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Experimental Study on The Performance of Nano Lubricant in Light Vehicle Engine

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ABSTRACT

The purpose of this study was to analyze the performance of conventional engine oil, additive, vegetable oil and nano lubricant in terms of power and torque. In this study, 70 nm hexagonal boron nitride (hBN) was dispersed in conventional engine oil (SAE10W40), additive and RBD palm oil. The engine performance was then tested with a chasis dynamometer using a Satria 1.5 cc engine vehicle. The result obtained from the dyno test shows the average maximum torque and power had increased by 0.45 % and 1.03 % respectively when the composition of hBN nano was added into the mixture of conventional engine oil, additive and RBD palm oil. These experimental studies show the potential of hBN and RBD palm oil as an additive for improving engine performance.

1. Introduction

Lubricants perform as anti-friction media. They play a major role in reducing the wear and friction between the two surfaces in contact with each other [1,2]. Due to relative movement between the machine components, a resistive force called friction is developed which causes wear and tear of machine parts. Friction can be minimized by interposing a substance of low shear strength between the two moving surfaces [3-5].

Due to growing environmental concerns, the increasing number of vehicles and the depletion of crude oil reserves in the world, have renewed interest in developing and using biodegradable lubricants derived from alternative sources [6,7]. Therefore, developing biodegradable functional lubricants has become a top priority in the lubricant industry [8,9].

Vegetable oil is much concerned as renewable source and possesses high biodegradability compared to mineral oil. Compared with mineral oils, vegetable oils have several properties that are required in a lubricant, such as a high viscosity index, high lubricity, low volatility and advanced properties that can be compared to mineral oil, including low toxicity and high biodegradability [10-12].

The additive is usually chemically-dissolved within the oil and acts on the contaminants and components rather than on the oil itself. The specific properties produced by an additive will help to

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enhance the oil properties that are already present in the lubrication oil. Besides that, an additive can increase the service life of lubrication oil by reducing the rate at which undesirable changes take place in the product. Without many of these, the oil would become contaminated, break down, leak out or not properly protect engine parts at all operating temperatures [13,14].

Nano lubricant is a new kind of engineering lubricant made of nanoparticles, dispersant and base lubricant. Nano lubrication offers a solution to many problems related to conventional lubricants. Nano-powders of some metals and their compounds are used and especially effective influence on the characteristics of lubricants. One approach is simply the use of additives in the base lubricant to change its properties. The ability of nano-sized particles to pass through conventional filters, and penetrate contacts that larger particles along with the enhanced scale-dependent properties of the nano-sized particles have made them a promising new type of lubricant additive. Hence, the nanoparticles will reduce friction as well as for efficient long-term engine protection [15-18].

2. Methodology

2.1 Lubricant Preparation

The lubricants that were needed for this experiment were SAE 10W40 engine oil, BARDHAL B1 (Engine treatment) and RBD palm oil. The type of nanoparticles used for this experiment was Hexagonal Boron Nitride (hBN). All lubricant engine oil, additive and RBD palm oil with a certain volume concentration were mixed. The volume of the lubricant used was 3.8 litres for the test lubricant. Table 1 shows the variation of the volume fraction of nanoparticle, ø.

Table 1
Variation of volume fraction of nanoparticle, ø

Volume fraction of nanoparticle (%)	Volume of nanoparticle (cm^3)	Mass of nanoparticle (gram)
0.0	0	0
0.01	0.38	0.87
0.05	1.90	4.37
0.07	2.66	6.12
0.1	3.80	8.74

The various composition of lubrication is as in Table 2 and 3.

