

Comparative study regarding friction coefficient for three epoxy resins

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Abstract. Three commercial epoxy diglycidylether of bisphenol-A (DGEBA) were used in this study namely Epiphen RE4020-DE 4020 (Bostik), Epoxy Resin C (R&G GmbH Waldenbuch), and Epoxy Resin HT-2 (R&G GmbH Waldenbuch). Epoxy resins are often used for the friction purpose but their friction resistance is quite low and it is thus necessary to enhance their friction resistance. In this paper it is shown how load, sliding velocity, and distance affect friction coefficient of epoxy resins.

1. Introduction

The name epoxy resins has over the years become synonymous with performance; epoxy resins have established themselves as unique building blocks for high-performance coatings, adhesives, and reinforced plastics. They are a class of thermoset materials used extensively in structural and specialty composite applications because they offer a unique combination of properties that are unattainable with other thermoset resins [1], [2].

Some of their most interesting applications are found in the aerospace and recreational industries [3]. As substitutes for metal in the construction of mechanical apparatus, engineering plastics offer advantages such as adhesives, coatings, encapsulates, and molding compounds, and economy in fabrication and decorating. Replacement of metals by plastics is favored as the physical properties and operating temperature ranges of plastics improve and the cost of metals and their fabrication increases [4]. Many polymers and polymer based composites are widely used for sliding couples against metals, polymers and other materials [5].

Formaldehyde-based systems are based on reacting formaldehyde with active hydrogen containing compounds such as phenol, urea, or melamine. This family of thermosets has low flammability, high rigidity, good dimensional stability, and low cost. Formaldehyde-based systems are heat-activated and are processed using compression or injection molding.

The most common resin is based on bisphenol A and is referred to as the "diglycidyl ether of bisphenol A" or DGEBA [4]. The materials must provide unique mechanical and tribological properties combined with a low specific weight and a high resistance to degradation in order to ensure safety and economic efficiency [6].

There have been numerous investigations exploring the influence of test conditions, contact geometry and environment on the friction and wear behaviour of polymers [7], [8], [9], [10]. The main advantage of polymers, from a tribological point of view, is their reasonably low rate of wear, especially corrosion type wear [11]. In this investigation, the influence of test speed and applied force



values on the friction coefficient behaviour of three unfilled epoxy resins was studied. Friction tests of epoxy resins systems were carried out at dry condition on a pin-on-disc geometry.

2. Experimental section

The experiments were carried out with three unfilled epoxy resins: Epiphen RE4020-DE 4020 (Bostik), Epoxy Resin C (R&G GmbH Waldenbuch), and Epoxy Resin HT-2 (R&G GmbH Waldenbuch). Friction coefficient studies of epoxy systems against steel disc are usually carried out at different load, sliding velocity, and distance conditions.

Tribological tests were done at room temperature for 5, 10, 15, 20, 25, 30 and 35 N force, and 0.5, 1, 1.5, 2, 2.5, 3 and 3.5 m/s speed for 1000 m distance using a TRM 1000 tribometer from Wazau pin-on-disk friction and the pin has a flat contact surface (figure 1).

The cylindrical pin specimens of 8 mm diameter and 20 mm length were tested against steel discs. Although using 0.5 m/s sliding speed lead to test duration of 34 min, it was insured that the test was carried within the steady-state region.

The calculations of friction coefficient were carried out using Tribo Control Wazau software. The weight loss was measured taken after 1000 m of sliding distance.

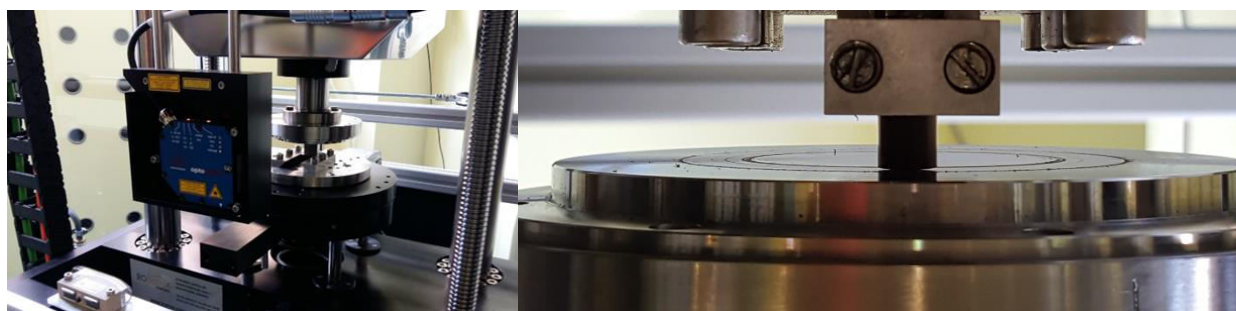


Figure 1. Tribometer TRM 1000 from Wazau.

3. Results and discussion

In general, epoxy is not an ideal material used in sliding wear applications due to its three-dimensional network structure [12] as compared with thermoplastics. As can be seen from the figures below, frictional coefficient is quite high. For all polymer materials, the friction coefficient starts with a running-in period followed by steady-state period [13]. Figure 2 shows the friction coefficient for C epoxy resin system as a function of applied loads. As can be observed friction coefficient increased together with applied load. The lowest value of the friction coefficient is for 5N. Figure 3 presents friction coefficient values for E epoxy resin system.

The higher the sliding speed the higher is the rise in temperature [14], and as the temperature reaches the softening point of the polymer, the friction coefficient increases. This situation can be however, improved by the addition of some fillers [15].

Figure 4 presents the variation of the friction coefficient with sliding distance for HT-2 epoxy resin system. The lowest average friction coefficient of $\mu = 0.2$ was obtained for HT-2 epoxy resin system at applied force of 10N. The surface changes were analyzed by using a Olympus Microscope but there we could not identify major changes.

