World Applied Sciences Journal 32 (3): 505-511, 2014
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2014.32.03.622

The Effects of Fuel Types on Lubricating Oil Properties of Bi-Fuel Motorcycle

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Abstract: 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 gasoline does, thereby generally extending the engine oil, piston ring and spark plug. This work compared the effect of both physical and chemical properties of motorcycle lubricating oil used by KRISS MODENAS 110cc motorcycle after running 5000 km using natural gas and gasoline respectively. The lubricating oil properties were tested according to standard ASTM methods. The results have shown that the lubricating oil where natural gas is used as the fuel suffers less property degradation as compared to the lubricating oil when gasoline was used as the fuel.

Key words: Ash content · Carbon residue · Lubrication oil · Natural gas vehicle · Motorcycle

INTRODUCTION

As one surface moves over another, there is always some resistance to movement. The force that opposes movement is called friction. At the other extreme the friction may be so great or so uneven, that movement becomes impossible or the surfaces can overheat or be seriously damaged. Because of that the lubricant is designed to minimize the damaged and improve the smoothness of movement of one surface to another [1]. Lubricants are usually liquids or semi-liquids, but may be solids or gases or combination of that. The important property of the lubricant is the viscosity. The viscosity will tell if the oil can manipulate the engine at operating temperature [2]. The failure of the lubricant to reduce friction occurs when the oil viscosity fail to operate at certain engine because of its viscosity has changed. The breakdown of the viscosity usually related to the contamination of the oil. There are different types of the possible contaminants for example water from condensation or combustion of fuel, unburned fuel in the engine, breakdown of the oil product such as base oil [2-5].

The touching surfaces of mechanical equipment must be lubricated in order to reduce friction and wear. In a four-stroke motorcycle engine, the oil does not burn together with the fuel, as in a two-stroke engine. The oil will circulate around the inner parts of the engine and after a time the quality will degrade. As we are well aware, the state of the lubricating oil has a direct impact towards the engine's performance and life [3-7].

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 [1-2].

The performance of engine lubricants is judged on their ability to reduce friction, resist oxidation, minimize deposit formation and prevent corrosion and wear.

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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 [8].

Increasing awareness for the environment has encouraged the use of cleaner burning natural gas as the fuel for internal combustion engines [9 - 14]. In Malaysia, where the supply of natural gas is in abundant, it is only logical to convert gasoline engines to use natural gas instead. Most conversions carried out to date are for gasoline fuelled public transport vehicles, in particular taxis, which can run on both natural gas and gasoline. Monogas taxis have recently been introduced [15]. However, statistics have shown that nearly five million units or over half of the motor vehicles in Malaysia are motorcycles. These are mostly small capacity, two or four stroke motorcycle owned by the lower income group, where maintenance is infrequent, if any. Thus, as can usually be observed, motorcycles are a big contributor of air and noise pollution [16]. The later is especially significant where the motorcycle engine has suffered extensive wear. Natural gas being a cleaner burning fuel tends to prolong engine life due to lesser degradation of the lubricating oil as shown by the results of this study.

This study was conducted to compare the lubrication oil properties after the motorcycle had been running for 5000 km. This paper will presents the results of the study and compare the differences of the physical and chemical properties of the lubrication oil when using natural gas and gasoline as the motorcycle's fuel after running the above said distance.

MATERIALS AND METHODS

Experimental Setup and Procedure: The motorcycle used for this study is MODENASS KRISS 110, 4-stroke single cylinder engine. The engine has been redesign and 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 and engine temperature. The test data is converted to standard operating conditions using ECE Code.

Lubricating oil sampling for testing purposes was performed according to a procedure as described 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.

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	Rating		SF OR SG
	Viscosity	SAE Grade	20W-40
	Capacity	(L)	1.1
Cooling system			
	Cooling method		Air cooled
Ignition system			Magneto to CDI
Ignition timing			
	Angle	(°/rpm)	6.5 BTDC /1200 ~ 27 BTDC / 4000
Spark plug type			NGK C6HAS
	Gap	mm	0.7
	Regularity		C
Air cleaner			
	Type		Wet element air filter
	Number (qty)		1

Table 2: Gasoline specification (PETRONAS Primas PX2)

Description	Value
Density @ 15°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	
50% evaporated, °C	105
90% evaporated, °C	152
Colour	Yellow

