International Journal of Interdisciplinary Innovative Research & Development (IJIIRD)
ISSN: 2456-236X
Vol. 10 Issue 01 | 2025

DEVELOPMENT OF POLYMER COMPOSITE FOR IMPROVING WEAR PROPERTY

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DOI: 10.5281/zenodo.16403137

ABSTRACT

To develop a polymer composite to improve wear properties, specifically for automotive clutch plates. The problem being addressed is the inherent weaknesses of conventional polymers, such as low wear resistant and poor thermal stability. The new materials used in the composite include epoxy resin, Kevlar fiber, and glass fiber, selected for their properties such as high strength, durability, and resistance to friction and thermal degradation. The composite clutch plates were fabricated and subjected to wear tests, including the pin-on-disk method, to evaluate their performance under simulated operating conditions. The pin-on-disk test was conducted to measure wear rate and frictional behavior. Parameters such as sliding speed, applied load, and sliding distance were varied to real-life conditions. The results demonstrated significant improvement in wear resistance compared to conventional clutch plate materials. The epoxy resin provided excellent adhesion and toughness, while Kevlar fiber contributed high tensile strength and wear resistance. Glass fiber enhanced dimensional stability and thermal resistance, creating a composite with superior performance characteristics. The findings reveal that the developed polymer composite effectively reduces wear and friction, ensuring longer service life and higher reliability of clutch plates. The results states that the polymer composite material is suited as a pressure plate in the clutch plate and handled various conditions like load, rpm and our developed material is stronger than primary material and can be use composite material as replacement of primary material in future as per need. This breakthrough has potential applications in the automotive industry, offering durable solutions that can improve operational efficiency.

Keyword: - Kevlar fiber, Glass Fiber, Epoxy resin, wear test, composite material, clutch plate

1. INTRODUCTION

Composite materials are replacing conventional materials like ceramics, cellulose and asbestos due to ease of processing and productivity [1]. With the development of technology in recent decades, more and more multi-purpose and lighter materials are needed in a wide range of industries [2]. Due to their high strength-to-weight ratio, polymers have received significant attention in different mechanical manufacturing fields. One of the greatest disadvantages of polymers is that they are prone to wear and have little resistance to friction. Therefore, it is important to look for ways to improve and enhance the surface's wear resistance through surface reinforcement [3]. In present days' fibre reinforced composite (FRC's) materials are widely used in various engineering applications including aviation, automotive and engineering structures due to their high stiffness, strength, lightweight and damping properties [4]. In general, polymers mechanical properties are insufficient for many structural purposes. Their stiffness and rigidity are particularly low when compared to ceramics and metals. These challenges are resolved by mixing polymers with other fabrics [5]. Wear is defined as damage to a solid surface, generally involving progressive loss of material, due to relative motion between that surface and contacting substance or substances [6]. One of the most popular composites are polymer-based composites, which are composed of a polymer resin as base and fiber reinforcements. Thanks to their attractive characteristics such as easy fabrication and reasonable price, these materials are widely produced and used. In this context, because of its appealing mechanical features, optimum sticking, strong chemical resistance, and wide variety, Epoxy resin is frequently used in making polymer-based composites [7]. Pin-on-disk wear tests are used to study reciprocating sliding wear. a pin is loaded against a flat surface in the presence of a reciprocating motion; depending on the stroke length and sliding conditions are distinguished, the former having a wide stroke much longer than the contact width, and the latter a small stroke, typically of the order of magnitude of the contact width [8]. A single matrix material is used to create hybrid composites, which are made up of more than one type of fibre. Hybrid composites are more cost-effective than standard composites because of their special properties. This direction has been taken by a number of researchers [9]. It is remarkable to notice that wear of paper-based friction material seems to be more sensitive to changes in energy input due to inertia, rather than change in energy load due to velocity [10].

2. EXPERIMENTAL WORK

2.1 Material Preparation

The composites were prepared by using two types of fibres like Glass and Kevlar with Epoxy resin as per their weight and different properties. A reinforcement with 22 layers used and epoxy resin as the matrix material. The composite properties (mechanical strength and hardness) are also reliant on the appropriate choice of fibre type (E-glass, S-glass), size, diameter, and orientation. E-glass fibre offers enhanced strength up to 2000-3500 MPa. Composite properties (such as wear resistance and mechanical) are also reliant on nature (glass fibre), the orientation of glass fibre and processing method. In the present work, the weight of E-glass fibres equal to 6 gm, was used as primary reinforcing materials. The E-glass fibre was procured from local market. Fibre (E-glass, Kevlar) mechanical and physical properties are presented in Table 1. Kevlar fibre is another secondary reinforcing fibre in composite plate, where it is also referred to as Kevlar-29 fibre possessing a strong rigid molecular structure. Aramid based on Kevlar-29 fibres has widely applied that offer high performance in composite structures. Kevlar 29 fabric made of 220 gsm (g/m2) possessing the weight of glass fibres equal to 13 gm, was used as secondary reinforcing materials. The Kevlar fibre was procured Laxmi Fiber Composite, New Delhi, India. This might be due to lower weight to high strength, heat resistance, fatigue and wear resistance characteristics.