Table 2
Composition (Vol %) of lubricating oils

Sample no.	Compositions (Vol %)			
	SAE 10W40 (%)	Additive (BARDHAL B1) (%)	RBD palm oil (%)	hBN (%)
1	92	6.58	1.32	0
2	92	6.58	1.32	0.01
3	92	6.58	1.32	0.05
4	92	6.58	1.32	0.07
5	92	6.58	1.32	0.1

Table 3
Composition of lubricating oils (ml)

Sample no.	Compositions			
	SAE 10W40 (ml)	Additive (BARDHAL B1) (ml)	RBD palm oil (ml)	hBN (g)
1	3500	250	50	0
2	3500	250	50	0.87
3	3500	250	50	4.37
4	3500	250	50	6.12
5	3500	250	50	8.74

2.2 Preparation of Nano Lubricant

The hBN nano-powder of 70 nm was prepared by dispersing in SAE 10W40 diesel engine oil, BARHAL B1 (Engine treatment) and RBD palm oil. Four hBN nano lubricant samples at different concentrations as per Table 1 were prepared for this experiment. The mass of nano powder for each sample was weighted using analytical balance. Each sample of nano was circulated with the mixture lubricant for 1 hour using a digital high-speed overhead stirrer. A stirrer was inserted into the container and operated continuously at 300 rpm to mix continuously.

2.3 Experimental Method

In this study, the performance test was conducted using a chasis dynamometer, a two-wheel drive type to determine the power and torque of the vehicle engine. For this study, Satria 1.5cc engine car (Figure 1) was used to evaluate the performance of hBN nano lubricant in the engine. The vehicle was parked on the rollers with its drive wheels on the corresponding rollers. Before starting the test, the original engine oil was drained out and replaced by nano lubricant. The O_2 sensor was placed at the vehicle exhaust to obtain the air-fuel ratio. The engine was connected with two wires. The first wire was connected to the engine regulator for fuel reading and another wire, connected to the spark plug for ignition reading at the engine. For running the test, the dyno driver accelerated the engine at different speeds. The vehicle's drive wheels span on corresponding rollers and give output to the screen. Power and torque were recorded by Dyno Dynamics software (Figure 2). The experiment was carried out at various speeds from 1500 - 4500 rpm to ensure the results were precise and reliable.

Fig. 1. Dyno test at various speeds from 1500 - 4500 rpm

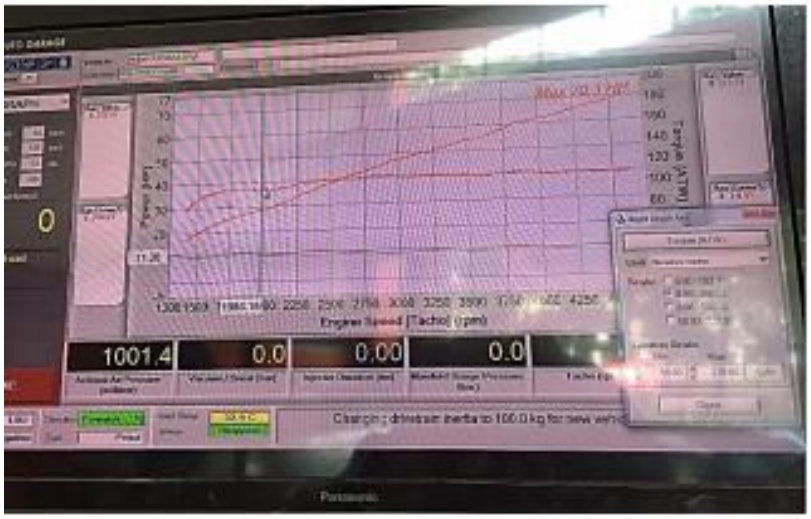

Fig. 2. Power and torque were recorded by Dyno Dynamics software

3. Results and Discussion

3.1 Engine Performance Analysis of Engine Oil, Additive and RBD Palm Oil

From the tests that have been done, data obtained in the form of power and torque from the engine on the use of a mixture of engine oil SAEl OW40, additive and RBD palm oil. The test was done at an engine speed of 1500 - 4500 rpm.

From Figure 3, a comparison mixture of engine oil and additive with a mixture of engine oil, additive and RBD palm oil was made. The graph shows the maximum power for a mixture of engine oil, additive and RBD palm oil that was 71.7 hp compared to the lubricant without the addition of RBD palm oil, 71.6 hp. The power increased between both tests (0.14 %).

For the torque performance, the maximum torque for a mixture of engine oil, additive and RBD palm oil was 116.16 Nm and for lubricant of engine oil and additive was 115.21 Nm at 3142.39 rpm. The torque increases about 0.82 %.

