Study of Performance of SI Engine Test Rig by using Ethanol Petrol Blends

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ABSTRACT: Ethanol can be long identified or known as a high quality transportation fuel. It can be used in low-level petrol blends (E-10 to E-40) for unmodified vehicle designed to run on petrol, or in higher level blends (E-85, E-95 and E-100 with appropriate modification in the ignition system of the engine) for dedicated or flexible fuel vehicles (FFVs). Because ethanol has not been used extensively in high level blends, the technology to fully take advantages of its excellent fuel properties has not yet been developed to a mature state. Significant improvements in ethanol utilization technology are expected in the near future. Ethanol has been advanced in good energy efficiency, power and emission performance and is also identified better than conventional diesel or petrol fuels that are now being used largely for transportation purposes. Ethanol is developing a recognizable market share globally in transportation fuel market due to a new combination of cellulosic biomass production technology with advanced utilization technology for ethanol vehicles. It is well known that the future availability of energy resources, as well as the need for reducing CO2 emissions from the fuels used has increased the need for the consumption of natural fuel which can be regenerated. This dissertation is done by taking a reference of commercial gasoline which is blended with 5% ethanol originally. Hence 5%, 10%, 20% and 30% ethanol blended with petrol initially was tested in SI engines. Physical properties relevant to the fuel were determined for the four blends of gasoline. A three cylinder, four stroke, varying rpm, Petrol (MPFI) engine was tested on blends containing 5%,10%,20% and 30% ethanol and performance characteristics, and exhaust temperature are measured.

INTRODUCTION

There is a fast depletion of fossil fuels; the search for alternate fuels has become very important to get the continuous supply of energy. SI engines have an alternate fuel i.e. Alcohol as they have their properties just like gasoline fuels. No engine alteration is needed if alcohol is blended in small quantities with petrol fuel. Carbon monoxide (CO) and un-burnt hydrocarbons (UBHC) are the major exhaust pollutants which results in human health disorder. These exhaust pollutants are formed due to incomplete combustion of fuel. They majorly cause many health disorders such as sensation of vomits, bronchitis, asthma problems, emphysema, reflexes are slow down, dizziness and drowsiness and many more. Apart from environmental disorders these pollutants also causes detrimental effects on plant and animal life. Quite few reasons for the formation of pollutants are the vehicles age and their maintenance also.

There are a number of gases present in the environment which causes pollution and greenhouse effect and the major contributor is the transport sector due to the heavy, and increasing, traffic levels. In spite of ongoing activity to promote efficiency, the sector is still generating significant increases in CO2 emissions. As transport levels are increasing continuously in developing countries, fairly huge political decisions should have to be taken to reduce this problem in the future. Furthermore, due to the continuous supply of petroleum, today, the main contributor to emissions of greenhouse gases is the transport sector, out of which carbon dioxide is particularly important. The carbon dioxide emissions originate mainly from the use of fossil fuels; mostly petrol and diesel oil in transportation systems, and also some originates from other types of fossil fuels such as natural gas and Liquefied Petroleum Gas (LPG). If international and national aims for reducing net emissions of carbon dioxide are to be met, the use of commercial fuels in the transport sector has to be substantially reduced.

In India every year two third of fuel energy is used in transportation for which petrol or diesel is greatly suited. Due to their availability and wide utility their price are also increasing at a very fast rate. Many types of liquid fuels that is made from various artificial ways now a days are initiating to work with the conventional fuels so as to compensate the rates of fuel used and to control the harmful emissive constituents which generates because of the use of fossil fuel alone.

A fuel known for many decades are the Ethanol's. Indeed, when Henry Ford designed the Model T, he has an expectation that ethanol which is made from renewable biological materials could be a main automobile fuel, yet, because of its high price it is not widely used. But ethanol, as a fuel for spark ignition engines has some advantages over gasoline; some of them are better anti-knock qualities and reduction of carbon monoxide and UHC emissions. Even though having these

There is rapid increase in fuel prices and oil consumption and also scarcity of petroleum based fuels have accelerated an interest for use of alternative, renewable sources of energy like biodiesel and alcohol-based fuels. Ethanol (C2H5OH an alcohol) is the world's largest and fastest growing source of renewable energy with almost all the developing country having some form of bio fuel industries, due to its clean green image, ease of manufacture and it has an ability to be blended with petrol easily. Ethanol has become widely used renewable fuel in recent years designed to operate with higher concentrations of ethanol with up to 10% by volume blended in to petrol for spark ignition engines or up to 85% for use in Flex-Fuel vehicles. Spark-ignition engines can also be run by ethanol only or blended up to 40% with Diesel fuel for use in C.I engines