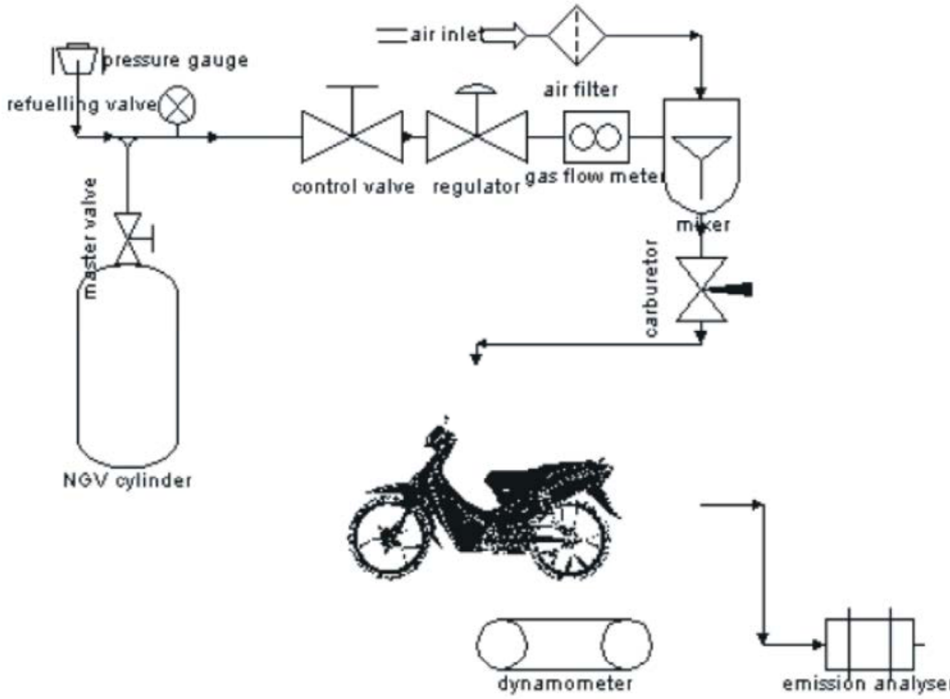


Fig. 1: Schematic diagram of NGV-Motorcycle test rig

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

Table 4: Lubricating 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

The specifications of the motorcycle are listed in Table 1 and the schematic diagram of the experimental rig is shown in Fig. 1. Natural gas and gasoline (PETRONAS Primas PX2) has been used as a fuel to run the motorcycle. The specification of gasoline and the composition of the natural gas are shown in Table 2 and Table 3 respectively.

Standard Test for the Lubricating Oil: All lubricating oil samples in this research were test according to the standard method from ASTM (The American Society for Testing Material) [17]. All the methods and standards used during the research are as listed in Table 4.

RESULTS AND DISCUSSION

A good lubricating oil has a high viscosity when operates at high temperature. But, after certain time, lubricating oil need to be changed since the viscosity was reduced with the presence of impurities and not reliable to protect the engine [2, 3]. For four-stroke motorcycle, lubricating oil will ensure the engine is fully protected and at the same time perform lubrication to the piston. Fig. 2 illustrated the lubricating oil temperature while Table 5 represent results for lubricating oil testing after running 5000km on natural gas and gasoline respectively.

Sulphated Ash Content Test: The sulphated ash content is a measure of the non-combustible constituents or metallic materials contained in the tested sample.

Table 5: Lubricating oil testing result

	Lubricating Oil Sample (Petronas Sprinta 4XT)		
Properties	Sample 1 New Engine	Sample 2 Gasoline Fuelled Engine	Sample 3 Natural Gas Fuelled engine
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 (°C)	262	208	262
Pour Point (°C)	-6	-9	-9
Water Content	0	0	0
Kinematics Viscosity (40°C)	151.9	92.28	140.2
Kinematics Viscosity (100°C)	16.58	10.45	13.63

