactic acid) blends in biomedical applications". Adv. Drug Deliv. Rev. Vol 107, issue (1), Page 47–59,2016
4. Habibi, Y.; Murariu, M.; Dubois, P. "Polylactide (PLA)-based nanocomposites. Prog". Polym. Sci. Vol 38, issue (1), Page 1504–1542,2013
5. Rosa, M.D. "Poly(lactic acid)-modified films for food packaging application: Physical, mechanical, and barrier behavior". J. Appl. Polym. Sci. , Vol 125, issue (1), Page 1-15,2012.
6. Samper, M.D.; Aldas, M.; López, J. "On the use of PLA-PHB blends for sustainable food packaging applications". Materials , Vol 10, issue (1), Page 1–26,2017
7. Buzarovska, A.; Grozdanov, A. "Biodegradable poly(L-lactic acid)/TiO2 nanocomposites: Thermal properties and degradation". J. Appl. Polym. Sci. 2012, Vol 123, issue (1), Page 2187–2193,2012
8. Edwin A. Segura González " Preparation and Characterization of Polymer Composite Materials Based on PLA/TiO2 for Antibacterial Packaging", Polymers,Vol 10,issue (1), page 13-65,2018
9. Anek Pal Gupta "Synthesis and characterization of carboxymethyl guar gum nanoparticles stabilized polyaniline/carboxymethyl guar gum nanocomposites" J Nanostruct Chem ,Vol 5, issue (1), Page 405–412,2015
10. Orth, E.S., Grein-iankovski, A., "The use of gum Arabic as ''Green'' stabilizer of poly(aniline) nanocomposites: a comprehensive study of

spectroscopic, morphological and electrochemical properties". J. Colloid Interface Sci. Vol 434, issue (1), Page 18–27 2014.
11. John, A. "Polyaniline materials by emulsion polymerization pathway". Prog. Polym. Sci. Vol 33, issue (7), page 732–758 ,2008.
12. Monty, J., Linhardt, R.J. "Polysaccharide-based nanocomposites and their applications". Carbohydr. Res.Vol 405, issue (1), Page 23–32 ,2015.
13. Azar, F.F., Olad, A., Mirmohseni, A. "Development of novel hybrid nanocomposites based on natural biodegradable polymermontmorillonite/polyaniline: preparation and characterization". Polym. Bull. Vol 71, issue (1), Page 1591–1610 ,2014.
14. Chen, S., Yang, Z., Liu, L., Wang, H. "Flexible electrical conductive nanocomposite membrane based on bacterial cellulose and polyaniline". J. Phys. Chem. B , Vol 115, issue (1), Page 8453–8457, 2011.
15. Bhat, R., Deshpande, R., Venkataraman, A. "Synthesis, characterization and studied of PANI-MMT nanocomposites". Nanosci. Nanotechnol. Vol 2, issue (4),page 90–98 ,2012.
16. Chen, W., Xue, G. "Facile synthesis of polyaniline-sodium alginate nanofibers". Langmuir , Vol 22, issue (1), Page 3899–3905,2006.
17. Huh, D.S. "The study of DC conductivity for polyaniline-polymannuronate nanocomposites". Bull. Korean Chem. Soc. Vol 29, issue (12), page 2423–2426 2008.
18. Malhotra, B.D. "Polyaniline-carboxymethyl cellulose nanocomposite for cholesterol detection". J. Nanosci. Nanotechnol. Vol 10, issue (1), Page 1–10 , 2010.
19. Han, F., Gao, C., Zhang, B. "Synthesis and characterization of carboxymethyl guar gum and rheological properties of its solutions". Carbohydr. Polym. Vol 88, issue (3),page 1015–1022, 2012.
20. Xu, Z. "In situ polymerization approach to graphenereinforced nylon-6 composites". Macromolecules, Vol 43 , issue (1),page 6716–6723,2010.
21. Gu, H. Lee and R. J. Wu, "The Oxidation of SiC Particles and Its Interfacial Characteristics in Al-Matrix Composites" Journal of Materials Science, Vol. 36, Issue (10), Page 2441- 2449,2001.
22. Q. Liu, J.-C. Lee, D. Zhang and R. J. Wu, "Interfacial Reaction between the Oxidized SiC Particles and Al-Mg Alloy," Chinese Science Bulletin, Vol. 46, issue (3), Page 1948-1952,2001.
23. R. Gurler, "Sliding Wear Behavior of a Silicon Carbide Particle-Reinforced Aluminum-magnesium Alloy," Journal of Material Science Letters, Vol. 18, issue (7), Page 553-554,1999.

24. A. Garcia H. “Synthesis and Microstructural Characterization of Al-Mg Alloy-SiC Particle Composite,” Material Letter, Vol. 62, Issue (1), Page 2623-2625,2008.
25. L. J. Huang, “Effects of Mg Content on Microstructure and Mechanical Properties of SiCp/Al-Mg Composites Fabricated by Semi-Solid Stirring Technique,” Transactions of Nonferrous Metals Society of China, Vol. 20, issue (10), Page 1851-1855,2010.
26. M. K. Surappa, “Aluminum Matrix Composites: Challenges and Opportunities,” Sadhana, Vol. 28, issue (1), Page 319-334,2003.
27. T.-M. Yeh, “Integrating the Taguchi Method and Response Surface Methodology for Process Parameter Optimization of the Injection Molding”, Applied Mathematics & Information Sciences, Vol 8,issue (3) Page 1277-1285,2014.
28. . khalife, “Optimization of physical and mechanical properties of calcium silicate nanocomposite by Taguchi method”, Scientific Journal Management System, vol 10, issue (3), Page 77-90,2010.
29. A. Asghar, A.A. “A comparison of central composite design and Taguchi method for optimizing Fenton process”, ScientificWorldJournal , Vol 1, issue (2), Page 1-25,2014
30. . Tabassi, “Effects of polymer modification on the permeability of cement mortars under different curing conditions: a correlational study that includes pore distributions, water absorption and compressive strength”, Construction and Building Materials , Vol 28, issue (1) , page 561-570,2012