The country like Brazil, Sweden & USA have marked their existence in the Bio-Gasoline based substitute auto fuel sector by the creation of the flexible fuel vehicle technologies and purpose of ethanol gasoline blends as high as E85 to E100 (Frank et al. 1998), (Pikunas et al. 2003). The profitable and environmental constraints have required a country like India to involve in a required consumption of just E10 as fuel in their light duty vehicles. While there is no shortage of sugarcane production in India, which is one of the main sources for automotive ethanol fuel, making it to be the second largest producer in world, India still lacks the technological advancement in terms of engine modification and material compatibility trouble. Ethanol while being a renewable bio–mass based substitute fuel also has some added performance based properties mainly the higher octane number, inherent oxygen content, and a higher latent heat of vaporization which in return allows a higher power to be extracted from the engine both in the customized and unmodified state.

ADVANTAGE OF ETHANOL

1. A number of technical advantages of ethanol: Ethanol is an efficient, clean, 100% natural energy alternative to petroleum fuels.
2. It prolongs engine life and reduce the need for maintenance
3. It is safer to handle, being less toxic, more biodegradable, and having a higher flash point
4. It reduces some exhaust emissions
5. Use of ethanol in a conventional petrol engine substantially reduces emissions of unburned hydrocarbons, carbon monoxide, sulfates, polycyclic aromatic hydrocarbons, nitrated polycyclic aromatics hydrocarbons, and particulate matter,
6. It promotes rural development
7. It is renewable energy
8. It is 100% biodegradable
9. It can be used as a petrol fuel additives /lubricity agent.
10. It can be used in on road vehicle, off road vehicle and marine vessels.
11. Ethanol is safe to transport due to high flash point

DISADVANTAGE OF ETHANOL

The technical disadvantage of ethanol includes:

1. Fuel freezing in cold weather
2. Reduced energy density
3. Degradation of fuel under storage for prolonged periods
4. Direct use of ethanol oil has generally been considered to be not satisfactory and impractical for both direct and indirect petrol engines
5. The cost of ethanol is higher than the petrol fuel

LITRATURE REVIEW

Juozas Grabys et al investigated on ethanol-gasoline blended fuel and pure gasoline on an SI engine, the performance and pollutant emission has been experimentally showed and compare. It has been observed that after the ethanol was added, it results in decrease of the heating value of blended fuel while it increases the octane number of blended fuel. Engine test results have shown that the engine power and specific fuel consumption of the engine has been increased slightly as they used ethanol-gasoline blended fuel which also decreases the emission of carbon monoxide considerably. It happens because of the leaning effect caused by the addition of ethanol, and carbon dioxide emissions get increased due to the better combustion, while HC emission decreases in some engine working conditions.

Bang-Quan He, Jian-Xin Wang investigated an EFI system which is an electronic fuel injection, used to observe the outcomes of ethanol blended gasoline fuels on emissions and catalyst conversion efficiencies in a spark ignition engine. Results have shown that engine out regulated emissions can be decreased by ethanol. The engine-out total hydrocarbon emissions (THC) can be significantly reduced by using fuel having 30% ethanol by volume at operating conditions while at idle speed it can reduce engine-out THC, carbon monoxide and nitrogen oxide emissions, but the conversion of unburned ethanol is low but the unburned ethanol and acetaldehyde emissions are efficient in dropping acetaldehyde emissions. Engine-out emissions, catalyst conversion efficiency, engine's speed and load, air/fuel equivalence ratio has close relation with tailpipe emissions of THC, carbon monoxide and nitrogen oxides. In addition to that, brake septic energy consumption can be decreased by the blended fuels.

Amit Pal, S. Maji, O.P. Sharma and M.K.G.Babu et. al. operated a Kirloskar, four stroke, 7.35kW, twin cylinder, DI diesel engine in dual fuel mode (with substitution of up to 75% diesel with CNG). This experiment has shown results that showed considerable reduction of smoke and almost 10% to15% increase in power and 10% T6 15% reduction in fuel consumption and 20 to 40 % saving in fuel cost (considering low cost of CNG). The most amazing results showed the reduction of noise of engine by 33% which may extend the life on engine significantly and also the results in reducing the sound levels of big diesel engines to that of small sized gasoline engine.

