Experimental Investigation of Ethanol-Methanol-Gasoline Blend on Multi cylinder SI Engine using Catalytic Converter

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Abstract— This research work encircles exhaust emissions from spark-ignition engine fuelled Ethanol-Methanol-Gasoline blend with Catalytic Converter mounted on tail pipe. As the research needs to be done in the laboratory to study the ability of the SI Engine to reduce exhausts emissions of Carbon Monoxide, HC (unburned hydrocarbons) and NOx. This study gives the emissions capabilities and the effectiveness of catalysts of Catalytic Converter. The use of low content of ethanol methanol in gasoline is being compared to pure gasoline test results. A combustion and emission characteristic of ethanol-methanol-gasoline blend is studied. When the engine is tested with ethanol methanol gasoline blend the concentrations of CO, HCand NOx emissions is significantly decreased compared to the pure gasoline whereas CO_2 goes on increasing.

***Keywords*:** Spark Ignition engine, Alternative fuel, Catalytic Converter and Emissions

I. INTRODUCTION

The alcohol such as ethanol and methanol is an octane boosting compound and most prominent additives can be mixed with gasoline and used as a alternative fuel. The Oxygen content of ethanol and methanol reduces the emissions such as CO, HC and NOx while the CO_2 concentration increases from the exhaust gases. The Oxygen content is seen to decrease the temperature of the exhaust gases also. The research needs to be done by using Ethanol-Methanol-Gasoline blend at various loading conditions. The exhaust gases coming from the engine causes pollution and affects the environment. The search for alternative fuel is important from environmental point of view.

The Ethanol-Methanol-Gasoline Blend is claimed to have an impact on mechanical performance parameters e.g. Torque, Brake Power and Fuel Consumption, increase. The further study is planned to test the engine test rig for multiple blends and various loading conditions. A catalytic converter is placed at the tail pipe to reduce the exhaust emission of the engine. The gas analyzer is deployed for exhaust emissions analysis.

II. LITERATURE REVIEW

The exhaust gases from I.C.E lead to greenhouse effect, acid rain, ozone depletion etc. and hence climate change. The octane boosting compounds added for octane rating essential to resist knocking and run smoothly (A. Elfasakhany, 2015). Alcohol such as Methanol and Ethanol is blended to the Gasoline as an octane boosting compounds (F. Ansari, et, al, 2012). Methanol and Ethanol can produce from lingo-cellulosic material like wood, agricultural, forest residues and municipal waste (F. Ansari, et, al, 2013). Methanol and Ethanol possesses characteristic, properties that have positive influence on engine performance as well as exhaust emissions (F. Ansari, et, al, 2012). They are the world-recognized excellent alternative fuels because they are renewable, clean and abundant (L. Li, et, al, 2014).

Methanol and Ethanol addition to gasoline makes the engine operation leaner and improves engine combustion and performance (F. Ansari, et, al, 2013). In contrast with gasoline, methanol has a higher oxygen content of about 50% and Ethanol is having 34% of oxygen content. They enable more complete combustion and enhance the combustion temperature (L. Li, et, al, 2014). Methanol contains low carbon/hydrogen ratio and high flammability limit and burning speed (P. Geng, et, al, 2014). Ethanol and Methanol blended fuels reduce exhaust emissions, intake manifold temperature and increases volumetric Efficiency due to presence of oxygen content (M. Canakci, et, al, 2013). Methanol and Ethanol is having very less calorific value than that of pure gasoline (F. Ansari, et, al, 2012). Increase in Ethanol and Methanol percentage in gasoline fuel reduces the calorific value compared to pure gasoline (F. Ansari, et, al, 2013). It is having satisfying engine performance and combustion efficiency as well (X. Wanga, et, al, 2015). Blending of Ethanol-Methanol-Gasoline fuel enables the engine to run without any knock at high compression ratio, full load and at all speeds (K. Manikandan and M. walle, 2013).

The cylinder gas pressure in SI Engine with the use of Ethanol-Methanol–gasoline blends began increase of the engine loads. An ethanol-Methanol–gasoline blend corresponds to increase in the peak cylinder gas pressure and peak heat release rate. The use of Ethanol and Methanol increases the ignition delay but has no significant effect on the combustion duration. Ethanol and Methanol can be mixed with gasoline in any proportion without using additives, and no phase separation will be observed (P. Geng, et, al, 2014).