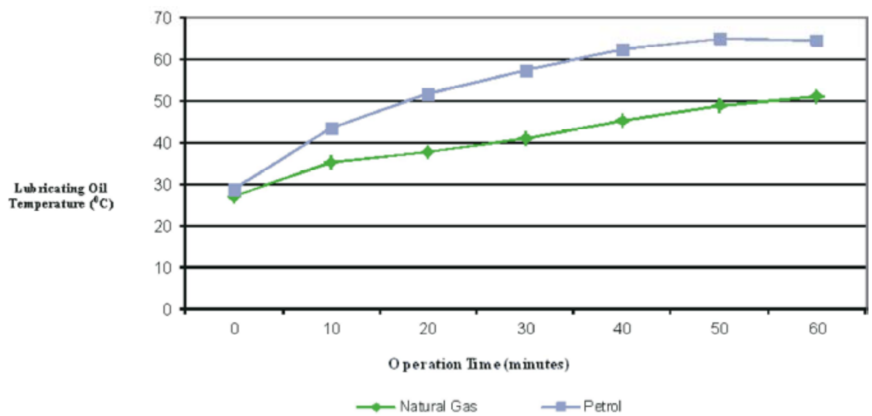


Fig. 2: Lubricating oil temperature during gasoline and natural gas operations

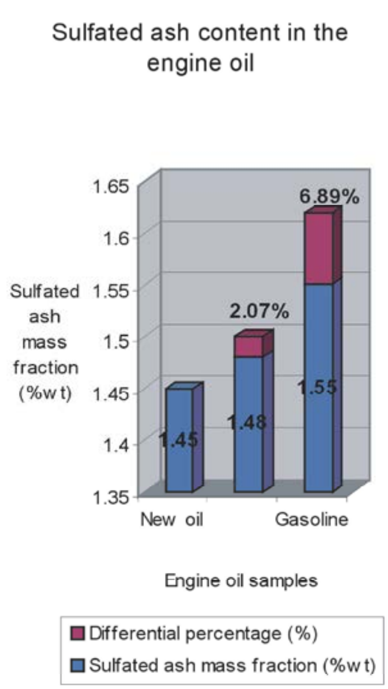


Fig. 3: Sulphated ash content in lubricating oil

These materials may exist in the lubricating oil and the fuel or as metallo-organic compounds in the additives. The sulphated ash test is very significant because it given an indication of the combustion chamber deposits and top ring wear problem, as well as buildup of contaminants. These contaminants usually originate from dust, dirt, wear debris and possibly lead salts derived from the combustion of leaded gasoline. Fig. 3 shows that for unused engine oil, the ash content is at 1.45%. However, after running for 2500 km, the sample from the natural gas and gasoline run engine showed an increase of 2.07 % (1.48 wt %) and 6.89 % (1.55 wt %) of ash content respectively. These indicate higher contamination from the gasoline combustion as compared to natural gas.

Carbon Residue Content Test: The carbon residue test indicates the amount of deposit left after evaporation and pyrolysis of the hydrocarbon under prescribed conditions. The test was originally designed to determine the carbon forming tendency of steam cylinder oils. In an internal combustion engine, carbon is deposited in the cylinder head and piston crown. The carbons originate

