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# A Comparison Study On Engine Oil Properties For Bi-Fuel Motorcycle

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**ABSTRACT:** All mechanical equipment must be lubricated in order to reduce friction and wear between the touching surfaces. For four-stroke motorcycle engine, the function of the engine oil play critical roles since the oil does not burn along with fuel in combustion chamber as two-stroke motorcycle engines. The oil will circulate around inside the engine and the quality of the oil will decreased time by time. In conjunction with that, the engine oil must be removed after certain running period or distance recommended by the engine manufactures. The use of natural gas as a vehicle fuel claimed to provide several benefits to engine components and effectively reduce maintenance requirements. It does not mix with or dilute the lubricating oil faster and will not cause deposits in combustion chambers as well as on spark plugs to the extend that the use of petrol does, thereby generally extending the engine oil, piston ring and spark plug. It is the intention of this paper to compare the effect of both physical and chemical properties of motorcycle engine oil used by MODENASS KRISS 110cc motorcycle engine after running 5000 km using natural gas and gasoline respectively.

## INTRODUCTION

In the four-stroke internal combustion engine, the fuel system provides a controlled mixture of fuel and air to the combustion chamber. This mixture is compressed by the piston being pushed upward by the action of the crankshaft and is then ignited by means of a spark plug. The resulting combustion gives rise to an increase in pressure in the combustion chamber which pushes the piston down and transmits this power to the crankshaft and thence to the wheels.

Lubrication system provides oil as a film between the moving parts of the engine to prevent wear from friction and to keep the engine cool. A lubricating oil with the necessary properties and characteristics will provide a film of proper thickness between the moving surfaces under all conditions of operation, remain stable under changing temperature conditions and not corrode the metal surfaces. The lubricating oil seals the rings in the cylinder, removes some heat from the piston, crankshaft and valve train, cushions the shock experienced by the bearings, clean particles and dirt from the bearings and the cylinder and reduces friction.

The performance of engine lubricants is judged on their ability to reduce friction, resist oxidation, minimize deposit formation, and prevent corrosion and wear. The major causes of engine malfunction due to lubricant quality are deposit formation, contamination, oil thickening, oil consumption, ring sticking, corrosion, and wear.

The environment in which it operates affects lubricant stability. Such factors as temperature, oxidation potential and contamination with water, unburned fuel fragments, and corrosive acids limit the useful life of a lubricant. This is the area where additives have made a major contribution in improving the performance characteristics and extending the useful life of lubricants.

The two common types of four-stroke cycle engine lubrication systems are the wet sump and the dry sump. In the wet-sump engine, the oil supply is contained within the engine, in the bottom of the crankcase. In the dry-sump engine, the oil supply is contained in a separate oil tank.

The main purpose of this research is to study the chemical and physical characteristics for the engine oil after operate 5000 km on petrol and natural gas respectively.

## RESEARCH METHODOLOGY

The motorcycle used for this study is MODENASS KRISS 110, 4-stroke single cylinder engine. The engine can operate on either gasoline or natural gas. A complete chassis dynamometer system is used to simulate a road operating condition to measure the performance of the motorcycle. A data translation converter and an IBM computer are used to record data such as engine speed, torque, power, exhaust temperature, engine temperature and etc-. The test data is converted to standard operating conditions using ECE Code.

In this research, engine oil sampling for testing purposes is done base on specific procedure by ISO 6460-1981 (E). According to this standard, weight as high as 75kg is used as an average load to replaced average weight of the motorcyclist at actual riding situation. Besides, the average speed allowed for this research is between 10 km/hr to 50 km/hr. The maximum frequency limit for the power generator used is 1500 rpm, so the maximum speed for the motorcycle during the testing is 48 km/hr.

The specifications of the motorcycle are listed in Table 1 and the schematic diagram of the experimental equipment is shown in Figure 1.

