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Investigation the effect of using Nano lubrication on fuel and oil costs for agricultural tractors

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ABSTRACT

The reduction of fix and variable costs has significant impacts on proper machinery management. To measure the effects of new machinery management on fuel and oil consumption, a study was conducted using empirical data on eight Massey Ferguson 399 model agricultural tractors at Amir-Kabir agro-industry, Iran in 2011. The performance of Nano-Diamond additive oil was compared with conventional oils. Results were shown that naturally low coefficient of friction combined with excellent chemical inertness made these additives very attractive in a wide range of applications in engine oils. Also, results shown : 21% and 25% reduction in fuel and oil consumption, respectively where Nano-Daimond additives was applied in oil and consequently a reduction of pollution was measured on engine exhausts. The use of Nano-Daimond oil shown a better performance for the reduction of fuel and oil on tractor engines' costs by 14% where compared to the conventional oil.

Introduction

There have been many investigations on the tribological properties of lubricants when different Nanoparticles were added. Surface roughness of engine parts plays an important role in the control of tribological properties. The Nano oils penetrated in narrow and very small holes and reduced the surface roughness of engine parts. This property increased the insulator through the surface and also reduced the surface contacts. The sphere-like Nanoparticles may result in rolling effect between the rubbing surfaces, and the situation of friction was changed from sliding to rolling. Tao et al. [8] investigated diamond Nanoparticles as an oil additive and found that under boundary lubricating conditions, the ball-bearing effect of diamond Nanoparticles existed between the rubbing surfaces, the surface polishing and the increase in surface hardness effects of the diamond Nanoparticles were the main reasons for the reduction in wear and friction [8]. Rapoport et al. [7,4–1] reported that the friction properties of the particles in oil were attributed to the following three effects: (a) the spherical shape of IF opens the possibility for an effective rolling friction mechanism; (b) the IF Nanoparticles serve as spacer, which eliminate metal to metal contact between the asperities of the two mating metal surfaces; and (c) third body material transfer. Third body can be considered as a mixture of oil, solid lubricant Nanoparticles, and wear particles [5]. With increasing load, the IF Nanoparticles penetrate into the interface, protecting the rubbed surfaces from a direct contact and thus increase the load-carrying capacity [6]. This paper investigates the effect of Base, Turbo and Nano- Diamond oils in Massey Ferguson tractor engines, on the friction parts, fuel and oil consumption. The effects of Nano oil additives on engine performance, fuel and oil consumption were investigated in the experimental fields and operating conditions. It was observed that Nano oil can be used in tractor engine without any problem in terms of engine performance.

Material and Methods

This study examined the tribological properties of lubricating oils with and without Nanoparticles, namely; Base, Turbo, and Nano-Diamond oils. These oils properties are shown in Table 1. Test experiments were conducted on eight reciprocating six-cylinder engines, Massey Ferguson model 399 tractor. Tractors were working about six months in a year (at an average of 10 to 16 hours a day). They were being used for soil preparation and sugarcane transportation in high dust haze conditions. The first oil sampling after 120 hours of operation was taken from each tractor while 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 characteristic tests such as spectrometric, TBN, viscosity and the pollution of water and fuel were performed utilizing test equipments presented in laboratory of oil test, company of Alborz-Tadbir karan, Iran. The spectrometric test was conducted to measure chemical elements in the particles and also to recognize amount and types of chemical compounds. Spectroscopy is a technique for detecting and quantifying the presence of elements in the oil and is Based on the ASTM D-6595 standard. The intensity of the emitted light was proportional to the quantity of the element present in the sample allowing the concentration of that element to be determined. Other indicators were viscosity and viscosity index (VI) and also TBN. The kinematic viscosity of the lubrication oil was measured at 40°C, in mm_2/s and were Based on the ASTM

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D445 standard. Also, fuel consumption was measured using the full tank method in all the experimental stages.

This study examined the tribological properties, fuel and oil consumption of lubricating oils with and without Nanoparticles, namely; Base, Turbo and Nano oil. Nano-Diamond oil was provided by Naniax company in Iran.