Ethanol and Methanol has much higher octane number this allows engines to have much higher compression ratios and thermal efficiency. At varying compression ratios, the fuels containing Methanol and Ethanol will absorb more heat from combustion chamber leads to decrease the pressure of the combustion chamber accordingly (N. Maharaja and B. Kumar, 2014), (S. Shayan, et, al, 2011). The blended fuels are recommended to be used especially at high vehicle speeds. Blends are used to test the engine under steady state operating temperature; wide-open throttle conditions (A. Elfasakhany, 2015). The required air-fuel equivalence ratio increases with the increase of ethanol and methanol percentages in fuel blends or decreased in wheel power (M. Canakci, et, al, 2013)

III. OBJECTIVES

The aim is to reduce the exhaust gas emissions with the use of Ethanol-Methanol-Gasoline blend for various loading conditions. To achieve the aim following objectives are to be fulfilled:

1) To evaluate the exhaust emissions with and without catalytic converter for pure gasoline and Ethanol-Methanol-Gasoline blend for various loading conditions.
2) To evaluate the concentration of exhaust emissions such as CO, CO_2, NOx and HC with Ethanol-Methanol-Gasoline Blend for various loading conditions.
3) To evaluate the exhaust gas temperature when engine is fuelled with Ethanol-Methanol-Gasoline blend for various loading conditions.
4) To consolidate the results of gas analyzer, Torque, Fuel consumption and temperature.

IV.ENGINE TEST RIG FOR EXPERIMENTATION

The test rig consists of four cylinder, four-stroke, 9:1 compression ratio with 65 BHP, water cooled unit with carburetor. An eddy current dynamometer, model AG-80 which is of air gap type having arm length of 0.3 meters and dyno-constant of 9549.305. The piezo sensor model 111A20 with maximum pressure 2626.90 KN/m^2 is installed in 4th cylinder with resolution of 0.68 KN/m^2. It is provided with a low noise BNC cable. To measure the fuel consumption, Air purge level transmitter is incorporated in fuel metering flask. Similarly orifice meter for air flow measurement, Rota-meter to meter the cooling water to dynamometer and engine, and 2-wire K type 4 thermocouples to measure the temperatures at the following location:

T1: Inlet water temperature of the engine
T2: Outlet water temperature of engine
T3: Temperature at the exhaust gas manifold
T4: Temperature of exhaust gas after catalytic converter.

The reluctance type magnetic sensors are used for measuring the speed of the engine. It consists of a permanent magnet, a ferromagnetic pole piece and a coil of wire. The setup panel also consists of an air box to provide a smooth flow of air to the engine and avoids pulsating nature of intake air.

Fig.1 Engine Test Rig

Some of the important engine specifications are as under.

1) Engine : 4 Cylinder, 4 Stroke, 1405 cc

2) Cooling : Water Cooled
3) BP : 44.76 kW at 5000 rpm
4) CR : 9:1
5) Cylinder : 75mm dia , 79.5 mm stroke

V.EXPERIMENTATION

The experimentation was carried out:
1) To test the engine with pure gasoline and Ethanol-Methanol-Gasoline blend in the ratio 3.5:3.5:93 (Vol. %).
2) To test the engine exhaust emissions such CO, CO_2, HC and NOx from 2600-4000 rpm at various loading condition.
3) To test the Torque, Fuel consumption and temperature at various loading condition.

Test is conducted when engine reached at its steady state operating conditions.

Some of the important blend specifications are as under.

1) Density : 747 Kg/m^3
2) Flash Point : 41.70 ^{0}C
3) Air-fuel ratio : 11.5:1
4) LCV : 43 MJ/Kg
5) Octane Number : 87.54
6) Oxygen Content : 3.49 Wt.%
7) Carbon content : 78

Table 1 Fuel Properties (A. Elfasakhany, 2015)

Properties	Methanol	Ethanol	Gasoline
Molecular formula	CH_3OH	C_2H_5OH	C_8H_{18}
Molecular weight	32	46	114
Oxygen content (%)	50	34.8	0
Density (kg/m3)	792	785	740
LHV (MJ/kg)	20.0	26.9	44.3
Octane number	111	108	>90
Auto-ignition temp. (°C)	465	425	280
Air Fuel ratio	6.47	9.00	14.8
Latent heat of vapour (kJ/kg)	1103	840	305
Boiling point (°C)	64	78	85

