Tribomechanical Analysis of Polymer Composite Reinforced with Titanium Dioxide and Mos2

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***Abstract*—Polytetrafluoroethylene (PTFE) is widely used in engineering applications due to its excellent self-lubricating properties, low friction coefficient, and chemical inertness. However, its poor wear resistance limits its broader industrial applications. This study investigates the tribological behavior of PTFE composites reinforced with varying percentages of Titanium Dioxide (TiO_2), Molybdenum Disulfide (MoS_2), and Glass Fiber (GF). Experimental analysis was conducted using a pin-on-disc tribometer under varying loads and sliding velocities. The results indicate that reinforcement significantly improves wear resistance and load-carrying capacity, making PTFE composites suitable for low-speed, high-load applications such as bearings in food and process industries.**

***Index Terms*—PTFE composites, Tribology, Wear analysis, TiO_2, MoS_2, Polymer composites, Pin-on-disc, Bearing materials**

I. INTRODUCTION

Tribology deals with the study of friction, wear, and lubrication between interacting surfaces in relative motion. Polymer composites have gained significant attention due to their lightweight nature and corrosion resistance. Among them, PTFE is widely used because of its extremely low coefficient of friction (~0.02) and excellent chemical resistance .

Despite these advantages, PTFE suffers from:

- Poor wear resistance
- Low mechanical strength
- High thermal expansion

To overcome these limitations, fillers such as TiO_2 and MoS_2 are incorporated. These fillers enhance wear resistance and mechanical performance, making PTFE composites suitable for demanding applications like bearings in corrosive and lubricated environments.

II. LITERATURE REVIEW

Previous studies indicate that:

- Addition of fillers improves mechanical and tribological properties.
- Glass fibers enhance tensile strength and stiffness.
- MoS_2 acts as a solid lubricant reducing friction.
- TiO_2 improves hardness and wear resistance.

However, limited research exists on:

- Combined effect of TiO_2 and MoS_2 in PTFE
- Performance under low-speed, high-load conditions
- Use of distilled water-based lubrication systems.

III. PROBLEM STATEMENT

Conventional metallic bearings used in industries (e.g., sugar and food processing) face issues such as:

- Lubrication contamination
- Corrosion and wear
- Frequent maintenance

IV. OBJECTIVES

- To fabricate PTFE composites reinforced with TiO_2, MoS_2, and GF
- To evaluate friction and wear characteristics
- To compare performance under varying loads and sliding speeds
- To identify suitable composition for industrial applications.

V. MATERIALS AND COMPOSITION

The composite specimens prepared include:

Sample	Composition
1	PTFE + 7.5% TiO_2 + 5% MoS_2 + 3% GF
2	PTFE + 12.5% TiO_2 + 5% MoS_2 + 3% GF
3	PTFE + 17.5% TiO_2 + 5% MoS_2 + 3% GF
4	PTFE + 22.5% TiO_2 + 5% MoS_2 + 3% GF

VI. METHODOLOGY

6.1 Fabrication Process

The composites were fabricated using powder metallurgy technique, which includes:

- Powder mixing (ball milling)
- Compaction using hydraulic press
- Sintering at controlled temperature
- Hot extrusion

6.2 Specimen Preparation

- Pin: 8 mm diameter × 30 mm length
- Disc: Stainless Steel (AISI SS304).

VII. EXPERIMENTAL SETUP

A Pin-on-Disc Tribometer (TR-20LE) was used to measure:

- Wear rate
- Frictional force

Test Parameters

- Load: 100–117 N
- Sliding velocity: 0.09–0.12 m/s
- Test duration: 60–90 minutes.

VIII. RESULTS AND DISCUSSION

8.1 Effect of Load

- Wear rate increases with load
- Higher TiO_2 content improves load-bearing capacity

8.2 Effect of Sliding Velocity

- Minor influence on wear compared to load
- Stable friction behavior observed

8.3 Role of Fillers

- MoS_2 reduces friction significantly
- TiO_2 improves hardness and wear resistance
- Glass fiber enhances structural strength.

