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Investigation on Performance and Emission of a Spark Ignition Engine Using Methanol as Fuel Additive

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Abstract— Vehicles which had gone vintage suffer a lot of emission and performance related issues. At present these issues can only be compromised by replacing the whole vehicle or retrofitting the engine. Here we have established a low cost method to improve emission and performance characteristics of the engine using methanol blended gasoline as a working fluid. An experimental investigation is carried out to analyze the variation in performance and exhaust emission on a four cylinder, four stroke, spark ignition engine by adding methanol in the rations of 5%, 10%, 15% and benchmarked it against that of using pure gasoline (0% Methanol). The performance characteristics of M10 (10% Methanol) was found satisfactory, which gave maximum performance among all blends. A maximum reduction of 65.13% in HC emission during cold start was observed when 15% Methnol blend was used. And a significant 97.88% reduction in CO was observed at the maximum load. It is also observed that the exhaust temperature has reduced significantly with the addition of methanol thus indicating a possible increase in life of the engine on long run.

Index Terms— Gasoline, Exhaust Emissions, Methanol, Performance, Spark Ignition Engine.

1 Introduction

METHANOL is a clean burning, high octane blending component for gasoline alternative that is made from alternative non gasoline energy sources such as natural gas, coal and biomass. Methaol has properties which make them burn cleaner in gasoline engines. These properties include more O_2, high blending octane for smoother burning, a lower boiling temperature for better fuel vapourisation in cold start engines, high H/C ratio, and no sulphur contamination which can poision the catalytic converter of vehicle.

Perfomance tests were conducted for investigation of fuel consumption, brake thermal efficiency, brake power and brake specific fuel consumption, while exhaust emission were analyzed for CO, CO_2, HC and NO.

M.Alhasan [1] investigated the effect of using unleaded gasoline-ethanol blends on SI engine performance and exhaust emission. A four stroke, four cylinder SI engine (type TOYOTA, TERCEL-3A) was used for conducting this study. Performance tests were conducted foe equivalence air-fuel ratio, fuel consumption, volumetric efficiency, brake thermal efficiency, brake power, engine torque and brake specific fuel consumption, while exhaust emissions were analyzed for carbon monoxide(CO), carbon dioxide(CO2) and unburned hydrocarbons(HC). Using unleaded gasoline-ethanol blends with different percentages of fuel at three-fourth throttle opening position and variable engine speed ranging from 1,000 to 4,000 rpm. The results showed that blending unleaded gasoline with ethanol increases the brake power, torque, volumetric and brake thermal efficiencies and fuel consumption, while it decreases the brake specific fuel consumption and equivalence air-fuel ratio. The CO and HC emission concentrations in the engine exhaust decrease, while the CO2 concentration increases. The 20 vol. % ethanol in fuel blend gave the best results for all measured parameters at all engine speeds.

Babazadesh et al. [2] nvestigated the effect of oxygenate additives into gasoline for the improvement of physiochemical properties of blends. Methyl Tertiary Butyl Ether (MTBE), Methanol, Tertiary Butyl Alcohol (TBA), and Tertiary amyl alcohol (TAA) blend into unleaded gasoline with various blended rates 2.5%, 5%, 7.5%, 10%, 15%, and 20%. Physiochemical properties of blends are analyzed by the standard American Society of Testing and Materials (ASTM) methods. Methanol, TBA, and TAA increases density of the mixture, but MTBE decreases density. The Reid vapor pressure (RVP) of the gasoline is found to increase with the addition of the oxygenated compounds. All oxygenates improve both motor and research octane numbers. Among these four additives, TBA shows the best fuel properties.

2 Experimental Setup

2.1 Setup

A four stroke, four cylinder SI engine connected to the electric dynamometer was used for the study. The experimental set was as shown in Fig 1.

