EGTRIB Journal
JOURNAL OF
THE EGYPTIAN SOCIETY OF TRIBOLOGY
VOLUME 13, NO. 3, July 2016, pp. 1 - 12 ISSN 2090 - 5882

FRICTION AND WEAR OF SAND CONTAMINATED LUBRICATED SLIDING

Ramadan M. A.

Faculty of Engineering, Helwan University, Helwan, EGYPT.

ABSTRACT
This paper manages a test investigation of friction and wear responses from sand contaminated lubricated sliding. The influence of sand contaminants on the wear and friction is characterized. Analyses are completed utilizing segment of piston ring sliding against cylinder liner. Paraffin oil with and without sand contaminants is utilized. The effect of the concentration and also the particle size of sand are examined.

Based on the observations in the present work, it was found that the friction and wear essentially increase with increasing sand concentration in the lube. Solid proposal ought to be considered to enlighten the general population to change the oil filter of the Car Engine consistently.

KEYWORDS
Sand contamination, lubrication oil, abrasive wear, lubricated sliding.

INTRODUCTION

Motors in Middle East experiences serious wear as a result of dusty atmosphere. The dust penetrates all through the lube, sourced from outside medium as contaminants such sand, grits, chips and abrasive materials. These contaminants transmit through the lube and grab inside motor parts. The scraped activities of such contaminants result in harm of a corporate moving contact surfaces, creating escalated wear with respect to the motor parts [1-3]. The concentration and particle size of these contaminants essentially impacts the episode wear. Some examiners looked at amongst the effectiveness concerning the contaminants and lubricant additives on friction and wear, utilizing reciprocating and rotating movement under high loading [4, 5]. Proposals assessed harsher wear by "the morphology" of worn surfaces. The finished results exhibited the way that the lubricant defiling causes critical wear toward the mating surfaces, and resulting machine component breakdown [6, 7]. Different examinations report the result of abrasives defiled to lubricant versus friction and wear [8-10]. Results show that concentration of contaminants has an essential capacity in controlling wear and friction along at the contact surfaces. In like manner, Scanning Electron Microscope (SEM) demonstrated a predominant wear is abrasive wear. This wear is coming about because of sliding of hard surfaces of

contaminants over one more of mating surfaces [11-14]. Different examiners distracted with characterizing the wear elements and "soot" that tainted in lube [15, 16].

With an end goal to turn away the breakdown of motor components, the present work explores the outcome along the concentration and furthermore the particle size of sand defiling oil, utilizing segment of piston ring sliding against cylinder liner.

EXPERIMENTAL

The test rig consists of an electric motor which provides reciprocating motion for the segment of cylinder line (300 – 3100 strokes/ min.). The piston ring specimen was located on its place in the piston groove of a segment of piston clamped by chuck. The details of the test rig are illustrated in Fig. 1. The piston ring specimen is sliding against the inner surface of the segment of cylinder line in the presence of lubricant. The lubricant was paraffin oil. The friction force was measured using load cell which connected with a digital screen to detect the friction force.

