Tribological behaviour of composites under dry environment

4.1 Introduction:

The unique intrinsic tribological properties of polymers and related composites, like as reduced friction and superior wear resistance, have generated great attention in a range of sliding applications. The kind of sliding affects how polymers and composites in tribosystems wear. Predicting wear behaviour based on the link between surface traction, temperature, operational factors, material characteristics, and wear processes is one of the main problems in the study of wear of polymers and composites. In order to better understand the wear behaviour of polymers and their components under various situations and applications, a reliable link between wear, operating factors, and material characteristics is desired. In addition to performing laboratory testing, mathematical models and computer simulations may also be used to predict wear. The lack of a single plastic hardness scale that is appropriate for the large variety of commercially accessible polymers is the fundamental issue with the polymer group of materials. Due to the variety of sliding situations—which are often a mix of one or more straightforward categories that produce wear—its investigation is likewise challenging. Therefore, it is vital to comprehend every form of wear that might possibly occur for a particular polymer tribo-system, as well as the circumstances under which it might do so. The main topic of this chapter is the prediction of wear of polymers and their constituent parts. Additionally, the use of dimension analysis and the finite element method (FEM) in the creation of modelling clothing will be explored.

4.2 Material and synthesis (Hand lay-up method)

By using the Hand lay-up method two types of hybrid composites were fabricated and those are pristine composites and nanocomposites based on two-dimensional nanomaterial (Graphene). The reinforcements are glass fiber, Jute fiber, epoxy (Thermosetting polymer) is used as a matrix material and graphene is used as a filler material. Because of its outstanding thermal and electrical conductivity, graphene is lightweight and very rigid. Together with a very high aspect ratio, these characteristics make up a singular combination and nanoscale dimensions make graphene very appealing to be used as the filler in composite applications at the microscale. The different hand layup method fabricated composites are: hybrid composites $(0^0,0^0,0^0,0^0)_S$, $(0^0,30^0,45^0,60^0)_S$ and GFRP composites $(0^0,0^0,0^0,0^0)_S$.