Results showed that RBD palm oil addition to the engine oil and additive caused an increase in terms of torque and power. It can be concluded that vegetable oils have potential as lubricants.

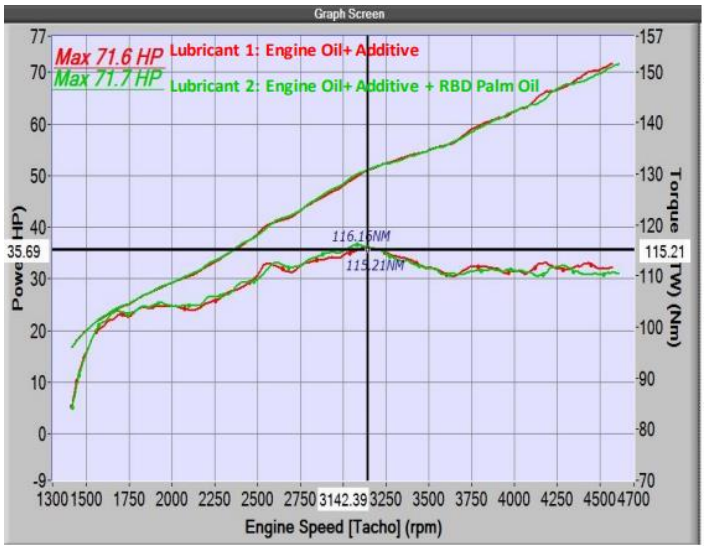

Fig. 3. Comparison of power and torque performance between engine oil + additive and engine oil + additive + RBD palm oil

3.2 Engine Performance Analysis of Engine Oil, Additive, RBD Palm Oil and hBN Nanoparticles

The mixture of engine oil SAE10W40, additive, RBD palm oil and hBN nano 0.01 - 0.1 % had been tested at various speeds 1500 - 4500 rpm. Table 4 - 7 below show the result from the dyno test.

Table 4
Power performance (hp) result

Speed (RPM)	Power (hp)				
	Engine Oil + Additive + Palm Oil	Engine Oil + Additive + Palm Oil + 0.01 % Nano	Engine Oil + Additive + Palm Oil + 0.05% Nano	Engine Oil + Additive + Palm Oil + 0.07 % Nano	Engine Oil + Additive + Palm Oil + 0.10 % Nano
1500	20.34	20.77	20.99	20.77	21.43
2500	39.05	38.27	39.48	38.27	39.80
3000	48.53	47.01	47.67	47.67	48.98
3500	54.92	52.92	53.57	54.23	54.66
4000	62.74	61.22	61.22	61.44	62.76
4500	70.79	68.66	67.57	68.66	70.19

Table 5
Power performance (%) result

Speed (RPM)	Power (%)			
	Engine Oil + Additive + Palm Oil + 0.01 % Nano	Engine Oil + Additive + Palm Oil + 0.05 % Nano	Engine Oil + Additive + Palm Oil + 0.07 % Nano	Engine Oil + Additive + Palm Oil + 0.10 % Nano
1500	2.11	1.06	-1.05	3.18
2500	-2.00	3.16	-3.06	4.00
3000	-3.13	1.40	0.00	2.75
3500	-3.64	1.23	1.23	0.79
4000	-2.42	0.00	0.36	2.15
4500	-3.01	-1.59	1.61	2.23

Table 6
Torque performance (Nm) result

Speed (RPM)	Power (Nm)				
	Engine Oil + Additive + Palm Oil	Engine Oil + Additive + Palm Oil + 0.01 % Nano	Engine Oil + Additive + Palm Oil + 0.05 % Nano	Engine Oil + Additive + Palm Oil + 0.07 % Nano	Engine Oil + Additive + Palm Oil + 0.10 % Nano
1500	95.32	95.70	97.96	98.57	101.33
2500	111.7	108.37	109.29	108.67	111.73
3000	114.04	110.82	112.35	112.96	116.02
3500	112.87	108.37	108.98	110.2	111.43
4000	112.28	108.67	109.29	109.29	111.73
4500	112.28	107.45	107.45	108.06	110.82

