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Effect Of Addition Of Graphite Particles As A Solid Lubricant To Lubricating Oils

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1. Introduction

Friction and wear are inherent phenomena that accompany the relative motion of two surfaces near each other. These are found everywhere in everyday life and in various industrial applications, where these play an important role and often the main role for achieving optimal work. In various applications, both low and high values of friction and wear are required, which indicate the need for the ability to control these processes. Awareness of the later has led to intensive research, accumulation of a large number of empirical results in the middle of the 20th century; to the formation of tribology – the science that studies friction, wear and other related processes arising from the motion of contacting surfaces. The term "tribology" comes from two Greek words: "tribos" – friction, and "logos" – science. In practice, tribology is a science of controlling and managing wear, friction and lubrication[1].

Commercially layered compound powders, usually as solid lubricants, dispersed in oil were also included. The solid lubricants, such as MoS_2 dispersed in oil exhibited beneficial effects by reducing the friction and wear. Chu et al.[3] found that graphite existed on the rubbing surfaces stably and formed composition film with the oil-soluble additives. Bartz[4] found that an "optimal concentration" existed, and the wear rate actually increased with increasing the concentration over the optimal point of the solid lubricant dispersed in oil under heavily loaded conditions, and the larger the size of the solid lubricant particles, the larger the wear rate of surface. With fine particles at heavily loaded condition, the lubricating effectiveness was improved. Bartz have found that the addition of solid lubricant to mineral oil can have beneficial or detrimental effects on the antiwear performance of these oils depending on the other types of additives in oils, particle hardness and particle size of the solid lubricant[2]. In spite of good development and progress in lubricants, billions of US dollars are being lost in many industries and

motor vehicles globally due to engine frictions. Therefore, there is a great need to develop more efficient and effective lubricants.

In this study, the growth of tribo-films is investigated for the commonly used anti-wear additive "graphite powder". The influences of additive structure and contact conditions on tribofilm growth are determined in a cross-pin wear tester. The understanding of the contributing factors for the development of tribological predictions for rolling bearings. formation of tribo-films can promote the development of antiwear predictions for rolling bearings.

A new[5] mechanism for the action of antiwear tribofilm is proposed. A mixed lubrication model is developed and tribofilm growth integrated into this model to simulate the effects of tribofilm on lubrication. The dynamic evolution of the contacting surfaces due to plastic deformation, wear and tribofilm growth continuously change the lubrication characteristics inside the contact.

2. Materials and Methods

Experiments were carried out using pin-on-disc wear tester, as shown in Fig. 1. It consists of a rotary horizontal steel disc driven by variable speed motor. The test specimen is held in the specimen holder that fastened to the loading lever. Through two thin spring steel sheets, where strain gauges are adhered, friction force can be measured. Friction coefficient was determined through the friction force measured by the deflection of the spring steel sheets by strain gauges. The load is applied by weights. Test specimens were in the form of a cylindrical pin of 6 mm diameter and 30 mm length. The commercially supplied graphite particles (99.98% purity with average particle size lower than 50 μm) were suspended in acetone and sonicated using ultrasonic dispersing technology for more than 6 h until the particles was obtained. After sonication, the graphite particles were dispersed in two different types of lubricating oils (POA and paraffin oils) using ultrasonic homogenizer, with concentration of 0,5,10,15,20 wt.%. The test rig is fitted by a load cell, to measure the frictional force generated in the contact zone between the rotating disc and stationary pins. Rotational speed was 170 r.p.m. and 10 N normal load was applied by means of weights attached to a loading lever. The rotating specimens were lubricated before and every 30 secs. during the test. Every test time was 5, 10, 15 min. The test specimens are prepared from carbon steel (St. 60), (0.6 wt. % C, 0.25 wt. % Si, 0.65 wt. % Mn, 0.045 wt. % P and 0.045 wt. % S). The material loss of the test specimens during sliding was measured by weighing the specimen before and after test, using electronic balance of ±1 mg accuracy. The test specimens were loaded against counter face of grey cast iron disc (3.60 % C, 2.30 % Si, 0.50 % Mn, 0.12 % S, 0.75 % P), of 150 mm outer diameter, fastened to the rotating disc. Before the test, the friction surfaces of the test specimens and the cast iron discs were ground by 320 grid sand paper. Experiments were carried out at 25 °C.

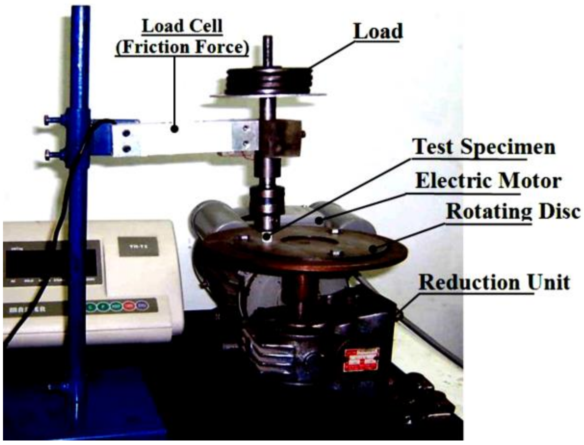

Fig. 1 Test Rig.

