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# EXPERIMENTATION ANALYSIS OF EMISSION AND COMBUSTION CHARACTERISTICS OF SINGLE CYLINDER SPARK IGNITION ENGINE USING VARIOUS ETHANOL – PETROL BLENDED FUELS

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**Abstract**
Today all transport system in India is depends upon fossil fuels. Consumption of fuel is increasing day by day and it is affecting country economy day by day.[4] Globally, around the world biofuels assume importance due to because of increasing and growing energy demand and environmental issues. Ethanol is best alternative fuel to reduce environmental issues and to meet growing demand of fuel. In India, ethanol is produced from sugarcane. India has achieved 10% of ethanol blending in 2022, now aiming to 20% ethanol blending by 2030. [1] In this study, experimental investigation has been done on Single Cylinder Four Stroke Spark Ignition Engine. In this study, we measure the performance, emission characteristics and combustion analysis of single cylinder spark ignition engine with various range of ethanol – petrol blends at various speed conditions. The engine performance parameters like Engine Torque, Brake Power, Brake Specific Fuel Consumption and Brake thermal efficiency are measured. And exhaust emission parameters such as CO, CO2, NOX, HC emissions are measured at different engine speed. The results obtained from study showed that addition of ethanol to petrol gives us improvement in combustion characteristics and reduction in exhaust gas emissions.

**Keywords:** Ethanol blend, Petrol, Engine, Emissions, Performance.

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## Introduction

Population around the world increasing day by day, that increased demand of vehicles and also demand for various industries which consume fossil fuel. Fossil fuels are limited in nature and they are going too depleted in some decays. Internal Combustion engine are working on fuels like petrol and diesel which are type of fossil fuels and use of this fossil fuels results in increasing emission of gases that gives adverse effect on human health and environment.

These environmental and health concerns desire us to be less dependent on fossil fuel. The limited nature of oil resources made studies on alternative energy resources and much more important in internal combustion engines in which oil products are used as energy resource.

India has great number of renewable energy resources. Because of these great available of renewable resources use of resources should be encouraged in all possible way. Government of India has prepared a road map to reduce dependency on fossil fuel and to reduce import fossil fuel by adopting biofuels and renewables and various energy efficiency norms.

Now a day's biofuels assume importance globally due to growing energy demand and various environmental concerns and health issues on human living being because of increase in pollution. To encourage use of biofuels or renewable resources, several countries have put various policy options, road map, incentives and subsidies which are suiting to their domestic requirements. As an effective tool to increase employment, rural development and to reduce pollution and import of fuel the primary approach for biofuels in India is to promote sugarcane production.

Sugarcane ethanol has been used in light duty vehicle fuel in Brazil since the beginning of 20th century. Brazil government promoting use of ethanol and to support the adaption and use of ethanol in existing gasoline engines because of low quality of fuel and corrosion problem. By 1931, improvement in ethanol production and use enabled the government to use 5% ethanol in gasoline engine mandatorily. [11]

In recent years, ethanol has become widely used as renewable fuel with up to 10% by volume concentrations with gasoline for regular S.I. engines and for using ethanol more than 85 % with gasoline we have to use flex fuel vehicles. These vehicles are designed to run with higher concentrations of ethanol. With regular S.I. engines we can use ethanol blended petrol up to 40 %. [25]

Biofuels such as ethanol which is colourless liquid with medium characteristics of odour can be produced by fermentation of biomass crops like wheat, sugarcane, corn, wood like plants. Using bioethanol as fuel for spark ignition engines gives more benefits than over petrol like anti knock properties, better emission characteristics, improvement in brake thermal efficiency and volumetric efficiency. Another major advantage of using ethanol as a fuel is that it is renewable energy source.

The results showed that as ethanol percentage is increased heating value of blended fuel decreased while engine torque and brake thermal efficiency increases. Similarly, at high ethanol-petrol blends HC emission, CO emission and fuel consumption decreases. But as increase in ethanol percentage with petrol not gives much more change in brake specific consumption.

## What is Flex Fuel Technology?

Flex fuel is the technology that allows vehicle to run on any fuel like petrol, ethanol, or combination of ethanol and petrol. The main principle of flex fuel system is to constant monitoring of parameters like air flow, fuel, temperature and many more. This monitoring on parameters is done electronically by a central computer and some special software that operates engine functionality according to usage conditions and fuel used.

