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Experimental Study of Exhaust Emissions & Performance Analysis of Multi Cylinder S.I.Engine When Methanol Used as an Additive

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Abstract

In the present day scenario emissions associated with the exhaust of automobiles resulting in global warming is a major menace to the entire world and also detrimental to health. Here an experimental attempt has been made to know the level of variation of exhaust emissions (Carbon monoxide, Hydrocarbons, Nitrusoxides) in S.I. four cylinder engine by adding methanol in various percentages in gasoline and also by doing slight modifications with the various subsystems of the engine under different load conditions. For various percentages of methanol blends (0-15%) pertaining to performance of engine it is observed that there is an increase of octane rating of gasoline along with increase in brake thermal efficiency, indicated thermal efficiency and reduction in knocking. On the other hand exhaust emissions CO and HC are considerably decreased but CO_2 and No_x simultaneously slightly increasing. It is notable that for these methanol blends combustion temperature is found to be high and exhaust gas temperature decreasing gradually.

Key words: emissions; gasoline engine; methanol; economy; temperature.

Introduction

Methanol has been proposed as a **fuel** for internal combustion and other engines, mainly in combination with gasoline. Historically, methanol was first produced from pyrolysis of wood. Presently, methanol is usually produced using methane as a raw material.

Both methanol and ethanol burn at lower temperatures than gasoline, and both are less volatile, making engine starting in cold weather more difficult. Using methanol as a fuel in spark ignition engines can offer an increased thermal efficiency and increased power output due to its high octane rating (114) and high heat of vaporization. However, its low energy content of 19.7 MJ/kg and stoichiometric air fuel ratio of 6.42:1 mean that fuel consumption will be higher than hydrocarbon fuels. The extra water produced also makes the charge rather wet and combined with the formation of acidic products during combustion, the wearing of valves, valve seats and cylinder might be higher than with hydrocarbon burning. Certain additives may be added to motor oil in order to neutralize these acids. Methanol, just like ethanol, contains soluble and insoluble contaminants. These soluble contaminants, halide ions such as chloride ions, have a large effect on the corrosively of alcohol fuels. Halide ions increase corrosion in two ways; they chemically attack passivating oxide films on several metals causing pitting corrosion, and they increase the conductivity of the fuel. Increased electrical conductivity promotes electric, galvanic, and ordinary corrosion in the fuel system. Soluble contaminants, such as aluminum hydroxide, itself a product of corrosion by halide ions, clog the fuel system over time. Methanol is hygroscopic, meaning it will absorb water vapor directly from the atmosphere. Because absorbed water dilutes the fuel value of the methanol and may cause phase separation of methanol-gasoline blends, containers of methanol fuels must be kept tightly sealed.

Manufacture of Methanol

Methanol is made by a method different from that used in the preparation of the other alcohol. The naphtha fraction from the distillation of crude petroleum is used as a raw material for the manufacture of methanol. When naphtha is reacted with a high steam ratio, under pressure and at high temperature, synthesis gas of low methane content is obtained. Most of the carbon from the naphtha is converted to carbon monoxide and carbon dioxide, which can be removed from the gaseous mixture to leave hydrogen of high purity.

$$C + H_2O \Rightarrow (1000\ ^\circ C)\, CO + H_2O$$

When a mixture of hydrogen and carbon monoxide in the ratio 2:1 is passed over a catalyst (e.g. a mixture of zinc oxide and chromium oxide) under high pressure and at high temperature, methanol is formed.

$$CO + 2H_2 \Rightarrow (400°C)CH_3OH \text{ (Methanol)}$$

Properties of Methanol

Physical and chemical properties	**Methanol**	**Gasoline**
Molecular weight [g/mole]	32.04	~100
Elemental composition by weight % Oxygen % Carbon % Hydrogen	 50% 37.5% 12.5%	 (mix of C4 to C14 hydrocarbons)

Physical and chemical properties	**Methanol**	**Gasoline**
Specific gravity	0.7915 60¡F	0.72-0.78
Boiling point [^{0}C]	64.7	27-225
Water solubility [mg/L]	miscible	100-200
Vapor pressure [mm Hg] (@ 25 [psi] (@ 100^{o}F)	 126 4.63	 -- 7-15
Heat of combustion [kJ/kg]	19,930	43,030
Liquid Dispersion Coefficient @ [m^2/s] 25°C	1.65 x 10^{-9}	---
Flash Point (^{o}C)	12¡C (54¡F)	-43 (¡F)
Vapor Density @ 1 atm; 10°C	1.4	2-5

