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Conversion of 4-stroke Motorcycle SI Engine as Multi fueled Eco friendly two wheeler

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ABSTRACT

From the study of the used 4-stroke motorcycle performance using ethanol, methanol, propane, gasoline, it confirmed that E85, M85, LPG can be effectively used as an alternative fuel if the engine is properly tuned and modified. The motorcycle used was HERO HONDA CD100 (1980's model) whose carburetor was purposely designed for the use of gasoline. The required actual air-fuel ratio of E85 is 9.87:1, M85 is 6:1, while that of gasoline 14.7:1.Under the required fuel-rich mixture for E85, the main nozzle size was increased by 12% to 0.85 mm from the original size of 0.75 mm used for gasoline 91.The compression ratio and ignition timing remained unchanged. In average, the consumption rate of E85 was 45.3 km/l, 19% more than gasoline which was 35.9 km/l. Similarly the consumption rate of M85 was 29.6 km/l. The consumption rate of LPG is 52.1 km/l. For the emission of burning E85, the measured quantities of carbon dioxide (CO) 2.74 vol. and of hydrocarbons (HC) 3463.Where as for M85 the emissions will be, carbon dioxide (CO) 2.64 vol. and of hydrocarbons (HC) 3330 and for the propane (LPG) the emissions will be, carbon dioxide (CO) 2.37 vol. and hydrocarbons (HC) 2925. All were much below the legislation limits, that is, < 4.5% vol. CO and 10,000 ppm HC.

Keywords *- IC Engines, SI Engine, alternative fuels, Ethanol, Methanol, Propane, emissions.*

INTRODUCTION

Alternate fuels are derived from resources other than petroleum. Some are produced domestically, reducing our dependence on imported oil, and some are derived from renewable sources. Often, they produce less pollution than gasoline or diesel. The importance of world oil supply and demand, its price fluctuations, and political instability in oil producers caused energy crisis and suffered world economic. In addition, environmental problems, air pollution and global warming, have become urgent issues for all to concern. Emission from burning fossil fuels is a major attribution to air quality, mainly big cities dense in population and vehicles.

Agricultural products like sugar cane and cassava are suitable feedstock for ethanol production. Methanol is a renewable energy source that can be produced from just about anything containing carbon. Potential source includes natural gas, coal, and biomass. Currently most methanol is produced from natural gas, or methane, using steam, pressure, and a catalyst. LPG is obtained from the process of natural gas and crude oil extraction and as by-product of oil refining. Its primary composition is a mixture of propane and butane.

Ethanol and gasohol, the blend of gasoline and ethanol, methanol are proved to be used as an alternative fuel in automobiles. At present, the premium gasoline 95 is gradually replaced by gasohol, E40, M40 and E20, M20 and finally phased out. Ethanol is a potential clean fuel with similar characteristics to gasoline; the study of the use of highly blend ethanol, fuels like E85, 85%vol ethanol blended with 15% gasoline, Methanol M85, 85%vol methanol blended with 15% gasoline, in the 4-stroke motor cycles is encouraged. Because motorcycles are necessary vehicles for low and middle incomes, over 20 million motorcycles consuming gasoline have been used national wide. The study of the use of E85, M85, LPG as an alternative fuels in a used motorcycle -carburetor type will be conducted in 2 areas, that is, fuel consumption and emission.

THEORY

NECESSITY OF USING ALTERNATIVE FUELS

In the automobile field now the fuel used is known as petrol and diesel. Basically both the fuels petrol and diesel is obtained from the crude oil (i.e.) petroleum. Now the problem is its availability is decreasing day by day in bulk and insufficient for future decades. Hence an alternative fuel is essential to fight against scarcity. In terms of long sight some alternative fuels are suggested and experimented by various manufacturing units with technicians, such alternative fuels are as follows:

1. Ethyl alcohol
2. Liquefied Petroleum gas (LPG)
3. Methyl alcohol
4. Compressed Natural gas (CNG)
5. Natural gas
6. Bio-fuels
7. Hydrogen
8. Electricity

In this project we have installed LPG, Ethyl alcohol, Methyl alcohol as alternative fuels in four stroke gasoline engines

Several researchers have investigated the use of LPG in SI engine. Scientists and researchers have done numerous experimental and theoretical investigations on SI engine fuelled with LPG at different operating parameters and conditions and promising results have been obtained with regard to thermal efficiency, fuel economy and exhaust emission point of view. In studies carried out it was found that at the range of lean to stoichiometric equivalence ratios, the flame propagation speed of LPG is faster than of gasoline but at rich mixture gasoline has the higher flame speed. Due to the high flame propagation speed of LPG at lean mixture, combustion characteristics of LPG are superior to that of gasoline in lean burn engines

