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EFFECT OF ALUMINIUM OXIDE NANO-PARTICLES ON TRIBOLOGICAL PROPERTIES OF EPOXY COMPOSITES

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ABSTRACT
Nowadays, friction reduction has become a solution for new automotive engines due to the constraint of reducing power required and carbon dioxide emissions. Increase wear resistance has important effect on useful life of engine parts. In the present work discuss the tribological properties of epoxy composites. Epoxy filled with nano-particles of Al_2O_3 and different content of paraffin oil were used as bearing materials. The influence of Al_2O_3 on tribological properties of epoxy composites is discussed.

Test specimens were prepared in the form of cylindrical shape with cross section of 7 mm diameter and 30 mm length. The test specimens were loaded by 10 N weight against counterface of the carbon steel disc.

It was noticed that the friction coefficient for epoxy composite decrease to minimum values with increasing aluminum oxide nano-particles up to 6% and 0.4% oil. The aluminum oxide nano-particles decrease the adhesion between epoxy and steel surface and increase the hardness of test specimens. The wear resistance can be increase for epoxy composite by increasing aluminum oxide nano-particles up to 6% and 0.5% oil. The increase of oil content decrease the friction coefficient

KEYWORDS
Wear resistance, friction coefficient, epoxy and aluminum oxide nano-particles.

INTRODUCTION
Nowadays, friction reduction has become a solution for new automotive engines due to the constraint of reducing power required and carbon dioxide emissions. After advertisements about crash testing with Euro New Car Assessment Program rating stars, low carbon dioxide emission now constitutes a commercial advantage for automotive sales as every manufacturer effort to improve car efficiency. Solutions for fuel economy may transaction with drag force resistance decrease, car weight reduce and engine efficiency improvement. From international opinion, engine friction appear a non-negligible part of engine power loss, that effect on determines engine efficiency. Engine efficiency is evaluated by making comparisons between different engines used

with the New European Driving Cycle. This driving cycle has been designed by a European committee to assess pollutant emissions of automotive engines through a driving period meant to represent a confirmed average customer usage [1].

Nano-particles can be used as fillers in polymeric composites for improving the tribological properties of the material, [2]. Tribological properties of polymer composites can also be quite promote with the addition of nanoparticles, such as nano-Al_2O_3, [3]. Polymer composites are exceedingly used as bearing surfaces. Several trials were exerted to introduce new self-lubricating polymeric materials for bearing applications, where external lubricant such as oil or grease can be excluded and the design can be simplified and maintenance cost can be reduced, [4]. A polymer nano-composite is known as a composite material with a polymer matrix and filler particles that own at least one dimension lower than 100 nm, [5]. In desert areas, abrasive particles such as sand come in the machines cause dangerous wear of the moving surfaces, [6, 7]. Abrasive wear of composite materials is a intricate surface failure and harm process, influenced by a number of factors, such as surface roughness, mechanical properties of the original material and the abrasive, loading condition, environmental impact. Microstructure is one of the main factors; while, its action on the wear mechanism is intractable to investigate experimentally, [8, 9]. Aluminum alloys are very suitable for structural applications in aerospace and transport industries due to their sprightly weight, high strength to weight proportion, and opposition to corrosion, [10]. Aluminum oxide is famous for its hardness and is often used as grinding medium.

The area of nano-technology is growth the applications of engineering and technology. The polymer contained nano-particles or nano-composites are the growing field of research for improving the materials, [11]. There is an increasing request to improve materials based on thermosetting polymers due to the comparatively high thermal constancy and environmental reluctance as well as the perfect tribological performance. Thermosetting polymer composites are applied as substrate, covering, and plastic bearings additional in the automotive, railway and transport industries, [12]. The major obstacle is their comparatively poor wear resistance. however many thermoplastic materials show self-lubricating action, [13], while the lubricating properties of thermosetting polymers want to be adjust by solid lubricants or by the filling of nano-particles of choice materials in particular ZnO nano-particles. Based on the practical results, it can be found that, the addition of Al_2O_3 to polyethylene increase the hardness and the wear resistance of the composite. The increase of oil content decreased the wear. Polyethylene coating filled by Al_2O_3 particles content and 10 wt. % oil content present zero wear, [14]. Aluminum oxide particles as filling material in polyvinyl chloride coating excess the hardness and the wear resistance. The increased of the content of the oil breed a decrease in wear. Minimum wear explain in polyvinyl chloride with 9 wt. % Al_2O_3 particles content and 10 wt. % oil content. Excess oil content increases the ability of embedment of the sand particles, [15].

The main aim of this work is to develop epoxy composites to be used as bearing material in different engineering applications. It is proposed to use aluminum oxide nano-particles and paraffinic oil as filling materials.