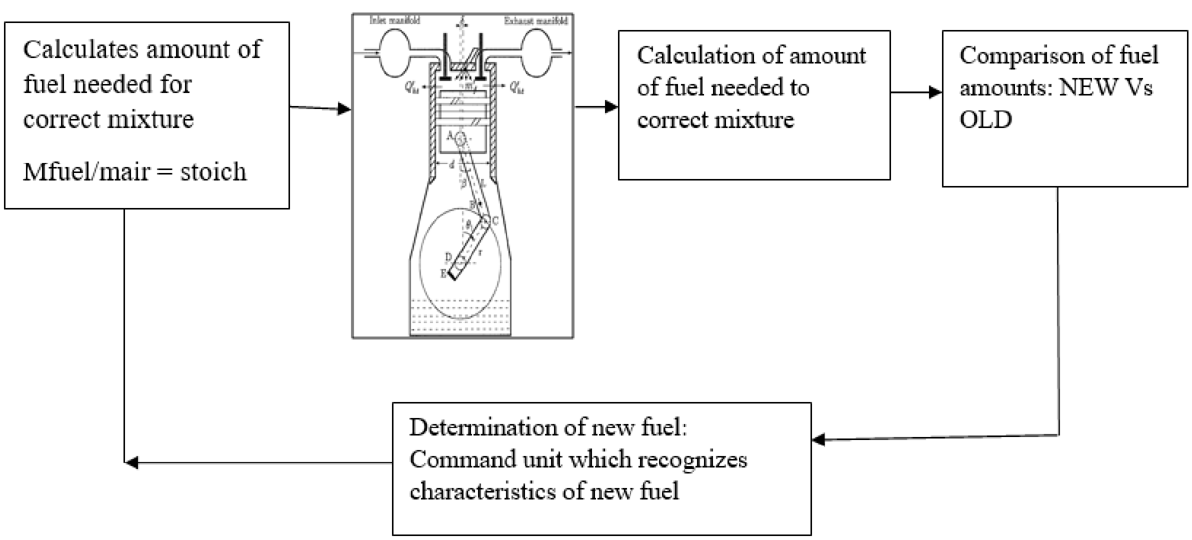



Fig. 01 Flowchart: Flex Fuel Technology

The greatest challenge behind using flex fuel injection technology as compared to injection of ethanol blended petrol or pure ethanol (E100) or Ethanol blended petrol up to (E85) having to quickly detect and adjust for each change in ethanol-gasoline ratio. Change in fuel is determined using capacitive sensor which is used to detect fuel ratio before combustion these sensors are too much costly which is only disadvantage of using flex fuel technology.

**Methods and Procedure followed:**

The fuels used in this experimentation are ethanol and petrol. Ethanol used is pure or absolute ethanol and only used for experimentation purpose. Experimentation was performed on various ethanol blended fuels like E0, E10, E20, and E30. The experiments were performed at variable engine speeds using various ethanol petrol blends to measure various performance, emission and combustion parameters of engine at 1200 rpm, 1400 rpm, 1600 rpm, and 1800 rpm.

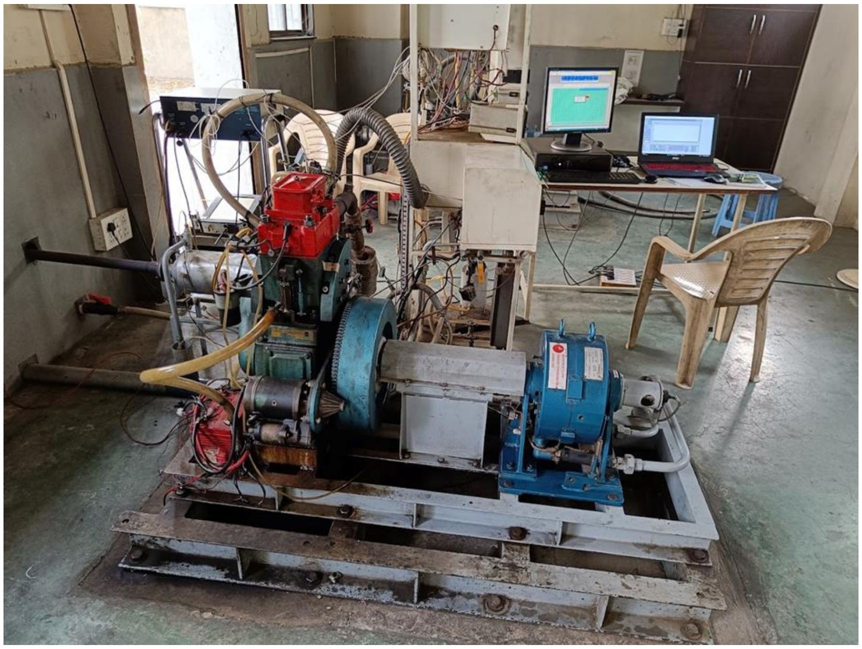
Hydrocarbon, Carbon monoxide, Carbon dioxide emissions and excess oxygen and all these combustion parameters were analysed from exhaust gas analyser or combustion analyser.