Table 1:Specification of Motorcycle

| | | |
|---|---|---|
| Type | | 4 st, 1 cyl, SOHC |
| Bore x stroke | (mm) | 53.0 x 50.6 |
| Displacement | ($cm^3$) | 111 |
| Compression ratio | | 9.3 |
| Carburettor type | | KEIHIN PB18 X 1 |
| Diameter of throttle valve | mm | 18 |
| Diameter of venturi | mm | 18 |
| Type of choke valve | | Butterfly |
| Lubrication system | | Forced lub. Wet |
| Engine oil<br>Rating | | <br>SF OR SG |
| Viscosity | SAE Grade | 20W-40 |
| Capacity | (L) | 1.1 |
| Cooling system<br>Cooling method | | <br>Air cooled |
| Ignition system | | Magneto to CDI |
| Ignition timing<br>Angle | ( $^o$/rpm) | <br>6.5 BTDC /1200 ~ 27 BTDC / 4000 |
| Spark plug type<br>Gap | <br>mm | NGK C6HAS<br>0.7 |
| Regularity | | C |
| Air cleaner<br>Type<br>Number (qty) | | <br>Wet element air filter<br>1 |

(Modenas KRISS 110 Operating Manual)

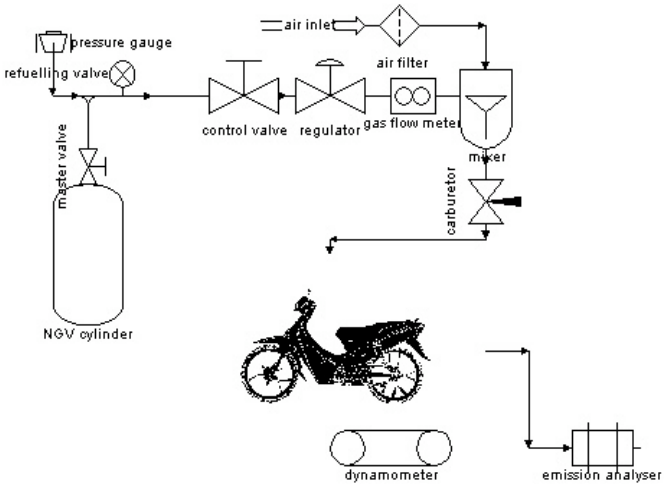


Figure 1: Schematic diagram of NGV-Motorcycle Test

Natural gas and PETRONAS Primas PX2 has been used as a fuel to run the motorcycle. The specification of petrol and the composition of the natural gas are shown in table 2 and table 3 respectively.

Table 2: Petrol Specification

| Description | Value |
|---|---|
| Density @ $15^0$C, kg/l | 0.733 |
| Research Octane Number (RON), g/l | 97.0 |
| Lead Content, kPa | 0.008 |
| Reid Vapour Pressure, %wt | 62 |
| Total Sulphur | Trace |
| Distillation<br>50% evaporated, $^0$C<br>90% evaporated, $^0$C | <br>105<br>152 |
| Colour | Yellow |

Table 3: Natural Gas Composition

| Component | Mol % |
|---|---|
| $C_{6+}$ | 0.07 |
| $C_3$ | 0.90 |
| $iC_4$ | 0.29 |
| $nC_4$ | 0.13 |
| $iC_5$ | 0.07 |
| $N_2$ | 0.68 |
| $C_1$ | 93.07 |
| $CO_2$ | 1.10 |
| $C_2$ | 3.70 |
| Compressibility | 0.9977 |
| Density | 0.7404 kg/$sm^3$ |
| Relative Density | 0.6042 |
| Molecular Weight | 17.4663 |
| Gross Calorie Value | 39.20 MJ/$sm^3$ |

**Standard Test For The Engine Oil**

All engine oil samples in this research were test according to the standard method from ASTM (The American Society For Testing Material). All the method and standard used during the research are as listed in table 4.

Table 4: Engine Oil Properties Standard Testing

| **Test** | **Standard** |
|---|---|
| Sulphated Ash Content | ASTM 874 – 92 |
| Carbon Residue content (MCRT Method) | ASTM D 4530 – 30 |
| Kinematics Viscosity | ASTM D 445 – 88 |
| Colour (ASTM Colour Scale) | ASTM D 1500 – 91 |
| Flash Point (Cleveland Open Cup) | ASTM D 92 – 90 |
| Pour Point | ASTM D 97 – 93 |
| Density, Specific Gravity, API Gravity | ASTM D 1298 – 85 |

**RESULTS AND ANALYSIS**

A good engine oil has a high viscosity when operates at high temperature. But, after certain time, engine oil need to be changed since the viscosity was reduced with the presence of impurities and not reliable to protect the engine. For four-stroke motorcycle, engine oil will ensure the engine is fully protected and at the same time perform lubrication to the piston. Figure 2 illustrated the engine oil temperature while table 5 represent results for engine oil testing after running 5000km on natural gas and petrol respectively.

