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Spark Ignition Engine Emission Characteristics by Using Blend of Ethanol and Gasoline

Mayank Bhasin, Mohit Bhandwal*, Mukesh Roy and Basant Singh Sikarwar

Department of Mechanical Engineering, Amity University Uttar Pradesh, Noida – 201313, Uttar Pradesh, India; mbhandwal@amity.edu

Abstract

This paper focuses on the effect on emissions in smaller engines such as bikes, by using a blend of ethanol and gasoline at NO LOAD condition and its comparison with the engine running on gasoline only. The exhaust emissions of the 4 stroke Kawasaki boxer model engine were tested and evaluated by using blend of 5%, 7% and 10% ethanol and results are plotted. The results showed that the increase in HC emissions at full acceleration and decrease at partial acceleration is observed with increase in ethanol content in gasoline. CO emission decrease to less extent at full acceleration and decrease to a greater extent at partial acceleration with increase in ethanol content in gasoline. NO_x decreases by fewer rates at full acceleration and by high rate at partial acceleration with increase in ethanol content in gasoline. This paper presents various types of pollutions emitted by vehicles, their effect on human health and various measures to curb the pollution by use of alternate fuels.

Keywords: Carbon Dioxide-Co_2, Carbon Monoxide-Co, Ethanol, Emission, Hydrocarbon-Hc, Nitrogen Oxide-Nox, Oxygen-O_2, Spark Ignition Engine

1. Introduction

Fossil fuels are rapidly depleting because of the increasing use of fossil fuels for energy production. Emission from the fuels used in the automobile industry is another major concern in today's time which has increased the need for utilization of regenerative resources[1]. Delhi is the most polluted city. The particulate matter PM 2.5 (fine particles less than 2.5 micrometers in diameter) and PM 10 (coarse particles with 2.5 to 10 micrometer in diameter) can enter your lungs, bloodstream and even heart and can lead to serious illness like asthma, Chronic Obstructive Pulmonary Diseases (COPD), cardiovascular diseases[2,3]. Exhaust emission depends on fuel consumption, operating condition, oxygen content, A/F equivalence ratio and chemical structure. Nitrogen oxides are formed during combustion by reacting with air in the atmosphere forming ozone and causing photochemical smog. NO_x are pollutants that can cause lung irritation and weaken the body's defence against respiratory infections such as influenza and pneumonia along with shortness of breath and chest pains and increases the susceptibility of a person to asthma. Carbon monoxide is a poisonous gas and is formed when there is insufficient oxygen in fuel to convert carbon into carbon dioxide. CO reduces the blood's oxygen carrying capacity and if inhaled can block the transport of oxygen to heart, brain, and other vital organs in the body and is directly linked with visual impairment, mental dexterity, poor learning capacity, nausea, headaches, dizziness and even death. Fetuses, new born children, and people with chronic illness are mostly affected by CO emissions. Carbon dioxide affects the environment and contributes to global warming. Hydrocarbon emission occurs when fuel molecules in the engine do not burn or burn partially. Hydrocarbons react in presence of nitrogen oxides and sunlight to form ozone which is a major component of smog. They also escape into air through fuel evaporation.

*Author for correspondence

This gas affects the respiratory system causing coughing, choking and reduced lung capacity[4]. The government should strengthen vehicle emission standards, regulations and enforcements and seek new ideas to reduce fuel consumption such as ethanol or biodiesel blending with gasoline and improve the air quality in the city. Ethanol blending is the practice of blending petrol (or gasoline) with ethanol. The different blends are named as E5 meaning 5% ethanol in 95% gasoline. Similarly, E7 means 7% ethanol in 93% gasoline blend so on till E85 (which is used generally for larger and modern engines). Many countries including India has started the practice of blending ethanol and gasoline to reduce the vehicular exhaust emissions which is a major concern nowadays but the percentage of blending varies in different countries. The renewable ethanol content is expected to result in a net reduction in carbon dioxide, carbon monoxide and hydrocarbon emissions. Ethanol is derived by sugarcane molasses which is by product in conversion of sugarcane juice to sugar. Usage of alcohol as fuel for SI engine has some advantages when compared to gasoline. Ethanol has better antiknock characteristics than gasoline. The engine thermal efficiency can be improved with the increase in compression ratio[5]. Alcohol burns with lower flame temperature and luminosity owning to decreasing the peak temperature inside the cylinder, so that the heat lost and NO_X emissions are lower[6]. The heating value of the fuel (Q_C) is the heat moved out of the system during combustion when reactants and products are at same temperature as its states. The fuels octane number is the measure of the engine quality of a gas (gasoline). Higher the octane no. the less susceptible is the gas to knocking when burnt in a standard engine. The heat of vaporization is a measure of heat essential to cause a phase change from a liquid to a gas of fuel. The lowering of temperature of air-fuel mixture is as the result of high octane number which removes energy from neighboring air while vaporizing.