P. A. Hubballi, and T.P. Ashok Babu et al investigated Denatured spirit (DNS) , DNS-water blends as fuels experimentally and study in a four cylinder four stroke SI engine. Study was made on performance tests for (BTE) Brake Thermal Efficiency, Brake Power (BP), Engine Torque (T) and Brake Specific Fuel Consumption (BSFC). Carbon monoxide (CO), hydrocarbons (HC), oxides of nitrogen (NOx) and carbon dioxide (CO2) are also observerd for their exhaust emissions. The observation of the experiments shows the break thermal efficiency, brake power, engine torque and brake specific fuel consumption was increased by both DNS and DNS95W5 but it also decreased the CO, HC, NOx and CO2 emissions in the exhaust. The DNS and DNS95W5 as fuels made the better results in performance of engine and made less engine exhaust emissions.

Alvydas Pikūnas tested the performance of engine and pollutant emission of an SI engine thus comparing it by using ethanol-gasoline blend and pure gasoline to study nad investigate it experimentally. The observation showed that the octane number of the blended fuel increases while decreasing the heating value of blended fuels when ethanol is been added. The results of the engine test indicated that when ethanol–gasoline blended fuel is used, the engine power and specific fuel consumption of the engine slightly increase; CO emission decreases dramatically as a result of the leaning effect caused by the ethanol addition; HC emission decreases in some engine working conditions; and CO2 emission increases because of the improved combustion.

EXPERIMENTAL PROCEDURE

The engine was started at no load. After adjusting the fuel feed control to enable the engine to achieve the rated speed of 1500rpm, it was allowed to run until the steady state condition is reached, with the fuel measuring unit and stop watch, the time elapsed for the consumption of 10cc, 20cc, and 30cc fuel was measured and averaged. Fuel consumption, rpm, exhaust temperature, power output were also measured. The engine was loaded gradually keeping the speed within the permissible range; observations on the different parameters were recorded. Short term performance tests were also carried out on the engine with the petrol to generate the base line data; subsequently the ethanol-petrol blends were used to evaluate its potential suitability as fuel. With the every subsequent reading the remaining blend is taken out of the engine by the drain pipe and engine is again charged with the new ethanol-petrol blends to take new readings.

SPECIFICATION OF ENGINE

Engine Make - Maruti MPFI
Fuel - Petrol
No. of cylinders -three
No. of strokes/ cycles -4
Rated power -5 hp
Rated rpm -1500 rpm
Bore - 67 mm
Stroke length - 72 mm
Starting condition -Cold start
Method cooling -Water cooled
Method of ignition -spark ignition

EXPERIMENTAL-SETUP

Fig. Test Rig.

Fig: Water flow measuring rota meter.

Fig: Fuel flow measuring system

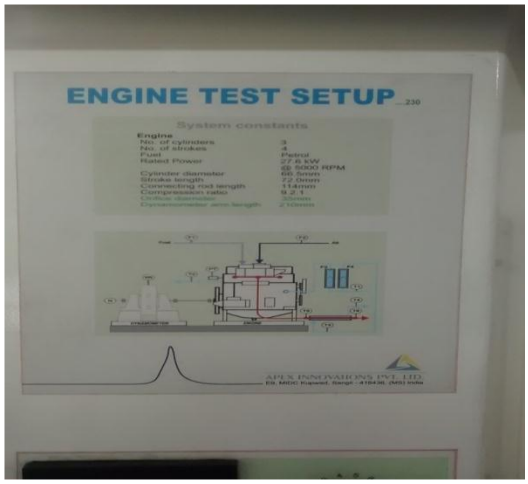

Fig: Specification of test Set up.

-FUEL MEASUREMENT

The fuel is supplied to the engine from the main fuel tank through a graduated measuring fuel gauge (Burette). The measure the fuel, close the stop cock and start the stop clock, measure the time taken for the consumption of X cc of fuel.

AIR INTAKE MEASUREMENT

The suction side of the engine is connected to an Air tank. The atmospheric air is drawn into the engine cylinder through the air tank. The manometer is provided to measure the pressure drop across an orifice provided in the intake pipe of the air tank. This pressure drop is used to calculate the volume of air drawn into the cylinder.