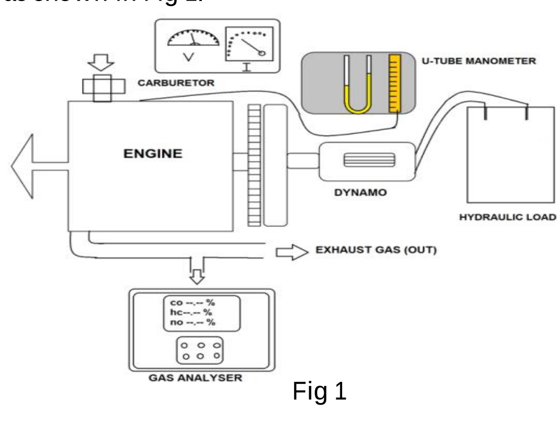

Fig 1

2.2 Specifications

Engine:

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Number of cylinders: 4
Type: 4 strokes
Bore: 73.02mm
Stroke: 88.90mm
Displacement: 1,498cc
Compression Ratio: 7.2:1
Max Power: 7.35kw @ 1,500 RPM
Max Torque: 47 Nm @ 1,500 RPM

Dynamometer:

The dynamometer coupled to the engine output shaft was an integral part of the test rig. Imposing load on the engine was by varying the input voltage and current to the electric dynamometer.

Gas Analyzer:

DELTA 1600-L determines the emission of CO (%), CO (%), HC (ppm), with means of infrared measurement and O (%) and NO (ppm) with means of electrochemical sensors.

2.3 Procedure

The engine was started using gasoline, during which dynamometer was disengaged. Engine speed was maintained constant at 1,500 RPM. The coolant flow was also maintained constant at .14 litres per second. Parameters such as engine speed input voltage and input current to the dynamometer, time for 10cc fuel consumption, exhaust gas temperature and exhaust emission readings were recorded. The above procedure was repeated for 0.6kW, 2.16kW, 4.56kW and 6.72kW. 6.72kW was considered as the safe maximum load for dynamometer. Then the engine was allowed to cool down sufficiently. Before running the engine with next volume of fuel blend, it was made to run for a sufficient time to consume the remaining fuel from previous test. The same procedure was followed for 5%, 10% and 15% methanol by volume of gasoline used.

3 Results and Discussions

The results of analysis of experiment, both for performance and emission are discussed in this section.

3.1 Variation in Engine Performance

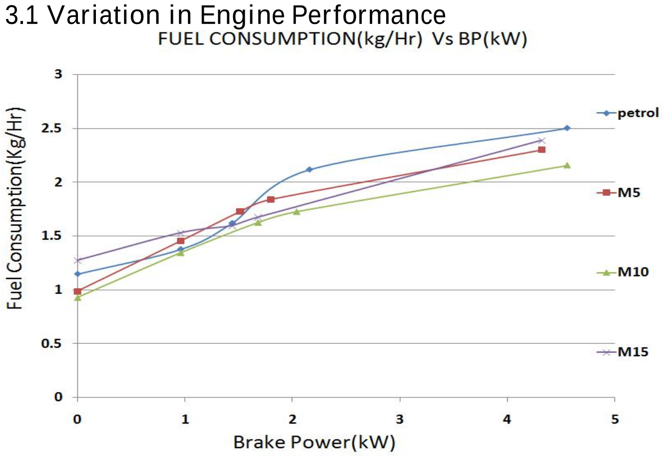
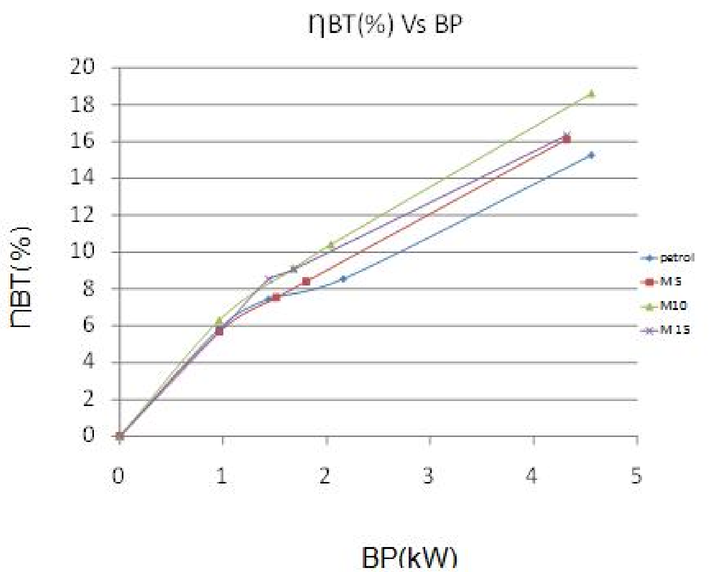