EXPERIMENTAL

Experiments were executed using pin on disc tribometer. It consists of a rotary horizontal steel disc driven by a changeable speed motor. The specifics of the pin on disc are shown in Fig. 1. The test specimen is caught in the specimen holder that fixed to the loading lever. Through load cell, as strain gauges are found, friction force can be measured. Friction coefficient was determined over the friction force measured by load cell. The normal load is applied by dead weights. The counterface in form of a steel disc, of 100 mm outer diameter, was fastened to the rotating disc. Its surface was a smooth surface. Test specimens were prepared in the form of cylindrical shape with cross section of 7 mm diameter and 30 mm length. The test specimens were loaded by 10 N weight against counterface of the carbon steel disc.

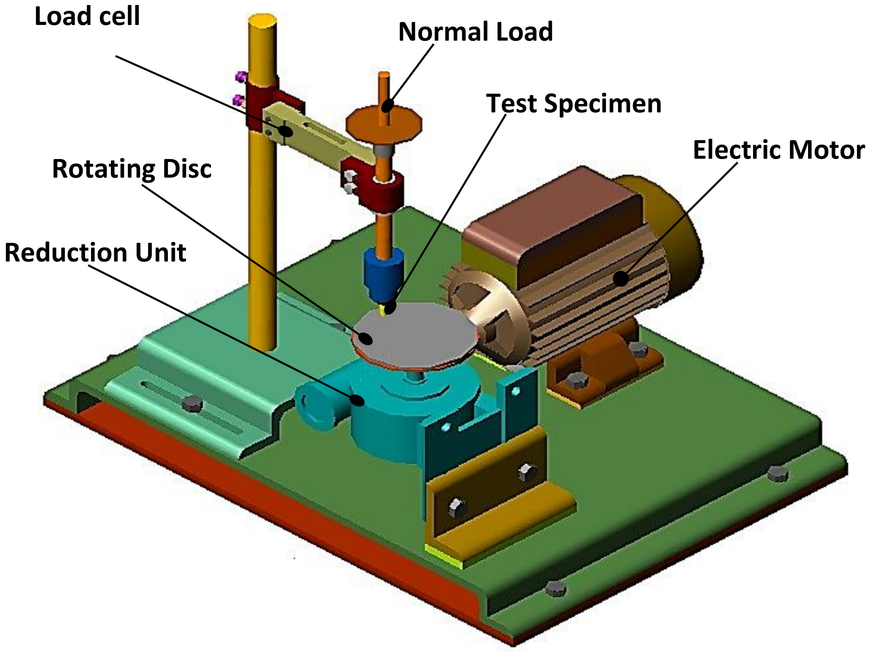

Fig. 1 Arrangement of friction test rig.

Test specimens were prepared by mixing the epoxy by nano-particles of aluminum oxide of 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 wt. % content, and paraffinic oil by 0, 0.1, 0.2, 0.3, 0.4 and 0.5 wt. % contents. The COF was determined through the friction force measured by the deflection of the load cell divided on the normal load, while wear was measured by the difference between the weight of specimen before and after test using a digital balance of 1.0 mg accuracy. The Al_2O_3 nano-particles with (100 nm). The preparation procedures for test specimens show in Fig. 2.