The stoichiometric combustion reaction is

$$C_3H_8+5O_2 \longrightarrow 3CO_2+4H_2O + 2220 \text{ KJ/mole}$$

$$C_4H_{10}+13/2O \longrightarrow 4CO_2+5H_2O + 2874 \text{KJ/mole}$$

TABLE: 1. % COMPOSITION OF LPG

% Composition	LPG
Methane	-
Ethane	0.2
Propane	57.3
Butane	41.1
Pentane	1.4

In spark ignition engines, the fuel normally mixed with air in the engine intake system. Combustion of the fuel-air mixture reacted inside the engine cylinder controls engine power, efficiency, and emissions. If oxygen is sufficient, a hydrocarbon fuel can be completely oxidised. That is, the carbon in the fuel is then converted to carbon dioxide CO_2, and the hydrogen to water H_2O. Exhaust gas composition depends upon the relative proportions of fuel and air fed to the engine, fuel composition, and completeness of combustion. In practice, the exhaust gas of an internal combustion engine contains complete combustion products; CO_2 and H_2O, as well as incomplete combustion products; CO, H_2, unburned hydrocarbons, and soot. Under fuel rich operating conditions, the amounts of incomplete combustion products become more substantial since oxygen is insufficient to complete combustion inside the cylinder.

The stoichiometric air-fuel ratio or fuel-air ratio depends on fuel composition. Fuel-air mixtures with more than or less than the stoichiometric air requirement can be burned. With excess air or fuel-lean combustion, the extra air in unchanged forms appears in the products. Under the fuel-rich mixtures, the incomplete combustion occurs because there is insufficient oxygen to oxidize fuel carbon and hydrogen. The incomplete combustion products are a mixture of CO_2 and H_2O and carbon monoxide CO and hydrogen H_2 as well as nitrogen N2. Because the composition of the combustion products is significantly different for fuel-lean and fuel- rich mixtures, and because the stoichiometric air-fuel ratio or fuel-air ratios depend on fuel composition; it is more informative to define the fuel-air equivalence ratio, or the relative air-fuel ratio, as follows:

$$\lambda = \frac{(A/F)actual}{(A/F)stoic} = 1/\Phi$$

For fuel-lean mixtures: $\Phi < \lambda$

For stoichiometric: $\Phi = \lambda$

For fuel-rich mixtures: $\Phi > \lambda$

For gasoline C_8H_{15}, the stoichiometric combustion reaction is

$$C_8H_{15} + 11.75(O_2 + 77.6\ N_2) \longrightarrow 8CO_2 + 7.5\ H_2O + N_2 + 5460\ KJ/mole$$

$$(A/F)stoic = 14.7$$

For fuel containing oxygen, ethanol, methanol fuel oxygen is included in the oxygen balance between reactants and products .The stoichiometric combustion reaction is written as:

$$C_2H_5OH + 3(O2 + 3.773N2) \longrightarrow 2CO_2 + 3H_20 + 11.32N2 + 1368\ KJ/mole$$

$$CH_3OH + 1.5(O2 + 3.773N2) \longrightarrow CO_2 + 2H_2O + 5.66N2 + 726\ KJ/mole$$

The stoichiometric air-fuel ratio of E85, a mixture of 85% ethanol and 15% gasoline, would therefore be about 9.

$$(A/F)stoic = 9$$

The stoichiometric air-fuel ratio of M85, a mixture of 85% methanol and 15% gasoline, would therefore be

$$(A/F)stoic = 6.47$$

TABLE: 2 PROPERTIES OF FUELS

PROPERTY	GASOLINE	ETHANOL	METHANOL	LPG
Chemical formula	C_4 TOC_{12}	C_2H_5OH	CH_3OH	C_3H_8
Molecular weight	100-105	46.07	32.04	44.09
Carbon (% by weight)	85-88	52.5	37.5	81.72
Hydrogen (% by weight)	12-15	13.1	12.6	18.28
Oxygen (% by weight)	0	34.7	49.9	0
Density(kg/l)	0.72	0.79	0.79	0.51
Boiling point(^{0}C)	27	78	65	54
Vapour pressure (kPa)	55	15.9	32	220
Octane no.	81-90	108	111	105
Flash point(^{0}C)	-43	13	11	-60
Auto ignition temperature(^{0}C)	257	423	464	410
HCV(MJ/KG)	42	30	23	49.8
Stoichiometric air-fuel ratio	14.7	9	6.47	15.67