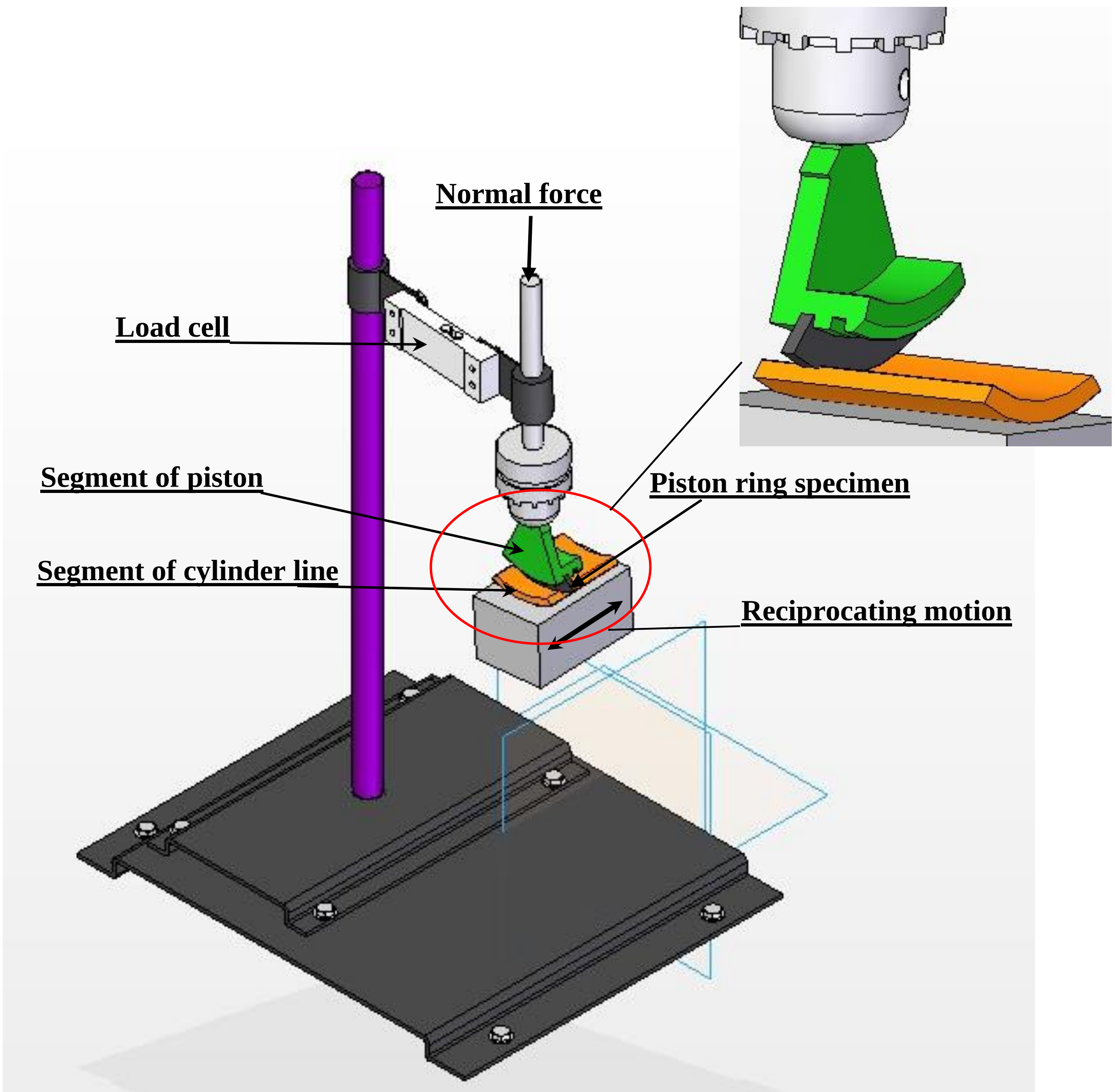


Fig. 1 Test rig.

The test approach in this work was partitioned into two sections. The test specimens of the primary bit was considered as reference which subjected to fresh oil while the specimens of the second partition is subjected to oil contaminated with sand. The effect of different concentration of sand particles (2 g/L, 4 g/L, 6 g/L, 8 g/L and 10 g/L) has been studied. These concentrations are chosen according to the high level of dust in the Middle East. The sand particle sizes used are (0 – 80 µm), (80 – 200 µm) and (200 – 500 µm). All experiments are done at room temperature and carried out at constant normal load (6 N) which applies the same side pressure on the cylinder wall. Also, experiments carried out at constant speed (150 strokes/ minute), constant running time (600 seconds) and constant travelling distance (20 mm). The velocity of the piston segment is chosen to resemble the worst friction and wear conditions where the mixed lubrication regime is prevailing. The worst friction and wear conditions were found near the top and the bottom of the cylinder wall of internal combustion engine where the velocity is small.

RESULTS AND DISCUSSION

Every experiment has been undertaken three times and the mean value are plotted. The effect of sand contaminated in lubricant on the friction was studied for different particle sizes of sand. Figure 2 shows the effect of sand contaminated in lubricant on the friction for sand of particle size 0 – 80 µm. It is clearly shown that the friction coefficient increases with increasing the sand concentration in lubricant. This can be attributed to the additional particles which come into the contact, whereupon increase the friction.

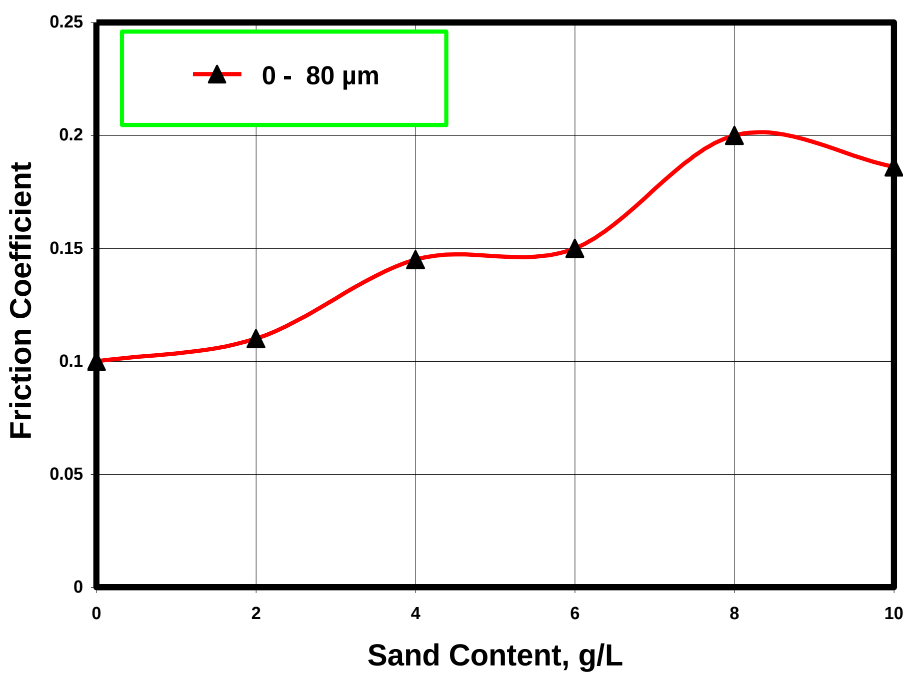


Fig. 2 Effect of sand contaminated in lubricant on the friction for sand of (0 – 80 µm) particle size.