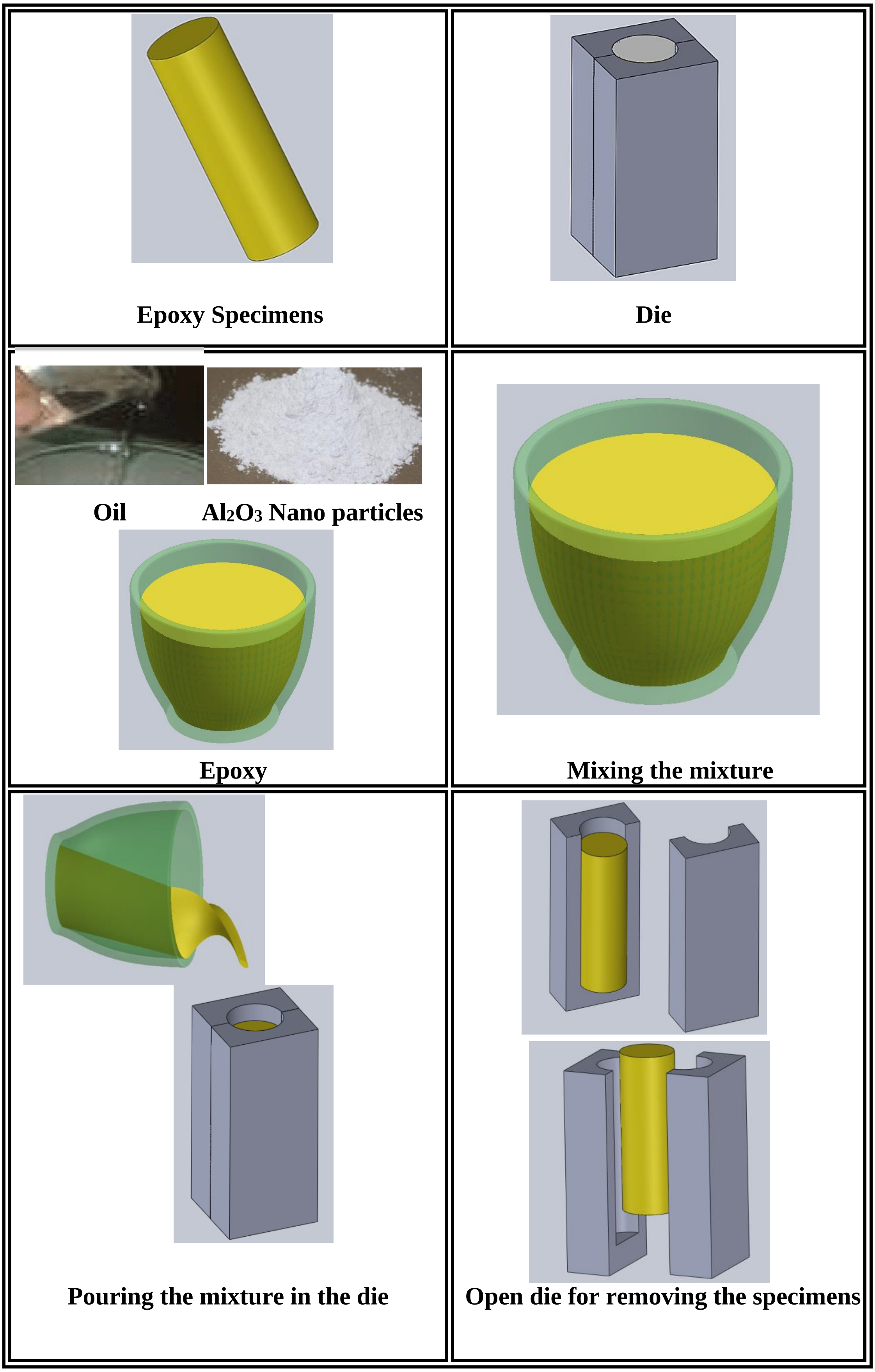

Fig. 2 Steps of test specimens preparation.

RESULTS AND DISCUSSION

The relation between friction coefficient and aluminum oxide nano particles content for epoxy composites was illustrated in Fig. 3. As seen, the increase of oil content caused slightly decrease in friction coefficient. This behavior can be related to the ability of oil to coating the contact surface. Increase aluminum oxide content show slightly decreasing in friction value, where the addition of aluminum oxide particles into epoxy increases the hardness of epoxy composite.

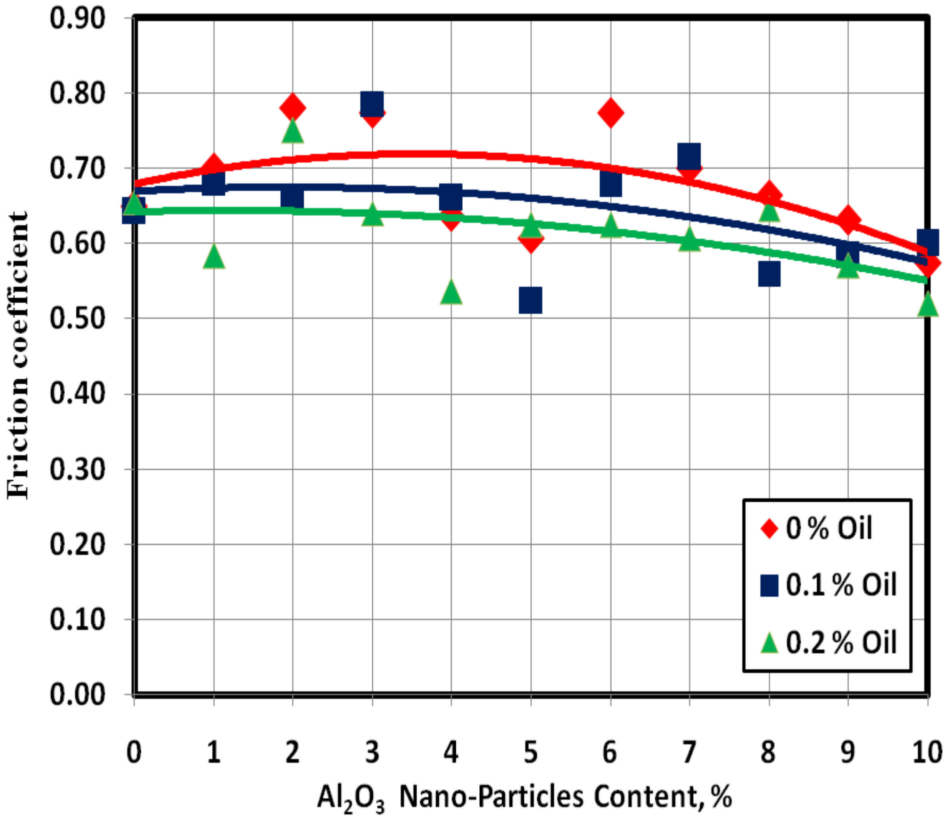

Fig. 3 Friction coefficient of epoxy test specimens filled by Al_2O_3 and paraffin oil.