Results and Discussion:

Particles wear:

Fig 1 shows the effect of oil types on particles wear in over time. The ratio of Cr wear was uniform where the use of Nano oil was measured, while for conventional oil, wear increased from (90 – 150 h) and arrived to 18.27 in 150 h. According to the Fig 1, Nano oil also showed a lower wear as compared to the Turbo oil for other particles. The sphere-like Nanoparticles may result in better rolling effect between the rubbing surfaces when the boundary lubrication occurs, such that the lubricant with Nanoparticles achieved good friction reduction performance. The performance of Nanoparticles on rolling effect was also reported by Rapoport et al. [7] and Tao et al. [8]. It appears the Turbo oil must be changed after 90 hr of operation in order to prevent of excessive wear, while the oil change was not necessary until 150 hr where Nano oil was used. The ratio of Cr wear in applied Nano oil in tractor engines was 15.8 lower than Turbo oil. Actually, the Nano particles protected the engine parts against friction. Lee et al. (2009) found that the friction coefficient of the Nano-oil was less than that pure oil over the entire orbiting speed ranges between 300 and 3000 rpm [3]. The anti-wear mechanism was attributed to the deposition of Nanoparticles on the worn surface, which may decrease the shearing stress, thus improving the tribological properties. 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. The Nano-additive reduced the risk of direct metal–metal contact hence achieving a very positive tribological role against surface adhesion, wear, and eventually global friction [2]. The value of the particles wear decreased during the used of Nano oil. Tao et al. (1996) investigated diamond Nanoparticles as an oil additive and found that under boundary lubricating conditions, the ball-bearing effect of diamond Nanoparticles existed between the rubbing surfaces, the surface polishing and the increase in surface hardness effects of the diamond Nanoparticles were the main reasons for the reduction in wear and friction [8]. The deposition of Nanoparticles on the worn surface can decrease the shearing stress, and hence reduce friction and wear. The sphere-like Nanoparticles may result in rolling effect between the rubbing surfaces, and the situation of friction was changed from sliding to rolling. Therefore, the friction coefficient could be reduced. Under low-load conditions, the rolling friction was a dominant mechanism, because the shape of IF Nanoparticles was preserved. On the other hand, under high-load conditions, the IF film at the asperity crests attributed to the addition of Nanoparticles can decrease the straight asperity contact and increase wear resistance [5]. For the anti-wear test, when CuO was added to the SF oil and the Base oil, the worn scar depths were decreased by 16.7 % and 78.8%, respectively, as compared to the oils without Nanoparticles. For the friction-reduction test, when CuO was added to the SF oil and the Base oil, the friction coefficients were reduced by 18.4% and 5.8%, respectively, as compared to the oils without Nanoparticles [9].

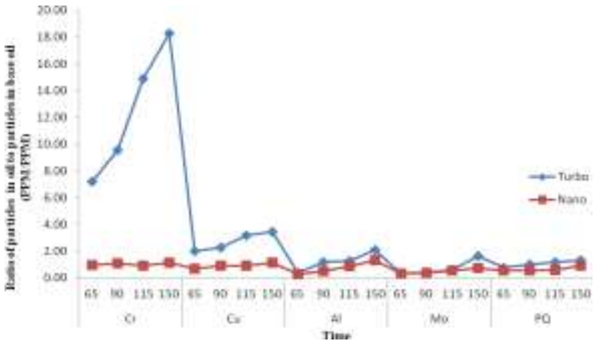

Figure 1 Effect of oil types on particles wear in the over time.

Fuel consumption:

According to Fig 2 the amount of feul consumption in employed Turbo oil in tractor engines increased as compared to the Base oil while the amount of consumption fuel reduced in used of the Nano oil. Fuel consumption in used of the Nano oil reduced by 0.45 lit/hr as compared to the Base oil. It appears wear on the engine parts reduced and also oil productivity increased in used of the Nano daimond-additive. The higher viscosity increases the Sommer field number, such that the lubrication regime may change from boundary lubrication into mixed or hydrodynamic lubrication, so a lower friction coefficient can be observed at lower temperature. Inordinate usage of Turbo oil (for 150 hr) reduced the effectiveness and thereupon increased the fuel consumption by 0.67 lit/hr as compared to the Base oil. It can be seen the Nano particles reduced the friction coefficient and wear scar diameter (particle quantifier) and also increased the isolation between engine parts and compression in cylinder chamber as compared to the pure oil. Reduction in engine efficiency and oil performance, has occurred due to excess usage of the Turbo oil. Fig 2 shows the effect of additive types on fuel consumption for the Base, Turbo and Nano oil. As can be seen, the fuel consumption of the Nano-Diamond oil was low as compared to the Base oil. Actually, the average fuel consumption of the Nano-Diamond oil was decreased by 21%, as compared to the Base oil without Nanoparticles.

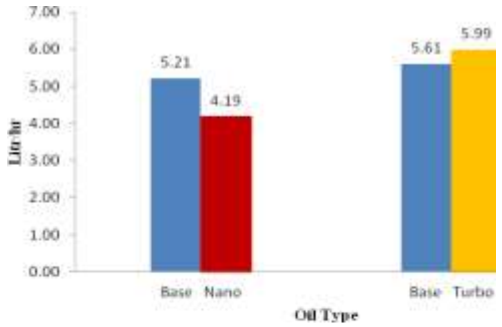

Figure 2 Effect of additive types on fuel consumption in Massey Ferguson 399 model tractors.