Also, there is the possibility of partially metal/metal contact and consequent high friction coefficient, Fig. 3. At the beginning of the trend where the lubrication oil is free

abrasives, the friction coefficient value was small (0.1). This can be attributed to the oil film which completely separating surfaces, Fig. 4. At the end of trend, the friction coefficient slightly decreases and this may be due to the rolling action of sand particles.

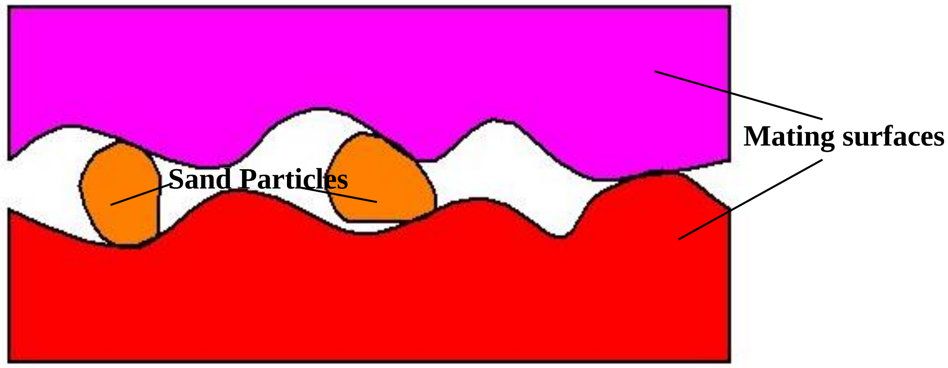


Fig. 3 Illustration of wear mechanism.

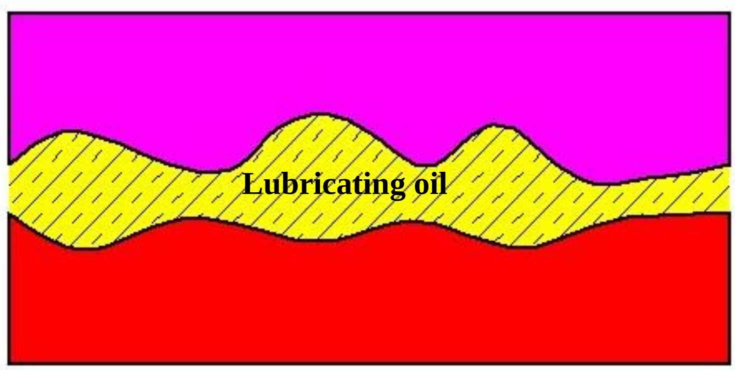


Fig. 4 Illustration of wear mechanism.

Friction coefficient displayed at sand of (80 – 200 μm) particle size, Fig. 5, showed slight increase with increasing sand concentration in lubricant. This may be due to increasing the number of sand particles that get into the contact which accelerates the friction. The friction coefficient values were lower than that observed at sand of particle size 0 – 80 μm, due to the relatively big particles, which completely separate the surfaces and decrease metal/metal contact, Fig. 6.

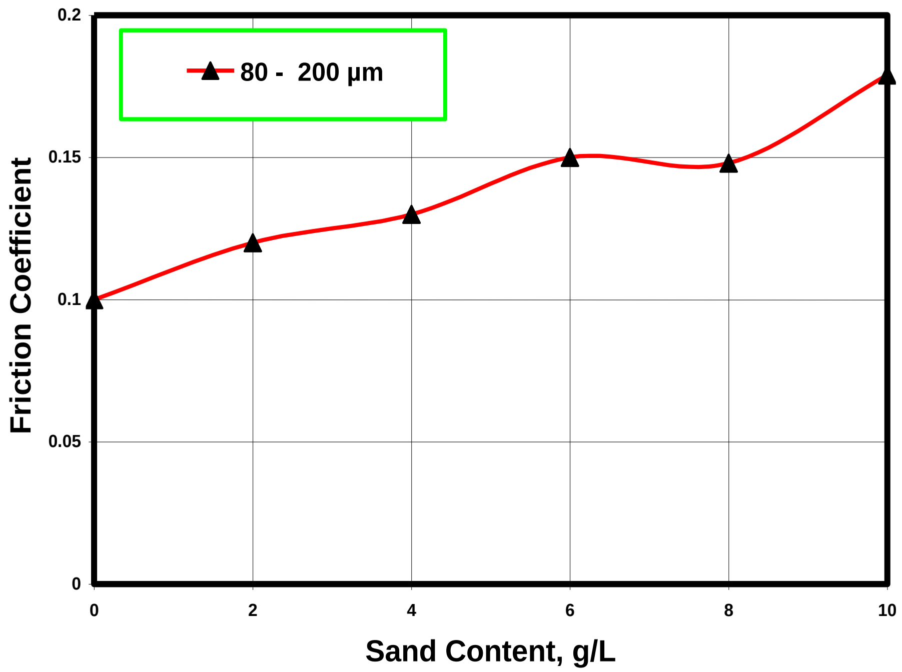


Fig. 5 Effect of sand contaminated in lubricant on the friction for (80 – 200 µm) particle size.