The engine was first run on neat petrol and then its blends. The entire fuel samples were tested by same procedure and readings of engine speed, engine torque, fuel consumption, exhaust emission values were recorded during experiment for various fuel mixtures. Performance parameters such as brake power, brake thermal efficiency and brake mean effective pressure were estimated using software.

Table 01: Composition of ethanol-petrol blended sample used

| Nomenclature | %Ethanol | %Petrol |
|---|---|---|
| E0 | 0 | 100 |
| E10 | 10 | 90 |
| E20 | 20 | 80 |
| E30 | 30 | 70 |

**Experimental Setup:**



**Specifications of Engine Setup:**

| | |
|---|---|
| Product | Research Engine Test Setup 1 Cylinder, 4 Stroke, Multi fuel |
| Engine | Make Kirloskar Single Cylinder 4 Stroke |
| No. of Cylinders | 1 |
| No. of Strokes | 4 |
| Cylinder Diameter | 87.5 mm |
| Stroke Length | 110 mm |
| Connecting Rod Length | 234 mm |
| Orifice Diameter | 20 mm |
| Dynamometer Arm Length | 185 mm |
| Fuel | Petrol<br>Power = 4.5 KW @ 1800 RPM, Speed Range = 1200 to 1800 RPM,<br>CR Range = 6.1 to 10.1 |
| | Diesel<br>Power = 3.5 KW, Speed = 1500 RPM, CR Range = 12.1 to 18.1,<br>Injection Point Variation = 0 to $25^0$ BTDC |
| Dynamometer | Type: Eddy Current, Water Cooled with loading Unit |
| Fuel Tank | 15 Lit |
| Calorimeter | Type: U Tube, Range – 25-250 LPH |
| EGR | Water Cooled, Range – 0-15% |
| Crank Angle Sensor | Resolution: 1deg, Speed: 5500 RPM |
| Temperature Sensor | Type: RTD |
| Load Sensor | 0-50 kg |
| Fuel Flow Transmitter | Range: 0-500 mmWc |
| Air Flow Transmitter | Range: 250 mmWc |
| Rotameter | Engine Cooling: 40-400 LPH |
| Overall Dimension | W 2000 * D 2500 * H 1500 mm |

