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# Experimental Investigations of Palm Oil Based Associative with Petrol on Performance and Emission of Four Stroke Engine

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ABSTRACT

*This work investigates the effect of using palm oil based additive on four stroke engine performance and exhaust emission. This investigation focused on the comparison of performances of an internal combustion engine fitted with the fuel additive. Performance tests were conducted for, fuel consumption, engine torque and engine power, while exhaust emissions were analyzed for carbon monoxide (CO), carbon dioxide ($CO_2$), oxygen ($O_2$) and unburned hydrocarbons (HC) at variable engine speed ranging from 1000 to 6000 rpm. The results showed that the effect of the adding fuel addictive gives more power and increases fuel efficiency compared to the fuel without additives.*

**Keywords**: *Fuel additive, engine performance, four stroke, emission.*

## Introduction

The application of palm based oil in internal combustion engine is a new development of automotive field. Fuel additives (FA) such as palm based oil can be used as renewable fuel resources. Presently, fuel additive is prospective material for use in automobiles as an alternative to petroleum based fuels. The main reason for advocating fuel additive is that it can be manufactured from

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natural products or waste materials, compared with petroleum, which is produced from non-renewable natural resources.

Petroleum-based fuel was developed over many years in concert with spark-ignition (S.I.) engines and provides excellent performance in such engines. However, the increase in prices of petrol fuel, reduced availability, more stringent governmental regulations on exhaust emissions and the foreseeable future depletion of world-wide petroleum reserves provide strong encouragement for the search for alternative fuels. Besides designing more efficient engines to save fuel, we need to look for other energy sources to completely or partially substitute the fuels we are using at present to lower the demand and dependence on fossil fuels. Furthermore, environmental protection issues have been emphasized around the world in recent years, so it is urgent to find some clean and suitable alternative fuels to meet environmental needs. Fuel additives are one of the possible fuels for petrol replacement in S.I. engines. Fuel additives are very important, since many of these additives can be added to fuel in order to improve its efficiency and its performance. Palm oil base or waste vegetable oil can be used as renewable fuel resources. It is a petrol replacement that is manufactured from palm oil base, which is produced by adding some chemical properties followed by chemical process.

## Literature Survey

The addition of ethanol to diesel fuel simultaneously decreases cetane number, high heating value, aromatics fractions and kinematic viscosity of ethanol blended diesel fuels and changes distillation temperatures [1]. With the aid of additive and ignition improver, CO, unburned ethanol and acetaldehyde emissions of the blends can be decreased moderately, even total hydrocarbon emissions are less than those of diesel fuel. The results indicate the potential of diesel reformation for clean combustion in diesel engines.

The effects of ethanol fumigation (i.e. the addition of ethanol to the intake air manifold) and ethanol-diesel fuel blends on the performance and emissions of a single cylinder diesel engine have been investigated experimentally and compared [2]. The optimum percentage for ethanol fumigation is 20%. This percentage produces an increase of 7.5% in brake thermal efficiency, 55% in CO emissions, 36% in HC emissions and reduction of 51% in soot mass concentration. The optimum percentage for ethanol-diesel fuel blends is 15%. This produces an increase of 3.6% in brake thermal efficiency, 43.3% in CO emissions, 34% in HC and a reduction of 32% in soot mass concentration.

Different percentages of cetane number enhancer (0, 0.2, and 0.4%) were added to blends, and the engine tests were performed on a 4-cylinder high-speed DI diesel engine [3]. The results showed that the brake specific fuel consumption (BSFC) increased, the diesel equivalent BSFC decreased, the thermal efficiency improved remarkably, and NOx and smoke emissions decreased simultaneously when diesel engine fueled with ethanol–diesel blend fuels; NOx and smoke emissions further reduced when CN improver was added to blends.

Two organic additives with different physico-chemical parameters was investigated in a diesel–ethanol mixture [4]. Fuel formulations were prepared with 2% additive and ethanol contents between 10 and 20% in volume in relation to the diesel fuel. Blends, with or without additive, were compared in two diesel engines with direct and indirect injection. Engine behavior seemed to be improved in the presence of additives with a reduction of pollutant emissions in exhaust gas, cyclic irregularities and ignition delay. The effects of different ethanol–diesel blended fuels on the performance and emissions of diesel engines were evaluated experimentally [5]. The results indicate that: the brake specific fuel consumption and brake thermal efficiency increased with an increase of ethanol contents in the blended fuel at overall operating conditions.