Fig. 2. : Specific Fuel Consumption"SFC" (Kg / Hr) VS Brake Power (kW)

Variation in the specific fuel consumption with brake power for different additive blend is shown in Fig 2. M10 (10% Methanol, 90% Gasoline) was the blend which gave minimum specific fuel consumption. As presence of oxygen is high in methanol, this inculcated relatively equivalent specific fuel consumption plots.



The variation of brake thermal efficiency with brake power for different blends of additives was as shown in Fig 3. Brake thermal efficiency was found higher when using methanol blended gasoline in compare with gasoline without methanol. This indicated the efficient combustion inside the chamber. Maximum brake thermal efficiency was obtained with a 10% methanol blend.

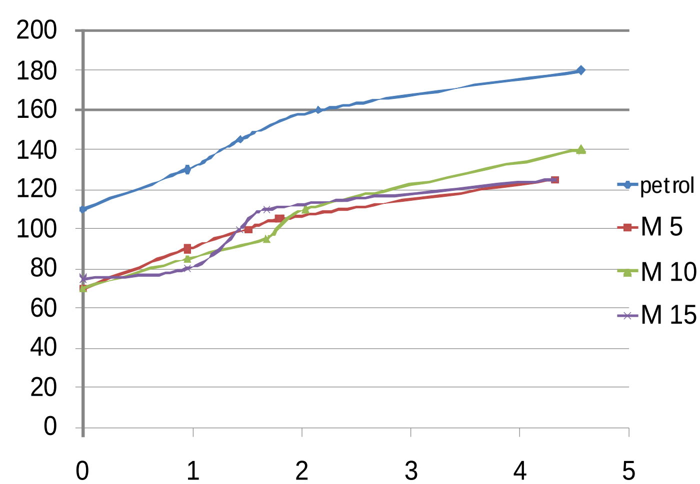


Fig. 4: Exhaust temperature (^{0}C) VS Brake Power (kW)

Variation in exhaust gas temperature with increase in loads for different additive blend was as shown in Fig 4. The exhaust gas temperature when methanol was used along with gasoline was lower than that of gasoline. 5% methanol blend showed minimum exhaust gas teemperature, there was no significant difference in variation for 10% and 15% methanol

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blends. Thus lower exhaust gas temperature indicates a possible increase in the life of the engine on a long run.

3.2 Variation in Exhaust Emissions

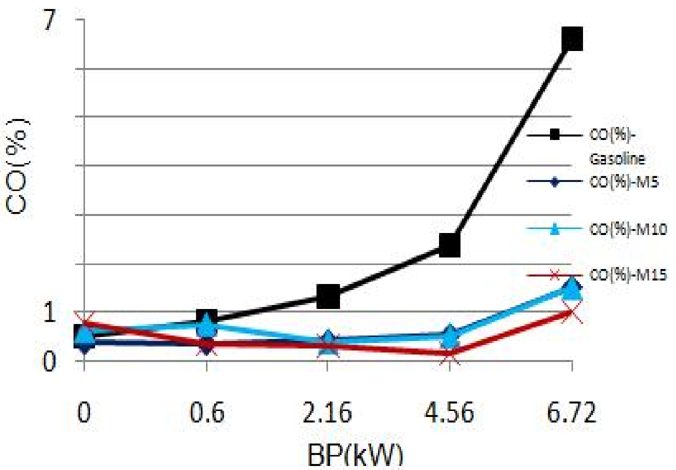


Fig. 5: Carbon Monoxide “CO”(%) VS Brake Power (kW)

Variation in the CO emission with different additive-fuel blends and loads was as shown in Fig 5. As the percentage of additive increased CO emission was reduced. This was clearly due to cleaner combustion of methanol-blended gasoline. The higher oxygen content in oxygenate additives supports a cleaner combustion, also the CO will be oxidized in a large extent to CO_2.