4.3 Sliding wear tests (Ball on disc)

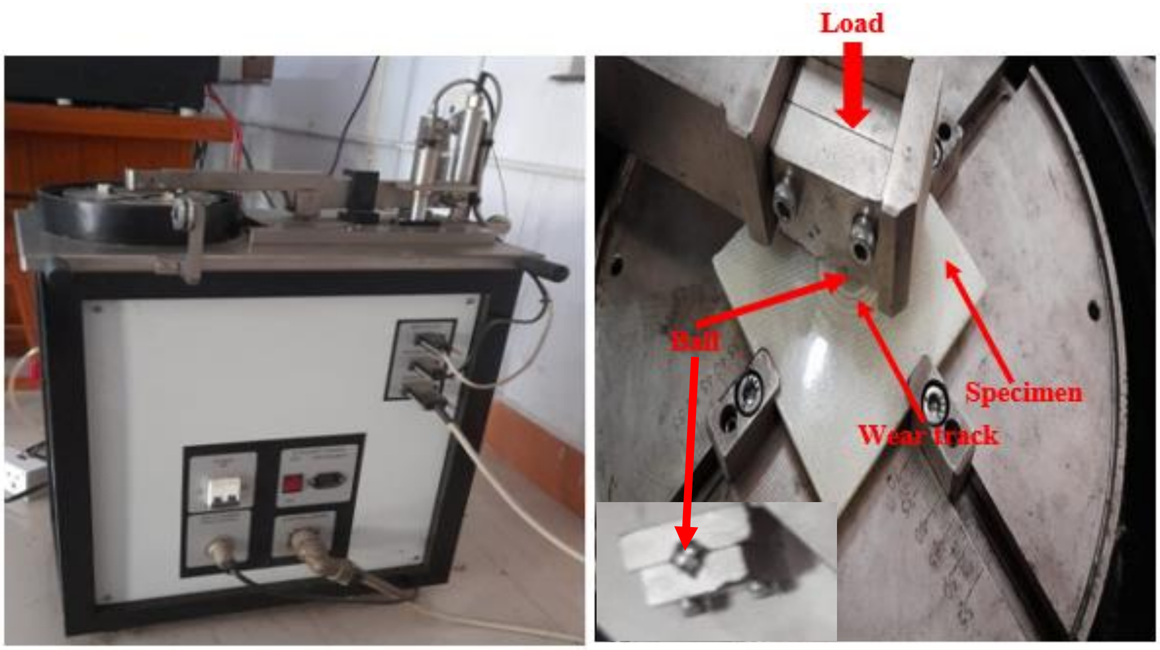

Figure 4.1. Ball on disc tribometer.

Fiber reinforced polymer composites such as angle hybrid composite $[60,45,30,0]_S$, Zero hybrid composite $[0,0,0,0]_S$ and Zero GFRP Composites were put through a sliding wear test in a dry sliding condition. The wear tests were carried out using a Ball-on-disk and pin-on-disk test rig (DUCOM Instrument Pvt Ltd.). A lever mechanism was utilised to deliver the force to the composite specimen blocks (35 mm ×35 mm×4.5 mm), which were spun against a stationary 10 mm steel ball. Wear tests were conducted on angle hybrid composite $[60,45,30,0]_S$, Zero hybrid composite $[0,0,0,0]_S$ and Zero GFRP composite $[0,0,0,0]_S$ specimens under various loads of 35 N, 48 N, and 54 N. An electronic balance with a 10^{-4} gm precision was used to measure the mass loss of the composite specimen following the wear test. Using Equation (4.1), the wear volume loss was calculated

$$VLS = \frac{\Delta M}{\rho} \tag{4.1}$$

The wear volume loss is represented by VLS (mm^3), the mass loss resulting from the wear test is represented by ΔM (gm), and the density of the composite is represented by ρ (gm/cm^3).

