FABRICATION AND TRIBOLOGICAL STUDIES OF HYBRID COMPOSITE MATERIAL

K.Surendrababu¹, Sathiyaraj S², M.Issac Premson³, D.GuruMugilan¹, E.Sridharan¹

Associate Professor¹, Assistant Professor², UGScholar³, Aarupadai Veedu Institute of Technology, Vinayaka Mission’s Research Foundation, Deemed to be University, Tamil Nadu, India,
Corresponding Author : surendrababu@avit.ac.in

Abstract. Many attempts have been undertaken to mechanically or chemically create various types of inorganic filled polymers. These methods, however, necessitate the alteration of the filler material through intricate polymerization reactions, making them unsuitable for industrial use. Waste flyash recovery is challenging, and the utilisation rate is poor. This flyash is employed in novel composite materials as a filler or partial reinforcement. Flyash is employed as a filler material for polymer matrix composites in this study. Aramid and E-Glass fibres are utilised as reinforcement with epoxy resin to improve the bonding strength between the fibres and filler materials, resulting in a high load bearing capacity. The specimens are tested for mechanical properties such as tensile, flexural, and impact according to ASTM standards. The maximal impact strength was seen at a 5wt% flyash addition, however the tensile and flexural strength were steadily lowered with the addition of 5wt% flyash.

Keywords: flyash, polymer matrix, fibres, reinforcement, filler material, Aramid, E-Glass.

1. INTRODUCTION
For service longevity, Mechanical and tribological synergy is required for components that are in relative motion with their counterparts in any product. Traditional materials frequently outperform modern materials in each of these area. As a result, the part will fail prematurely. This has opened the door to new possibilities evolution of custom materials, i.e. composites, to fit specific applications. To synthesis and study the mechanical behaviour of Aramid/E-glass composite. This project comprises the creation of an a polymer composite reinforced with Flyash particles, as well as the study of its reaction to various mechanical behaviours. A fast and basic understanding of the following will aid in familiarising oneself with the present project and its goals.

Bheemappa Suresha et.al[1] Epoxy Hybrid Composite Fabrication and Tribological Behavior. Shubhajit Dasj et.al [2] Fabrication and tribological analysis of SiC/B4C nanoparticle-reinforced AA6061 hybrid metal matrix composites. Jaswinder Singh[3] The features of Al/SiC/Gr hybrid composites that can be used in a range of tribological applications are discussed.. RManikandan[4] This study focuses on fabricating aluminium hybrid metal matrix composites with environmentally friendly agricultural waste, cow dung ash, and boron carbide using two-stage stir casting. D Lingaraju[5] Nanoparticle reinforced plastics are gaining
popularity as a means of developing novel materials that maximise the efficient use of natural resources, particularly renewable resources.

2. MATERIALS AND METHODS

2.1. Materials Used

2.1.1. Thinner
Before and after combining Epoxyres with fillers, thinner is used to clean the beaker and other containers. Thinner is shown in figure 1.

![FIGURE 1: Thinner](image)

2.1.2. White Wax
The white wax aids in the removal of laminates from the moulding board without causing them to break. We can remove the manufactured laminate from the moulding board without any breakage or damage by applying white wax before removing it for one hour. White Wax is shown in figure 2.

![FIGURE 2: White Wax](image)

2.1.3. Moulding board
The base surface on which an composite laminate is built is moulding board. Its dimensions are 400mm x 400mm. In this moulding board the laminate is prepared with varying percentage nano by using handlay–up technique.

2.1.4. Mechanical stirrer
The mechanical stirrer is used for constant stirring of flyash with epoxyres in for more than 15 minute. It makes uniform distribution over the matrix. Mechanical stirrer is shown in figure 3.

![FIGURE 3: Mechanical Stirrer](image)
2.1.5. **Epoxy Resin**

Epoxy resin is matrix material and it is in the form of liquid wax. Epoxy resin is shown in figure 4.

![Mechanical Stirrer](image)

**FIGURE 3:** Mechanical Stirrer

2.2. **Hardener**

Hardener is the hardening and curing agent which is used to solidify the epoxy resin material along with reinforcement. Because of the resin which is very less viscosity we are using hardener to solidify the resin. Here we are using the tri-ethylene tetra amine as a hardener for epoxy resin. Hardener is shown in figure 5.