The performance of a constant speed, stationary diesel engine using ethanol-diesel blends as fuel were performed using 5, 10, 15 and 20% ethanol-diesel blends [6]. Diesel fuel was used as a basis for comparison. The effect of using different blends of ethanol-diesel on engine horsepower, brake specific fuel consumption, brake thermal efficiency, the exhaust gas temperature and lubricating oil temperature were studied. The results indicated no significant power reduction in the engine operation on ethanol-diesel blends (up to 20%) at a 5% level of significance. Brake specific fuel consumption increased by up to 9% with an increase of ethanol up to 20% in the blends as compared to diesel alone [7]. The effect of using unleaded gasoline–ethanol blends on SI engine performance and exhaust emission was performed [8]. A four stroke, four cylinder SI engine was used for conducting this study. The CO and HC emissions concentrations in the engine exhaust decrease, while the $CO_2$ concentration increased. The 20% vol. ethanol in fuel blend gave the best results for all measured parameters at all engine speeds.

The objectives of the present study were to study the effect of engine performance due to different ratio of fuel additive. The engine performance was evaluated by measuring the power and torque of the engine. The effect of fuel additive on consumption for internal combustion engine were also studied to determine the effect of fuel additive on emission such as CO, $CO_2$, $O_2$ and HC produced in the exhaust gas.

## Analysis

In this work, experiments were conducted to test the fuel additives, which was palm oil based to study its effects on engine performance. A good condition car with a standard naturally aspirated engine was used to conduct these experiments.

The experiments conducted were to investigate the parameters of the engine performance fuel consumption and also emissions test. These experiments were conducted as a comparison test between the pure petrol and the fuel additives. A Dynapack chassis dynamometer will be used in all tests

To perform the experiments, a standard was used as a guidance to ensure accurate data and results. ISO 1585-1982 standards were used for all the experiments. All tests were done after the engine has reached its operating temperature to ensure consistent readings. This is because the combustions of the fuel and air in the combustion chamber are not consistent when the engine is cold and when the engine is hot.

In this experiment, several parameters were set beforehand in accordance to the standards. These parameters are as follows:

Atmospheric conditions:
Temperature ($T_0$) = 298 K (25°C)
Dry pressure ($P_{so}$) = 99 kPa
Test atmospheric conditions: Temperature ($T$)
Spark ignition engine: 288K < T < 308K
Diesel engine: 283K < T < 313K
Pressure ($P_s$): For all engine: 80 kPa < P < 110 kPa

The test conditions for this experiment were:

- The net power test shall consist of a run at full throttle for spark ignition engine and at fixed load fuel injection pump setting for diesel engine.
- Performance data shall be obtained under stabilized operating condition, with an adequate fresh air supply to the engine.
- The temperature of the inlet air to the engine (ambient air) shall be measured within 0.15 upstream of the point of the entry to the air cleaner.
- No data shall be taken until torque, speed and temperature have been maintained substantially constant at least 1 min.
- The engine speed during a run shall not deviate from the selected speed by more than ±1% or ±10 min $^{-1}$, whichever is greater.
- Observed brake load, fuel consumption and inlet air temperature data shall be taken simultaneously and shall in each case be the average of two stabilized consecutive values which do not vary more than 2% for the brake load and fuel consumption.

The car that was used for this experiment was in a good condition to prevent other unwanted factors affecting the results of the experiment, and also to get repeatable results. The equipment that was used was a chassis dynamometer, temperature sensor, and pressure sensor. The chassis dynamometer was used to apply the load on the wheels to simulate real driving condition, while the sensors were used to measure the temperatures and pressures of the atmospheric air intake. The engine was first fitted with the original petrol to obtain the benchmark power and torque curve. This benchmark was then used to compare the results obtained for the fuel additives.