TEMPERATURE MEASUREMENT

A digital temperature indicator with selector switch is provided on the panel to read the temperature in centigrade, directly sensed by respective thermocouples located at different places on the test rig. Thermocouples details

T_1= Inlet water temperature to engine jacket and calorimeter

T_2= Outlet water temperature from engine jacket

T_3= Inlet water temperature to calorimeter

T_4= Water outlet temperature from calorimeter

T_5= Exhaust gas inlet temperature

T_6= Exhaust gas outlet temperature

PERFORMANCE TEST

1-BRAKE POWER

$$B.P = \frac{2\pi NPgl}{6000}$$

N = Engine speed in R.P.M

P =Load on the engine in kg

l = Dynamometer arm length in meter (0.2 m)

g **= gravity acceleration, m/sec², (9.81)**

2- BRAKE MEAN EFFECTIVE PRESSURE

$$bmep = \frac{60B.P}{\pi/4D^2LNnN_c100}$$

Where

B.P =brake power in kW

D =bore of the cylinder of the engine (0.067 m)

L =stroke length of the cylinder (0.072 m)

N= speed of the engine in rpm

n = number of revolutions of crank per cycle (2 rev.)

N_C=number of cylinders

(3 cylinder)

3- ENGINE TORQUE

$$T = g \times P \times L_D$$

Where

P= load on the engine, kg

L_D **= dynamometer arm length, m**

g **= gravity acceleration, m/sec², 9.81**

4-Brake specific fuel consumption

$$BSFC = \frac{FUEL\ FLOW\ IN\ {}^{kg}/_{hr}}{B.P}$$

5-Brake thermal efficiency

$$\eta_{br.th} = \frac{B.P \times 60 \times 1000 \times m_f}{100 \times 0.06 \times \rho \times C_V} \times 100$$

Results of 20% blends

Air density(Kg/m^3) 1.16

Brake power (kW)	BMEP (Bar)	Torque (N.m)	BSFC kg/kwH	BTh.eff. (%)	Air flow (kg/hr)	Vol.eff (%)
14.9	9.20	54.9	0.345	24.79	57.9	85.4
18.6	9.53	56.9	0.321	26.69	72.3	88.7
22.3	9.86	58.9	0.284	30.07	82.0	86.7
21.1	8.22	49.1	0.361	23.73	87.0	80.9
24.1	8.54	51.0	0.374	22.86	99.2	84.0

6- Air-fuel ratio

$$ {}^{A}/_{F}\ RATIO = \frac{AIR\ FLOW}{FUEL\ FLOW}$$

RESULTS AND DISCUSSIONs

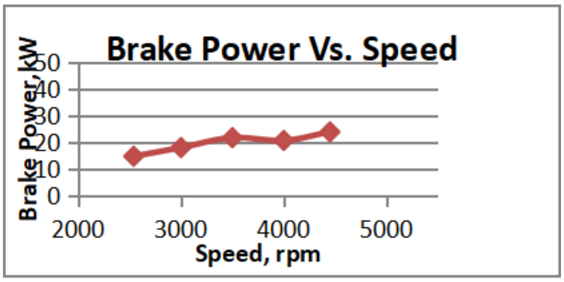

Fig: Graph of Brake power and Speed for pure petrol.

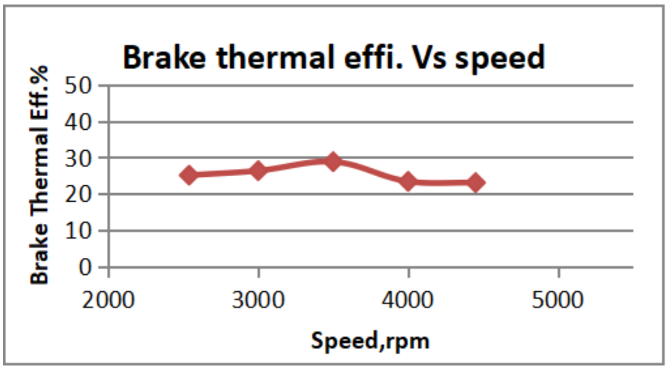

Fig: Graph of Brake thermal efficiency and speed for pure petrol.