Oil consumption:

Table 1 shows the effect of oil additives on the total Base number and oil durability. According to Fig 3 the durability of the Nano and Turbo oil was 9.74 and 9.21, respectively (for 150 hr operation) and also TBN shown for Base oil in every engine (for 120 hr operation). In this experience durability of the Nano oil was higher compared to the conventional and Base oil. By employing the Nano oil, reduction in the trend of the TBN losses created by reducing in friction and oil sediment. The anti-wear mechanism was attributed to the deposition of CuO

Nanoparticles on the worn surface, which may decrease the shearing stress, thus improving the tribological properties [9]. It seems that the best results were achieved in the change of the Nano oil in 150 hr operation, while conventional oil must change earlier. Increasing in the fuel consumption occurred when used of the Turbo oil for 150 hours.

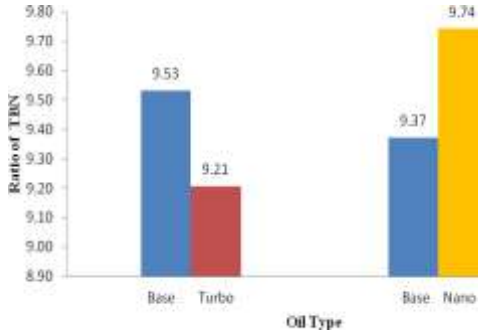

Figure 3, Effect of additive types on oil consumption in Massey Ferguson 399 model tractors

Effect of additve types on fuel and oil costs:

The oil consumption reduced where Nano oil was used. Table 2 shows the effect of oil types on the fuel and oil consumption costs for engines of Massey Ferguson model 399 tractor (for 150 hr operation). The pre-results was shown that Nano oil price per every liter was more expensive as compared to the other oils. Hence, tractor drivers have to pay more money for buying Nano oil. On the other hands, the fuel consumption for Nano oil was lower than Turbo and Base oils (Table 2). Also, the fuel consumption in employed of the Turbo oil was higher where it was compared to the Base oil. It appears that occurred by excess usage of the Turbo oil and attributes losses. Recent experiments revealed that addition of Nano particles on lubricants results in better viscosity as compared to that of oils without addition of Nano-particles. Consequently, the total costs reduced in used of Nano oil as compared to the Turbo and Base oils (Fig 4). There was the most total costs (fuel and oil) in used of the Turbo oil as compared to the Nano and Base oils. As a result of, employed Turbo oil for 150 hours increased the total costs. It appears the employing of the Turbo oil in the lower time will be created the better results in reduction the total costs.

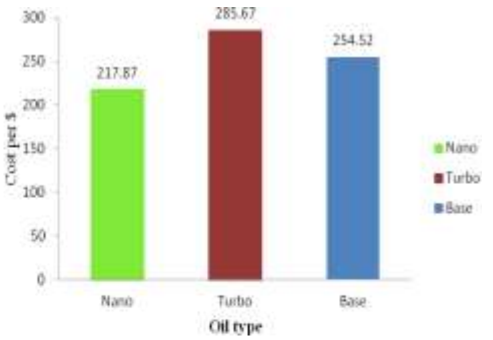

Figure 4, Effect of additive types on total cost (fuel and oil consumption) in Massey Ferguson 399 model tractors.

Conclusion:

It was found that, wear reduced by use of Nano oil for lubrication the tractor engines as compared to the Turbo oil shown the same specifications. There was reduction in wear intensity of the tractor engine parts, by the use of Nano oil for lubrication. Nano-Diamond used as additives in lubricating oils revealed useful life of the oil and anti-wear behavior. Eventually, the investigations showed as 21% and 25% reduction on fuel and oil consumption, respectively. It was found that Nano-Daimond oil has a better performance for the reduction in fuel and oil on tractor costs by 14% as compared to conventional oil. The outcome shows that the employed Turbo oil for 150 hours increased the total costs by 12 percent.

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Table 1. The peroperties of oils, employed in Massey Ferguson 399 model tractors

Properties	Base oil	Turbo oil	Nano oil
Level of quality	CD/SE	CH-4/CG	CH-4/CG
Kinematic viscosity (cSt @ 40 °C)	191.22	182.04	183.48
Viscosity index	115	120	120

Table 2. The effect of oil types on fuel and oil consumption in Massey Ferguson 399 model tractors

Type oil	Oil consumption (Litr)	Cost for 150 hours ($)	Fuel consumption (Litr)	Cost for 150 hours ($)
Nano	14.5	38.43	628.05	179.44
Turbo	14.5	29	898.35	256.67
Base	18.13	27.38	795	227.14