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No_x Emission from Bi-Fuel Motorcycle

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ABSTRACT

The growth in population plus the growth in energy consumption per person have combined together to give dramatic increase in both air and water pollution problems. The automotive vehicles have been a significant contributor to air pollution on total mass basis. Emission of oxides of nitrogen from combustion devices is a topic of tremendous current discussion. The appearance of several recent reviews and conferences focusing on NO_X attest to the widespread interest in this pollutant. The clean air act has created intensified interest on NO_X control because of their aggressive program to achieve ambient air quality standards for ozone. As a respond to this matter a group of a researcher from Gas Technology Centre (GASTEG), Universiti Teknologi Malaysia have been conducting a study on the use of natural gas as a fuel for motorcycle. The first stage of the study has succeeded in converting a fuel system of a motorcycle from petrol to a compressed natural gas (CNG). A series of test on exhaust emission have been conducted and the result shows that natural gas fuelled motorcycle give zero emission on NO_X compared to 6ppm to 9ppm for petrol fuelled motorcycle at an engine speed of 0 to 425rpm.

Keywords: *Emission, Natural gas and Motorcycle*

1. INTRODUCTION

Combustion of fossil fuels in an engine can be described as the chemical conversion of hydrocarbons and oxygen into water and carbon dioxide. During this conversion thermal energy is released which, in turn, is used to generate power. Beside to carbon dioxide, internal combustion engines emit other greenhouse gases such as carbon monoxide (CO), oxides of nitrogen (NO_X), unburned hydrocarbon and non-methane hydrocarbon (NMHC). The formations of these greenhouse components in an internal combustion engine are the result of various chemical and physical changes during the combustion process [1, 2].

The oxides of the nitrogen (NO_X) emissions are reported to contribute to a variety of environmental problems, including acid rain and acidification of aquatic systems, ground level ozone (smog), and visibility degradation. For these reasons, NO_X emissions are regulated in many ways by different levels of government throughout the country. The oxides of the nitrogen have proved to be the most intractable of gaseous pollutant from combustion. Two of the gaseous oxides of nitrogen, nitric oxide (NO) and nitrogen dioxide (NO_2), collectively known in a pollution context as NO_X, are emitted from combustion process as a trace species. The oxides of nitrogen have a composition of about 97 to 98 percent nitric oxide (NO) and about 2 to 3 percent nitrogen dioxide (NO_2). In the combustion process, NO_X forms when the temperature of the combustion process is high enough to cause the nitrogen in the air to react with oxygen [1, 2].

Gasoline powered vehicles produce oxides of nitrogen (NOx) that when combined with volatile organic compounds (V0C's) which are produced by trees naturally, will react with sunlight in the lower atmosphere to form ozone, a primary constituent of smog. CNG powered vehicles are clean - they emit 85% less NOx, 70% less reactive hydrocarbons, and 74% less carbon monoxide than similar gasoline powered vehicles. The use of CNG-fuel vehicles significantly reduces emissions of ozone precursors [2].

A significant change has occurred in the energy policies of many nations throughout the world, including Malaysia. These new policies and the programs to implement them, herald the beginning of global transition away from oil as the dominant transportation fuel and toward the use of cleaner, more abundant and eventually sustainable energy resources. Natural gas has proven to be cleaner, cheaper, safer and more domestically abundant than gasoline or other transportation fuels. Propelled by favorable government policies and aided positive economic and environmental attributes, natural gas vehicles have an impressive growth in Malaysia [3-7].
A project in which utilizes natural gas for motorcycle was carried out by the GASTEG Research Group from Universiti Teknologi Malaysia for the first time in Malaysia. The group has put up significant efforts to study the use of Compressed Natural Gas (CNG) in a motorcycle in order to reduce pollutants emitted by the motorcycle exhaust emission.

A novel natural gas conversion kit was developed and tested using locally produced motorcycle, MODENAS

KRIS 110, 4-stroke single cylinder engine. CNG stored at 3000 psi is used as a fuel. This paper describes the comparison of NO_X emission from the bi-fuel motorcycle while running on natural gas and petrol.