CO_2, CO Trade off with different blends

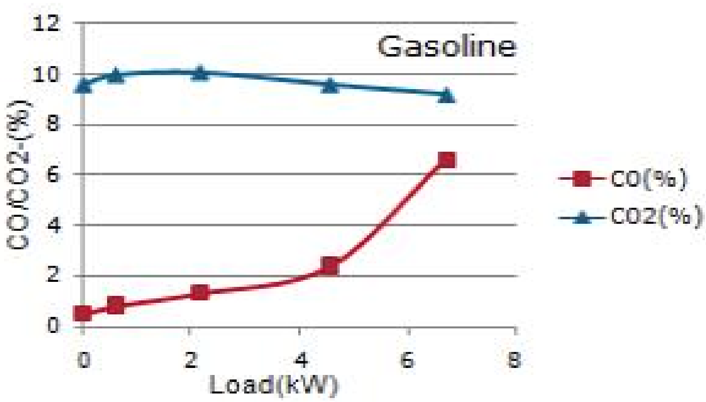


Fig. 6: CO / CO_2 (%) VS Brake Power (kW) using 0% Methanol

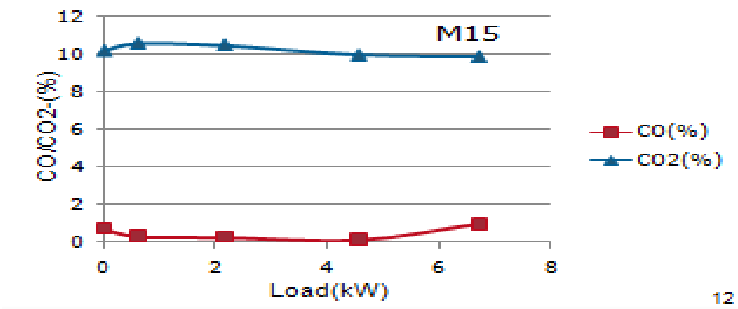


Fig 7. : CO / CO_2 (%) VS Brake Power (kW) using 5% Methanol

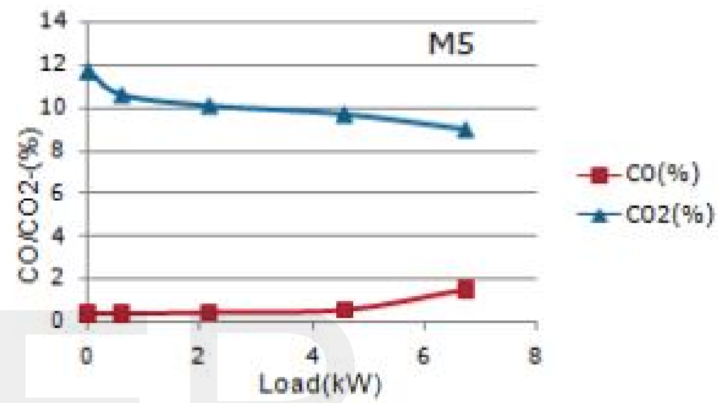
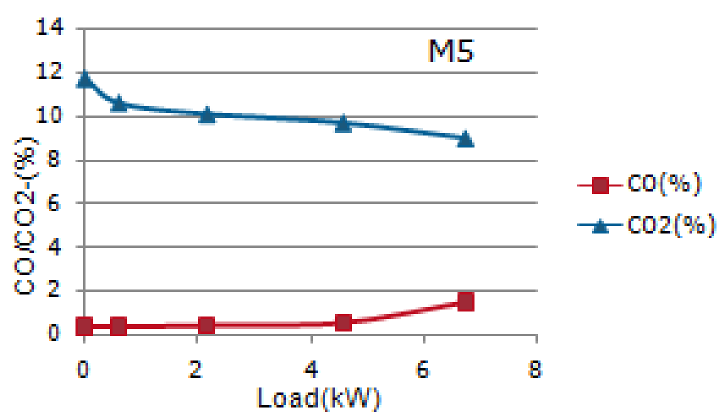