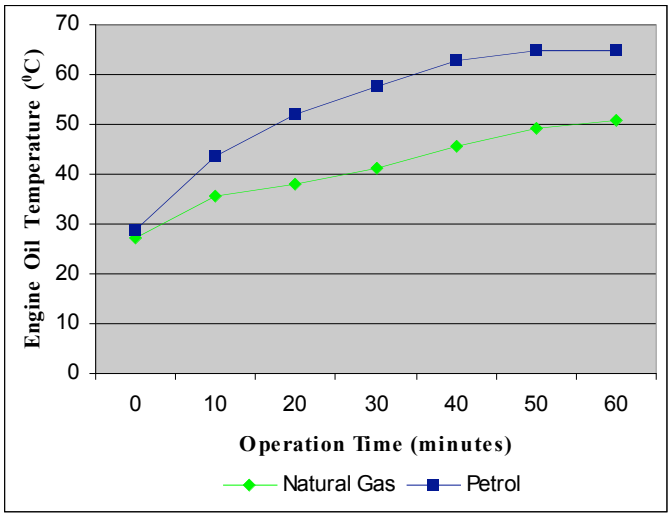


Figure 2:Engine oil temperature during petrol and natural gas operations

Table 5: Engine Oil Testing Result

| Properties | Engine Oil Sample | | |
|---|---|---|---|
| | Sample 1 New Engine Oil | Sample 2 Petrol Fuelled | Sample 3 Natural Gas Fuelled |
| Ash Content (wt %) | 1.6593 | 1.6943 | 1.7858 |
| Carbon Residue Content (wt %) | 1.3333 | 1.5322 | 1.4479 |
| Colour | L4 | D8 | D8 |
| Density (kg/m$^3$) | 895.5 | 898.5 | 936.5 |
| Specific Gravity | 0.8956 | 0.8995 | 0.9374 |
| API Gravity | 26.42 | 25.90 | 19.51 |
| Flash Point ($^0$C) | 262 | 208 | 262 |
| Pour Point ($^0$C) | -6 | -9 | -9 |
| Water Content | 0 | 0 | 0 |
| Kinematics Viscosity (40$^0$C) | 151.9 | 92.28 | 140.2 |
| Kinematics Viscosity (100$^0$C) | 16.58 | 10.45 | 13.63 |

**Sulphated Ash Content Test**

The sulphated ash content test is one of the test to study the influenced of chemical characteristics changes to the physical of engine oil. The purpose of engine oil sulphated ash content test is to determine the content of metal-containing additives in the engine oil and also to estimate the presence of metal substance in the engine oil used. All those substance are the product from the cylinder wall and piston ring wear during the operation of the engine.

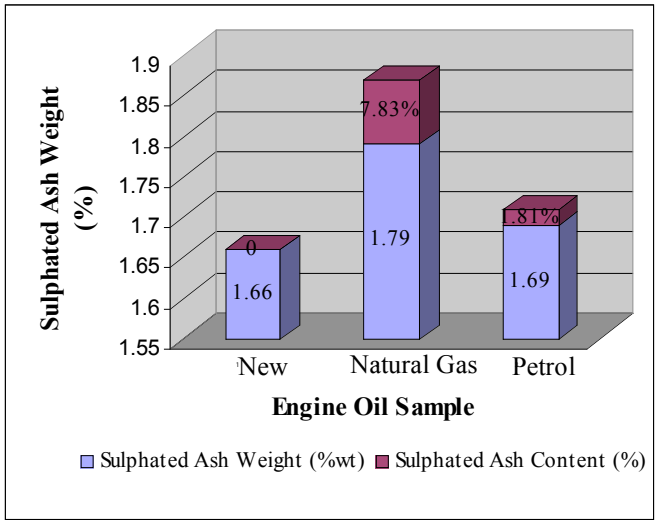


Figure 3: Sulphated Ash Content In Engine Oil

From the test, it was found that the content of the ash in the Petronas 4XT engine oil is 1.66 wt%. After 5000km operations on natural gas, the ash content increased 1.73 wt% to 7.83 wt%. For petrol, the ash content increased 0.03 wt% to 1.69 wt% after running for 5000km. The increased of sulphated ash content in the engine oil while running on natural gas is due to the type of engine oil used inappropriate with that type of fuel. Figure 3 illustrated sulphated ash content in engine oil for both type of fuel after running 5000 km.