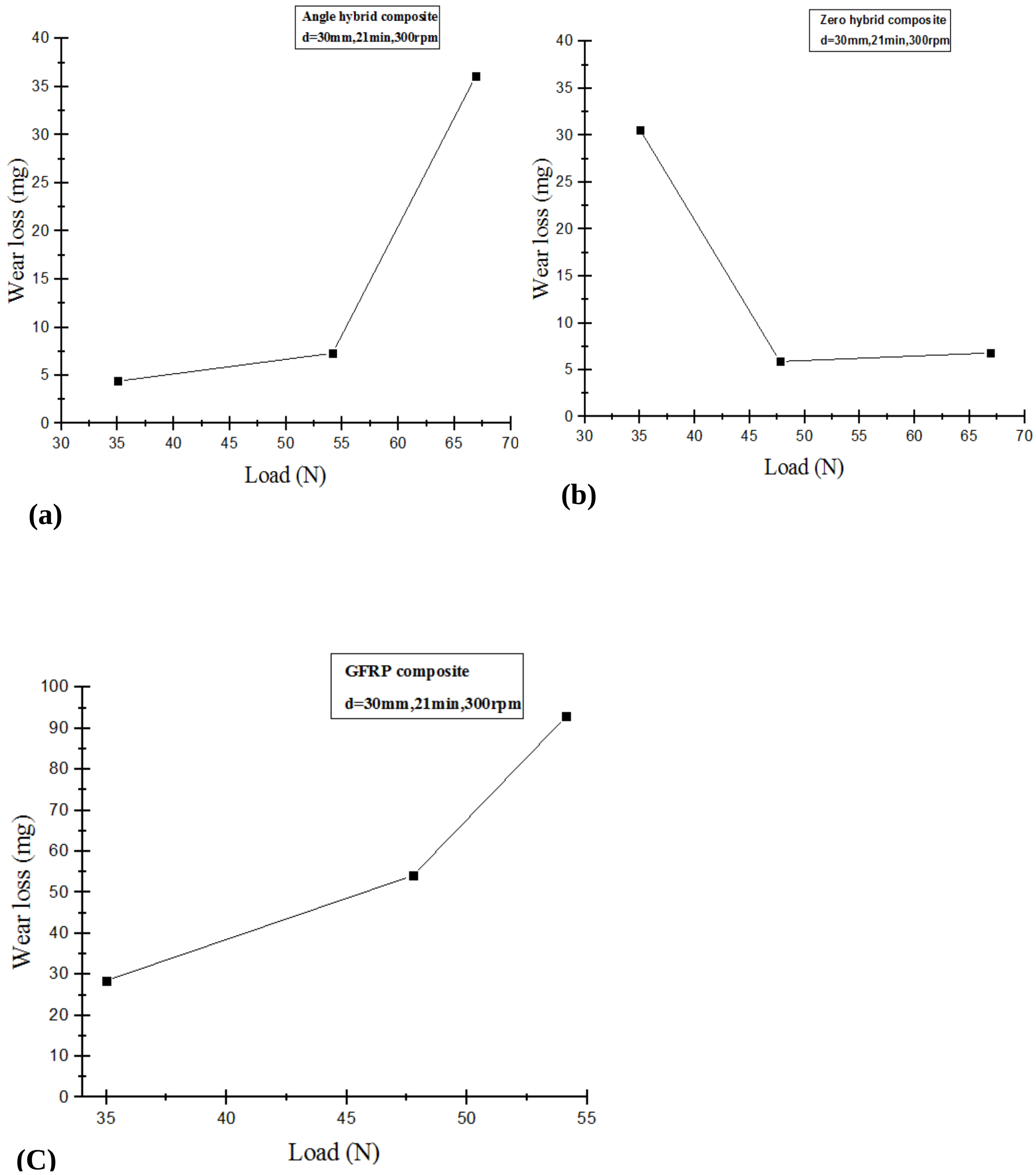

Figure 4.2. Effect of load on wear loss (a) Angle hybrid composite $[60,45,30,0]_S$ (b) Zero hybrid composite $[0,0,0,0]_S$ (c) GFRP composite $[0,0,0,0]_S$

4.4 Dry wear of friction material

First, we consider the pin-on-disk studies of 3D printed composite material experimentally under 118 N loading condition where the composite pin is sliding against the rotary steel disk under 300 RPM and running continuously upto 19 minutes. Figure 4.5 and Figure 4.6 shows their experimental data for the variation of wear mass loss. It is clear that any quantitative approximation for operation circumstances will require getting rid of the reliance on the sliding distance, even though the wear mass loss as a function of the three input parameters is useful for making qualitative judgements.

4.5 Material and synthesis (3D printing method)

The composites are fabricated by the 3D printing method. 3D printed composites consist of onyx as a matrix material and the different reinforcements are glass fiber, carbon fiber, high strength high temperature glass fiber and aramid (Kevlar) fiber. Onyx is a mixture of nylon (thermoplastic polymer) and chopped carbon fiber. The different 3D printing method fabricated composites are: Continuous Kevlar fiber reinforced thermoplastic composites (K-FRT) and High strength high temperature glass fiber reinforced thermoplastic composites (HSHT-GF-FRT).