2. MATERIALS AND EXPERIMENTAL

2.1 Experimental Equipment

The motorcycle used for this study is KRISS 110, 4-stroke single cylinder. The motorcycle fuel system has been modified so that it can operate on either petrol or natural gas. The specifications of the motorcycle are listed in Table 1.

2.2 Experimental Rig

A complete chassis dynamometer system and an emission analyser are used to simulate a road operating condition to measure the performance and the exhaust emission. A data translation converter and an IBM computer are used to record data such as engine speed, torque, power, exhaust temperature, engine temperature and so on have been record. The test data is converted to standard operating conditions using ECE Code, EPA 86 and ISO 3929. The schematic diagram of the experimental rig is shown in Fig. 1.

Table 1. The Specification of MODENASS KRISS 110cc Motorcycle

Type		4 st, 1 cyl, SOHC
Bore x stroke	(mm)	53.0 x 50.6
Displacement	(cm^3)	111
Compression ratio		9.3
Carburetor 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	SAE Grade	1.1(L)
Cooling system		Air cooled
Ignition system		Magneto to CDI
Ignition timing angle	(^{o}/rpm)	6.5 BTDC /1200 ~27 BTDC / 4000
Spark plug type/gap	0.7 (mm)	NGK C6HAS

(Modenas KRISS 110 Operating Manual)

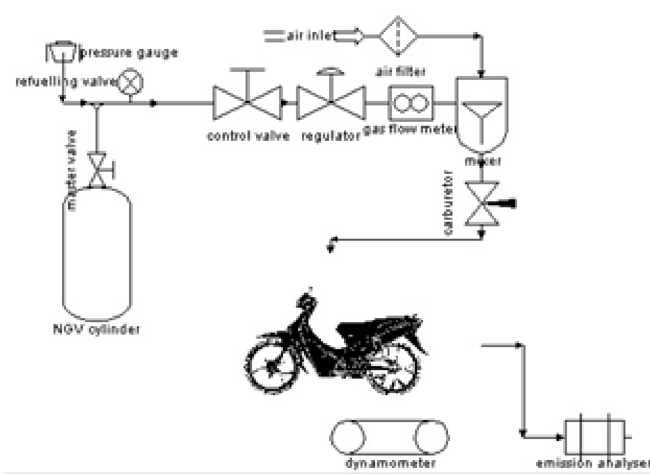

Fig. 1. Schematic Diagram of the Bi-fuel Motorcycle Test

2.3 Exhaust Emission Tests Standards

The exhaust emission analysis for both gasoline and natural gas were examined at three different operation conditions that is cold start, idles speed and average engine speed. The emission analysis is accordance with the ISO 3929, ISO 6460, ISO/TR 6970 and EPA 86 test procedures. The motorcycle were tested on dynamometer at cold start and various engine speed; 0, 175, 250, 320, 430 rpm. The test on emission of NO_X was measured using ENAREC 2000 emission analyser.

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

Table 2. 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 3. Gasoline Specification

Description	Value
Density @ 15^0C, 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, ^0C 90% evaporated, ^0C	 105 152
Colour	Yellow

3. RESULTS AND DISCUSSION

Fig. 2 illustrates the relationship of combustion for both, gasoline and natural gas with the emission produced during the testing on various engine speeds. At low engine speed, the combustion of gasoline gives poor combustion efficiency. The combustion efficiency for this fuel gives an increment with the increasing of engine speed. Natural gas shows impressive combustion efficiency although at low engine speed. The higher combustion efficiency of natural gas is due to the advantages of this fuel. Unlike gasoline, which must be vaporized before ignition, natural gas is already gaseous when it enters the combustion chamber. When the intake valve opens, the gas enters the combustion chamber, where it is ignited to power the vehicle.

