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Tribological Performance of Nano-Diamond as Oil additives used in Massey Ferguson model 399 tractor Engines

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Today Nanotechnology has important role to reduce engine wear costs by using Nano particles in engine oils. Higher costs of repair and engine maintenance push engineers to employ technology. Regarding the remarkable role of Nanoparticles on oil efficiency, especially at high loads and pressure, Nanotechnology would be an important technology by reducing damages served to engine. Nano diamond is one of those additives which could practice less engine wear, special at high dust and haze conditions in agricultural demand with high loads. To study the effect of Nano oil on agricultural engines performance, eight Massey Ferguson model 399, tractors manufactured in Iran were studied. Those tractors were same in operating conditions; moreover, each block of experiment was based on hours and years of operation and maintenance conditions. Nano oil was used in four tractor engines and Behran turbo diesel oil with equal Nano oil characteristics was utilized in the others. Samplings were taken at 65, 90, 115, and 150 interval hours of operation. Subsequently, each sample was analyzed by atomic absorption spectrometry. In addition, Particle Quantifier (PQ), total base number (TBN), viscosity, fuel and water pollution tests were also applied. The results showed that usage of Nano diamond oil additive in agricultural tractor engines would reduce wear of Iron, Chromium and PQ by 50, 46 and 59 percent as compared to the base oil, respectively. In fact, Nano-oil utilized in agricultural tractor engines showed 17 percent more durability than base oil.

Introduction:

Most of contacting surfaces such as gears, bearings, and seals are lubricated with a specific lubricant to control the friction and wear in industry. Base oil is generally used in engines to reduce the scoff and wear of contacting surfaces. However, the base oil provides the poor tribological property so that it should be frequently exchanged to prevent the failure of engines performance. Therefore it is important to enhance the tribological properties of base oils. A lot of research has been conducted on the tribological performance of diamond Nanoparticles (He-long et al., 2007 & Chou and lee, 2008). The friction behavior can also be analyzed by considering the Stribeck curves [Cho et al. 2000 & Talk, 1996], which are the friction coefficient as a function of rotation speed, normal force and viscosity of oil. Briefly, the Stribeck curve presents the relationship between friction coefficient and lubrication conditions as seen in Fig. 1.

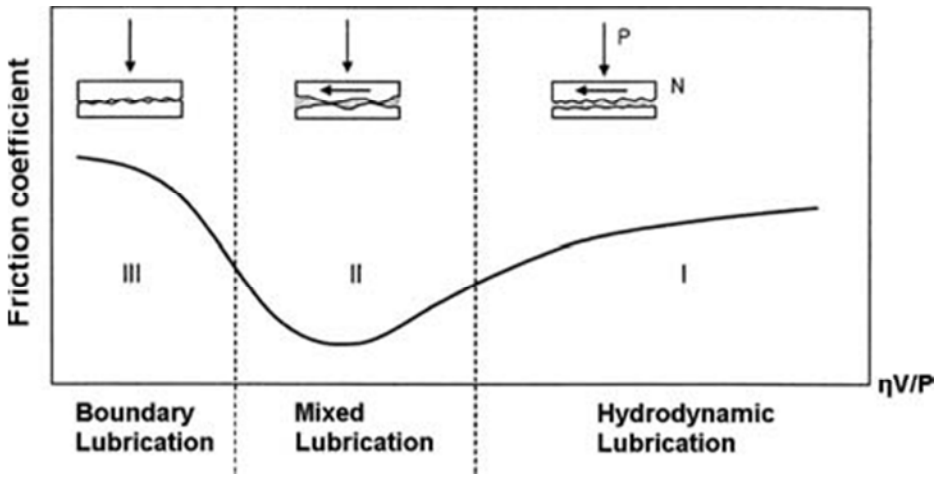

Fig 1 Stribeck curve and categorization of lubrication [8]

As one of the methods to enhance the tribological properties of lubricants, many researchers have added Nanoparticles in the lubricants. For example, Hisakato and Kanno [1999] carried out the friction and wear tests of ceramic disks by using fullerene Nanoparticles (1 wt.%) containing ethanol, and the topographical analysis was performed on the micro-asperities of the wear surfaces to observe the behavior of fullerene particles. It was expected that Nano-diamond additive could be increase the oil productivity in the engine, especially at high pressure and loads for agricultural operations. Basically, the reduction of damages by the

use of Nanotechnology is not only able to reduce the repair and maintenance costs, but they are also able to control the timelines costs.