Methanol as an additive

Methanol behaves much like petroleum and so, it can be stored and shifted in the same manner. It is more fixable fuel than hydrocarbon fuels permitting wider variation from ideal A: F ratios. It has relatively good lean combustion characteristics compared to hydrocarbon fuels. It wider inflammability limits and higher flame speeds have showed higher thermal efficiency and lesser exhaust emissions compared with petrol engines. The specific heat consumption with methanol as fuel is 50% less than petrol engine. Exhaust CO and HC are decreased continuously with blends containing higher and higher percentage of methanol. 1% methanol in petrol is used to prevent freezing of fuel in winter. Tertiary butial alcohol is used as an octane improving agent. Because of its excellent anti-knock characteristics of the fuel, it is much suitable for S.I. engines. Isopropyl alcohol is used as anti-icing agent in carburetor. Addition of methanol causes methanol gasoline blend to evaporate at much faster rate than pure gasoline below its B.P.

Experimental Setup & Description

Four stroke multi cylinder petrol engine is connected to the hydraulic dynamo meter with the help of coupling and mounted on the rigid frame, digital RPM indicator, U-tube manometer, air filter, fuel measuring tube. And gas analyzer is also arranged.

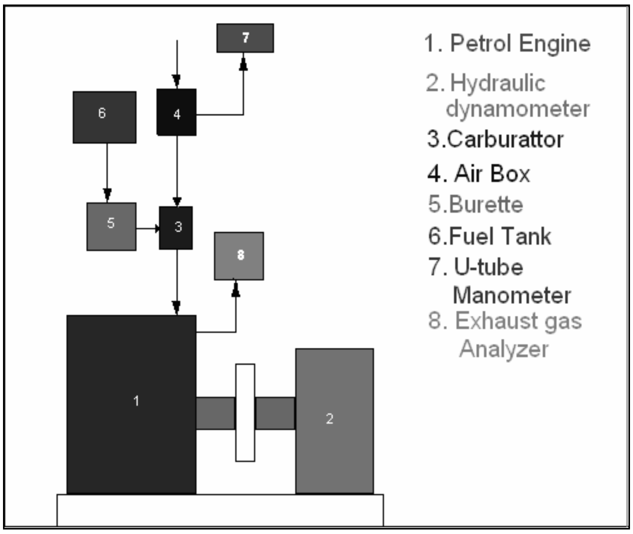


Figure 1: Experimental Setup.

Four-Stroke Engine

A four-stroke, four cylinders, stationary petrol engine, of specification given in appendix was used for the testing purposes. It was rigidly mounted on the test rig with air and fuel intake lines. The inlet manifold of the engine was suitably modified to handle alcohol bi-fuel mode.

Hydraulic Dynamometer

The hydraulic dynamometer is coupled with the engine shaft and mounted on rigid frame and speed sensor placed at the shaft it’s shows speeding rpm.

Carburetor

The carburetor used was a Solex Carburetor. M/s. Carburetor Limited, Madras, has manufactured it in India. It contains a starter valve in the form of a flat disc having holes of different sizes. These holes connect the petrol jet and starter jet sides to the passenger, which opens in to the air horn just below the throttle valve. At the time of starting, bigger holes connect the passenger so that more fuel may go to the engine. The throttle valve being closed the whole of engine suction applied to the starting passage 1, so the petrol from the float chamber passes through the starter petrol jet and rises into passage 2, some of it comes out and mixes with the air entering through the air jet. This air fuel mixture is rich enough for starting for engine.

After engine has started, the starter lever is brought to the second position, so that smaller holes connect the passage reducing the amount of petrol .In this position the throttle valve is also partly open, so that the petrol is also coming from the main jet. The reduced mixture supply from the starter system in this situation is, however, sufficient to keep the engine running. When the engine reaches the normal running temperature, the starter is brought “off” position

Throttle Control Mechanism:
In order to have control of the throttle of the carburetor, the design was done considering the length of pull of the throttle cable under wide-open throttle condition. The mechanism consists of a threaded bolt moving over a nut. The throttle cable is fixed to the end of the bolt and so, the movement of the threaded bolt controls the pull of the throttle cable.