Table 2 Gas Analyzer Specification

Parameters	Measuring range	Resolution
CO	0-15% Vol.	0.01%Vol.
CO_2	0-20% Vol.	0.01 % Vol.
HC	0-30,000 PPM	1 PPM
O_2	0-25% Vol.	0.01%Vol.
NOx	0-5000 PPM	1 PPM
Lambda	0-9.999	0.001

VI.RESULTS AND DISCUSSIONS

The test is conducted with catalytic converter at no load condition from 2600-4000rpm. The following are the significant observation on CO, HC, CO2, NOx and temperature as discussed below:

6.1 CO Emissions

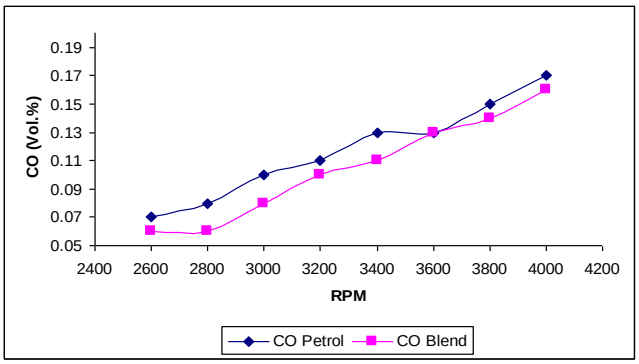

Fig.2CO Emissions

The effect of the pure gasoline Vs. Ethanol-Methanol–Gasoline blend on CO emissions for different engine speeds is shown in Fig.2. It can be seen that the CO concentration is slightly less for Blended fuel as compared to pure gasoline. CO Vol. % increases from 0.07 to 0.17 for pure gasoline whereas for blend it increases from 0.06 to 0.16 for 2600 to 4000 rpm. The maximum reduction in CO for blended fuel is 0.02 Vol. %. It is due to the presence of oxygen content in the blended fuel. The concentration of CO in the exhaust gas depends on the oxygen content, which promotes the oxidation of CO in engine exhaust process.

6.2 HC Emissions

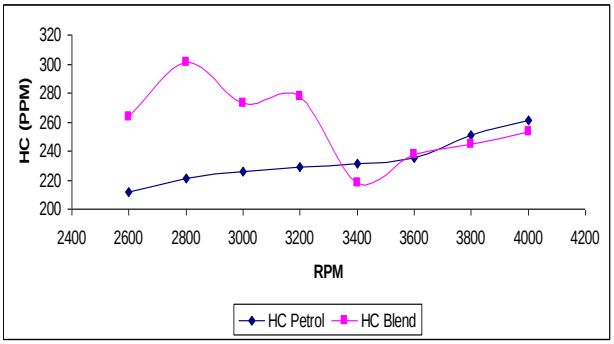

Fig.3HC Emissions

The effect of the pure gasoline Vs. Ethanol-Methanol–Gasoline blend on HC emission for different engine speeds is shown in Fig.3. The HC PPM increases from 211.755 to 261.5 for pure gasoline and for blend it decreases from 263.6 to 253.33 for 2600 to 4000 rpm. The maximum reduction in HC for blended fuel is 13.09 PPM. It can be seen that at lower engine speeds the concentration of HC is more for blended fuel. At higher operating speed the concentration of HC is low as compared to that of pure gasoline. This is because blended fuel shows high efficiency at higher operating speeds. As the speed increases there is vast downfall of HC concentration as shown in fig.3.

6.3 CO_2 Emissions

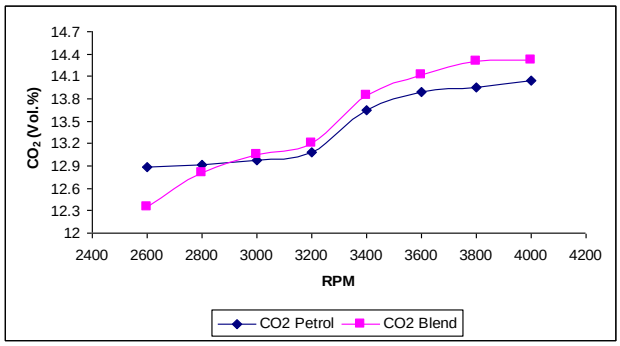

Fig.4CO_2 Emissions

The effect of the pure gasoline Vs. Ethanol-Methanol–Gasoline blend on CO_2 emission at different engine speeds is shown in Fig.4. CO_2 Vol.% increases from 12.88 to 14.04 for pure gasoline and for blend it increases from 12.35 to 14.32 for 2600 to 4000 rpm. The maximum increase in CO_2 for blended fuel is 0.34 Vol.%. It can be seen that CO_2 concentration is more than that of pure gasoline, it is Due to the presence of Oxygen content in the blended fuel. The increase in CO_2 concentration is due to improved combustion process.