**Carbon Residue Content Test**

Carbon residue content in the engine oil is a product from unburned hydrocarbon and ash from combustion. In general, the increasing of carbon residue content will affect the whole of engine oil quality.

The increasing of carbon residue content will reduced the viscosity of the engine oil, flame temperature, the colour of the engine oil and will shortened the life time of the engine oil.

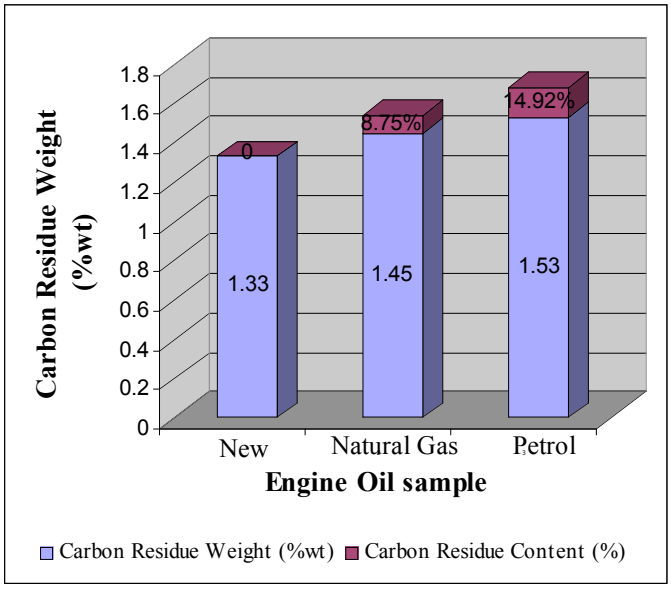


Figure 4: Carbon Residue Content In Engine Oil Sample

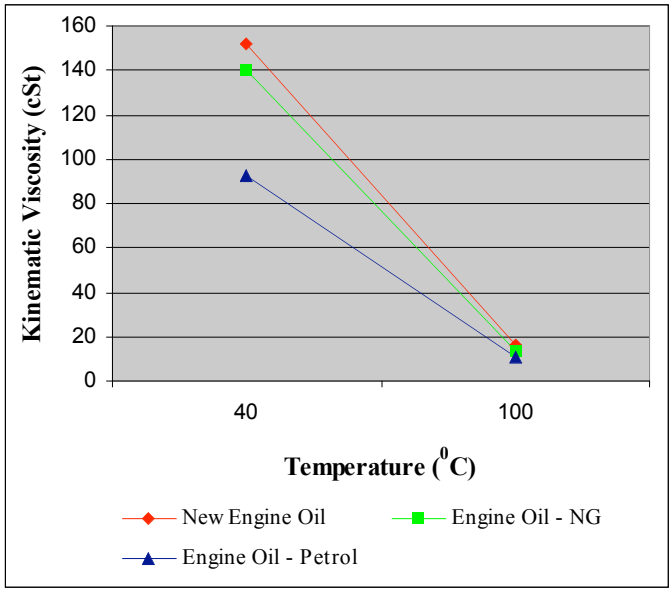


Figure 5: Kinematics Viscosity For Engine Oil Sample

Base on figure 4, the carbon content from new engine oil is 1.33 wt%. Natural gas combustion produced 1.45-wt% carbon residues while petrol combustion produce 1.53-wt% carbon residue after operates 5000 km on each types of fuel. The different of sulphated ash content between two types of fuelled shows that natural gas engine give better and clean combustion.

**Kinematics Viscosity**

Viscosity is one of the most important physical properties of lubricating oil. It is one factor responsible for the formation of lubricating films under both thick and thin film conditions. Viscosity affects heat generation in bearings, cylinders and gears due to internal fluid friction. It affects the sealing properties of oils and the rate of oil consumption. It determines the ease with which machines can be started at various temperatures, particularly cold temperatures.