Air Filter
The main purpose of air filter is to remove the dust and dirt and passes thought the clean air to carburetor, so it is mounted on the frame at above the 5m.

U- Tube Manometer
The purpose of the U-tube manometer to shows the head different, the u-tube has connected to the inlet suction pipe before air entering into the filter based on this to find out actual volume of flow.

Fuel Measurement Tube
The fuel measuring tube is used for measuring the how much quaintly of fuel flows through the carburetor.

Exhaust Gas Analyzer
The crypt on 290 series is a fully microprocessor controlled exhaust gas analyzer employing Non-Dispersive Infra- Red (NDIR) techniques. The unit measures carbon monoxide, carbon dioxide and hydrocarbons. A further channel is provided employing electrochemical measurement of oxygen. Zero may be a commanded at any time by the operator, and automatically executed by the analyzer. An automatic auto zero check is performed every thirty minutes when the analyzer is switched on.

Test procedure
The engine was started in neat petrol mode at no load condition. The engine speed, time for 10 cc petrol consumption, exhaust temperature and Exhaust Gas analyzer values were noted. The above steps were repeated for 0 kg, 3 kg, 6 kg, 9 kg, 12 kg and full load conditions. The alcohol- petrol fuel substitutions are enter into the fuel tank substitution percentages are 3%,5%, 10%,15%.First enter the methanol 3% additive with gasoline. The engine speed, time for 10cc petrol consumption, exhausts temperature and Exhaust Gas Analyzer values were noted. The process was repeated at 6 kg, 9 kg and so on. The similar procedure was followed for 3%, 5%, 10%, and 15% alcohol- petrol additives, like methanol- petrol. All the observations for the various kg of substitutions and for the various loads were tabulated and the efficiency obtained in each case was calculated. The values of efficiency exhaust temperature, total fuel consumption and, emissions were compared for alcohol- petrol fuels 3%, 5%, 10% and 15% substitution of petrol conditions.

Observations

Table 1: Calorific Values of various Blends.

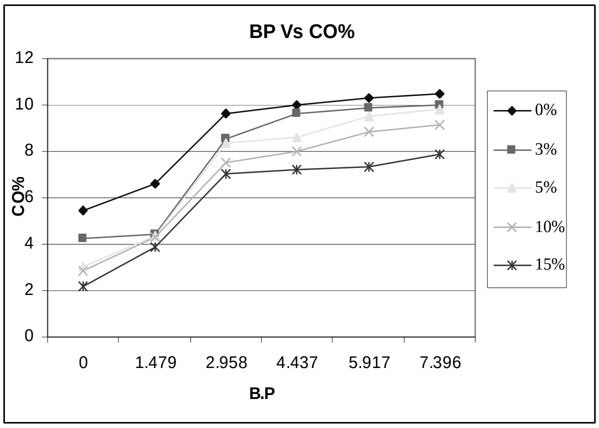
%of substitution	Methanol (KJ/kg)	%of substitution	Petrol (KJ/kg)	Methanol-petrol(kj/kg)
3%	690	97%	42680	43370
5%	1150	95%	41800	42950
10%	2300	90%	39600	41900
15%	3450	85%	37400	40850

Results and Discussion

Exhaust Emissions Characteristics

The experimental results for different load conditions for various percentages of methanol compared with gasoline in the form of graphs are shown below. Emission characteristics are improved for additive methanol compared to petrol except NOx which is slightly higher than gasoline. This indicates that the combustion efficiency is high for additive gasoline

Carbon Monoxide

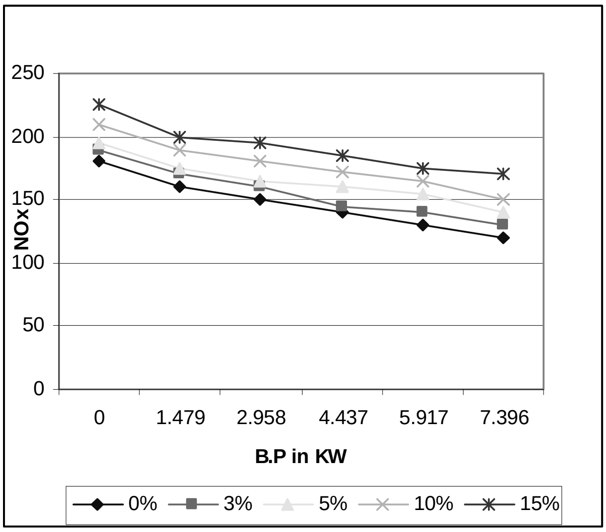


Graph 1: B.P Vs CO at various additives and load.