Table 7
Torque performance (%) result

Speed (RPM)	Power (%)			
	Engine Oil + Additive + Palm Oil + 0.01 % Nano	Engine Oil + Additive + Palm Oil + 0.05 % Nano	Engine Oil + Additive + Palm Oil + 0.07 % Nano	Engine Oil + Additive + Palm Oil + 0.10 % Nano
1500	0.40	2.36	0.62	2.80
2500	-2.98	0.85	-0.57	2.82
3000	-2.82	1.38	0.54	2.71
3500	-3.99	0.56	1.12	1.12
4000	-3.22	0.57	0.00	2.23
4500	-5.29	0.00	0.57	2.55

Figure 4 shows the graph of torque and power obtained from dyno engine testing at various rpm. It showed the addition of hBN nanoparticles with a mixture of engine oil, additive and RBD palm oil caused an increase in terms of torque and power. The maximum power increased from 71.6 hp for the mixture of engine oil, additive and RBD palm oil to 74.6 hp with the addition of hBN nano 0.1 % at 4900 rpm. The results show by the addition of nanoparticles, the power performance increases and the increment of the performance was about 4.2 %. The average maximum power increment of hBN 0.01 - 0.1 % nano lubricant was 1.03 %. This shows that by addition of nanoparticles, will increase engine efficiency due to the smoothness of engine operation.

From the graph, it can be seen that the power of the engine increases and passes the point maximum of the torque at 3000 rpm because power is torque that is multiplied by speed. The engine was most efficient between 2500 rpm and 3000 rpm means that those speeds is the best time the engine breathes. Furthermore, as the speed increases, it gets harder and harder to get the optimal amount of air and fuel into the cylinder and burn it at the optimal rate. The faster the engine speed, the less available to exhaust the burnt gases.

The above graph shows the torque for engine oil, additive, RBD palm oil and 0.10 % of nano lubricant started at a speed of 1500 rpm was 101.33 Nm. The torque increased until it reached a maximum torque of 116.02 Nm at 3000 rpm. Then the torque of the engine decreased to 111.43 Nm at 3500 rpm. The increment of torque value from 1500 rpm until maximum torque at 3000 rpm was about 14.5 %. The average torque increment of nano 0.01 - 0.1 % lubricant was 0.18 %.

The graph shows at lower rpm from 1400 rpm until 2400 rpm the torque gave lower torque value, until the speed reached 2500 rpm the torque value increased. The maximum torque obtained for this test was at 3000 rpm and the torque value begins to drop as the engine speed increases. This shows this engine was running at an acceptable rpm range at 2500 – 3000 rpm which is the time for cylinders to be filled with air and gasoline. The more air and gasoline, the more powerful the engine will be at a given rpm because more fuel-air mix translates to greater torque and thus greater power.