Friction coefficient of epoxy composite filling by Al_2O_3 and paraffin oil was shown in Fig. 4. Friction coefficient decreases with increasing Al_2O_3 and oil content. Increase aluminum oxide particles with increasing oil contnt show significant decreasing in friction value, this behavior may be related to the aluminum oxide particles decrease the adhesion between epoxy and steel surface. The oil play important effect on decreasing friction value, because the oil facilitate the sliding between two surface. Increasing aluminium oxide over 6 % show slightly increasing in friction values. This behavior may be related to weakness of test specimens and the aluminum oxide particles separated from test specimens to sliding surface. The mechanism of show the oil cover contact surface and reduce the adhesion between epoxy and steel surface was shown in Fig. 5.

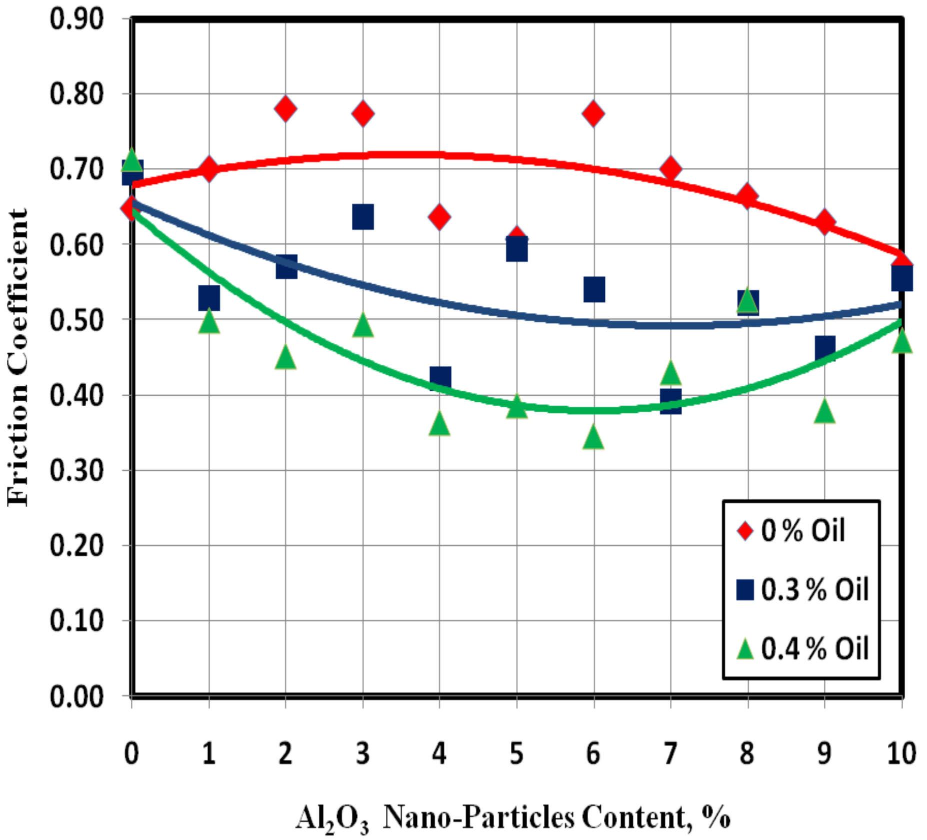

Fig. 4 Friction coefficient of epoxy test specimens filled by Al_2O_3 and paraffin oil.

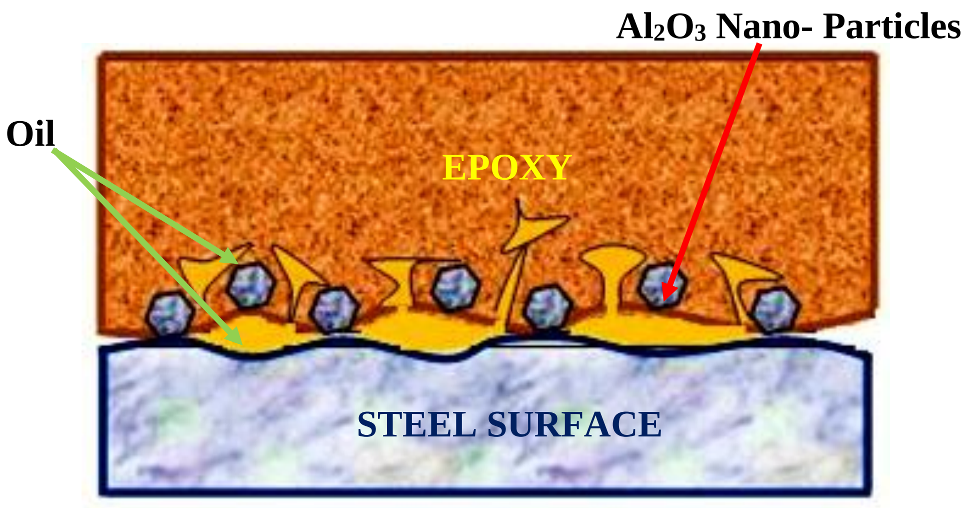

Fig. 5 The oil cover contact surface and reduce the adhesion between epoxy and steel surface

Other improved in frictional properties of epoxy composite, when increase aluminum oxide nano-particles were shown in Fig. 6. The friction coefficient decrease with increasing Al_2O_3 contents. Increasing oil content show more effect on decreasing friction values, the oil cover more contact surface and facility sliding of test specimens on steel surface. In presence of oil on sliding surface the epoxy nonstick on steel surface and aluminum oxide particles sliding on contact surface. Figures 7 and 8 Shows the electro scan for test specimens show the oil cover the contact surface of test specimens.