![Epoxy Resin](image)

**FIGURE 4:** Epoxy Resin

![Hardener](image)

**FIGURE 5:** Hardener

2.3. **E-GLASSFIBER**

Fibre glass is a type of fiber-reinforced plastic in which glass fibres are pushed into the material. Fiberglass is also known as glass reinforced plastic or glass fibre reinforced plastic for this reason. Fiberglass is a light, robust, and less brittle material. The best thing about fiberglass is
that it can be moulded into a variety of intricate shapes. Fiberglass is frequently utilised in bathtubs, boats, aircraft, roofing, and other uses because of this. E Glassfiber is shown in figure 2.6.

2.4. Aramid Fiber

Heat-resistant and strong synthetic fibres are known as aramid fibres. They’re employed in aerospace and military applications, as well as bicycle tyres, maritime cordage, and marine hull strengthening, and as an asbestos alternative. Aramid Fiber is shown in figure 7.

2.5. Flyash

Flyash, also known as flue-ash, is one of the byproducts of combustion, and it contains the small particles that rise with the flue gases. Bottom ash refers to ash that does not rise. Fly ash is the powder that is produced when coal is burned in a mechanical environment. All flyash in contains considerable quantity of silicodioxide (SiO2) (both amorphous and crystalline) and calcium oxide (CaO), both of which are endemic components in many coal-bearing rockstrata. Flyash is shown in figure 8.
3. MANUFACTURING TECHNIQUE

Hardener was the nano composite formation taking (1:1 Ratio) the flyash dipresed through ashear mixing process. Then 10% hardener was added into the epoxy–fly ash mixture by weight and through mixed. Handlay-up is the most widely used manufacturing technique. The square steel mold with the dimension of 400mm x 400mm was used to be prepared and the releasing agent a aqueous solution of polyvinyl alcohol (PVA) is applied on the mould evenly. The laminate are allowed to cure for 48 hours and therers in was cool edt room temperature similarly the 0% laminate is prepared. Machine dasper dimensions of American Society for Testing and Material (ASTM) D3039, D790, and D256 were used to manufacture standard tensile, flexural, and impacts specimens from the cured laminate of nano composites.

3.1. Handlay-Up Technique

Hand lay-up is the most basic way of composite processing. This approach also has a low infrastructure need. The processing procedures are straightforward in figure 9. To begin, a release gel is sprayed on the mould surface to prevent the polymer from clinging to it. To achieve a nice surface finish on the product, thin plastic sheets are used on the top and bottom of the mould plate. Woven mats or chopped strands can be used as reinforcement. Mats are cut to fit the mold's dimensions and laid on the mold's surface once the Perspex sheet has been applied. The rmosetting polymer in liquid form is then completely mixed with a prescribed hardener (curing agent) in a proper proportion and poured onto the surface of the metal for put in the mould. With the help of a brush, the polymer is spread evenly. The second layer of mat is then placed over the polymer surface, and a roller is pushed through the mat-polymer layer with little pressure to remove any trapped air and excess polymer. The method is continued for each polymer and mat layer until all of the layers have been restacked.

The 5w % of flyash is added to the resin while mixing at a rate of 1000 rpm, this was conducted for 20 minutes until the

![FIGURE 9: Handlay up Method](image)

3.2. Experimental Procedure

STEP-1 Prepare the mould on the 400mm*400mm
STEP-2 Clean the mould using thinner
STEP-3 Apply the gel (PVA) on the mould using cotton.
STEP-4 In a digital weighing balance, weigh the Epoxy resin, hardener, syntactic foam, and fibre.
STEP-5 The preparation of a mixture of flyash and epoxy resin. A mechanical stirrer was used to mix the flyash particles with epoxy resin. The hardener was then added to the scattered suspension.
STEP-6 The maton is then placed in the mould and the resin is applied.
STEP-7 A roller is used to ensure that the resin is distributed evenly throughout the fibre.
STEP-8 After that, apply the glue and place the fibre on the foam.
STEP-9 Repeat the process and the sheet is allowed to dry for 48hrs.
STEP-10 After drying the composite material is removed from the mould.
STEP-11 Machined the laminate to get the required size for testing.