Property	Fuels	
	Ethanol	**Gasoline**
Molecular formula	C_2H_5OH	C_7H_{17}
Octane number	106-110	91-96
Density(g/cm^3)	0.785	0.72-0.78
Heat of vaporization(KJ/kg)	840	305
Stoichiometric fuel/Air ratio	0.1111	0.0685
Molecular weight(kg/kmol)	46	100-110
Lower heating value(MJ/kg)	26.9	44

Figure 1. Shows the ethanol and gasoline properties.

Figure 1, shows the ethanol and gasoline properties. The volumetric efficiency of ethanol is higher than gasoline which is indicated by high heat of vaporization, thereby increasing the power output.

2. Literature Review

Author in[7] experimentally investigated the performance and exhaust emissions of multi cylinder engine with gasoline and gasoline blended with E5 and E10 blend. The results of the study indicated that brake specific fuel consumption is greater than before while brake thermal efficiency, emission of carbon monoxide and hydrocarbon decrease with ethanol unleaded gasoline blends. Author in[8] considered different blends of ethanol gasoline I engines and determined that ethanol could lessen the emission of CO and UHC to some degree. Author in[9] used several blend rates of ethanol-gasoline in test. The results were that the octane number and engine power output were increased by 5% for 10% ethanol addition. Author in[10] tested three fuels namely base gasoline, E50 and E85 and found that running with E85 would decrease UHC and CO emissions in comparison with gasoline alone. Author in[11] investigated the effect of E85 blended fuels on engine performance. They showed that when blended fuels were used the engine torque and power increased with E85 by 4%. Author in[12] stated that using ethanol gasoline blended fuel instead of gasoline alone can lower CO_2 emission. Author in[13] showed that power decreased, CO increased and CO_2 decreased. From the above, it can be concluded that without modifying the engine design for large engines pollutant emission can be reduced by alcohol-gasoline blended fuels.

3. Experimental Setup

The engine used is Kawasaki boxer 100 cc 4 stroke engine shown in Figure 2, Figure 3, shows the experiment with the exhaust gas analyser. Figure 4, gives the specification of exhaust gas analyser used to measure the emission. In the experiment the percentage of carbon dioxide, carbon monoxide, hydrocarbon, nitrogen oxide, and oxygen emissions were done by AVL digas 444 analyser. The readings are taken at full acceleration and partial acceleration at no-load condition. E5 (5% Alcohol), E7 (7% Alcohol) and E10 (10% Alcohol) mixtures are prepared in the lab.

Figure 2. 100 cc Kawasaki engine.

Figure 3. Experimental setup with AVL gas analyzer.

Make	AVL
Type	AVL Digas 444
Power supply	110V-220V 25 W
Warm up time	7 min.
Connector gas in	180 l/h, max. overpressure 450 hPa
Response time	T95 15s
Operating temperature	5 …45 C
Storage temperature	0…50 C
Relative humidity	95%, non-condensing
Inclination	0…90
Dimension (w x d x h)	270 x 320 x 85 mm3
Weight	4.5 kg net weight without accessories
Interfaces	RS 232 C, Pick up, Oil temperature
probe	

Figure 4. Specification of exhaust gas analyser.

4. Results

O_2, CO and CO_2 emissions were plotted on parts per million bases and HC AND NO_X emissions were plotted on % volume basis. It was seen that CO emission decreases dramatically as a result of the leaning effect caused by the ethanol addition; HC emission decreases only in some engine working conditions; and CO_2 emission increases because of the improved combustion.

4.1 At Full Acceleration

Hydrocarbon emission increases with increase in ethanol blend in gasoline at full acceleration conditions as can be seen from Figure 5.

Carbon monoxide emission decreases with increase in ethanol blend in gasoline at full acceleration conditions as can be seen from Figure 6.

Nitrogen oxide emission decreases with increase in ethanol blend in gasoline at full acceleration conditions as can be seen from Figure 7.

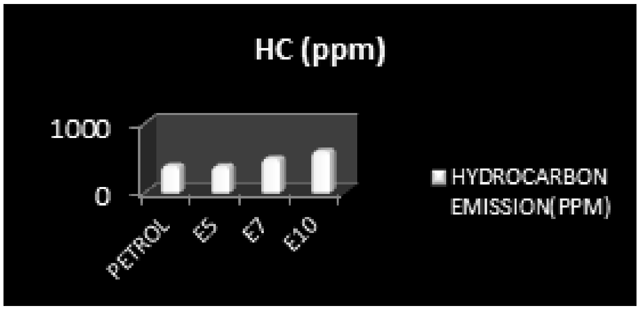


Figure 5. HC emission at full acceleration.