Fig: 1 MULTI FUEL BIKE

EXPERIMENTAL PROCEDURE:

While using LPG as an alternative fuel we have to use a LPG conversion kit (1.1) to feed the metered amount of gas mixes with the air. These metered amount of gas mixed with the air enters the carburetor and then enters into the engine cylinder. To get the system working, we put the LPG cylinder into a case, and hanged it on the rear side of the bike. The LPG converter was fixed under the fuel tank, right side of the bike. The inlet gas pipe (1.2) is connected to inlet of the carburetor, and a vacuum pipe is connected to the inlet manifold of cylinder.

Fig: 1.1 LPG CONVERTION KIT

Fig: 1.2 LPG REGULATORS WITH HOSE PIPES

Special storage tanks (fig: 1.3) for E85 and M85 are welded to one side of the bike and they are connected to the carburetor inlet by using petrol pipes (fig: 1.4) and nipples (fig: 1.5)

Upon the engine tuning at the relative rich air- fuel ratio of 0.85 which theoretically gave the best power output, the main nozzle size was increased by 12% to be 0.85 mm from its original size of 0.75 mm used for gasoline 91. The compression ratio and the ignition timing remained unchanged

Fig: 1.3 Special storage tanks

Fig: 1.4 petrol pipes for E85 & M85

Fig: 1.5 nipples

Fig: 1.6 E85, M85, and GASOLINE

FUEL CONSUMPTION RATE TEST

There were 2-test conditions – the long-riding at the controlled speed of 60 km/h on the certain route of about 20-km/trip and the city road test at the average speed of 50 km/h.

1. City road test at the average speed of 50 km/h

The test data were collected from daily riding in the city at the average speed of 60 km/h.

2. Long ridding test at the control speed of 60 km/h

The long riding test was performed on the local road at the average speed of 60 km/h. During that period, the traffic was light and the weather was sunny and breeze. Each trip was about 20 km and the speed was controlled at 60 km/hr.

EMISSION MEASUREMENT

1. Turn on the emission test instrument and select the 4-stroke engine mode.

2. Start the engine and then insert the oxygen sensor right in the middle of its exhaust pipe.

3. Once data on the reading screen are stable, print out the recorded data.

4. Remove the sensor and turn off the engine.

RESULTS

Once the used 4-stroke motorcycle tested, HERO HONDA CD 100 was thoroughly inspected and well set, the comparative tests, consumption rate and emission, between the use of gasoline and E85, M85, LPG were conducted. The test steps were as follows:

1. Perform the road test – long riding and city riding

2. Periodically measure emission

3. After riding for about 50 km, then change fuel to E85, M85, and LPG respectively and repeat the steps 1 and 2.

When fuelled with gasoline, the millage given by the 4-stroke engine is 36.9 km/l. For E85 the stoichiometric air-fuel ratio is about 9.87: 1 which has given a millage of 56.9 km/L. Similarly, when fuelled with M85 the millage that has drawn from the 4-sroke engine is 37.0 km/l, when fuelled with LPG the millage is given as

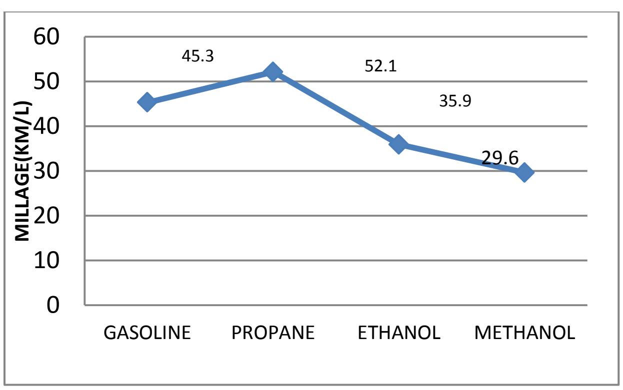
46.9 km/l. The compression ratio and the ignition timing remained unchanged.

Once the engine is properly tuned up and modified, its riding performance with E85, M85, LPG fuels was as comfortable as fuelling with gasoline. There was no difficulty in engine starting except that in the cold weather, it needed to choke the engine.