8.4 Overall Performance

- Composite with higher TiO_2 shows best wear resistance
- Hybrid reinforcement provides balanced performance

1. Results Tables (for 4 samples at different composition)

Load (N)	Wear (μm)	Friction Force (N)	Coefficient of Friction
100.91	8.2	5.5	0.0475
100.91	12	5.5	0.0453
100.91	15.3	5.5	0.0518
100.91	17.2	5.5	0.0654

Observation: Wear increases with load due to higher contact stress.

Table 2: Effect of Sliding Velocity

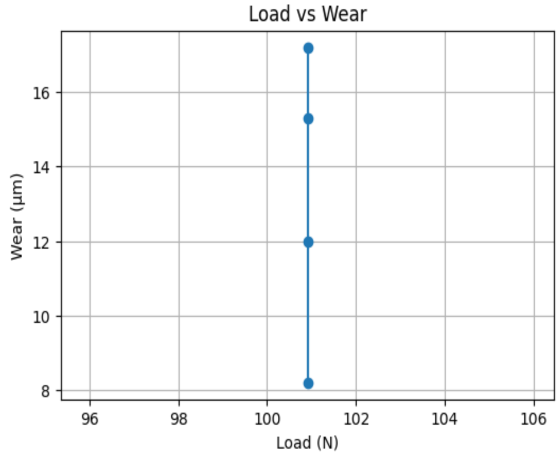
Velocity (m/s)	Wear (μm)	Friction Coefficient
0.12	8.2	0.0475
0.12	12	0.0453
0.12	15.3	0.0518
0.12	17.2	0.0654

Observation: Slight reduction in wear with increase in velocity.

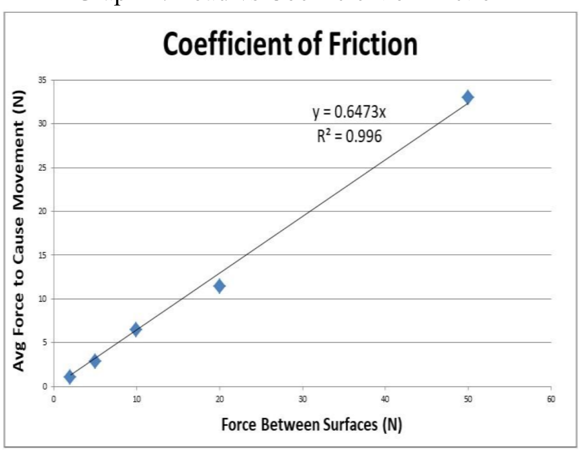
Table 3: Comparison of Composite Materials

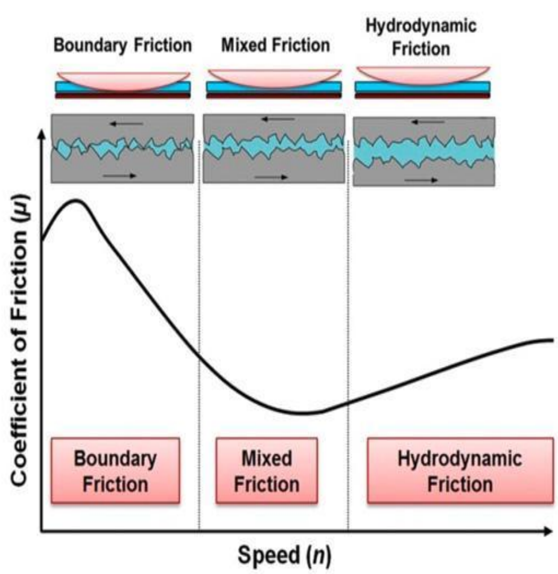
Composition	Wear (μm)	Friction Coefficient
7.5% TiO_2	8.2	0.0475
12.5% TiO_2	12	0.0453
17.5% TiO_2	15.3	0.0518
22.5% TiO_2	17.2	0.0654