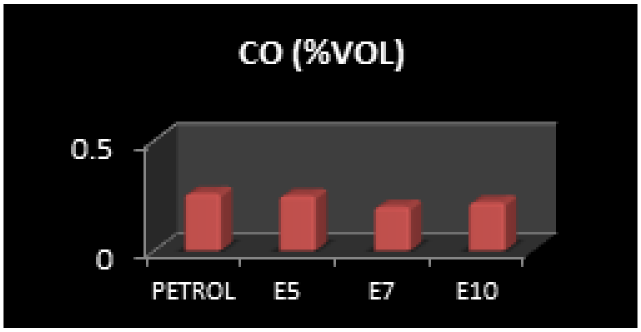


Figure 6. CO emission at full acceleration.

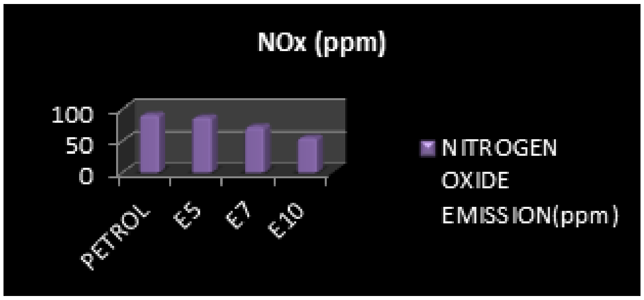
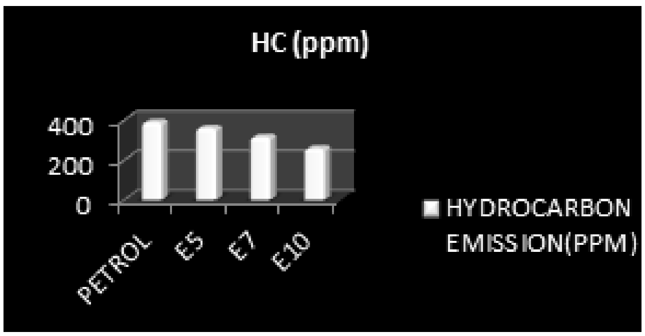


Figure 7. NO_X emission at full acceleration.

5. Acceleration

Hydrocarbon emission decreases with increase in ethanol blend in gasoline at partial acceleration conditions as can be seen from Figure 8. Nitrogen oxide emission decreases with increase in ethanol blend in gasoline at partial acceleration conditions as shown in Figure 9.

Carbon dioxide emission decreases with increase in ethanol blend in gasoline at partial acceleration conditions as can be seen from Figure 10.



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a. At partial acceleration

Figure 8. Emission of Hc at partial acceleration.

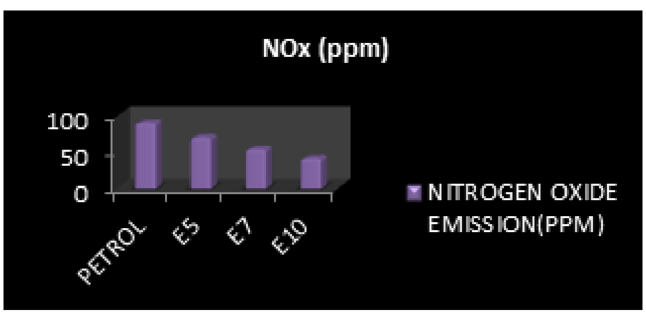

Figure 9. Emission of No_x at partial.

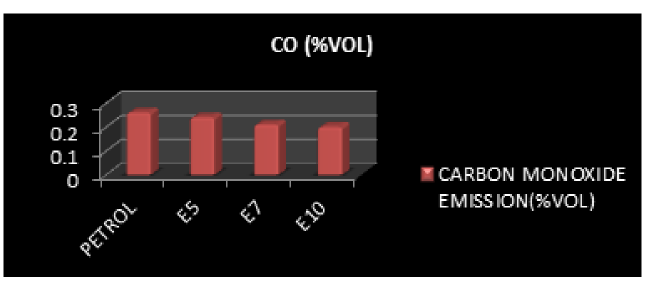

Figure 10. Emission of Co at partial acceleration.

6. Discussion

Since it is an old model bike engine, we can say that at E7 blend in both full and partial acceleration conditions, performs and excels in reducing the harmful pollutants in the atmosphere. This is the study and research done on small engines (under 150 cc), but with few changes in the cylinder diameter and modifications in the engine it can perform better on E15 mixtures as well.

7. Conclusion

The results as per shown above show us that for different blends E5, E7 and E10, Hydrocarbon emissions i.e., HC emissions at full acceleration increases and at partial acceleration decreases with increase in ethanol content in gasoline Carbon dioxide emission at full acceleration decreases and at partial acceleration increases with increase in ethanol content in gasoline. Carbon monoxide emission decrease to less extent at full acceleration and decrease to a greater extent at partial acceleration with increase in ethanol content in gasoline. Oxygen emission at full acceleration increases and at partial acceleration decreases with increase in ethanol content in gasoline. Nitrogen oxides emission at full acceleration decreases at less rate and decreases to a greater extent at partial acceleration with increase in ethanol content in gasoline. Finally we can conclude that 7% ethanol blends can be effectively used without any modification in air/fuel system and a little attention has to be taken on pressure rise in the engine.

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