6.4 Temperature (T4)

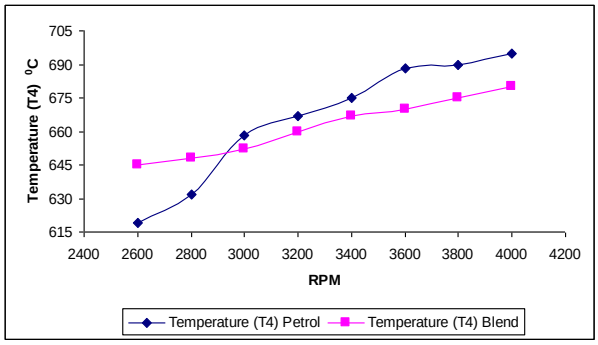

Fig.5 Temperature (T4^{0}C)

The effect of the pure gasoline Vs. Ethanol-Methanol–Gasoline blend on the temperature (T4) after catalytic converter for different engine speeds is shown in Fig.5. The temperature T4^{0}C for pure gasoline increases from 619 to 695 and for blend it increases from 645 to 680 for 2600 to 4000 rpm. The maximum reduction in temperature for blended fuel is 18^{0}C.The exhaust gas temperature for blended fuel is comparatively low than that of pure gasoline

6.5 NOx Emissions

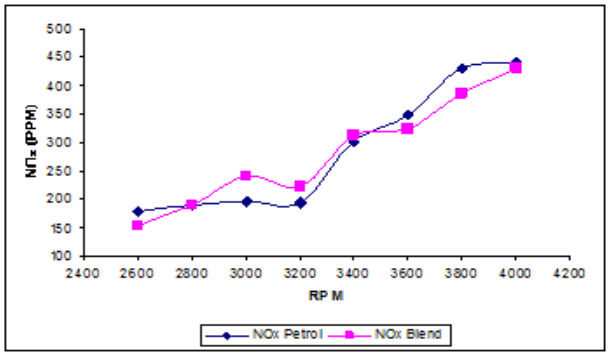

Fig.6NOx Emissions

The effect of the pure gasoline Vs. Ethanol-Methanol–gasoline blend on NOx emissions for different engine speeds is shown in Fig.6. NOx PPM increases from 177.5 to 441.5 for pure gasoline and for blend it increases from 153.5 to 430 for 2600 to 4000 rpm. The maximum reduction in NOx for blended fuel is 43 PPM. The NOx concentration is more for blended fuel compared to pure gasoline at lower operating speeds. At higher operating speeds the concentration of NOx goes on decreasing in case of blended fuel.

VII.CONCLUSIONS

1) The emissions such as CO, HC and NOx are comparatively low for Ethanol-Methanol-Gasoline blend as compared to pure gasoline at no load condition. This is due to improved combustion in presence of oxygen content. This endorses Ethanol-Methanol-Gasoline blend burns cleaner than pure gasoline.
2) The presence of oxygen content in Ethanol-Methanol-Gasoline :
   I. The concentration of CO_2 increases for theEthanol-Methanol-Gasoline blend as compared to pure gasoline at no load condition. Higher the concentration of Ethanol and Methanol in the blend, higher will be the amount of CO_2 in the exhaust gas.
   II. Exhaust gases temperature of Ethanol-Methanol-Gasoline blend is low as compared to pure gasoline fuel.
3) It could be concluded, the exhaust emissions are reduced for Ethanol-Methanol-Gasoline blend over the pure gasoline fuel.

VIII.FUTURE SCOPE

1) The emission pattern with one blend is mapped. The emissions are to be mapped for various ratiosof Ethanol-Methanol-Gasoline blend, with and without catalytic converter.
2) The emission pattern with no load condition is mapped. The emissions are to be mapped forvarious loading condition for various ratios of Ethanol-Methanol-Gasoline blend.

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