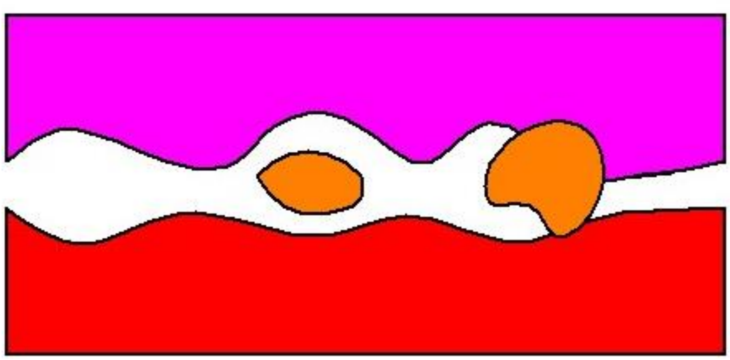


Fig. 6 Illustration of wear mechanism.

With increasing the particle size of sand to 200 – 500 µm as shown in Fig. 7, the friction coefficient fluctuate with tendency to decrease with increasing the sand content and this can be clarified by the irregular distribution of oil layer in the contact due to passing of particles through the contact. These variations increase with increasing particle size of

contaminants. Duplicate tests run to establish reproducibility show that the trends were valid.

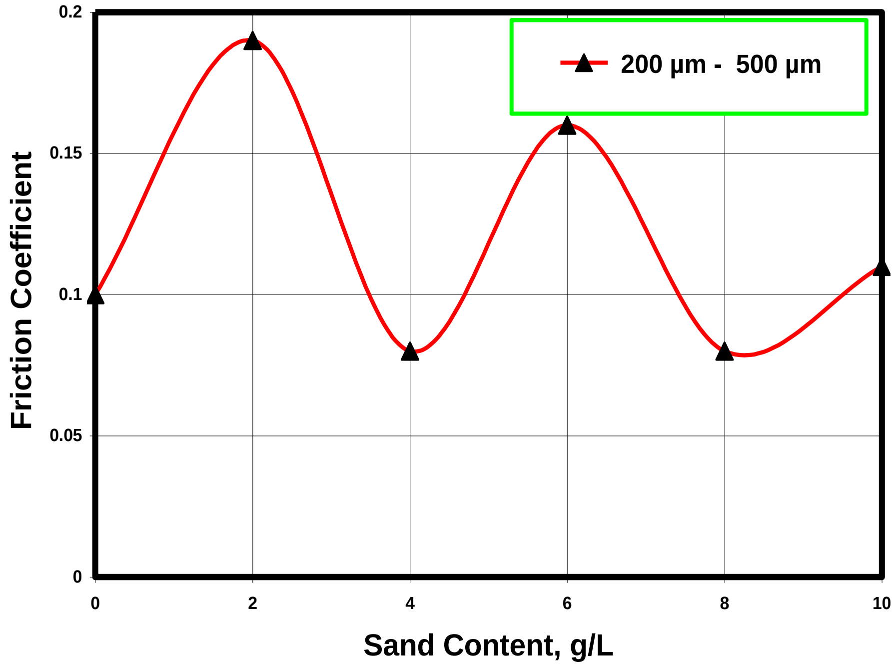


Fig. 7 Effect of sand contaminated in lubricant on the friction for (200 – 500 µm) particle size.

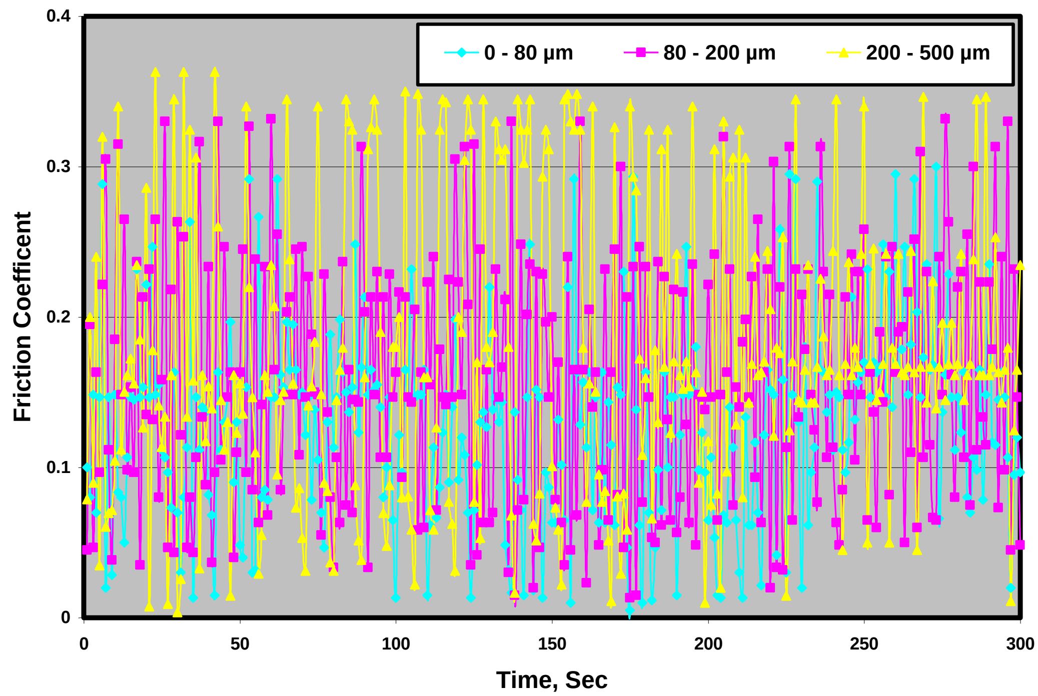


Fig. 8 Effect of particle size of sand contaminated in lubricant on the variation of friction at the same sand concentration.