Research Methodology:

This study addressed the using role of Nano oil on agricultural engines, performance of eight Massey Ferguson model 399, tractors manufactured in Iran in which the particle friction in the oil was recorded continuously as a function of the high load and elapsed time. A fullerene Nano-oil and base oil were prepared and tested in tractor engines to examine the direct effect and surface enhancement effect of Nanoparticles in lubricating oil. Eight Massey Ferguson model 399 tractors were used for this research. Those tractors were equal regarding operating conditions. The analysis of data in this study was performed by using a completely randomized block design. Each block of experiment was based on hours and years of operation and maintenance conditions. Engine model was four-stroke and also water-cooled Perkins diesel 1006. Tractors were working about six months in a year (at an average of 10 to 16 hours a day). The first oil sampling after 120 hours of operation was taken from each tractor while Behran azarakhsh oil (base oil) was used in tractor engines. The samplings were performed immediately after the engine was turned off. Nano oil was used in the four engines and Behran turbo diesel oil in the other engines with equal characteristics. Samplings were taken at 65, 90, 115, 150 hours of the operation. Finally, each sample was analyzed by atomic absorption, while viscosity, pollution of water, and fuel were also measured. The Particle Quantifier (PQ) is a ferrography screening tool. The PQ gives an index value that is not size dependent. This trendable value can assist in identifying large ferrous worn particles, whose size is greater than 10μm. This index helps to confirm growing normal wear, the onset of aggressive wear or the prospect of eminent catastrophic failure. Analyses of oil samples were calculated and oil type effect was studied on the engine's worn parts.

Result and Discussion:

The characteristics of engine wear, were investigated after using Nano, turbo and base oils in Massey Ferguson model 399 tractor engines. Reduce the friction coefficient and increases the load capacity of the friction parts in engine was exist by used of Nano-oil. A variety of mechanisms have been proposed to explain the lubrication enhancement of the Nanoparticle

suspended lubricating oil (i.e., Nano-oil), including the ball bearing effect, protective film, mending effect and polishing effect [Lui et al. 2004 & Tao et al. 1996].

These mechanisms can be mainly classified into two groups, as shown in Fig. 1. It is appear Nano diamond oil could reduce the friction coefficient by reduce wear in boundary and hydrodynamic lubrication.

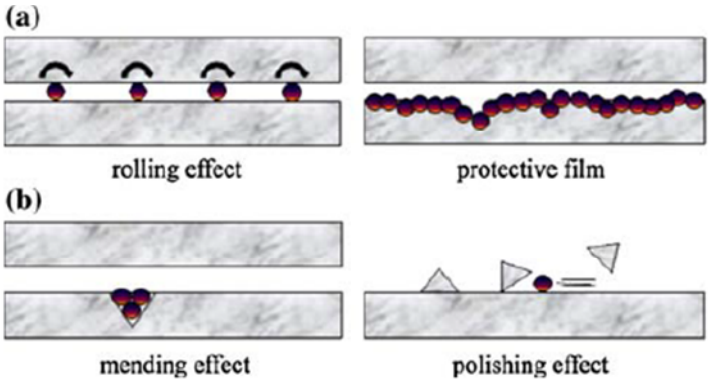

Fig. 2. Possible lubrication mechanisms by the application of nano oil

The use of Nano diamond in agricultural tractor engines as an oil additive reduced the rubbing in parts engine. Fig 3 shows the comparison of particles wear in used of Nano and base oil in agricultural tractor engines. Results showed that Nano-diamond oil can reduced the wear in Iron, Chromium, Aluminum, Copper and Molybdenum. The amount of reduced for those elements was 23.58, 1.26, 16.6, 13.7 and 6.7, respectively after 120 hr. Lubrication properties of both Nano-oils and base oil were evaluated by employing a disk-on-disk type tester. The lubrication tests were performed by measuring the friction surface temperature and friction coefficient at the disk-on-disk type tester under the various normal forces and fullerene volume fraction [Ishikawa et al. 2006]. The Stribeck curves [Xiao et al., 2003], which will be discussed in detail later, were introduced for Nano-oils and raw base oil to interpret the experimentally determined tribological properties of various oils. Particle quantifier in tractor engines was significant. Nano oil could reduced the amount of PQ by 23.5 rather than base oil after 120 hr. The first reason of this Phenomenon is the direct effect of the Nanoparticles on lubrication. Nano-diamond in lubricating oil plays the role of ball bearings between the friction surfaces. In addition, they also make a protective film to some extent by coating the rough friction surfaces. The other is the secondary effect of the presence of Nanoparticles on surface enhancement. The Nanoparticles deposit on the friction surface and compensate for the loss of mass, which is known as mending effect [9]. And also the roughness of the lubricating surface is reduced by Nanoparticle-assisted abrasion, which is known as a polishing effect [Tao and et al., 1996].