From fig.5.1 it is observed that CO increases with increasing load for all the percentage of methanol. If percentage of additive increases CO reduces. This is due to the batter combustion of gasoline when methanol used as a additive. The concentration of CO decreases with the increase in percentage of methanol in the fuel. This may be attributed to the presence of O_2 in methanol, which provides sufficient oxygen for the conversion of carbon monoxide (CO) to carbon dioxide (CO_2).

Nitrogen Oxide

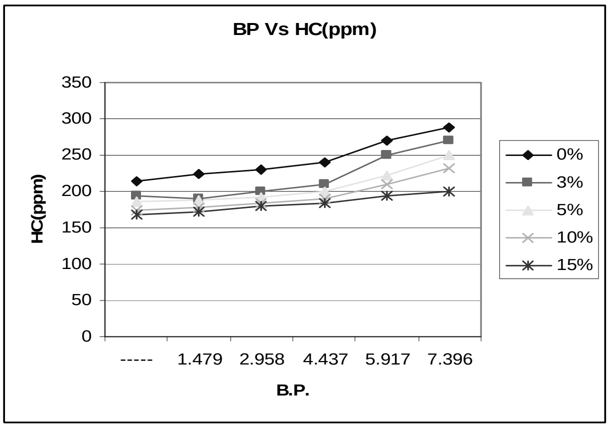
From fig. Show that NOx decreases with increasing load for all the percentage of methanol. If percentage of additives increases, NOx increases. The comparison of NOx emissions for gasoline and additives are shown in Fig.5.2. It can be seen that NOx emissions increase with increase in percentage of methanol in the petrol The NOx increase for additive of methanol may be associated with the oxygen content of the methanol, since the fuel oxygen may augment in supplying additional oxygen for NO_x formation. Moreover, the higher value of peak cylinder pressure and temperature for methanol when compared to petrol may be another reason that might explain the increase in NO_X formation.



Graph 2: B.P Vs NOx at various additives and load.

Hydro Carbons(HC)

From fig. It is observed that hydro carbon (HC) decreases with increasing load for all the percentage of methanol. If percentage of additive of methanol increases, HC reduces. The hydrocarbon emissions are inversely proportional to the percentage of methanol added in the fuel. The petrol fuel operation showed the slightly higher concentrations of HC in the exhaust at all loads. Since methanol is an oxygenated fuel, it improves the combustion efficiency and hence reduces the concentration of hydrocarbon emissions (HC) in the engine exhaust. Blending 10% additive with gasoline greatly reduces HC emissions especially at all load condition.

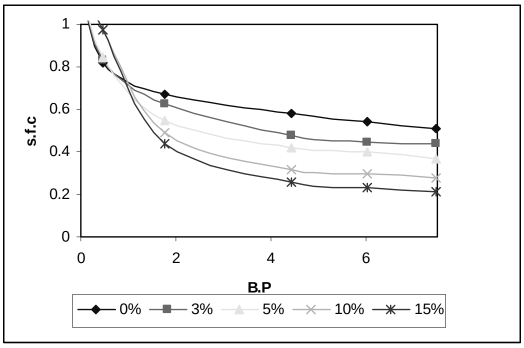


Graph 3: B.P Vs HC at various additives and load.

Performance Analysis

Results of the experiments in the form of brake power, brake thermal efficiency, specific fuel consumption for different load conditions for various additives of methanol with the gasoline.