Effect of particle size of sand contaminated in lubricant on the variation of friction at the same sand concentration was studied. With increasing the particle size of sand from (0 – 80 µm) to (200 – 500 µm) as shown in Fig. 8, the value of friction fluctuations increases. This may be due to increasing embedment of particles in one of the rubbing surfaces, additionally because of the separation and elimination of worn surfaces. It can be noticed that, the average value of friction coefficient increased with increasing sand particle size.

The contamination of sand particles in lubricant is unavoidable in Middle East. These particles cause abrasive wear for the sliding surfaces. With regard to the effect of sand concentration in lubrication oil on the wear rate of piston ring specimen, wear rate of piston ring specimen increased with increasing the sand concentration in lubricant as shown in Fig. 9. In this case, increasing the sand concentration will cause increase of material removal of piston ring specimen due to embedded abrasive particles as well as the abrasive action. The embeddability of the rubbing surfaces has the most important factor in controlling abrasive wear. This is clearly observed by photomicrographs of the surface of piston ring specimen, Fig. 13, where the harm of sliding surfaces take place by deep surface grooving due to penetration of sand particles. Also, it is clearly shown that the deep surface grooving increases with increasing the sand concentration.

Figure 10 shows the effect of sand concentration in lubrication oil on wear rate of piston ring specimen using sand of 80 – 200 µm particle size. The same trend is observed, where as in Fig. 9, the wear rate of piston ring specimen increased with increasing sand concentration in lubrication oil. The presence of contaminants in the lubricant forms a monolayer of abrasive particles which enter between the mating surfaces and cause wear when some of these particles are embedded in one of the rubbing surfaces and abrade the other one.

Table 1 wear values of piston ring specimen at different sand particle size and different sand concentration.

Wear values of piston ring specimen, mg		Sand concentration in lubrication oil, g/L					
		0	2	4	6	8	10
Sand particle size	0 – 80 µm	1	1	2	4	5	6
	80 – 200 µm	1	2	3	3.2	5	6.5
	200 – 500 µm	1	2.1	3.7	5	6.3	7

Also, Fig.11 shows an increase of wear rate for piston ring specimen with increasing sand concentration in lubrication oil. Table 1 shows a comparison of wear values of piston ring specimen at different sand particle size and different sand concentration. It can be obtained that wear values slightly increased with increasing abrasive particle size. This behaviour might be attributed to the fact that: as the particle size increases the

depth of penetration of the particle into the sliding surfaces increases and consequently the volume of material removed increases. Also, it is clearly observed that the wear values significantly increase with increasing sand concentration in lubrication oil. The sand concentration in lubrication oil has a significant effect on wear than the particle size of sand as shown in Table 1. "Photomicrographs" of sand show relatively sharp shape for the different sizes of sand particle as shown in Fig. 12.

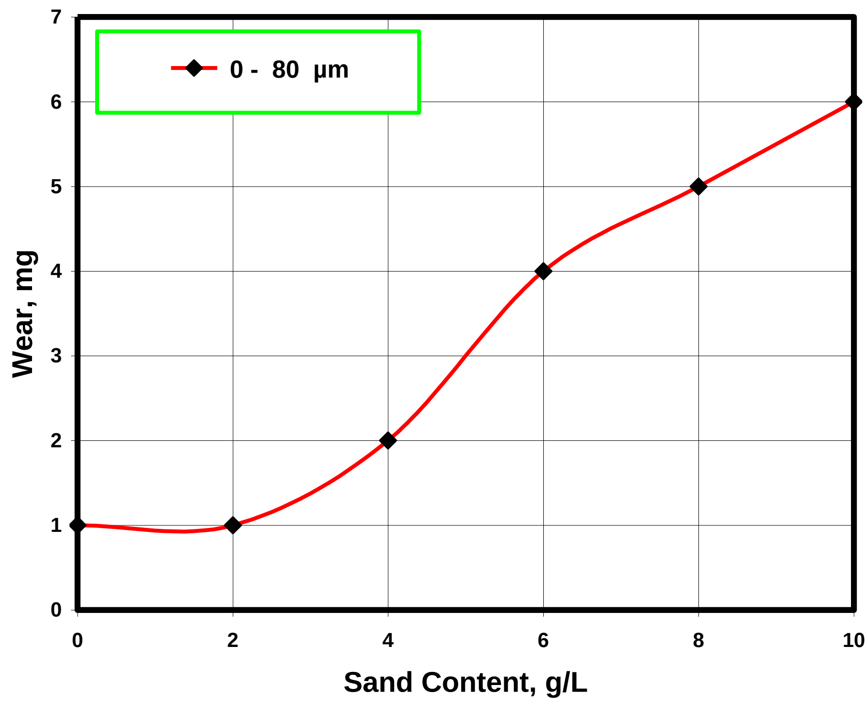


Fig 9 Effect of sand contaminated in lubricant on the wear for (0 – 80 µm) particle size.