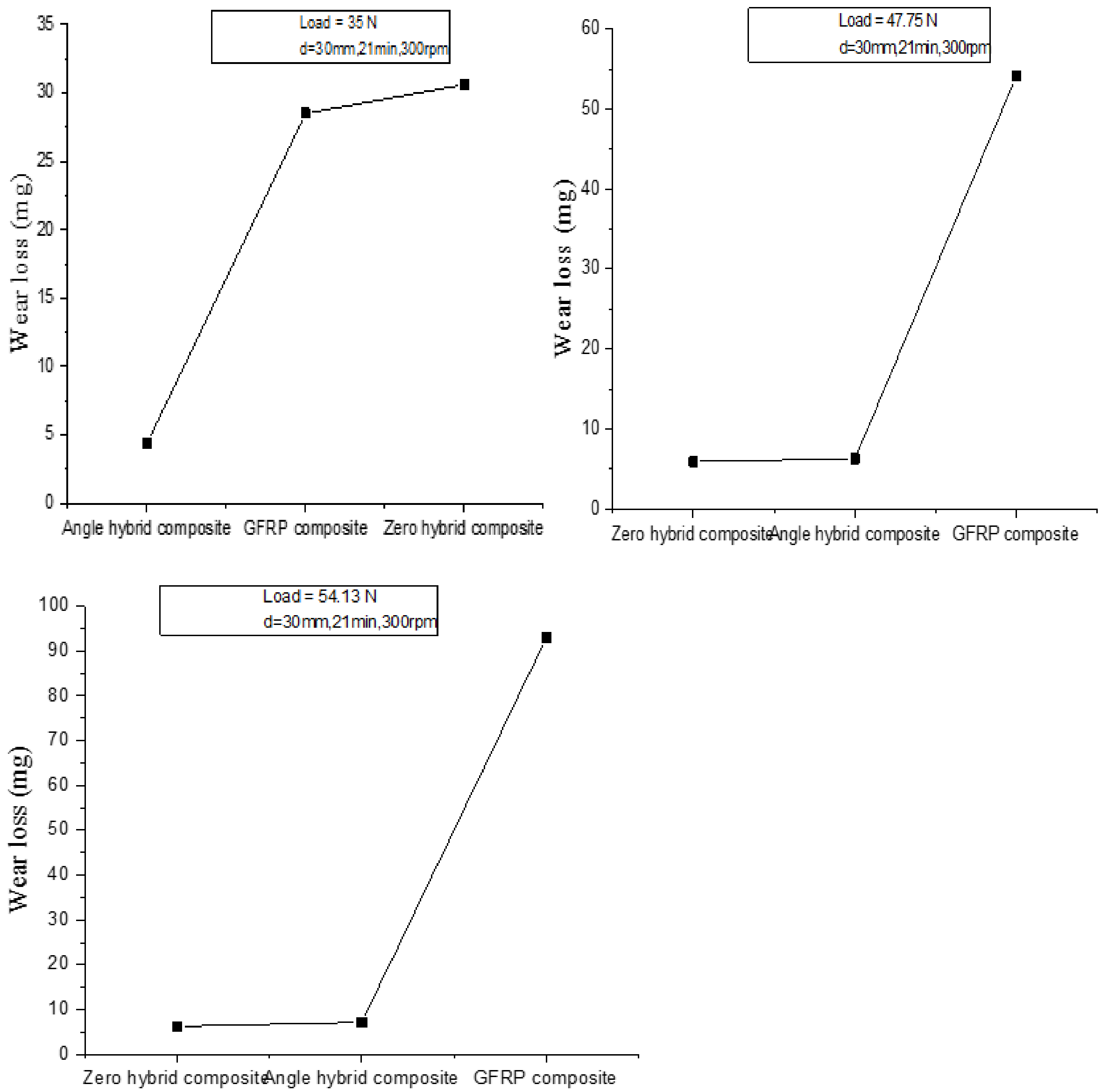

Figure 4.3. Effect of Material composition on wear loss.

4.6 Sliding wear tests (Pin on disc)

Figure 4.4. Pin on disc tribometer.