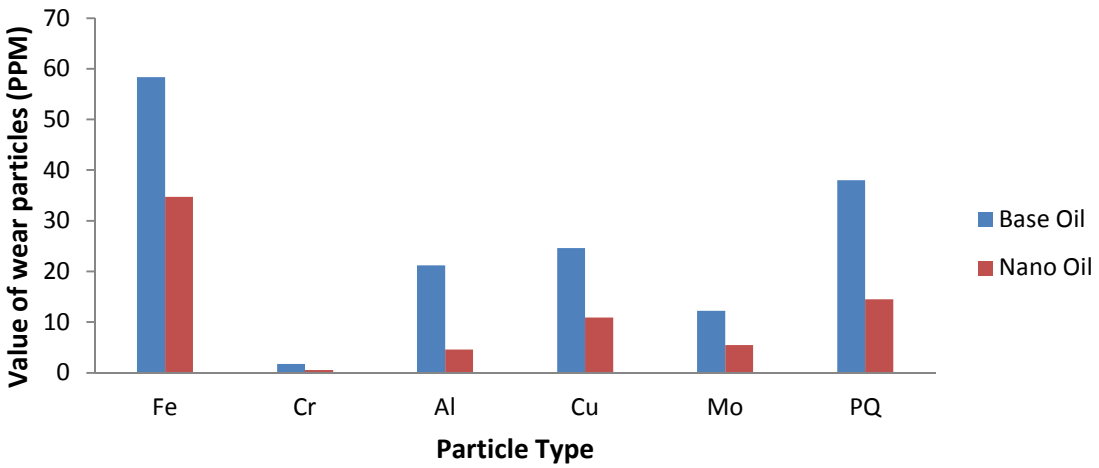

Fig 3 Effect of oil type on the engine parts wear

The friction coefficient for both Nano-oil and base oil were evaluated by varying the operating friction surface wear particle and PQ and also including the parameters temperature evaluated by TBN and viscosity changes. The friction coefficient of specimens in the tractor engines was significantly reduced by presence of Nano-particles in lubrication oil. As the results of various friction particles in lubrication oil between friction surfaces tests under presence of Nano-particles in the lubrication oil was observed to improve the lubrication performance in the friction surfaces by reducing the metal surface contacts.

Results indicate that the enhanced lubrication properties of the Nano-oil are due to the presence of Nano-diamond particles, which play the role of an abrasive material. According to the Fig 3, be used of turbo oil in tractor engines the amount of wear intensity increased in over time while wear intensity was lower in used of Nano-diamond oil. The experiments show Nano-particles as lubrication oil additive has good tribological property. Specially, it can represent excellent characteristics in aspects of reducing friction coefficient, increasing anti-wear property and self-repairing minute damage caused by friction (Tarasov and et al., 2002 & Bin-shi, 2004). As one can see that the friction coefficients for used of Nano-oil was less than that of base oil. It indicates that less metal contacts appear to be occurred in the presence of Nano-Diamond particles in engine oil. There are many methods for evaluation of dispersion stability. One method is the research of tribological property. This method is more credible and applied in scientific research and productive practice (Shi-tao and Ping, 2002). The Nanoparticles in the Nano-oil acted as the combination of rolling and sliding bearings between the frictional surfaces, leading to a significant decrease in friction coefficient;

approximately 67% and 88% at 200 N and 800 N, respectively, compared to the base oil (Lee and at al, 2009). The enhancement of lubrication property in the Nano-oils is also resulted from the surface modification by the presence of abrasive Nanoparticles to some extent. After severe surface modification was occurred by the prior Nano-oil lubrication, the friction coefficient of the specimen was rarely changed even without Nanoparticles in the new lubrication oil, indicating that the surface modification occurred by Nanoparticle abrasion significantly enhances lubrication property (Lee and at al, 2009). Hsiao et al (2009) previously reported a large reduction in the friction appeared after adding 2% or/and 3% of the Nano-diamond lubricant additive to a base oil.