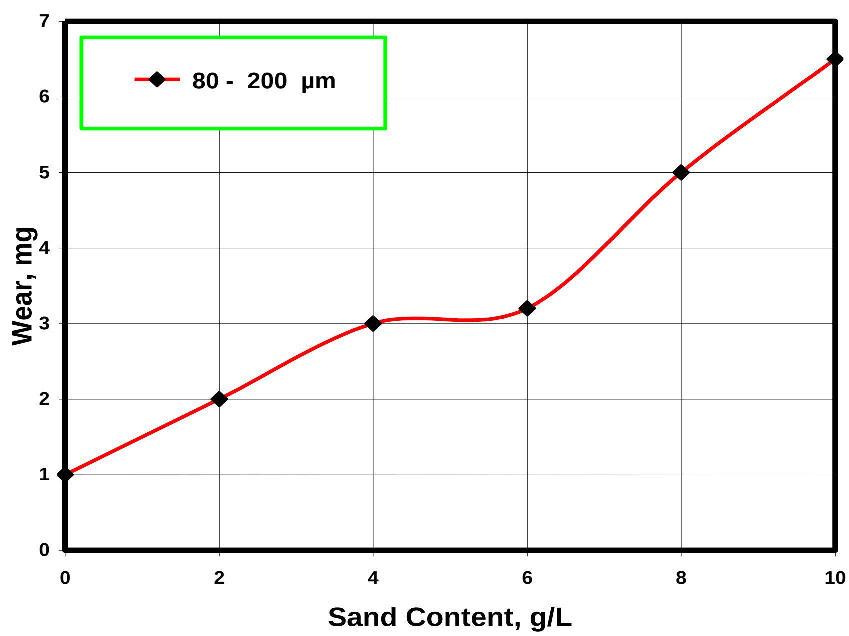


Fig.10 Effect of sand contaminated in lubricant on the wear for (80 – 200 µm) particle size.

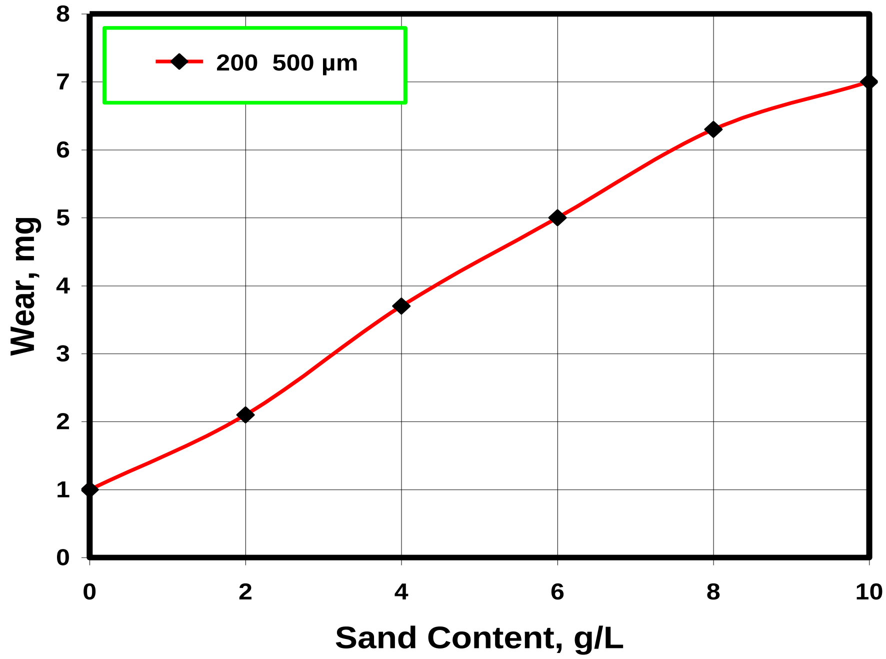


Fig.11 Effect of sand contaminated in lubricant on the wear for (200 – 500 µm) particle size.