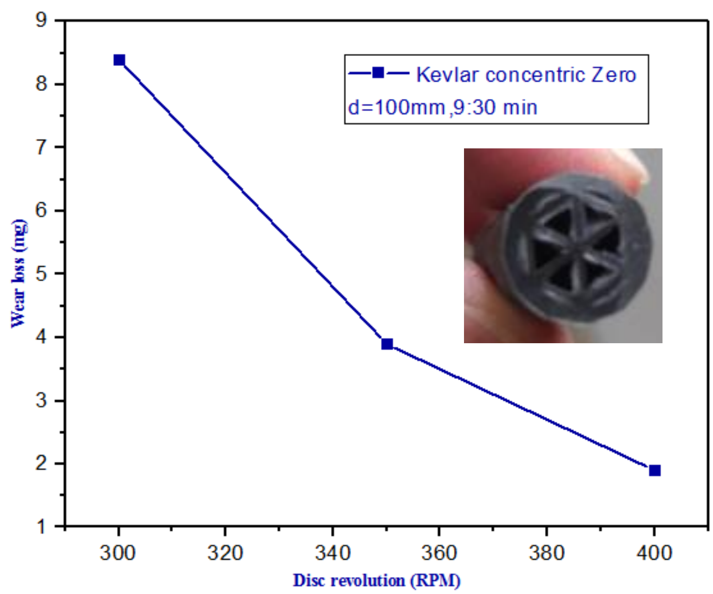

Figure 4.5. . Effect of Kevlar fiber and concentric filler on wear loss.

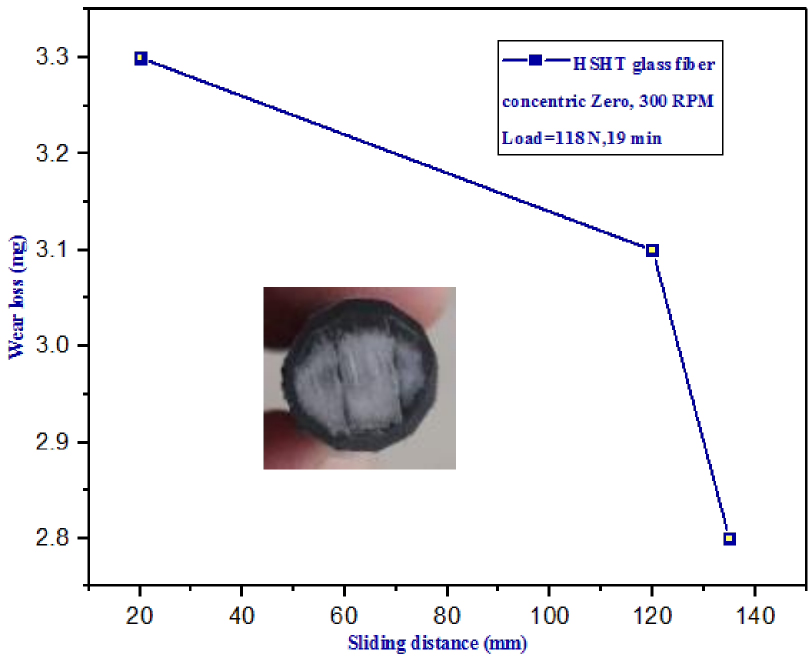

Figure 4.6. Effect of HSHT-Glass fiber and concentric filler on wear loss.

4.7 Concluding remark

The key findings of the work were the following in relation to the wear predictions and comparing with experimental data were as follows:

- When taking into account the accumulated wear mass loss as a function of Load: The wear loss increases with increasing load in case of angle hybrid and GFRP composite where as in case of zero hybrid composite first decreases and than increases.
- When taking into account the accumulated wear mass loss as a function of material: The wear loss is maximum in case of GFRP composite followed by angle hybrid composite and least value in case of zero hybrid composite.
- Zero GFRP composite $[0,0,0,0]_S$ displayed the best wear characteristics. Furthermore, it can be deduced from the results that the wear mass loss of the Zero GFRP composite $[0,0,0,0]_S$ is most significantly influenced mostly by applied load and sliding distance.
- When taking into account the accumulated wear mass loss as a function of RPM: The wear loss decreases with increasing disc revolution (RPM) in case of Kevlar fiber reinforced thermoplastic composites (K-FRT).
- When taking into account the accumulated wear mass loss as a function of sliding distance: The wear loss decreases with increasing sliding distance (mm) in case of High strength high temperature glass fiber reinforced thermoplastic composites (HSHT-GF-FRT).
- The best wear properties were demonstrated by High strength high temperature glass fiber reinforced thermoplastic composites (HSHT-GF-FRT).

It is advised to adopt the first technique, not a mix of the two, even though the relative sliding velocity can be regulated by either the disc rotating speed or the track diameter. Slider wear test examples taken from the literature demonstrate the effectiveness of the established constructive technique.