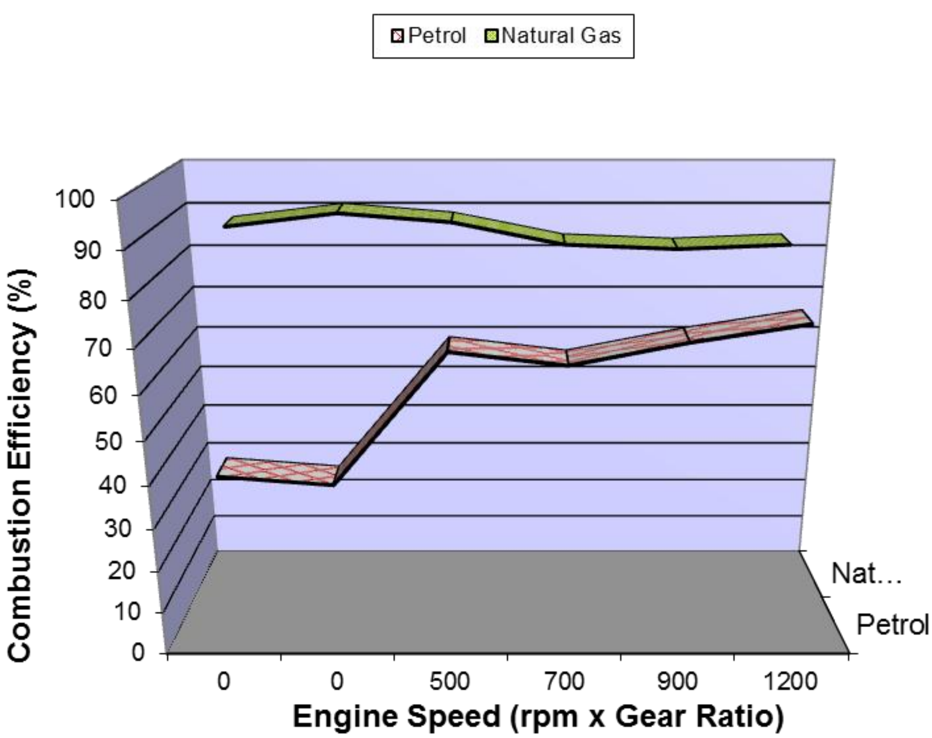

Fig. 2. Combustion Efficiency at Different Engine Speed

Fig. 3 illustrates the emission of NO_X produce by bi-fuel motorcycle at different engine speed. The emission of NO_X profile for gasoline showed the increment with the increasing of engine speed. Natural gas fuelled motorcycle is really effective to eliminate nitrogen oxides. According to the testing on bi-fuel motorcycle while using natural gas clearly shows that nitrogen oxides was totally eliminates when operates on natural gas compared to gasoline at different operation conditions. ENAREC 2000 emission analyser used to detect nitrogen oxides cannot give any reading during the bi-fuel motorcycle testing while using natural gas compared to an average of 6.8 vol. ppm at different engine speeds.

Fig. 4 shows profile of combustion efficiency at different engine temperature for gasoline and natural gas. This figure shows the relationship of combustion efficiency with combustion temperature in the engine. Gasoline gives high combustion efficiency at constant engine temperature. Natural gas as before, gives constant high combustion efficiency.

Fig. 5 shows the relationship of engine oil temperature and emission of NO_X. Emission of NO_X is increase steadily with temperature. Engine oil temperature for gasoline-fuelled motorcycle is higher than the engine oil temperature for natural gas fuelled for the same motorcycle. It shows that the temperature in the combustion chamber is higher when using gasoline as a fuel. This is because gasoline has much higher calorific value compared to natural gas. The impact of this fact is more significant in relation of the formation of NO_X. The higher operating temperature when using gasoline encourage much easier for the formation of NO_X as compared to when using natural gas.