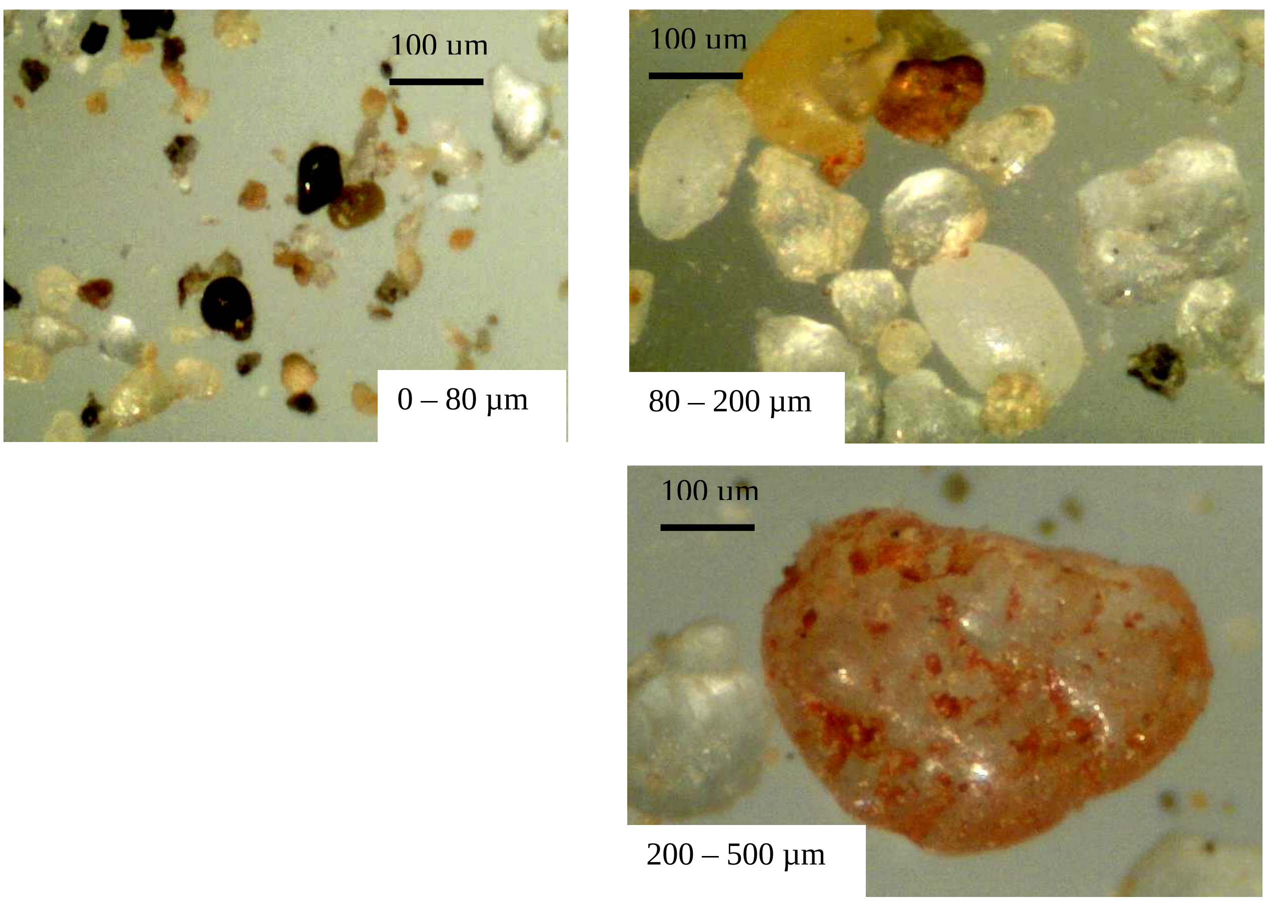
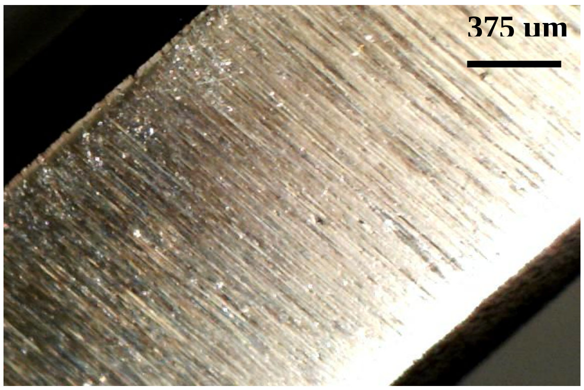
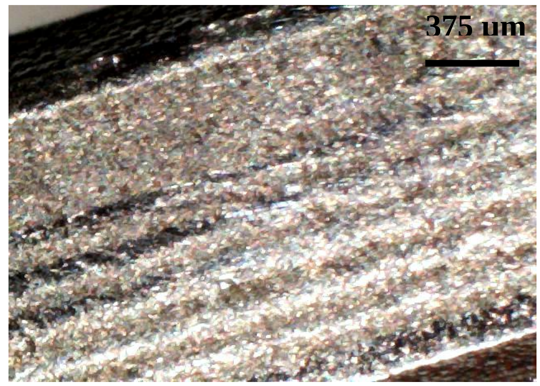


Fig.12 Photomicrographs of the sand dispersed in lubrication oil.

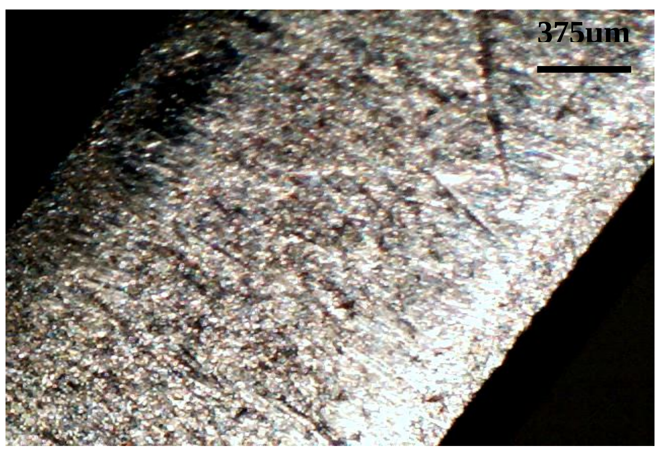
For more clarification of wear, photomicrographs for the surface of piston ring specimen were taken. Fig. 13-a, characterizes the surface of piston ring specimen tested using lubrication oil free of abrasives. Fig. 13-b shows the worn surface of piston ring specimen caused by abrasive wear using lubrication oil with sand concentration of 10 g/L. Worn surface of piston ring specimen tested using lubrication oil with sand concentration of 4 g/L, Fig. 13-c. It can be noticed that the surface wear of piston ring is accelerated by increasing the sand concentration in lubrication oil. The figure illustrates a wear mode in which breakdown of the boundary lubricant film occurs, where the shear mixed layer becomes unstable and severe plastic flow of the surface results.