The experiment was fairly straightforward and simple. The car was placed on the chassis dynamometer with the driving wheels fixed to the dynamometer. This is to ensure the car is safe to prevent any accidents from happening. Once the car was fixed to the chassis dynamometer, the test was conducted by applying a load on the driving wheels by the dynamometer. The car was then driven to overcome the load applied on the wheels, generating the power and torque curves on the dynamometer. The data were recorded according to the test conditions stated above. After the tests were done, the petrol was replaced with the mixture of petrol with fuel additives. Then the steps above were repeated to obtain the results. The test was conducted at the different amount ratio of fuel additives. The results obtained for the fuel additives were then compared with the results obtained from the petrol

In the test, the gaseous emissions of the car produced were recorded using a flue gas analyzer. The car was run at three different constant speeds, which are idling speed (800-1000 rpm), 2000 rpm, and 3000 rpm, 4000 rpm, 5000 rpm and 6000 rpm. For each of the speed, the data recorded were recorded in a one minute interval, for three times and the average of the three were taken to plot the results. The tests were done according to the ISO 1585 – 1982 standards, just like the previous tests.

## Results

Table 1: Designation Symbol for Fuel Type

| Fuel type | Designation |
|---|---|
| 100% Petrol | FA0 |
| 70%Petrol+30%FA | FA1 |
| 50%Petrol+50%FA | FA2 |
| 30%Petrol+70%FA | FA3 |

Table 1 show the designation used to describe the different combination of petrol with FA. These designations will be used throughout the discussion.

From the results obtained, it clearly shows that the FA3 produced the most power (49.51 kW), followed by FA2 (49.48 kW). The FA0 produced 48.23 kW while the lowest power was produce by FA1 (40.62 kW). These results prove that the fuel additive does increase the power of the engine as shown in Figure 1. The gain of the engine power can be attributed to the increase of the indicated mean effective pressure for higher fuel additive content blends. Force equal

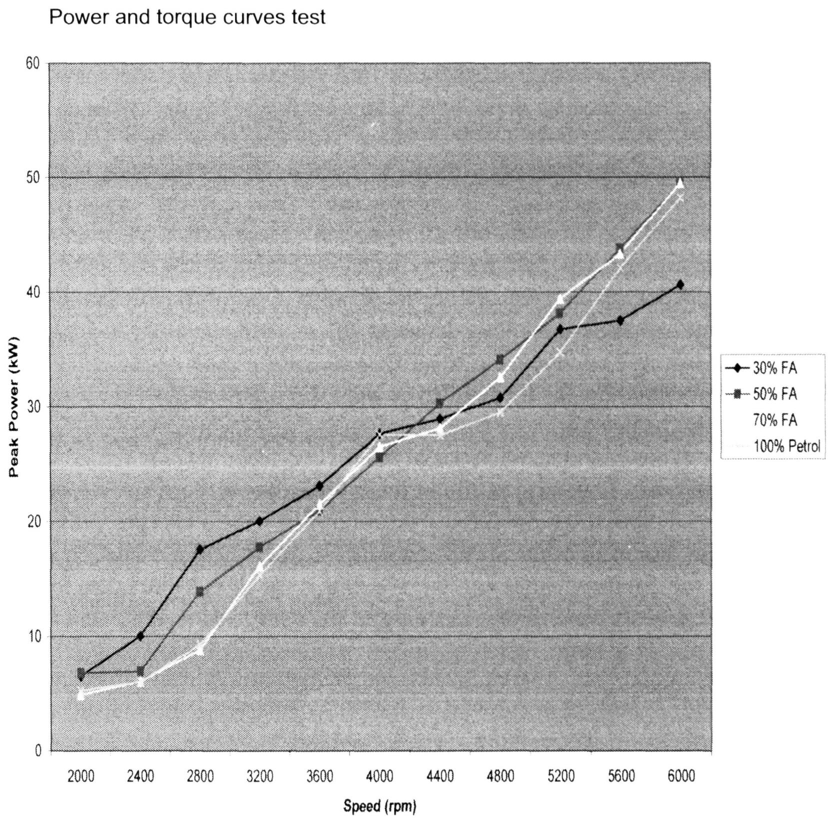


Figure 1: Power versus Speed

pressure times area, while torque equal force times the distance. The increasing of pressure will increase force and torque of the engine.

Figure 1 also shows the influence of different amount fuel additive on engine torque. The increase of fuel additive content increases the torque of the engine. It can be shown at FA3 which produced the most torque (504.271 Nm), followed by FA2 (504.030 Nm). FA0 produced torque at 491.297 Nm. While adding less fuel additives produced the lower torque, which FA1 only produced torque at 413.753 Nm as shown in Figure 2.