4. RESULT AND DISCUSSIONS

4.1. Tensile strength of the polymer composite laminates
Tensile test result of the hybrid polymer nanocomposite laminates were shown in Table.1

| S.NO | Flyash content (wt%) | Maximum tensile load(KN) | Maximum tensile strength(N/mm²) |
|------|----------------------|--------------------------|---------------------------------|
| 1.   | 0%                   | 18.09                    | 289                             |
| 2.   | 5%                   | 5.47                     | 97                              |

4.2. Tensile test results
When comparing results of both sample there is a gradual decrease in tensile strength of the polymer laminate test while adding a 5wt% of flyash. The graphical representation of the results were shown in figure.12
4.3. Flexural strength of the polymer composite laminates

Flexural test results of the hybrid polymer nano composite laminates were shown in table 2

| S.N. | FLY ASH content(wt %) | Maximum flexural strength(N/mm²) |
|------|-----------------------|---------------------------------|
| 1.   | 0%                    | 211                             |
| 2.   | 5%                    | 162                             |

![ FIGURE 12: Tensile Strength](image)

When comparing results of both sample there is a gradual decrease in flexural strength of the polymer laminates while adding a 5 wt% of fly ash. The graphical representations of the results were shown in fig 13.

4.4. Impact strength of the polymer composite laminates

Impact test results of the hybrid polymer nano composite laminates were shown in table 3.
TABLE.3 Impact test result

| S.NO | FLYASH content (wt%) | Test temperature (°C) | Absorbed energy (joules) |
|------|----------------------|-----------------------|-------------------------|
| 1    | 0%                   | 24                    | 06                      |
| 2    | 5%                   | 24                    | 14                      |

When comparing results of both samples, there is a gradual increase in impact strength of the polymer laminates while adding a 5 wt% of fly ash. The graphical representation of the results were shown in fig 14.

5. CONCLUSION
As a comparative study, the current work aims to evaluate fly ash as a filler material in polymer matrix composites and characterise the mechanical properties. Aramid/E-Glass polymer composite with varying percentage of fly ash have been successfully prepared using hand lay-up techniques. The created laminates were tested for mechanical qualities such as tensile, flexural, and impact.

The following findings are reported. The addition of fly ash as filler material reduced the tensile and flexural strength of the laminates. The strengths were decreased from 0% to 5% of fly ash laminate. But, the impact strength of the laminates was increased from 0% to 5% of fly ash laminate.

REFERENCES
[1] Bheemappa Suresha, and Rajashekaraih Hemanth et.al, Fabrication and Tribological Behavior of Epoxy
[2] Hybrid Composites, Fabrication and Tribological Behavior of Epoxy Hybrid Composites, Published 2018 by Wiley-VCH
[3] Verlag GmbH & Co. KGaA. Shubhajit Das, Chandrasekaran M., Sutanu Samanta, Palanikumar Kayarogam, Paulo Davim J., (2018) “Fabrication and tribological study of AA6061 hybrid metal matrix composites reinforced with SiC/B4C nanoparticles”, Industrial Lubrication and Tribology, https://doi.org/10.1108/ILT-05-2018-0166.
[4] Jaswinder Singh et.al, Fabrication characteristics and tribological behavior of Al/SiC/Gr hybrid aluminum matrix composites: A review, Friction 4(3): 191–207 (2016) ISSN 2223-7690,DOI 10.1007/s40544-016-0116-8.

[5] R Manikandan, T V Arjunan, et.al, Mechanical and tribological behaviours of aluminium hybrid composites reinforced by CDA-B4C, Mater. Res. Express 7 (2020) 016584 https://doi.org/10.1088/2053-1591/ab6b54.

[6] D Lingaraju, K Ramji, M Pramila Devi, U Rajya Lakshmi, et.al, Mechanical and tribological studies of polymer hybrid nanocomposites with nano reinforcements, Bull. Mater. Sci., Vol. 34, No. 4, July 2011, pp. 705–712.

[7] Uzun, A., Asikuzun, E., Gokmen, U. and Cinici, H. (2017), Vickers Microhardness Studies on B4C Reinforced/Unreinforced Foamable Aluminium Composites, Transactions of Indian Institute of Metals, doi 10.1007/s12666-017-1163-1.

[8] Ravindran, P., Manisekar, K., Narayanasamy, R. and Narayanasamy, P. (2013), “Tribological behavior of powder metallurgy processed aluminium hybrid composites with the addition of graphite solid lubricant”, Ceramic International, Vol. 39 No. 2, pp. 1169-1182.

[9] Chen, H.S., Wang, W.X., Li, Y.L. and Zhang, P. (2015), “The design, microstructure and tensile properties of B4C particulate reinforced 6061Al neutron absorber composites”, Journal of Alloys and Compounds, Vol. 632, pp. 23-29.

[10] Dou, Y., Liu, Y., Liu, Y., Xiong, Z. and Xia, Q. (2014), “Friction and wear behaviors of B4C/6061 Al composite”, Materials and Design, Vol. 60, pp. 669-677.