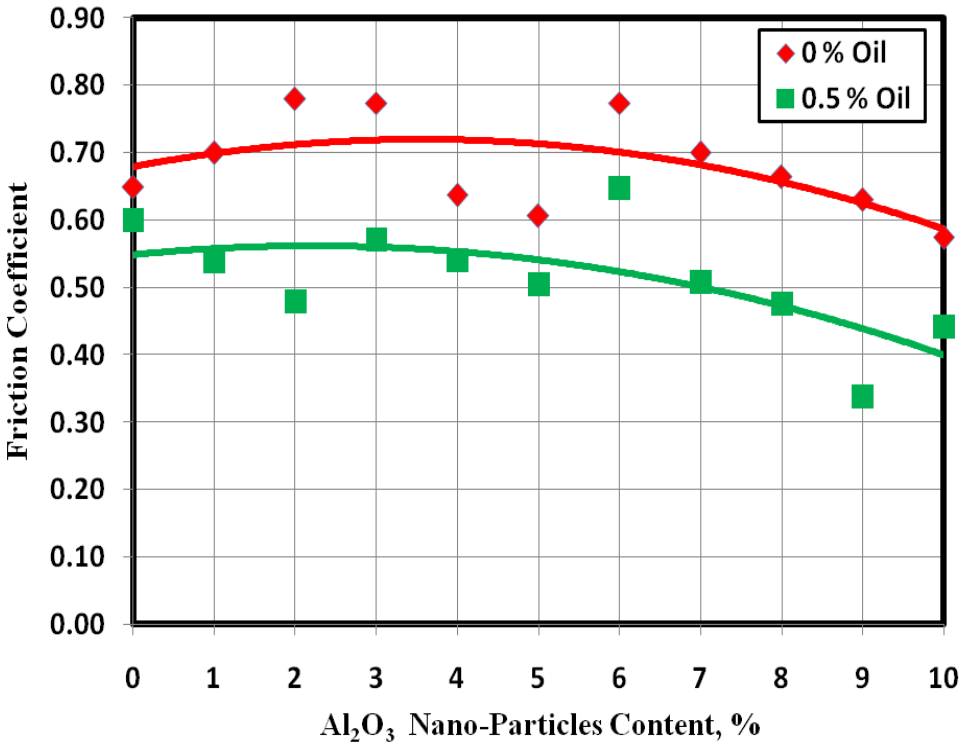

Fig. 6 Friction coefficient of epoxy test specimens filled by Al_2O_3 and paraffin oil.

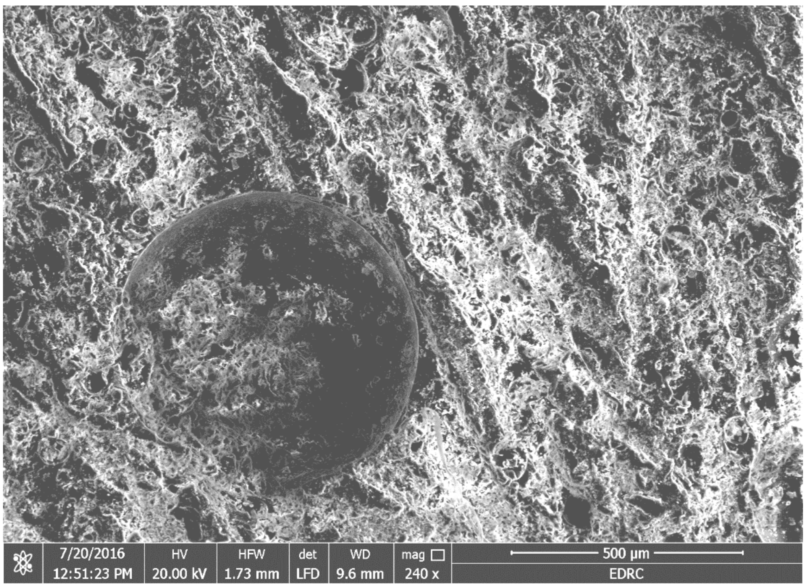

Fig. 7 The oil covers the contact area.

