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Experimental Investigation of S.I. Engine on Gasoline and Ethanol-Gasoline Blend for Engine Performance Characteristics

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Abstract- **With the continuous consumption and increasing use of conventional energy resources, it has become necessary to develop new means to reduce the consumption of conventional energy resources and increase the power output of the existing engines with reduction in fuel consumption and increase efficiency. The problem of fuel scarcity has become very serious for developing economies like India where industrialization is rapid and number of light and heavy vehicles is continuously increasing. The government is believed to be considering decontrolling and to regulate fuel prices according to international price of Petroleum fuels, a move that may see rates being hiked by oil industries, but diesel may continue to be sold at a subsidized rate, still deregulation is imminent. One of the options being considered is deregulating petrol prices. The country's preferred auto fuel, diesel will, however continues to be subsidized.**

Keywords- SI engine; blend; CO; UBHC; NOx; EGT; GHG

I. INTRODUCTION

India is the 6th largest consumer of fossil fuels in the world (TOI 26 May 2008) Looking to such a rapid increase in the international fuel prices and depletion of fuel, it has become necessary to suggest some means to reduce the cost of operation of our vehicles. Ethanol is an attractive alternative fuel because it is a renewable bio-based resource and it is oxygenated which reduces particulate emissions in I C engines. In this work the properties and specifications of ethanol blended with petrol fuel are discussed.

This is of special importance for India because the economy is facing substantial pressure from the United Nations Framework Convention on Climate Change (UNFCCC) to limit its carbon footprint. Thus, there is pressure on India to look for alternative and environment friendly sources that can fulfil its energy requirements in a sustainable manner and reduce pollution.

The Ministry of Petroleum and Natural Gas (MOPNG) issued a notification in September 2002 for mandatory blending of 5 percent ethanol [1] in nine major sugar producing states and four union territories from 2003.4 In 2003, the Report of the Committee on Development of Bio fuel, under the auspices of the Planning Commission, recommended a phase-wise implementation programme to blend bio-fuels with petrol and diesel. However, due to a supply shortage from 2004 to 2005, the ethanol-blending mandate was made optional in October 2004, but it resumed in twenty states in October 2006.5 In October 2007, the Government of India made it mandatory to blend 5 per cent ethanol in petrol across the country, with the exception of J&K, the Northeast and island territories. In 2008, the Government of India announced its National Bio-fuel Policy, mandating a phase-wise implementation of the programme of ethanol blending in petrol in various states. The blending level of bio-ethanol6 at 5 per cent with petrol was made mandatory from October 2008, leading to a target of 20 per cent blending of bio-ethanol by 2017. This was taken up by the oil marketing companies (OMCs) in twenty states and four union territories.

II. LITERATURE REVIEW

Ethanol has the property of absorbing moisture from the atmosphere until it has composition of 95% alcohol and 5% water (Hamrock,1994).The commonly available ethanol grade contain 10-20% water and therefore they are aqueous ethanol. Aqueous ethanol is much cheaper than petrol and anhydrous ethanol has the potential for lower emission and higher engine efficiency as compared to petrol. Study shows that NOx reduction of up to 49% can be obtained by using aqueous fuels.

Yu Bai et al. [3] concluded that that driving with switch-grass ethanol fuel as a replacement of gasoline contributes to the reduction of GHG emissions significantly, mainly due to the CO2 uptake from atmosphere in switch-grass agriculture. Driving 1 km using E85reduces GHG emissions by 65% compared with driving with gasoline. The reduction of dependency on fossil fuels in ethanol-fueled driving leads to a better performance on abiotic depletion and acidification.

Rong-Horng Chen et al. [4] concluded that during the open-loop control of ECU on fuel injection rate in the cold-start period, the fuel injection rate is roughly the same for all fuels (E0 through E40) used. This made the percentage of excess air in the air/fuel mixture of E5, E10, E20, E30, and E40 to be 2%, 4%, 9%, 14%, and 19%, respectively. For E5-E30, the engine can run smoothly. For E40, the air/fuel mixture in the engine was too thin so as to cause engine speed instability. As far as emissions are concerned, E5 and E10 performed almost indistinguishably from the gasoline (E0), while E20 e E40 clearly decreased HC, CO and NO emissions. Therefore, in conclusion, the ethanol content in gasoline for best cold-start emissions was determined to be at least 20 percent but no greater than 30 per cent.