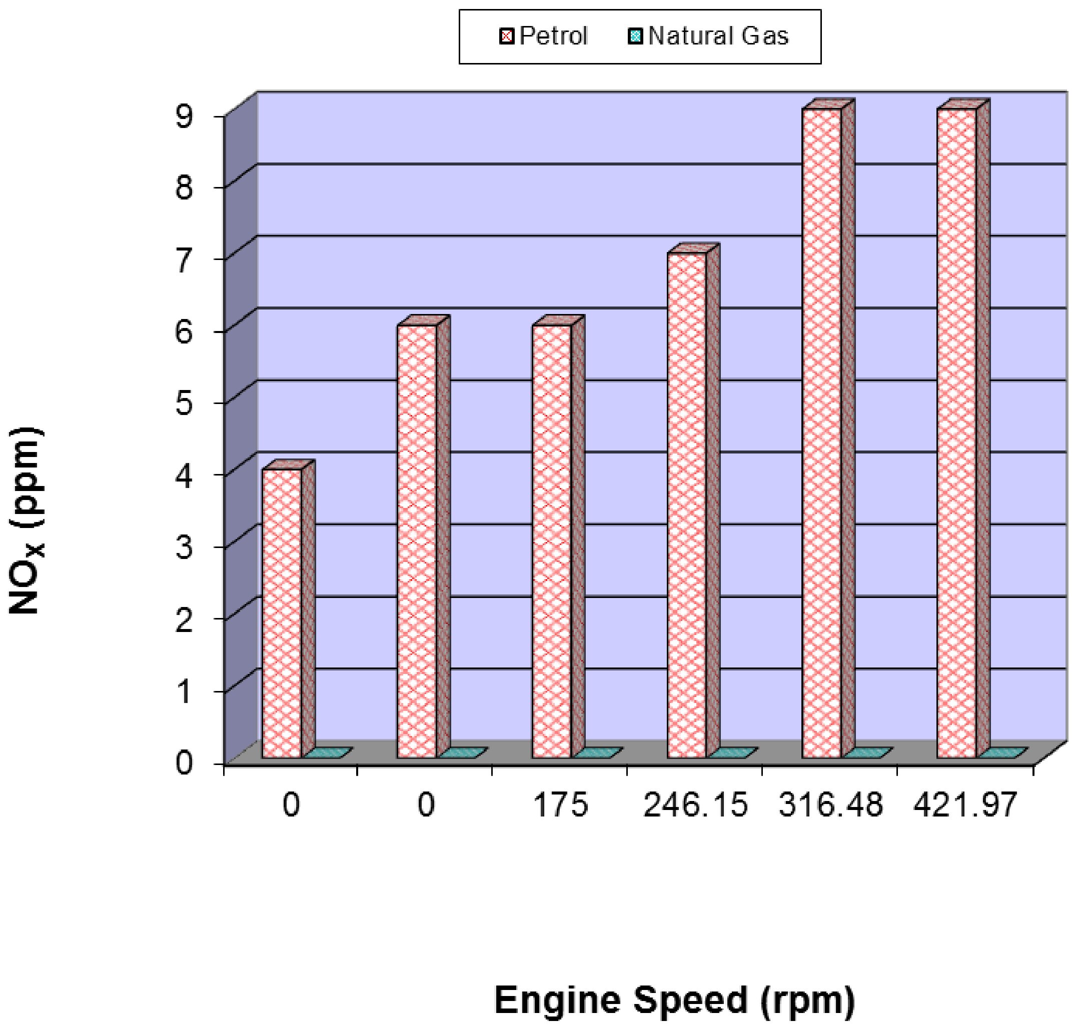

Fig. 3. Emission of NO_X at Different Engine Speed

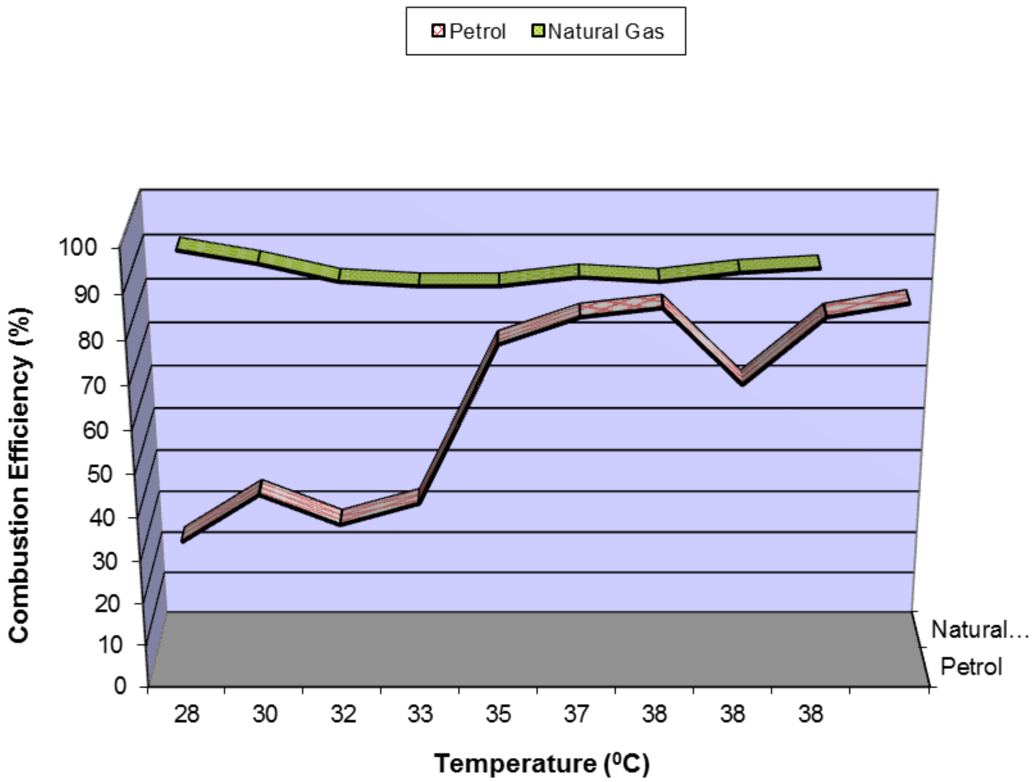

Fig. 4. Combustion Efficiency at Different Engine Temperature

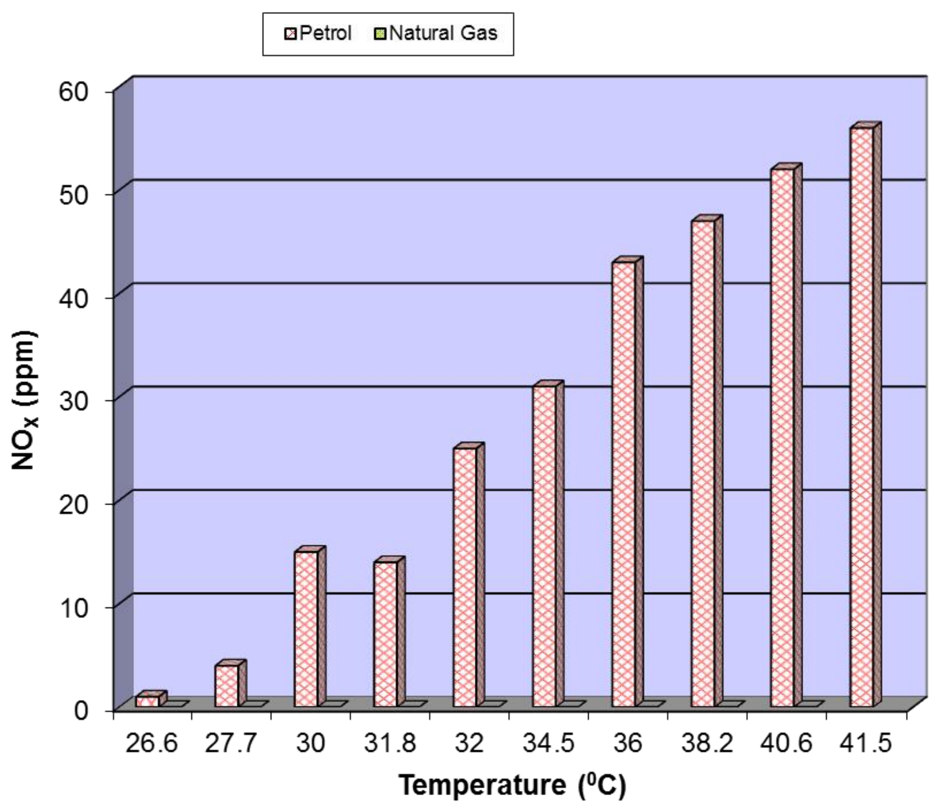

Fig. 5. Emission of NO_X at Different Engine Temperature

4. CONCLUSION

The test result shows very favourable indication for the use of natural gas as a fuel for motorcycle. Natural gas powered motorcycle totally eliminates nitrogen oxides as compared to the same motorcycle while run on gasoline. Since the pollution is quite critical to environment and human health, the natural gas motorcycle is one of the measures to solve this problem. Therefore, natural gas motorcycle is the key of the next millennium with clean city transportation.

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