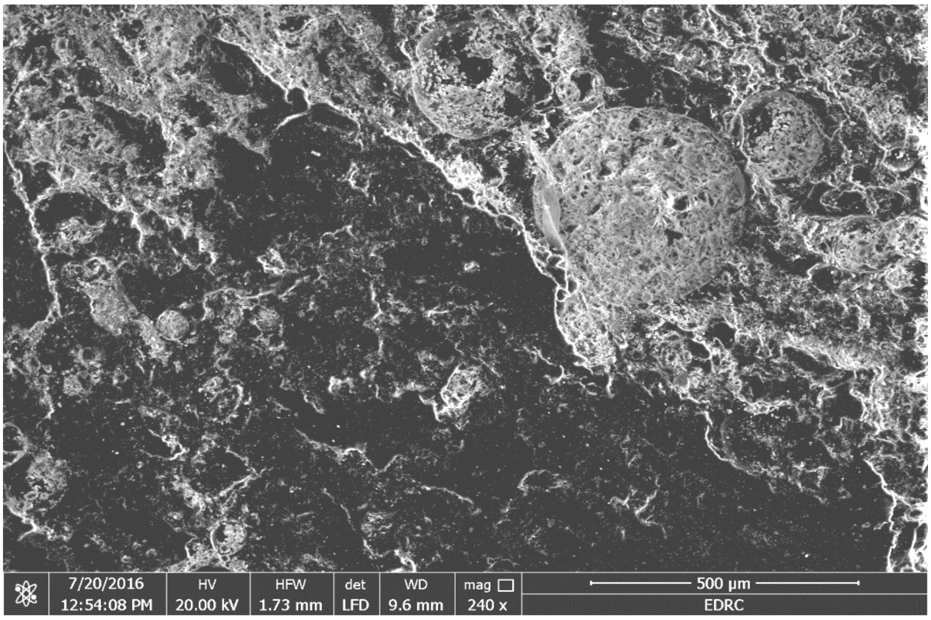

Fig. 8 The oil covers the contact area.

Wear of epoxy test specimens filled by Al_2O_3 and oil is shown in Fig. 9. Increase aluminum oxide show slightly decreasing in wear losses, up to 5 % Al_2O_3 this behavior attributed to increase bonding between particles of aluminum oxide and epoxy. The wear increase with increasing Al_2O_3 content over 5 % . This behavior related to the weakness of test specimens and decreasing the bonding between Al_2O_3 and epoxy resin. The cavities generated from separate Al_2O_3 particles from test specimens were shown in Fig. 10.

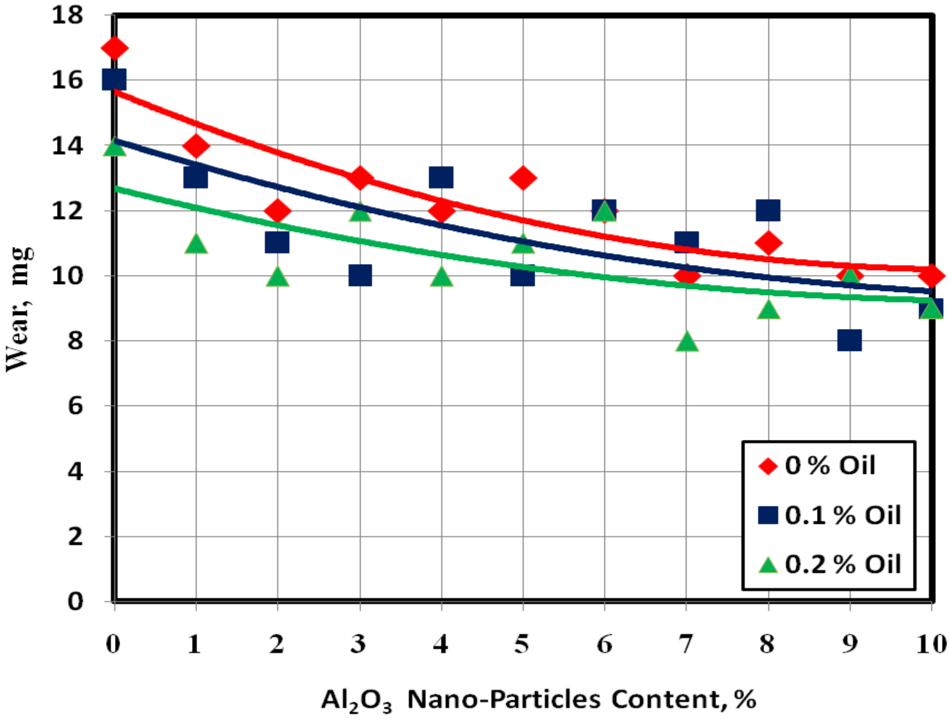

Fig. 9 Wear of epoxy test specimens filled by Al_2O_3 and paraffin oil.