M. Bahattin Celik [5] revealed that the engine power increased by about 29% when running with E50 fuel at high compression ratio compared to the running with E0 fuel. At the same time, the specific fuel consumption, CO, CO2, HC and NOx emissions were reduced by about 3%, 53%, 10%, 12% and 19%, respectively. As the compression ratio is increased, HC and NOx emissions increase. In this study, thanks to the usage of E50 fuel, the negative effect of compression ratio on HC and NOx was recovered and decreases in HC and NOx were obtained.

Mustafa Canakci et al. [6] investigated the exhaust emissions of an SI engine fueled with the ethanol- gasoline (E5, E10) and methanol-gasoline (M5, M10) fuel blends compared to those of pure gasoline. The test results showed that the use of ethanol-gasoline and methanol-gasoline fuel blends causes to decrease in CO and unburned HC emissions significantly at the vehicle speed of 80 km/h. This is due to improving combustion process as a result of oxygen content in ethanol and methanol. However, similar trend was not obtained for CO emissions at the vehicle speed of 100 km/h because of the different engine running condition. With the increase of ethanol and methanol fraction in the fuel blend, the air-fuel equivalence ratio increased. In general, the air-fuel equivalence ratio decreased with the increase of wheel power for the all test fuels. By using ethanol and methanol blended gasoline, CO2 and NOx emissions reduced at the vehicle speed of 80 km/h, while CO2 and NOx emissions of M10 increased slightly at the vehicle speed of 100 km/h depending on the engine running conditions.

M.A. Costagliola et al. [7] found that No appreciable differences in combustion development were found, while a slightly better global efficiency (about +5% as mean values) was achieved with E85. As regard regulated emissions, the alcohol blends generally provide emission reduction respect on gasoline. The strongest reduction is associated to E85 (-20% for THC and about -15% for CO and NOx).

Ramesh Babu Nallamothu et al. [8] investigated the performance and emissions characteristics with ethanol in gasoline engine. They concluded that at low speed of 1250 rpm all the fuel had the same CO emissions but up to medium engine speeds CO emissions of the blends for E5 and E0 are approximately the same. UBHC for E5 is the same at low speed of 1250 rpm and even low emission in the medium speed of 2000 rpm, which almost similar to E10 at maximum speed. But UBHC for E10 was low at speed of 1250 rpm and high at speed of 1500 rpm but it was the same at around 2500 rpm with E5.

III. MATERIALS AND METHODS

The experimental tests were carried in the I. C. Engine Laboratory of the Department of Mechanical Engineering, College of Technology, G.B. Pant University of Agriculture & Technology, Pantnagar, India. In this section, experimental details, various parameters studied and methodology used in the analysis are described in detail. This section deals with the brief description of experimental set-up, test engine, dynamometer, fuel measurement, exhaust gas analyzer and details about the instruments used. It also describes the methodology used for the measurement of various parameters and their analyses.

A blend is a mixture of two or more miscible liquid fuels like ethanol and petrol. Ethanol is mixed with petrol in varying percentage 5% , 10% , 15% etc. 10 ml sample is prepared in test tubes by mixing petrol and ethanol and kept for 24 hrs at room temperature. 15 – 20 ^{0}C. After 24 hrs samples are checked for proper miscibility, phase separation , any cloudy appearance so that only clear & successful samples are selected for further study.

For blends of ethanol and petrol containing 5, 10, 15, 20, 25 and 30 etc. percent of ethanol by volume were used. It was found that relative density at 15 ^{0}C of all the blends was between 0.7346 to 0.7548 and 0.7273 for petrol which was dependent on temperature.