## Fuel Consumption Tests

In this test, the fuel consumptions were measured in liters per km (L/km), for each amount of fuel ratio experimented at 50 km/hr. The results obtained are shown in Table 2.

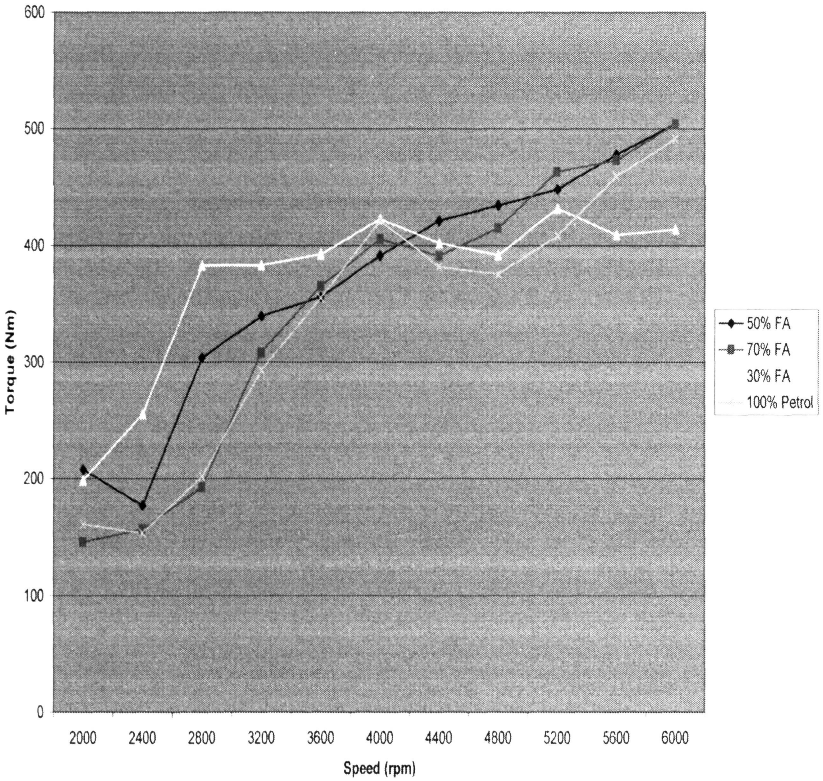


Figure 2: Torque versus Speed

Table 2: Fuel Consumption Tests Result Constant Speed at 50 km/h

| Fuel type | Fuel Consumption (L/km) |
|---|---|
| FA0 | 0.135 |
| FA1 | 0.129 |
| FA2 | 0.118 |
| FA3 | 0.135 |

From the Table 2 above, it shows that the FA2 uses less fuel compared to the petrol and other ratio fuel, with only 0.118 liters of fuel for a distance of 1 km. The next most economical fuel is the FA1. FA2 uses the same amount of fuel as FA0, which is 0.135 liters for a distance of 1 km.

## Gaseous Emissions Test

The aim of this test was to compare the emissions of the exhaust gas produced by the engine using the different amount of fuel additive. Table 3 shows the average data obtained:

Table 3: Gaseous Emissions Tests Results

**FA0:**

| Engine Speed | CO (%) | HC (ppm) | $CO_2$ (%) | $O_2$ (%) |
|---|---|---|---|---|
| Idle (800 1000 rpm) | 0.01 | 02 | 1.4 | 19.22 |
| 2000 rpm | 0.16 | 100 | 11.9 | 5.29 |
| 3000 rpm | 0.28 | 907 | 8.0 | 10.46 |

**FA1:**

| Engine Speed | CO (%) | HC (ppm) | $CO_2$ (%) | $O_2$ (%) |
|---|---|---|---|---|
| Idle (800 1000 rpm) | 0.04 | 05 | 1.6 | 19.12 |
| 2000 rpm | 0.50 | 157 | 13.8 | 2.48 |
| 3000 rpm | 0.32 | 122 | 12.0 | 6.25 |

**FA2:**

| Engine Speed | CO (%) | HC (ppm) | $CO_2$ (%) | $O_2$ (%) |
|---|---|---|---|---|
| Idle (800 1000 rpm) | 0.07 | 58 | 2.1 | 18.58 |
| 2000 rpm | 0.41 | 142 | 12.7 | 4.50 |
| 3000 rpm | 0.33 | 147 | 11.3 | 6.50 |