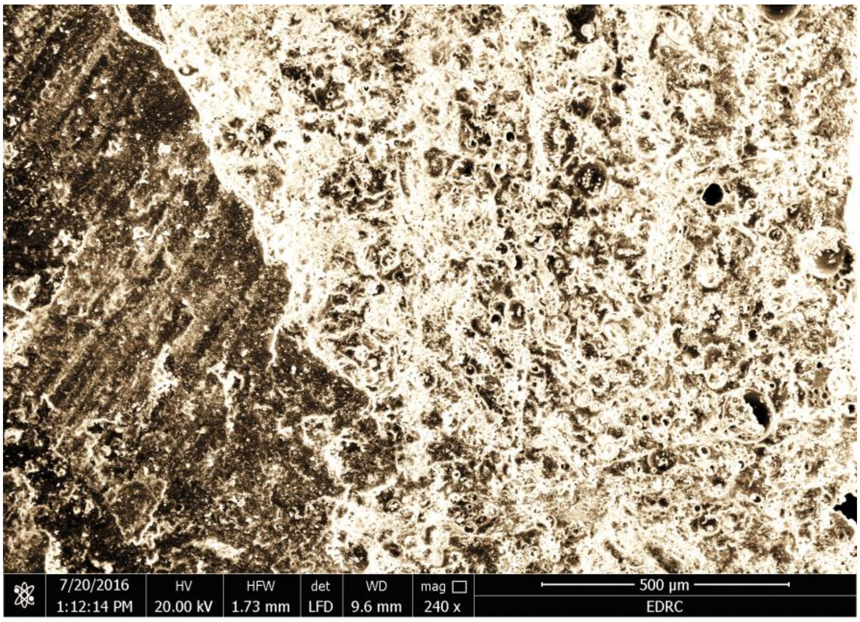

Fig. 10 Cavities from leakage the oil from test specimens

Figure 11 show the relation between wear losses and Al_2O_3 content, for epoxy test specimens filled by paraffinic oil. It can be noticed that the wear decrease with increasing Al_2O_3 content, this behavior may be related to the more homogeneity of test specimens. Increase Al_2O_3 content up to 5 % show increasing in wear losses. This behavior related to decrease the bonding between Al_2O_3 and epoxy.

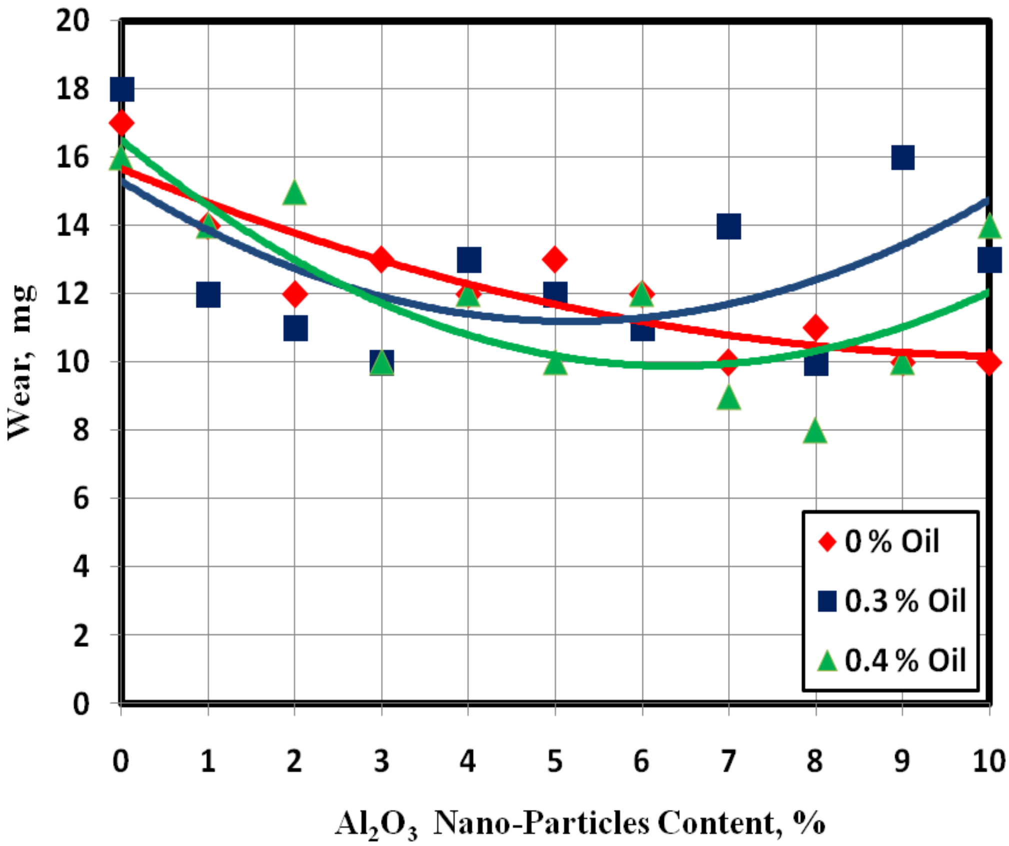

Fig. 11 Wear of epoxy test specimens filled by Al_2O_3 and paraffin oil.