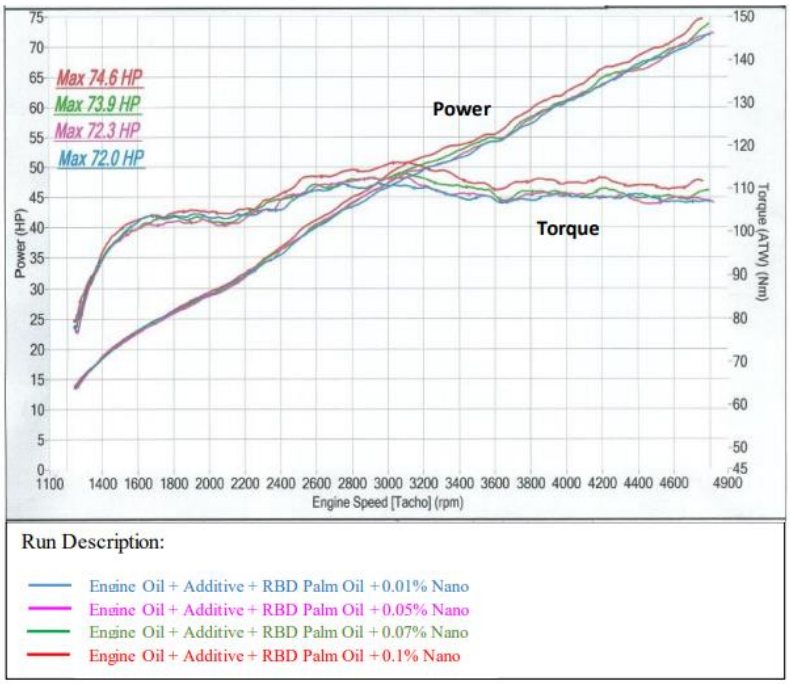

Fig. 4. Graph of engine power and torque performance for engine oil, additive, RBD Palm Oil and hBN Nano 0.01 - 0.1 %

Figure 5 and 6 show the power and torque performance of engine oil, additive, RBD palm oil and hBN nano 0.01 - 0.1 %. It can be seen in Figure 5 and 6 that at lower speeds the torque and power performance lubricant for nano (0.01 - 0.07 %) was not consistently compared at high speeds. Observed that the average power and torque performance for 0.1% nano increased by 2.52 % and 2.35 % respectively compared to the others.

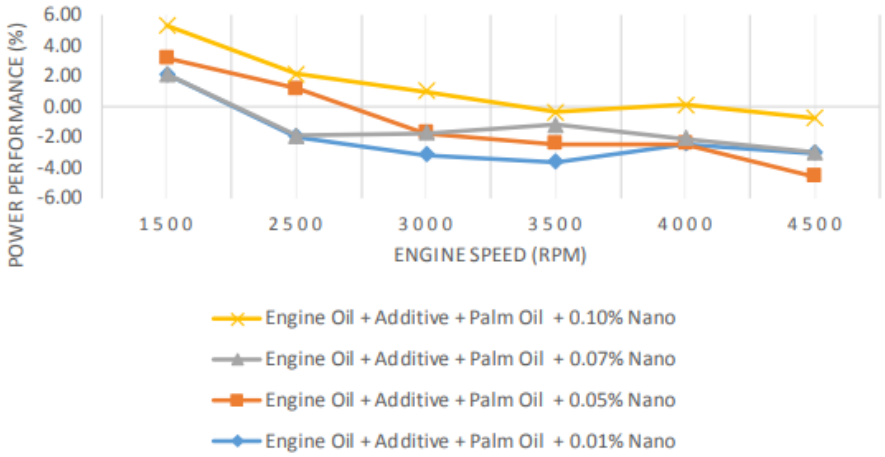

Fig. 5. Graph of power performance (%) for engine oil, additive, RBD palm oil and hBN nano 0.01 - 0.1 %

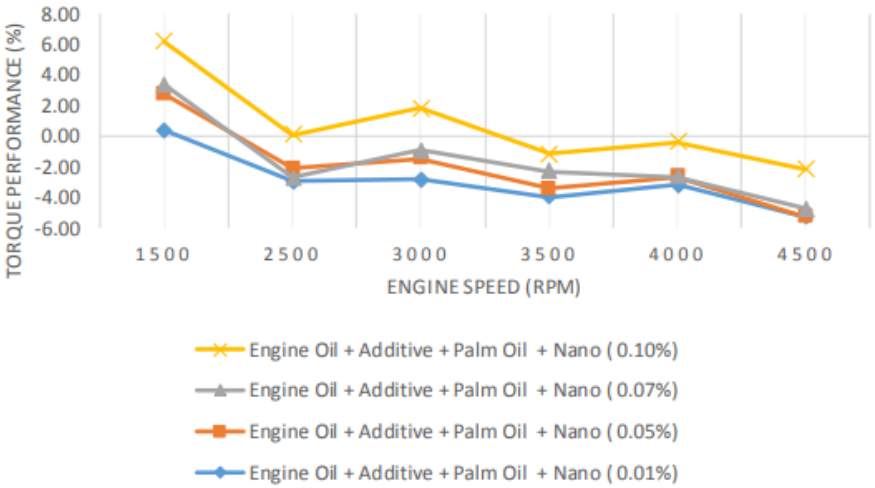

Fig. 6. Graph of torque performance (%) for engine oil, additive, RBD palm oil and hBN nano 0.01%-0.1

The maximum power and torque graph has been plotted in Figure 7. The graph illustrates the maximum power increased as the engine speed increased. Maximum power was achieved at high speeds and high load. From the graph, the highest maximum power recorded at nano lubricant was 0.10 % and relatively the performance increased by 0.95 %. The highest reading for maximum torque obtained was by applying nano lubricant 0.10 %. The percentage increment of the torque performance was 2.71 % compared with other nano compositions.