**FA3:**

| Engine Speed | CO (%) | HC (ppm) | $CO_2$ (%) | $O_2$ (%) |
|---|---|---|---|---|
| Idle (800 1000 rpm) | 0.04 | 19 | 2.0 | 18.70 |
| 2000 rpm | 0.27 | 130 | 11.2 | 6.02 |
| 3000 rpm | 0.38 | 519 | 9.1 | 8.99 |

For carbon monoxide (CO) emission at idling speed, FA1 produced more CO at 0.07%. The lowest CO was produced by FA0 at 0.01% while for FA2 and FA3 produced the same amount of CO at 0.04%. Meanwhile the FA1 produced the most hydrocarbons (HC), at 58 ppm (parts per million). At this speed, there is not much different between all ratios of fuel. The highest $CO_2$ is produced by FA1. FA0 produced more oxygen ($O_2$) compared to other.

At 2000 rpm, the FA2 produced the most CO, HC and $CO_2$ emission, at 0.50%, 157 ppm and 13.8% respectively. Again the lowest CO is produced by FA0 at 0.16%. At this speed, FA1 produced the most $O_2$ emission at 6.02%, followed by the FA0 at 5.29% and then the FA1 at 4.50%. The lowest $O_2$ is produced by FA2 at 2.48%.

As for the 3000 rpm test, FA3 produced the most CO at 0.38% compared to other ratio of fuel. The most amount of HC emission produced is by the FA0, with 907 ppm produced, followed by the FA3 at 519 ppm. The FA1 and FA2 produced a very low amount of HC emission with only 147 ppm and 122 ppm respectively. Meanwhile the FA2 produced the most $CO_2$ at 12%, while the FA0 produced a very low amount of $CO_2$ with just 8.0%. At this speed, FA0 produced the most $O_2$ at 10.46%.

## Conclusions

From the work done, it is concluded that the fuel additive gives an increase in power and better fuel consumption. But the emissions produced are higher than petrol. From the study, FA2 a will give reasonably well results in terms of both engine performance and emission test as compared to the 100% petrol. It is evident that the FA is capable of increasing the fuel efficiency of the SI engine as well as the overall performance. However the fuel emission tests reveal that the FA will actually increase the amount of HC, CO and $CO_2$ to the environment. A further study is needed to investigate to reduce the amount of HC, CO and $CO_2$ formed during combustion when FA is mixed with petrol for SI engines.

## References

[1] Bang-Quan He, Shi-Jin Shuaia, Jian-Xin Wang and Hong He (2003). "The effect of ethanol blended diesel fuels onemissions from a diesel engine", Research Center for Eco-Environmental Sciences.

[2] M. Abu-Qudais, O. Haddad and M. Qudaisat (1999). "The effect of alcohol fumigation on diesel engine performance and emissions", Jordan University of Science and Technology.

[3] Lu¨ Xing-cai, Yang Jian-guang, Zhang Wu-gao and Huang Zhen (2004). "Effect of cetane number improver on heat release rate and emissions of high speed diesel engine fueled with ethanol–diesel blend fuel", Institute of Internal Combustion Engine.

[4] P. Satge′ de Caro, Z. Mouloungui, G. Vaitilingom and J.Ch. Berge (2000). "Interest of combining an additive with diesel–ethanol blends for use in diesel engines", Universite′ d'Orle′ans.

[5] De-gang Li, Huang Zhen, Lu˘ Xingcai, Zhang Wu-gao and Yang Jian-guang (2004). "Physico-chemical properties of ethanol–diesel blend fuel and its effect on performance and emissions of diesel engine", School of Mechanical and Power Engineering.

[6] Ajav, E.A., Bachchan Singh and Bhattacharya, T.K. (1999). "Experimental study of some performance parameters of a constant speed stationary diesel engine using ethanol-diesel blends as fuel", Faculty of Technology, University of Ibadan, Nigeria.

[7] Chan-Wei Wu, Rong-Horng Chen, Jen-YungPu and Ta-Hui Lin (2004). "The influence of air–fuel ratio on engine performance and pollutant emission of an SI engine using", Department of Mechanical Engineering, National Cheng Kung University.

[8] M. Al-Hasan (2002). "Effect of ethanol–unleaded gasoline blends on engine performance and exhaust emission", Department of Mechanical Engineering, Amman College for Engineering Technology.