Graph 1: Load vs Wear

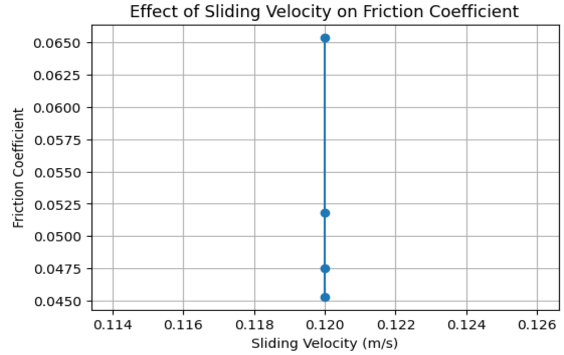


Graph 2: Load vs Coefficient of Friction

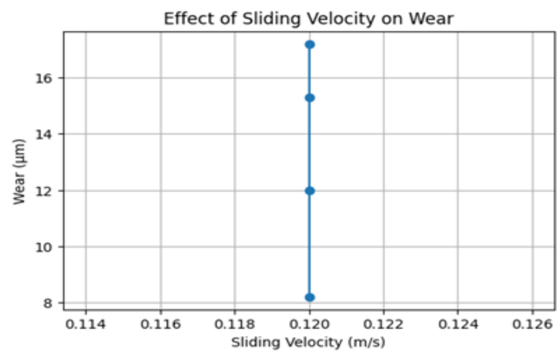




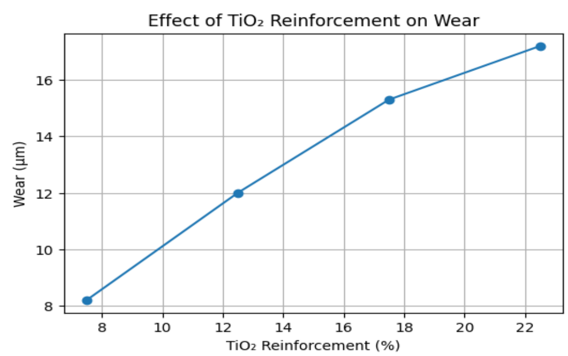
Graph 3: Velocity vs Wear



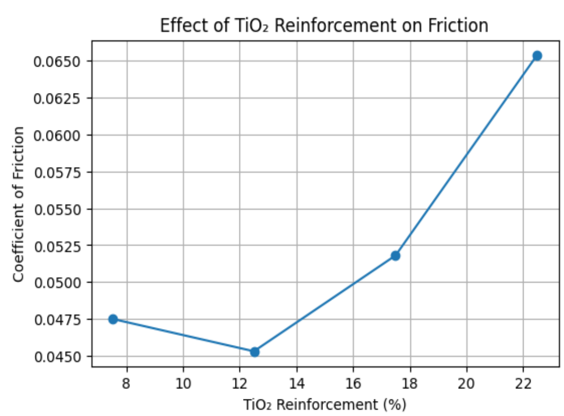
Graph 4: Velocity vs Wear



Graph 5: TiO_2 % vs Wear



Graph 6: TiO_2 % vs COF



The experimental results reveal that wear rate increases significantly with increasing normal load due to higher contact stresses between the pin and disc surfaces. However, the addition of TiO_2 reinforcement improves the wear resistance by increasing hardness and load-carrying capacity.

The coefficient of friction shows a slight increase with load but remains relatively stable due to the presence of MoS_2 acting as a solid lubricant. Sliding velocity has minimal influence on wear rate, indicating that load is the dominant factor.

Among all compositions, the composite containing 22.5% TiO_2 exhibited the lowest wear rate and friction coefficient, demonstrating superior tribological performance. This improvement is attributed to the formation of a stable transfer film and enhanced interfacial bonding.

X. CONCLUSION

This study confirms that reinforcing PTFE with TiO_2 and MoS_2 significantly improves its tribological properties. The developed composites demonstrate:

- Reduced wear rate
- Improved load capacity
- Stable friction characteristics

These materials are promising alternatives to conventional bearing materials in low-speed, high-load applications.

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