As illustrate in figure 5, the viscosity of any fluid changes with temperature, increasing as temperature decreases, and decreasing as temperature rises. On a cold morning, it is the high viscosity or stiff-ness of the lube oil that makes an engine difficult to start. But, the reduction of viscosity value for the engine oil for natural gas or petrol compared to the new one in this research is due to the presence of carbon residue. The accumulation of the carbon residue will shortened the life time of the engine oil since the quality of the engine oil influenced by the viscosity.

Referred to the figure 5, kinematics viscosity for the new oil at $40^0$C and $100^0$C is 151.9 cSt and 16.58 cSt respectively. For petrol, kinematics viscosity was reduced to 92.28 cSt at $40^0$C and 10.45 cSt at $100^0$C. Natural gas combustion engine oil kinematics viscosity also reduced to 140.2 cSt at $40^0$C and 13.63 cSt at $100^0$C. But, the degradation of kinematics viscosity for natural gas is lower compared to petrol.

**Density Test**

The oil density depends on the composition and the content of that oil. New engine oil density is 895.5 kg/m$^3$ and the density of the engine oil sample after the testing on petrol and natural gas are 898.5 kg/m$^3$ and 936.5 kg/m$^3$ respectively. The increasing of the engine oil density is cause by the increasing of sulphated ash in the engine oil. Figure 6 illustrates the comparison of the engine oil density.

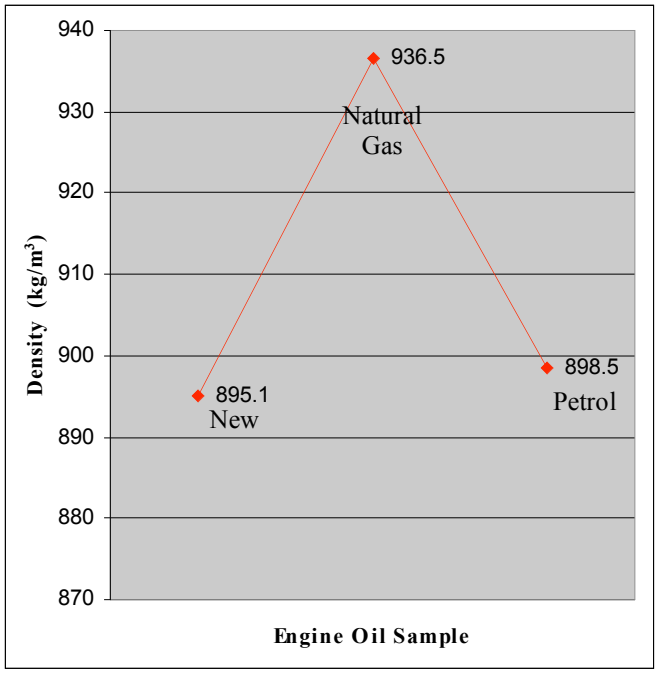


Figure 6: Comparison Of Engine Oil Density

As mention before, the engine use for running on natural gas is inappropriate with the characteristics of the fuel. As a result, the density of the engine oil increased due to the

increased of the accumulation of the sulphated ash content in the engine oil.

**Colour Test**

Different types of engine oil have different types of colour. Engine oil colour test was carried out through observation and compare it with the colour of numbered glass. The purpose of this test is to estimate the engine oil quality since the colour of used engine oil will change after certain time.

Base on testing result, the new engine oil colour from the colour test is lighter than 4 (L4). After 5000 km running on petrol and natural gas, both of the engine oil sample colour change to darker than 8 (D8).

**Specific Gravity and API Gravity**

Engine oil specific gravity is used to determine oil mass at certain volume of engine oil. Base on engine oil testing, the value for new engine oil specific gravity and API gravity is 0.8965 and 26.42 respectively. After 5000 km operations on petrol, specific density and API gravity for engine oil are 0.8995 and 25.90 respectively, compared to 0.9374 and 19.51 for specific gravity and API gravity after operations on natural gas for the same distance. Basically, the value of specific gravity is proportional with the increasing of density value.

**CONCLUSION**

According to the testing results on engine oil sample, it was found that the engine oil characteristics changed and influenced its quality. The presence of the impurities in the engine oil such as sulphated ash and carbon residue cause physical and chemical characteristic changes to the engine oil.

After testing 5000 km on petrol and natural gas, it was found that engine oil while operate on natural gas is much more clean and has longer life time compare to engine oil while operate on petrol.

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