TABLE: 3 Comparison of fuel consumption rate (GASOLINE, LPG, E85, M85)

	GASOLINE	PROPANE	ETHANOL	METHANOL
FORMULA	C8H15	C3H8	C2H6O	CH3OH
CALORIFIC VALUE (KJ/KG)	47,300	48,030	29,700	23,000
Energy densities(MJ/Kg)	46.4	49.6	33.1	19.7
MILLAGE (KM/L)	45.3	52.1	35.9	29.6

Fig1.7 Comparison of fuel consumption rate (GASOLINE, LPG, E85, M85)



The emission in the exhaust of burning both gasoline and other fuels like (M85, E85, and LPG) were periodically measured after the engine is properly tuned and modified the emission contents, carbon monoxide (CO) and hydrocarbon (HC), measured from all the fuels were stated in the following table:

TABLE: 4 3 Comparison of fuel Emissions (GASOLINE, LPG, E85, M85)

EMISSIONS	GASOLINE	PROPANE	ETHANOL	METHANOL
CO(% by vol)	3.01	2.37	2.74	2.64
HC(ppm)	3825	2925	3463	3330

The results show that the emissions CO and HC are less for LPG, E85and M85 (Note: though the emissions are less for gasoline after the engine is tuned and modified, at that high compression ratio, due to erratic combustion the life of engine gradually decrease if we use more for gasoline)

Fig 1.8 Comparison of fuel Emissions for CO (GASOLINE, LPG, E85, M85)

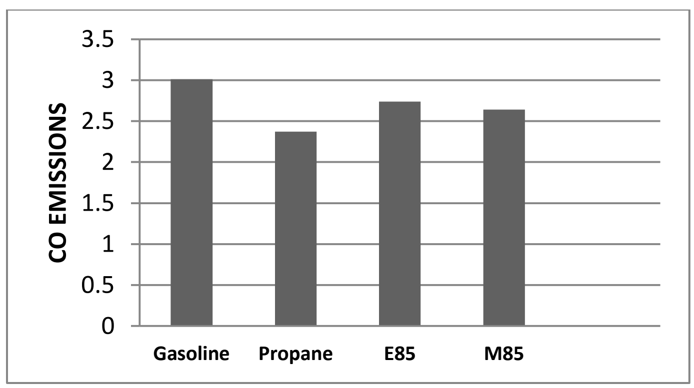
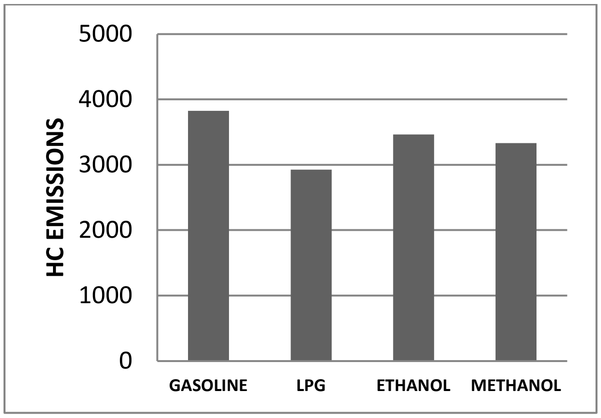


Fig 1.9 Comparison of fuel Emissions for HC (GASOLINE, LPG, E85, M85)



CONCLUSION

This study confirmed that E85, M85, LPG are effective alternate fuels used for a 4-stroke motorcycle if the engine conditions are properly tuned and modified and therefore must be taken into consideration in the future transport purpose. Apart from the fuel storage and delivery mechanism, multi fueled bikes deliver similar performance and good in combustion characteristics than gasoline. In the short term, LPG, E85, M85 as an alternative fuels could reduce the usage of fossil fuels, bring significant reductions in CO, HC, CO_2 emissions and help to reduce harmful green house gas emissions. Within a decade eco friendly vehicles will be more widely available and gaining market share across vehicle ranges.

FUTURE SCOPE

Future scenario for multi fueled eco friendly bike

Reducing our dependence on fossil fuels, cost saving, longer life of engine and less emission will attract the public for making use of eco friendly bike. Future of multi fueled eco friendly bike is bright, provided the following improvements in the system made.

1. M85and E85 has lower energy densities than gasoline. The engine fuel system needs to deliver larger flow rates of M85 and E85 and also the fuel range (miles driven on a tank full) decreases. Effort must be made to have more alternative fuels (M85, E85, and LPG) filling stations at convenient locations so that tanks can be filled up easily.

2. M85 and E85are more corrosive, material compatibility issues[10] of M85 and E85 fuels require modification of engine fuel system. Both elastomers (soft components used for seals and fuel lines) as well as metal, if not chosen properly, can be attack by M85 and E85.

3. Safety devices are to be introduced to prevent accident due to explosion of gas cylinder or leakage of gas pipes.

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