A four cylinder, 4-stroke, water cooled, vertical, four cylinder, computer assisted S.I. engine was selected for the study. The engine is commonly used for common field operations like light fleet of vehicles. The engine has 1817 cc displacement volume. The engine is coupled to an eddy current dynamometer Type- Eddy Current, Rating – continuous, 50Hz, load 0 - 100 kg with load cell, speed range 3000 rpm, Water cooled.

The emission test of the engine was conducted on E0 and E25 at increasing loads. In order to carry out emission test, initially the engine was started on petrol and then run for two minutes. The engine operation was then switched on to the fuels(E0 & E25) selected for the study at no load condition. The engine on selected fuel was further run for a minute under no load condition for warming up.

After warm up, the engine was gradually loaded up to various loads and rpm conditions to stabilize its operation. Once, the engine operation was stabilized, it was brought to high load condition gradually. The high load on the engine corresponds to the state of the engine when it is developing the continuous rated brake power at the rated speed, zero load means no load condition while the engine is running. The emission parameters measurement of the engine on different fuels was then carried out at the increasing loads. The experiment with each fuel type was done two to three times and the average value of different parameters measured was taken for analysis.

IV. RESULT AND DISCUSSIONS

In the present work the gasoline (E0) was blended with ethanol (25% ethanol-75%gasoline) to get E25 fuel blend, the engine was run on E0 and E25 fuel blends. The exhaust gas emission was measured using gas analyzer. It was intended to see the emission characteristics on pure gasoline and E25. The variation of CO, UBHC, NOx and exhaust gas temperature(EGT) were measured at increasing loads and engine rpm with increasing Brake mean effective pressure(BMEP). E25 shows lower CO emission as compared to E0 at all loads. At higher loads NOx emission also shows decreasing trend for E25 compared to E0. EGT decreases with E25 compared to gasoline, this may be due to lower heating value of ethanol. Ethanol also gives cooling effect. Ethanol has high octane number and is also an oxygenated fuel resulting in better combustion. The characteristics are shown below:

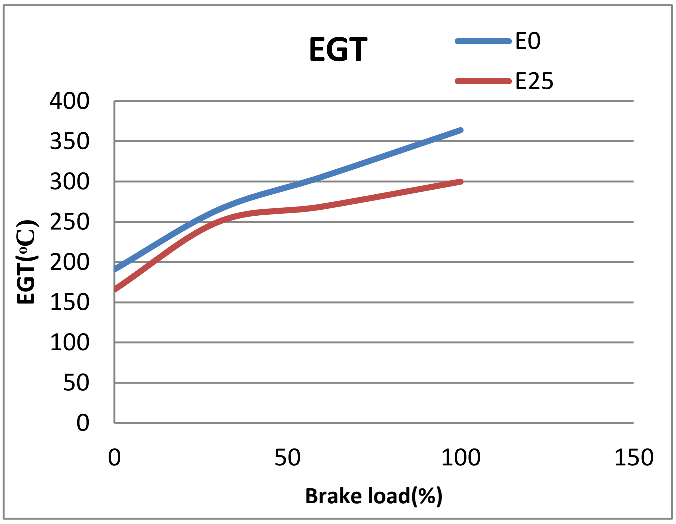

Fig.1: Variation of EGT with increasing load on the engine

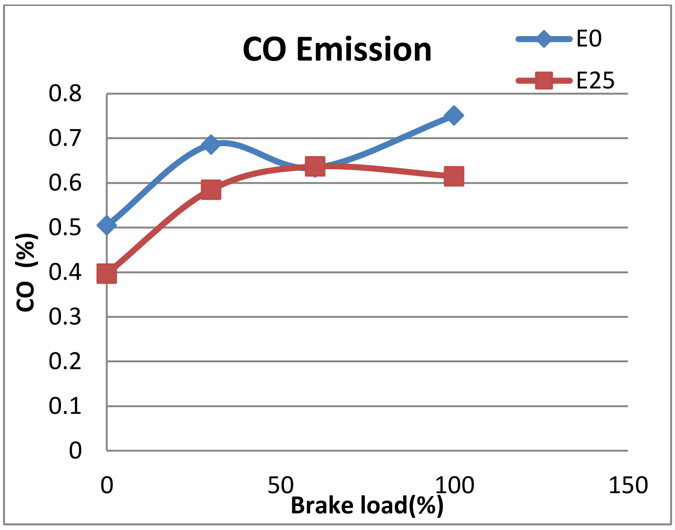

Fig.2: Variation of Carbon monoxide with increasing load on the engine

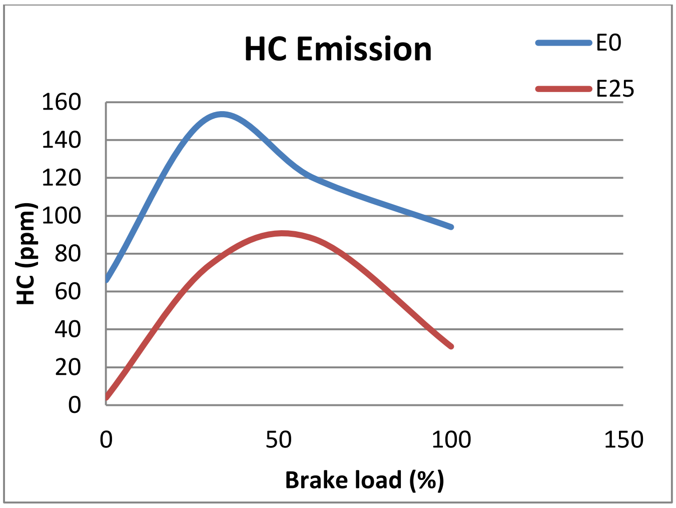

Fig.3: Variation of Unburnt hydrocarbon with increasing load on the engine

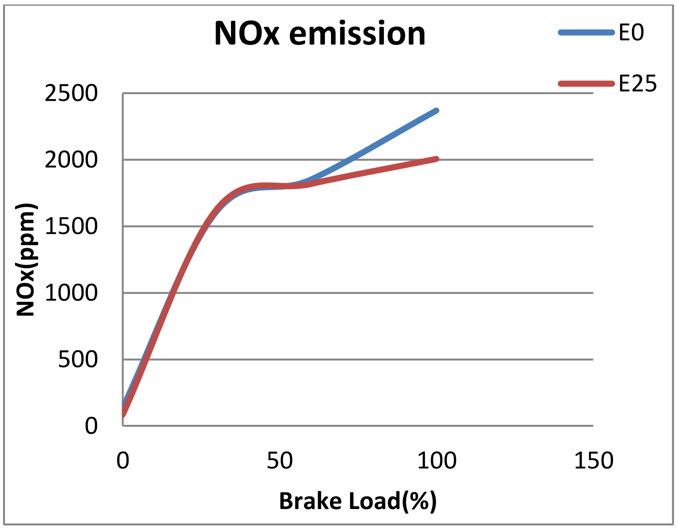

Fig.4: Variation of oxides of nitrogen with increasing load on the engine

V. CONCLUSIONS

From above results following may be expected

1. With E25 UBHC emission reduces with higher BMEP. At peak load conditions, around 34% reduction in UBHC emissions was achieved.

2. CO emissions also reduce using E25 blend. At no load around 21% reduction in CO emission was observed. At peak load 18% reduction was observed.

3. At higher loads NOx emission show decreasing trend. At no load 38% reduction in NOx emission was observed, while at high load conditions 15.4% NOx emission reduction was observed.

4. EGT also reduces using E25 as fuel in SI engine. At lower loads EGT for E25 initially shows increasing trend and afterwards downward trend. At all loads remains on lower side as compared to gasoline, while gasoline shows increasing trend.

The above points show that blending of ethanol with gasoline may result in reduced emissions giving cleaner air in the atmosphere and if ethanol prices are reduced it may improve the economy of our country and benefit to farmers. It will be especially beneficial for developing nations and thickly populated cities.

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