Fig. 8: CO / CO_2 (%) VS Brake Power(kW) using 10% Methanol



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This CO_2 / CO trade offs as shown (Fig 6, Fig 7, Fig 8, and Fig 9) can be attributed towards the high Oxygen content of methanol. The excess oxygen helps in the oxidation of CO to CO_2.

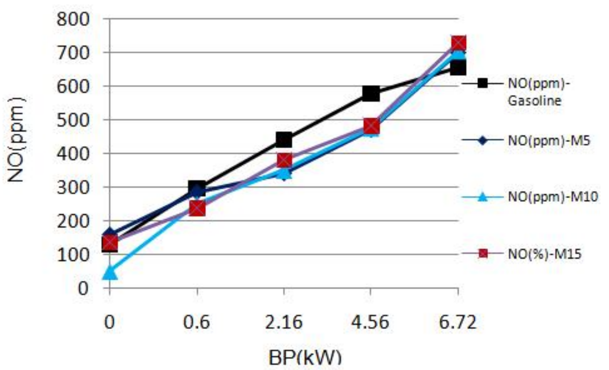

Fig. 10: Nitrogen Monoxide" NO" (ppm) VS Brake Power (kW)

Variation observed in the NO emission (ppm) at different loads with different additive-fuel blends is shown in Fig 10. NO emission level increased with increase in loading of the engine for all the additive-fuel blends. But there was a reduction in NO emission with increase in percentage of methanol in gasoline.

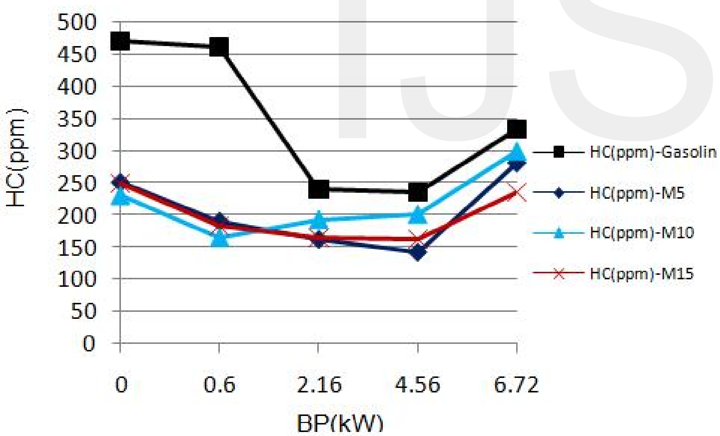

Fig. 11: Hydrocarbon "HC"(ppm) VS Brake Power(kW)

Hydro carbon emission was reduced significantly during the cold start of the engine while using methanol blended gasoline, indicating an improvement in combustion efficiency. This can be attributed towards the higher oxygen content of methanol. Chemically methanol is an aliphatic alcohol containing about 50% oxygen by mass. Blend of 10% Methanol with 90% Gasoline has produced the lowest HC emission during the cold start.

4 Conclusion

In this paper we investigated the impact of using Methanol blended gasoline as a fuel instead of using pure gasoline in a 4 stroke, 4 cylinder spark ignition engine.

The brake thermal efficiency while using M10 (10% Methanol) was found higher in compare with other methanol blends and 100% gasoline. Regarding emission characteristics, the major observations were, drastic reduction (65.13%) in HC emission during cold start of engine, and reduction (97.88%) in CO emission when the load was high. From the result it is evident that methanol-blended gasoline can be a good substitute as a fuel for vintage engines.

Presence of Oxygen gives a more desirable combustion characteristics resulting into low emission of CO, HC and higher emission of CO_2 as a result of complete combustion [3].

5 Acknowledgement

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