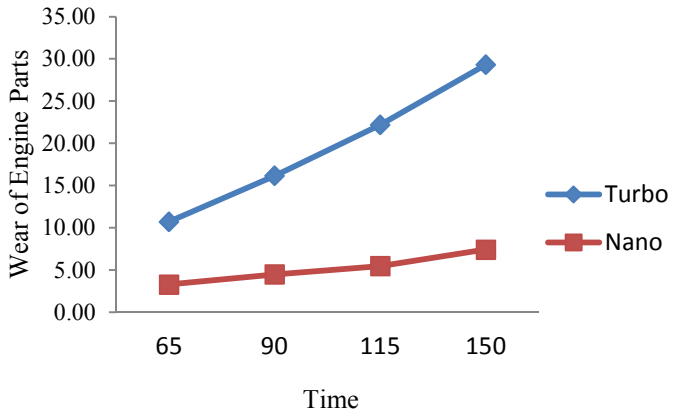

Fig 4 Effect of oil type on the wear of engine parts in over time

Conclusion:

In this work, the lubrication tests of Nano-oils and base oil were conducted, focusing on the effect of Nano particles additive on the lubrication properties of tractor engine oil. We have demonstrated a simple method to identify the role of Nanoparticles in lubrication using in high loads and haze condition. The used of Nano oil in tractor engines has many merits, such as simple operation, short process flow, low production costs and could realize commercial process. The dispersion stability of Nano-particle as lubrication oil additive is one of the key problem to realize good lubrication effect because Nano-particle easily agglomerate in liquid medium. So Nano-Diamond needs surface treatment for improving dispersion stability. By adding Nano-Diamond additive reduces the friction coefficient of lubrication oil. The results showed that usage of Nano diamond oil additive in agricultural tractor engines would reduce wear of Iron, Chromium and PQ by 50, 46 and 59 percent as compared to the base oil,

respectively. The results expresses that Nano- Diamond additive has stable tribologieal property, and Nano additive has excellent dispersion stability in lubrication oil.

References

1. CC. Chou, SH. Lee, "*Rheological behavior and tribological performance of a Nanodiamond-dispersed lubricant*", J of materials processing technology, 201 (2008) 542–547.
2. F.E. Talke, "A review of contact recording technologies", Wear 207, (1997) 118–121.
3. G. Liu, X. Li, B. Qin, D. Xing, Y. Guo, R. Fan, "*Investigation of the mending effect and mechanism of copper Nano-particles on a tribologically stressed surface*". Tribol. Lett. (2004) 17, 4.
4. J. Lee, S. Cho, Y. Hwang, H. Cho, C. Lee, Y. Choi, B. Ku, H. Lee, B. Lee, DS. Kim, "*Application of fullerene-added Nano-oil for lubrication enhancement in friction surfaces*", Elsevier, Tribology International 21, (2009) Figure 5.
5. L. Xiao, B.G. Rosen, N. Amini, P.H. Nilsson, "*A study on the effect of surface topography on rough friction in roller contact*", Wear 245, (2003) 1162–1169.
6. S. Tarasov, A. Kolubaev, S. Belyaev, M. Lerner, and F. Tepper,. "*Study* of *friction reduction* by *Nanocopper additives* to *Motor oil*". Wear, 252 (1–2), (2002) 63–69.
7. S. W. Cho, S. M. Choi and C. S. Bae, "*Frictional mode of barrel shaped piston rings under flooded lubrication*" Tribol. Int. 33, (2000) 545–551.
8. T. Hisakado, A. Kanno, "*Effects of fullerene C60 on the friction and wear characteristics of ceramics in ethanol*", Tribol. Int. 32, (1999) 413– 420.
9. T. Ishikawa, K. Hiratsuka, T. Sasada, "*Role of water in the lubrication of hydrogel*", Wear 261, (2006) 500–504.
10. W. Shi-tao, H. Ping. "*Tribology Fundamentals [M]*". Beijing: Tsinghua University Press, (in Chinese) (2002) 132-145.
11. X. Tao, Z. Jiazheng, X. Kang, "*The ball-bearing effect of diamond Nanoparticles as an oil additive*". J. Phys. D Appl. Phys. 29, (1996) 2932–2937.
12. XU. Bin-shi, "*Nanosurface Engineering [M]*", Beijing: Chemical Industry Press, in Chinese, (2004) 123- 132.
13. Y. He-long, S. Pei-jing, X. Bin-shi, W. Xiao-li, L. Qian, "*Tribological properties and lubricating mechanisms of Cu Nanoparticles in lubricant*", Academy of armored force engineering, Beijing 100072, (2007) 1-6.
14. Y. Hsiao, W. Hsub, J. Linb, "*The anti-scuffing performance of diamond Nano-particles as an oil additive*", Wear, Kun Shan University, China, 2009, 956-967.