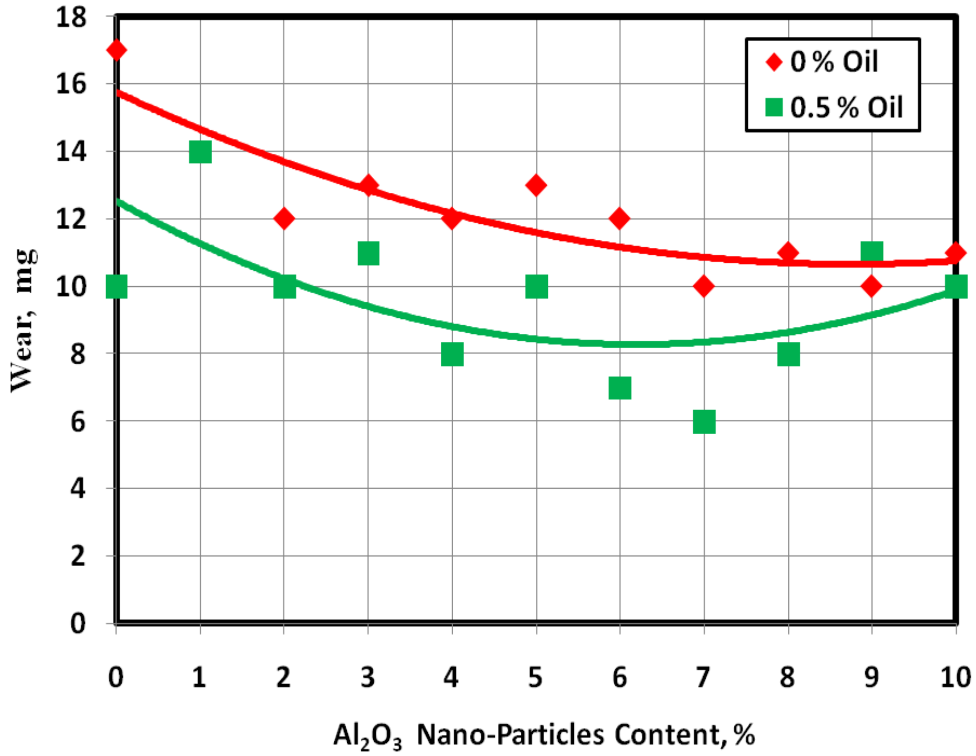

Fig. 12 Wear of epoxy test specimens filled by Al_2O_3 and paraffin oil.

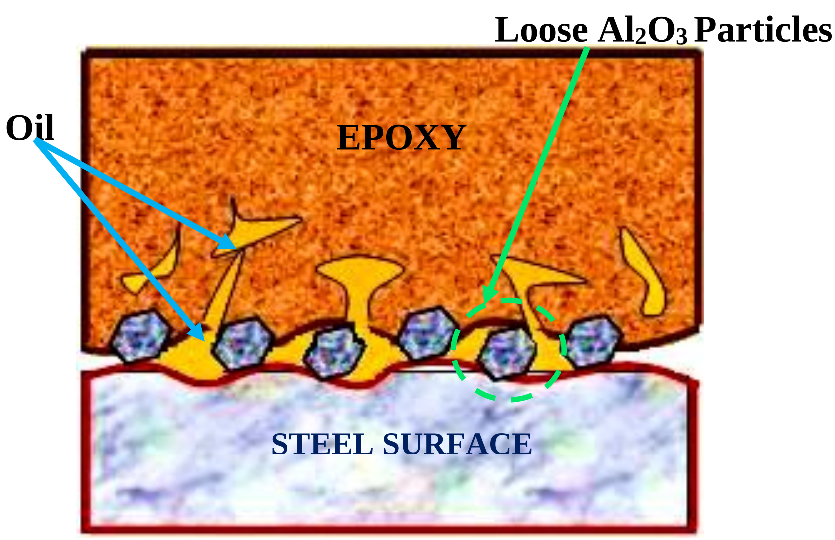

Fig. 13 Increase Al_2O_3 content and separated the particles from test specimens.

The relation between wear losses and Al_2O_3 content, for epoxy test specimens filled by paraffinic oil was shown in Fig. 12. It can be noticed that the wear resistance enhancing with increasing Al_2O_3 content. This behavior may be related to more homogenous between epoxy and Al_2O_3 and strong bonding between Al_2O_3 particles and epoxy. While the oil play important role for increase the wear resistance of test specimens. The minimum values of wear observed at specimens of epoxy contain 6% Al_2O_3 and 0.5%

oil. The mechanism shown the weakness of test specimens and separated the Al_2O_3 particles from test specimens was shown in Fig. 13.

CONCLUSIONS

1. The friction coefficient for epoxy composite decrease to minimum values with increasing aluminum oxide nano-particles up to 6% and 0.4% oil.
2. The aluminum oxide nano-particles decrease the adhesion between epoxy and steel surface and increase the hardness of test specimens.
3. The wear resistance can be increase for epoxy composite by increasing aluminum oxide nano-particles up to 6% and 0.5% oil.
4. The increase of oil content decrease the friction coefficient

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