The above explanation shows that the addition of hBN nanoparticles in the mixture of lubricant of engine oil, additive and RBD palm oil gave better engine performance. Several factors also made addition of hBN nanoparticles to increase the engine performance. First was the potential of the hBN nano to maintain heat stabilization due to the testing conducted continuously. Based on the physical properties of hBN nanoparticles, the hBN nano lubricant worked very effectively at high temperature and in an oxidizing atmosphere.

Secondly, surface roughness of the engine part was very important to determine the performance of the engine. Nanoparticles present several advantages. One of the advantages is the small size of nanoparticles that allows them to enter into contact areas easily and have a very large specific surface area. It will change the situation of friction from a sliding effect to a rolling effect. Consequently, by smoothing the rough friction contact surfaces, it will increase the performance of the engine.

This experiment shows that RBD palm oil as an additive-based lubricant can be applied to enhance engine performance and for a wide application range. The addition of RBD palm oil with optimized nano lubricant will enhance the physical properties of the nano lubricant thus improving the engine performance.

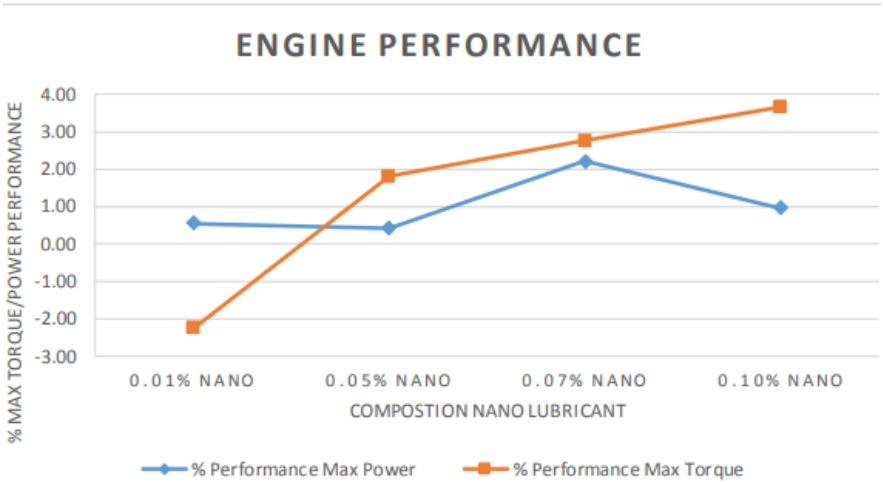

Fig. 7. Graph of maximum power and torque performance (%) for engine oil, additive RBD palm oil and hBN nano 0.01 - 0.1 %

4. Conclusions

The main objective of this study was to determine the performance of engine oil, additive, RBD palm oil and hBN nano lubricant in light vehicle engines. Analysis of engine performance in terms of power and torque for lubricant of engine oil, additive, RBD palm oil and hBN nano 0.01 - 0.1 % was made. The maximum torque engine performance testing has shown that the mixture of engine oil, additive, RBD palm oil and hBN nanoparticle gave a positive increment by an average of 0.45 %. For maximum power performance engine increased by an average of 1.03 %. The mixture of 0.1 % nano lubricant shows the highest maximum engine power and highest maximum engine torque among other nano lubricant concentrations. The achievement of this performance was because the hBN nano has good physical properties. It is confirmed from previous findings and additional evidence from this experiment that the addition of RBD palm oil as an additive with hBN nanoparticle has great potential as a lubricant and improves engine performance.

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