Fibre	Density (kg/m3)	Tensile Strength (Mpa)	Tensile Modulus (Mpa)	Young's modulus (Mpa)
Kevlar-29	311.11	3000	2500-3700	7000-8300
E-glass	144.44	2000-3500	500	7200-8000

Table-1: Physical and mechanical properties of fibres

In this present work, epoxy resin was used as the matrix material to prepare glass/Kevlar/epoxy hybrid composites. Epoxy matrix (LY556), hardener (HY951) procured from local market, were utilized as for strengthened composites. The properties of the LY556 and HY951 hardener used in manufacturing the composites are presented in Table 2.

Matrix	Density (kg/m3)	Young's Modulus (Mpa)	Tensile strength (Mpa)	Poison's ratio
Epoxy Resin (LY556)	400	3200	86.9	0.35

Table-2: Properties of LY556 epoxy matrix

2.2 Plate Construction

Specimens were prepared as sheets with multiple internal layers. First, reinforcing fibres were uniformly cut into 300 x 200 mm pieces. There are 22 layers of Kevlar & glass fiber are used. A hand-layup method was used to construct the specimens. The hand-layup technique produced high quality specimens with less defects. To create the specimens, a layer of epoxy was applied first and then each layer of fabric was placed. Hereby, the necessary amount of epoxy was applied and the spread-out procedure was performed special care. After all the layers were placed, the specimen was carefully covered with lamination paper to ensure that no wrinkles would occur when the weight was applied. The surface finish of the specimen is affected if there are any wrinkles on the sample. Trapped air and the extra epoxy were removed using a roller. Specimens were then cured at room temperature for two days. Details about the preparation of the samples are shown in Figure 1.

2.3 Specimen Preparation

The dimensions of the wear specimen are as follows:

1. Diameter of Specimen: 10 mm
2. Length of Specimen: 30 mm

Fig-1: Specimens for Wear test

3. EXPERIMENTAL SETUP

The Ducom Wear and Friction Monitor – TR 20 Series has been designed and developed by DUCOM INSTRUMENTS PVT. LTD. The Ducom Wear and Friction Monitor – TR 20 Series has become the industry standard in wear and friction analysis. The TR 20 Series tribometer is specifically designed for fundamental wear and friction characterization. This instrument consists of a rotating Disk against which a test pin is pressed with a known force. A provision for measurement of compound wear and frictional force is provided. The Ducom TR 20 Series along with select options provide researchers with very wide test capabilities. Options for lubrication recirculation, environment chamber, pin temperature measurement, elevated temperature tests, and low temperature tests, tests in corrosive environments and vacuum tests are available. The TR 20 Series comes with the WinDucom software for data acquisition and display of results. The WinDucom instrumentation and Data Acquisition permits users, the measurement of: • RPM • Wear • Frictional force Using the WinDucom Data Acquisition System, a PC acquires test data online and displays it in several ways. Graphs of individual tests can be printed. Results of different tests can be superimposed using the WinDucom CompariView feature for comparative viewing of results. Data can be exported to other software.

3.1 Specification

- Description: PIN/BALL ON DISC TESTER TR 20LE
- Model No: TR 20LE
- Pin diameter: 10 mm
- Disc (diameter x thickness): 100 x 8 mm
- Wear track diameter: 100 mm
- Sliding velocity: 0.5-10 m/s
- Disc speed: 500-900 rpm
- Normal load: 19.62 – 49.05 N
- Frictional force: 0 N

3.2 Testing Procedure

- Cleaned samples are fixed in the chuck of the wear testing machine.
- Select the Wear Track Diameter and Speed of the Rotating Disc.
- Select the loads (19.62 N, 39.24 N & 49.05 N) to be applied.
- Start the machine.
- Take the Wear readings and Frictional force at equal time intervals.
- Calculate Wear rate and Co-efficient of friction by using suitable formulae.
- Plot the graph of Wear rate v/s Sliding Distance and Co-efficient of friction v/s Sliding Distance.
- Repeat the steps for different materials.

Fig-2: Experimental setup

4. CONCLUSIONS

The pin-on-disc wear test performed under loads (2 kg, 4 kg, and 5 kg) and speed (500 rpm, 700 rpm and 900 rpm). As the load and speed increased, there was a observable rise in wear and surface temperature, resulting in greater material removal. The test confirms that higher loads accelerate wear, reducing the lifespan of the material under stress. Materials with higher wear resistance should be considered for applications involving heavier loads to ensure better performance, reliability, and durability over extended periods of use.

5. ACKNOWLEDGEMENT

We would like to extend our gratitude to Mr.N.S. Gaikwad, Professor of Department of Mechanical Engineering, NDMVP'S KBTCOE, Nashik for supporting and encouraging us to carry out this study with required facilities and guidance. Also thanks to Mr.C.S. Gawale for helping us to complete experiment in this study.

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