3. Results and Discussions

Figure 2 indicates the effect of adding different contents of graphite powder to paraffin oil on friction coefficient values, in 5, 10 and 15 Minutes. Where adding variable amount of graphite particles decrease friction values, where friction coefficient was 0.28, 0.355, 0.435 after 5, 10, 15 mins respectively for pure addition of paraffin oil, and friction coefficient reduced after adding different contents of graphite and reached to be 0.09, 0.155, 0.26 after 5, 10, 15 min of test. Meanwhile, Fig. 5 shows, weight loss (g) was 0.0008, 0.0012, 0.0016 after 5, 10, 15 minutes. After adding 20 wt. % of graphite powder to PAO oil, wear loss reduced to be 0.00011 (g) approximately. That means graphite powder reduced friction and formed a conformal protective coating on the sliding contact interfaces. This reason facilitates shear and slow down scratching between steel surfaces.

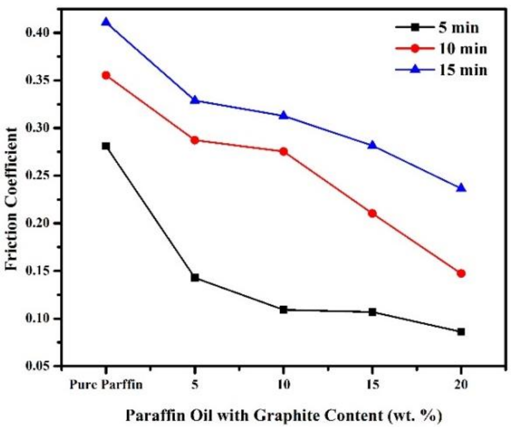

Fig. 2 Effect of addition of different contents of Gr particles to Paraffin oil on friction coefficient values.

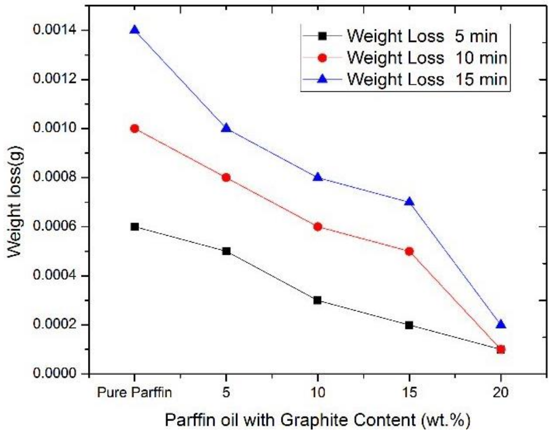

Fig. 3 Behavior of paraffin oil filled by different content of graphite particles.

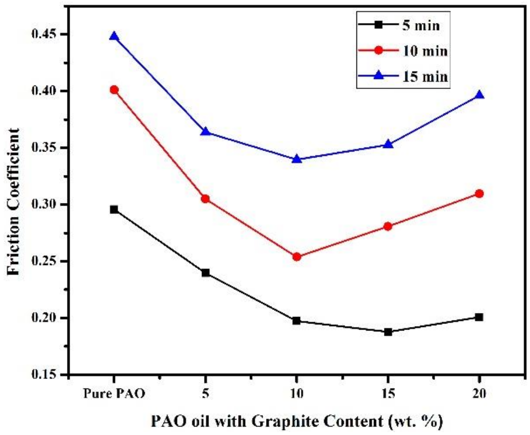

Fig. 4 Effect of addition of different contents of graphite to PAO on friction coefficient.

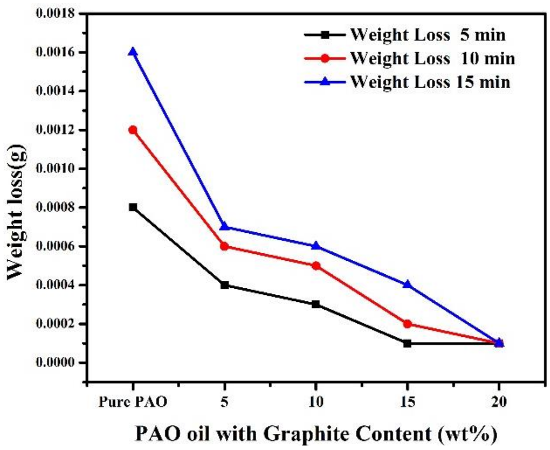

Fig. 5 Weight loss of steel specimen lubricated with PAO with different contents of graphite particles.

4. Conclusion

In conclusion, significantly improved performance for the wear values upon using graphite particles as a solid additive to lubricating oils. Consequently, the proposed coating strategy decreases the friction coefficient and wear values of the steel specimens as the precipitated antiwear acts as barrier to reduce the metallic contact.

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