4. Conclusions

Performed studies were carried out in order to analyze the influence of test speed and applied force values on the friction coefficient behaviour of three unfilled epoxy resins. For all polymers of this study the sliding distance was the same. The friction coefficient of all studied epoxy resins increases with the applied force.

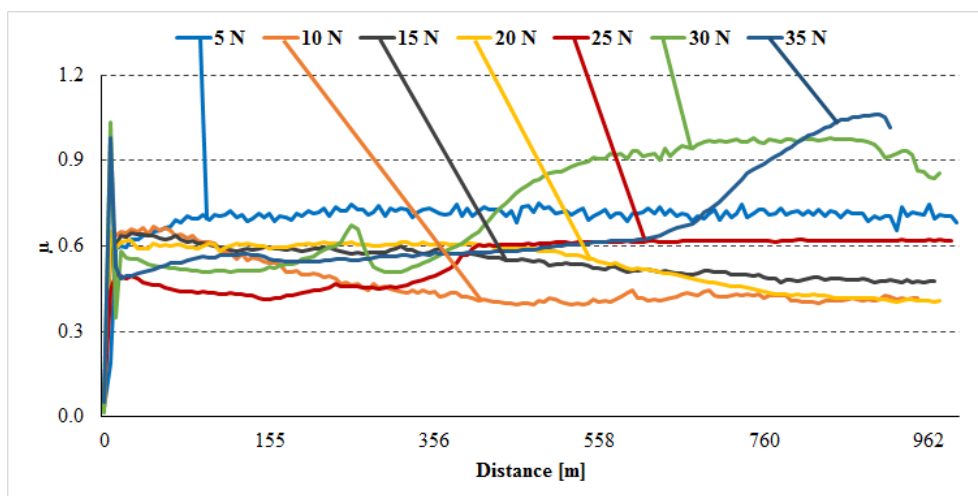


Figure 2. Friction coefficient for C resin system.

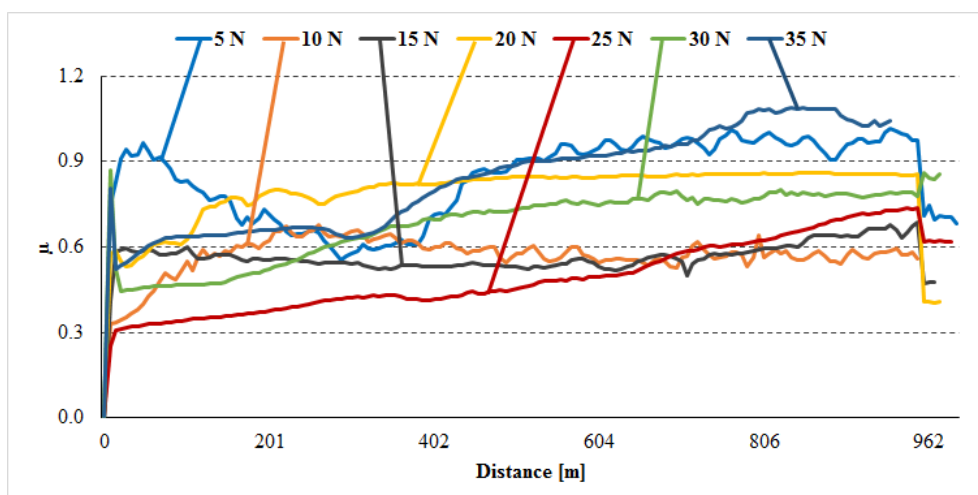


Figure 3. Friction coefficient for E resin system.

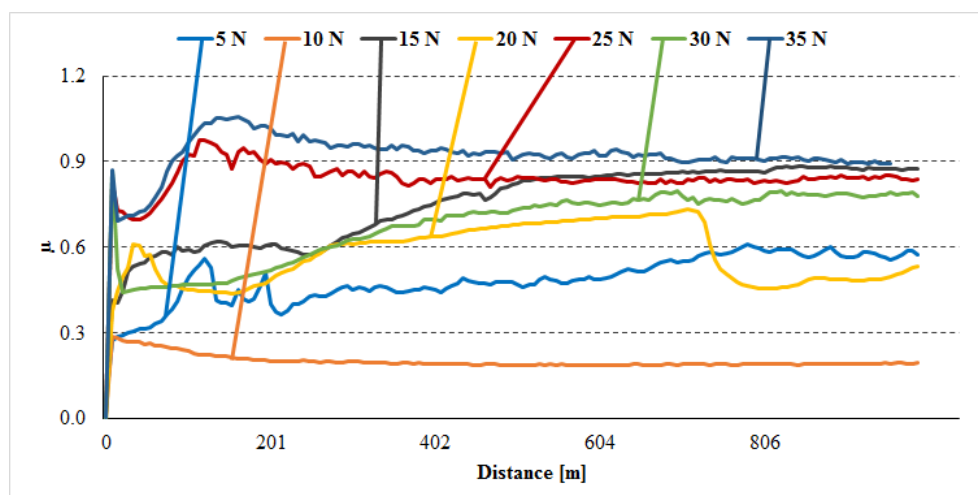


Figure 4. Friction coefficient for H resin system.

The sliding speed should be sufficient low in order to restrict the friction coefficient rise of the polymers used. It is observed that after 1000 m distance, μ for all materials tested varied in the range $0.2 < \mu < 1$. To conclude, epoxy resins polymers have a lower friction coefficient for every sample tested at applied force of 5N.

Acknowledgments

The authors would like to acknowledge the financial contribution of the Project 12 P01 024 21 (C11) /31.08.2012 (code SMIS 50414).

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