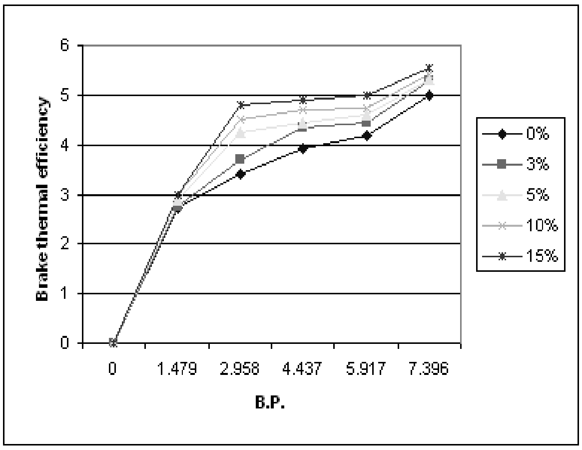
Specific Fuel Consumption



Graph 4: B.P Vs SFC of various additives.

The variation of SFC with brake power for different percentage of additives of methanol with the gasoline as shown in fig. The additive of methanol shows lower SFC compare to gasoline because of it has oxygen content so complete combustion takes place in combustion chamber. However SFC is lower for all the other additives. The SFC decreases with the increasing loads. It is inversly praportional to the thermal efficiency of the engine.

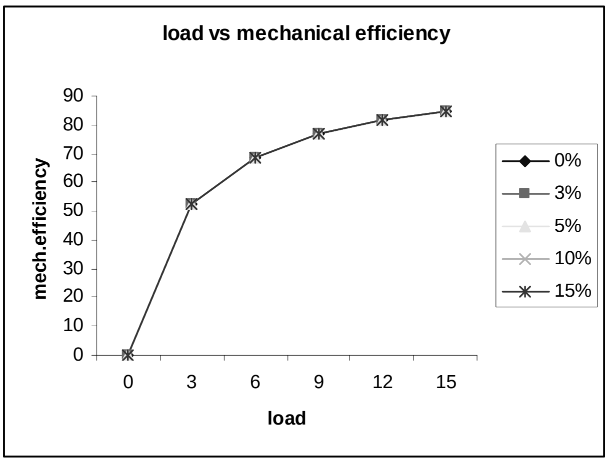
Brake Thermal Efficiency



Graph 5: B.P Vs BTH of various additives.

The variation of BTE with brake power for different percentage of additives of methanol with the gasoline as shown in fig.The additive of methanol shows The BTE is higher than the gasoline. The BTE is higher for various additives because of improve combustion efficiency. The brake thermal efficiency is based on B.P and calorific value. of the engine . Brake thermal efficiency gradually increases with increase in percentage of additives. It is observed that brake thermal efficiency is low at low values of B.P and is increasing with increase of I.P for all additives of fuel. For a additive of 3% the brake thermal efficiency is high at highr power values when compared with other additives of fuel and is slightly higher than the petrol at high values of B.P.

Mechanical Efficiency



Graph 6: Mechanical Efficiency.

The variation of mechanical efficiency with brake power at different loads as shown in fig 5.6.Mechanical efficiency SI engine is constant. Because brake power and frictional power are constant at various load conditions and additives of methanol why because speed of engine is set as constant.

Conclusion

Experiments have been conducted on multi cylinder petrol engine with different percentage of methanol as additive to gasoline. It is concluded that, the percentage of additive increases the emission characteristics improved expect NOx and CO_2.It is observed that the emission values of The HC and CO are decreased when compared with petrol. But The NOx emissions are increased due to presence of oxygen content in the methanol and also the combustion temperature is high. The engine performance indicating parameters like brake power, indicated power, indicated thermal efficiency, brake thermal efficiency, mechanical efficiency, etc. have been observed for various additives at different loads**.** The brake thermal efficiency increases with increase in percentage of additive. Thus methanol may be used as a additive for gasoline in future.

Appendix – 1

Engine specifications

(1) Engine type: Four-Stroke, stationary,S.I engine
(2) Make Ambassador
(3) Number of Cylinders: Four
(4) Maximum Power: 7.35 KW at 1500 rpm
(5) Maximum Torque: 47 N-m at 1500 rpm
(6) Bore: 73 mm
(7) Stroke: 90 mm
(8) Compression ratio: 7.8:1
(9) Type of load: water loading
(10) Type of Cooling: water-Cooled
(11) Type of starting: self starting

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