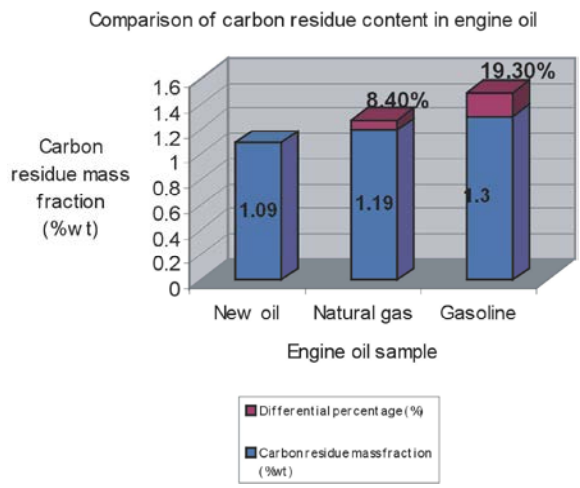


Fig. 4: Carbon residue content in lubricating oil samples

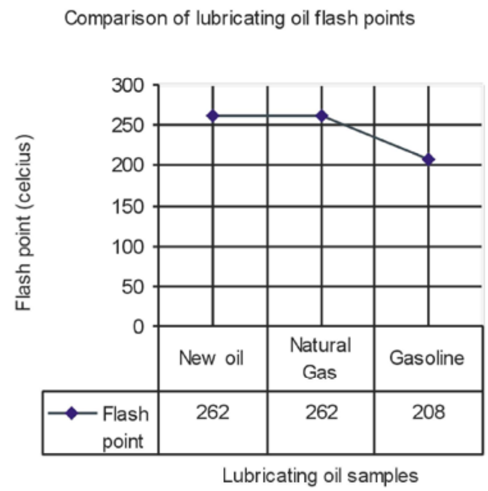


Fig. 6. Comparison on lubricating oil flash points

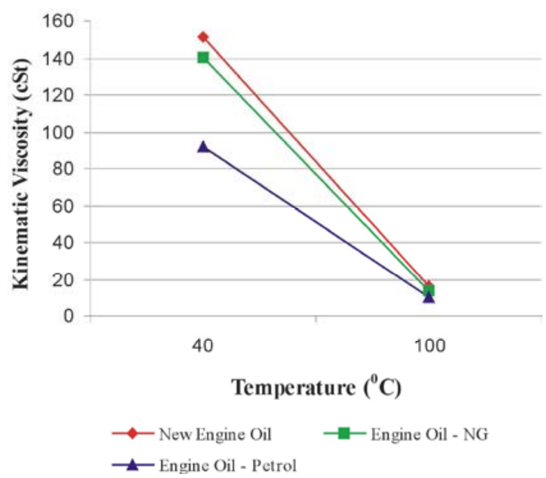


Fig. 5: Kinematics viscosity for lubricating oil samples

from the incomplete combustion of the fuel as well as the carbonising of the engine oil carried over by the piston rings into the combustion chamber. The increase in carbon contamination is usually accompanied in the decrease of oil viscosity. The carbon residue contents (wt %) for the unused, natural gas and the gasoline engine oil are 1.09 %, 1.19 % and 1.30 % respectively as shown in Fig. 4.

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 [1-4]. 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 Fig. 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 [3]. But, the reduction of viscosity value for the lubricating oil for natural gas or gasoline 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 lubricating oil since the quality of the lubricating oil influenced by the viscosity.

Kinematics viscosity for the new lubricating oil at 40°C and 100°C is 151.9 cSt and 16.58 cSt respectively. For gasoline, kinematics viscosity was reduced to 92.28 cSt at 40°C and 10.45 cSt at 100°C. Natural gas combustion lubricating oil kinematics viscosity also reduced to 140.2 cSt at 40°C and 13.63 cSt at 100°C. The degradation of kinematics viscosity for natural gas is lower compared to gasoline.

Flash Point: The lubricating oil sample flash points for natural gas fuelled engine seemed to be unaffected (Fig. 6). The results showed that the lubricating oil sample from the gasoline case is more combustible (the flash point becomes lower), probably due to the contamination with unburned fuel, which further indicated incomplete combustion.

Density Test: The oil density depends on the composition and the content of that oil. New lubricating oil density is 895.1 kg/m^3 and the density of the lubricating oil sample after the testing on gasoline and

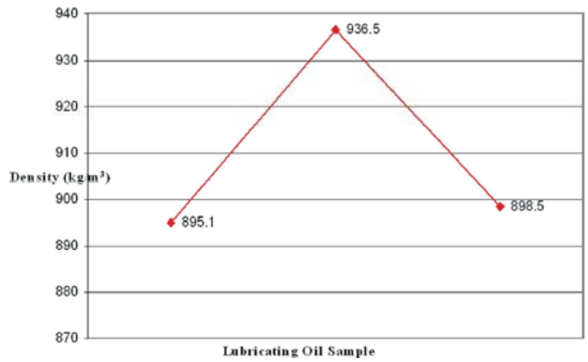
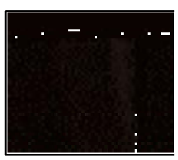


Fig. 7: Comparison of lubricating oil density

a) New (L4)

b) Natural Gas (D8)



c) Gasoline (D8)

Fig. 8: Colour comparison for lubricating oil samples

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 lubricating oil. Fig. 7 illustrates the comparison of the lubricating 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 lubricating oil increased due to the increased of the accumulation of the sulphated ash content in the lubricating oil.

Colour Test: Different types of lubricating oil have different types of colour. Lubricating oil colour test was carried out through observation and contrasts it with the colour of numbered glass. The purpose of this test is to estimate the lubricating oil quality since the colour of used lubricating oil will change after certain time. Base on testing result, the new lubricating oil colour from the colour test is lighter than 4 (L4). After 5000 km running on gasoline and natural gas, both of the lubricating oil sample colour change to darker than 8 (D8) as shown in Fig. 8.

Specific Gravity and API Gravity: Lubricating oil specific gravity is used to determine oil mass at certain volume of lubricating oil. Base on lubricating oil test, the value for new lubricating oil specific gravity and API gravity is 0.8965 and 26.42 respectively. After 5000 km operations on gasoline, specific density and API gravity for lubricating 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 lubricating oil sample, it was found that the lubricating oil characteristics changed and influenced its quality. The presence of the impurities in the lubricating oil such as sulphated ash and carbon residue cause physical and chemical characteristic changes to the lubricating oil. After testing 5000 km on gasoline and natural gas, it was found that lubricating oil while operate on natural gas is much more clean and has longer life time compare to lubricating oil while operate on gasoline.

ACKNOWLEDGEMENT

The authors wish to thank Mr. Martin King Ik Piau, Mr. Ong Hua Long for conducting a series of lubrication oil test and also Mr. Abu Samah Nasir and Mr. Mohd Redhuan Ramlee for their technical assistance. The Research Management Center (RMC), Universiti Teknologi Malaysia is also acknowledged for the financial assistance.

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