Results of 10% blends

Air density(Kg/m^3)				1.16		
Brake power (kW)	**BMEP (Bar)**	**Torque (N.m)**	**BSFC kg/kwH**	**BTh.eff. (%)**	**Air flow (kg/hr)**	**Vol.eff (%)**
14.7	9.20	54.9	0.327	25.34	59.6	89.3
18.2	9.53	56.9	0.308	26.95	72.9	91.3
21.9	9.86	58.9	0.282	29.45	83.0	89.2
20.8	8.22	49.1	0.348	23.81	87.7	82.7
23.9	8.54	51.0	0.356	23.30	100.2	85.6

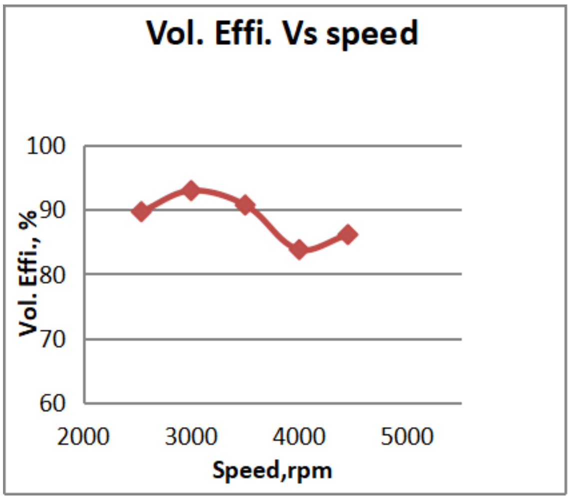

Fig: Graph of Volumetric Efficiency and speed of pure petrol

Results of 5% blends

Air density(Kg/m^3)			1.16			
Brake power (kW)	**BMEP (Bar)**	**Torque (N.m)**	**BSFC kg/kwH**	**BTh.eff. (%)**	**Air flow (kg/hr)**	**Vol.eff (%)**
14.9	9.20	54.9	0.347	24.67	57.9	85.2
18.5	9.53	56.9	0.324	26.45	72.3	88.8
22.3	9.86	58.9	0.287	29.82	82.0	86.8
21.2	8.22	49.1	0.362	23.67	87.0	80.5
24.2	8.54	51.0	0.377	22.75	99.2	83.8

Results of 30% blends

Air density(Kg/m^3)				1.16		
Brake power (kW)	BMEP (Bar)	Torque (N.m)	BSFC kg/kwH	BTh.eff. (%)	Air flow (kg/hr)	Vol.eff (%)
14.8	9.20	54.9	0.332	25.18	58.7	87.0
18.5	9.53	56.9	0.312	26.82	71.6	88.1
21.3	9.43	56.3	0.297	28.23	82.8	87.7
20.8	8.12	48.5	0.357	23.42	87.2	81.3
23.3	8.25	49.2	0.376	22.24	99.4	84.2

COMPARISION WITH DIFFERENT RESULTS

Petrol Blends having 5%, 10%, 20% and 30% Ethanol is prepared. These curves are plotted between loads, brake power, BTh.eff. (%) and BSFC. The values are calculated and then fed in the software set up configuration to get the desired results. The results obtained were noted and then curves were plotted as shown below to have a clear understanding of the variations of different parameters by using different blends.

CONCLUSIONS & FUTURE SCOPE

The data discussed clearly indicates that there will be a lean shift if experiment operated on E10 gasoline. The lean shift will result in increased brake power and brake thermal eff.

Brake Thermal Efficiency increases on blending. Brake Thermal Efficiency reaches a maximum at around 3600 rpm and then starts decreasing. BTE (break thermal efficiency) results in an increase on blending and it reaches extreme at around 3600 rpm (revolutions per minute) and then it will start to decrease. In comparison to commercial petrol it increases by 11.6% for 10% blend, 8.1% for 15%blend and 23.37% for 20%blend at 3600 rpm.

Brake Thermal Efficiency increases on blending. It reaches a maximum at 30 kg load and is generally higher for 3000 rpm than 4000rpm.At 20kg load, it increases by 45% for 10%blend, 32.2% for 20% blend, 7.91% for 30% blend at 3000 rpm and increase by 39.1% for 10% blend, 17% for 20% blend and 2.99 % for 30% blend at 4000 rpm with respect to commercial petrol.

Future scope

It is possible that analysis of the reasons for the apparent inconsistencies between the various study results will bring improved understanding of the requirements for ensuring that pollutant emissions are always minimized when running vehicles on ethanol fuels. Fuel options for reducing emissions include reformulating conventional fuels to reduce or increase Particular components or use of alternative fuels such as ethanol

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