(a)



(b)



(c)

Fig. 13 Photomicrographs of the surface of piston ring specimen tested using (a) lubrication without abrasives, (b) lubrication with sand concentration of 10 g/L and (c) lubrication with sand concentration of 4 g/L.

CONCLUSIONS

The current paper offers significant results about the friction and wear of sand contaminated lubricated sliding. Study the effect of the sand particles contaminated in the engine lubricant in the Middle East is critical, due to consequent severe wear and high friction rates which lead to machines and engines failure. With increasing the concentration of the sand particles in lubricated sliding contact, the friction and wear

increase. This may be due to increasing the number of particles that come into the contact which accelerates the friction. For wear situation, increasing the sand concentration will cause increase of material removal of piston ring specimen due to embedded abrasive particles. The embeddability of the rubbing surfaces has the most important factor in controlling abrasive wear. Also, friction and wear rate increase with increasing the particle size of sand contaminated in the lubricated sliding contact.

This study affirms the effect of sand particles contaminated in the lubricant on the friction and wear. They increase the friction between the sliding mating surfaces, and leads to "severe" wear, subsequently machine element failure.

REFERENCES

1. Sari M. R., Ville F., Haiahem A., Flamand L., "Effect of Lubricant Contamination on Friction and Wear in An EHL Sliding Contact", Mechanika, 2(82), pp. 1392 – 1207, (2010).

2. Aldi N., Morini M., Pinelli M., Spina P. R., Suman A., "An Interdisciplinary Approach to Study the Fouling Phenomenon", Energy Procedia, 82, pp. 230 – 285, (2015).

3. Ebert F. J., "Fundamentals of Design and Technology of Rolling Element Bearing", Chinese Journal of Aeronautics, 23, pp. 123 – 136, (2010).

4. Maru M. M., Tanaka D. K., "Influence of Loading, Contamination and Additive on the Wear of a Metallic Pair under Rotating and Reciprocating Lubricated Sliding", J. of the Braz. Soc. of Mech. Sci. & Eng., XXVIII(3), pp. 278 – 285, (2006).

5. Maru M. M., Tanaka D. K., "Oil Contamination and Additive Effects on the Wear and Friction of Metallic Specimens in Reciprocating Lubricated Sliding Tests", 7th International Congress of Mechanical Engineering, (2013).

6. Sheikh A. M., Khashaba M. I., Ali W. Y., "Reducing the Mechanical Wear in a Dusty Environment (Cement Factory)", International Journal of Engineering & Technology IJET-IJENS, 11(6), pp. 138 – 144, (2011).

7. Mousa M. O., Ali W. Y., "Particle Size Effect on Friction and Wear Caused by Abrasive Contaminants in Lubricating Oil", 3rd Int. Ain-Shams Univ. Conf. on Prod. Eng. & Des. For Development, pp. 27 – 29, (1990).

8. Ali W. Y., Mousa M. O., "Wear and Friction of Cylindrical Contacts by Lubricant Abrasive Contaminants", The EGTRIB First Tribology Conference, Cairo, Egypt, pp. 20 – 21, (1989).

9. Ali W. Y., Fodor J., Westcott V. C., " The Effect of Abrasive Contamination on Journal Bearing Performance", Presented in The ASME/ASLE Tribology Conference, Westtin William Penn, Pittsburg, Oct., pp. 20 – 22, (1986).

10. Alrawadeh M., Aldajah S., "Tribological Characterization of the Sand Particles Concentration on Sliding Lubricated Contact", International Journal of Advanced Technology in Engineering and Science, 3(5), pp. 2348 – 7550, (2015).

11. Rabinowicz, E., "Friction and Wear of Materials", Wiley: New York, NY, USA, (1965).

12. Bhushan, B., "Introduction to Tribology", Wiley: New York, NY, USA, (2002).

13. Rabinowicz, E., "Friction and Wear of Materials, 2nd ed", Wiley: New York, NY, USA, (1995).

14. Khruschov, M. M., "Principles of abrasive wear", Wear, 28, pp. 69 – 88, (1974).

15. Yunus S., Abd-Rashid A., Abdul-latip S., Abdullah N. R., Ahmed M. A., Abdullah A. H., "Comparative Study of Unused Engine Oil (Perodua Genuine and Castrol Magnatec Oil) Based on Property Analysis Basis", Procedia Engineering, 68, pp. 326 – 330, (2013).

16. La Rocca A., Bonatesta F., Fay M. W., Campanella F., "Characterisation of Soot in Oil from A Gasoline Direct Injection Engine Using Transmission Electron Microscopy, Tribology International, 86, pp. 77 – 84, (2015).