**Results and Discussion:**

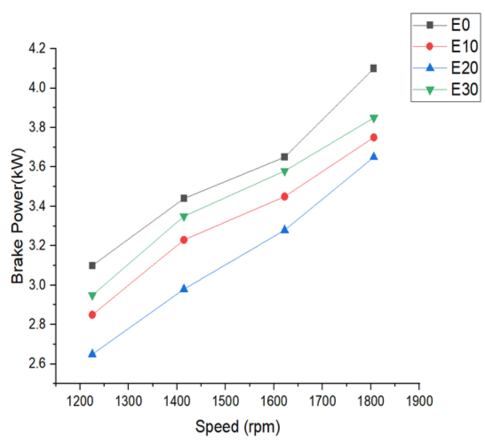


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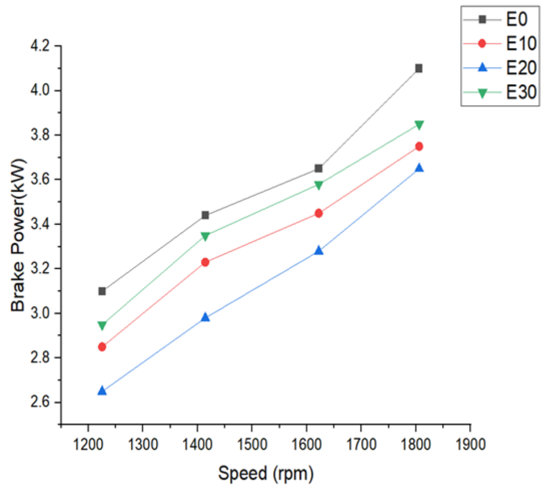
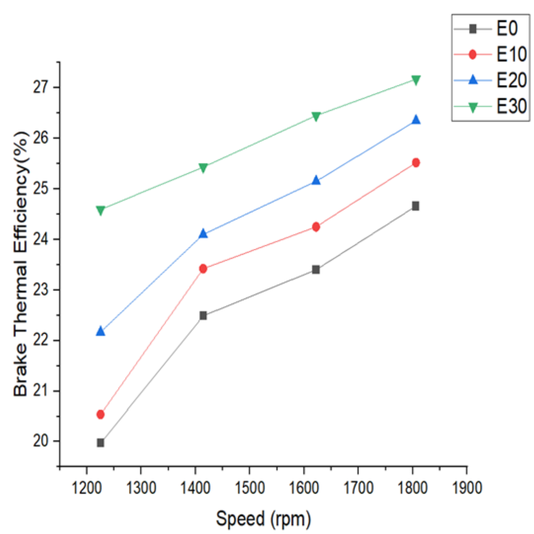
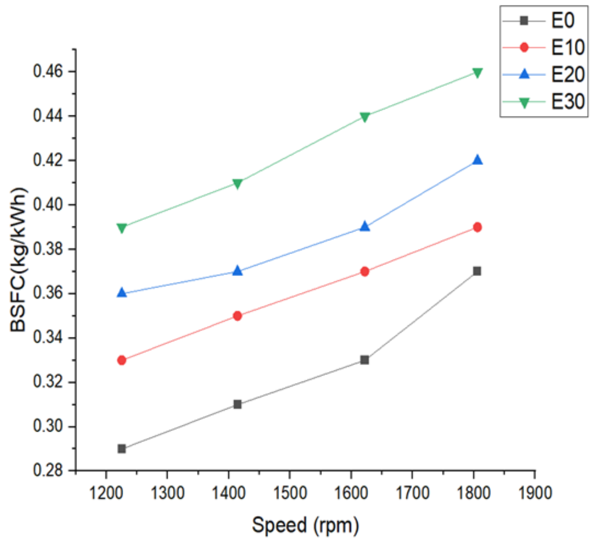
Fig. shows variation of engine torque with respect to engine speed for various ethanol blends. From fig., it shows that torque increases steadily with increase in speed and falls gradually as further increment in speed. This in decrease in speed due to various frictional losses and decrease in lower volumetric efficiency of engine with respect to higher engine speed. The maximum torque recorded at higher percentage of ethanol and maximum engine speed and it was 22.3Nm at 1225 rpm, 23.4Nm at 1414 rpm, 25.6Nm at 1622 rpm and 18.63Nm at 1806 rpm for petrol, E10, E20 and E30 respectively.




The brake power variation with respect to Engine speed is show in fig. The brake power increase steadily with increase in engine speed. The lower brake power values of higher ethanol blends like E20 and E30 compared to E0 i.e. petrol can be associated to their lower calorific values. The maximum brake power of the engine was recorded at different engine speeds for different ethanol blends and it was 3.1 kW at 1225 rpm, 3.44 kW at 1414 rpm, 3.65 kW at 1622 rpm, and 4.1 kW at 1806 rpm. The brake power for petrol is higher as compared to various ethanol blends i.e. E10, E20, and E30.




The brake thermal efficiency with respect to engine speed is shown in fig. The brake thermal efficiency increased steadily with increase in engine speed up to a certain maximum value and then goes on decreasing with increase in engine speed. The decrease in brake thermal efficiency at higher engine speed is due to lower combustion efficiency which is associated with reduction in time for complete combustion. The maximum brake thermal efficiency at various ethanol blends and various engine speed at maximum percentage of ethanol E30 and it was 24.59% at 1225 rpm, 25.43% at 1414 rpm, 26.45% at 1622 rpm, 27.17% at 1806 rpm.




Brake Specific Fuel Consumption is the ratio of mass flow of fuel which is tested and effective power. Brake Specific Fuel Consumption is depends on relationship among fuel density and lower heating value. Above graph shows variation of BSFC with respect to engine speed. Graph shows that brake specific fuel consumption of E0, E10, E20, and E30 is increasing steadily with increase in engine speed. The minimum BSFC of 0.29 at 1225 rpm, 0.31 at 1414 rpm, 0.33 at 1622 rpm and 0.37 at 1806 rpm.

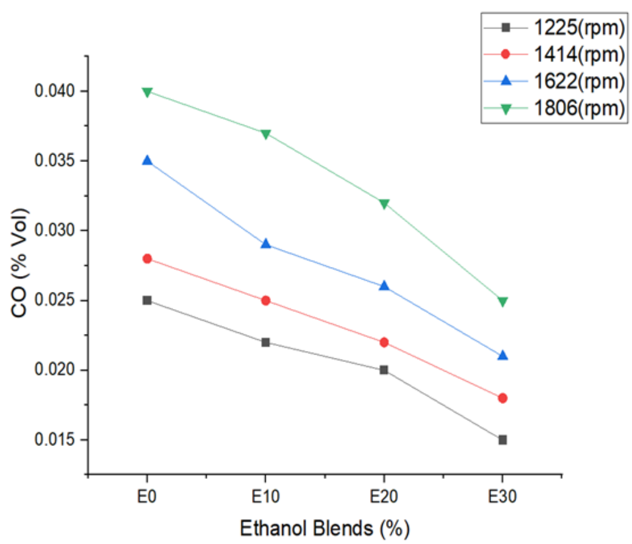



Fig. shows CO (Carbon Monoxide) with respect to by varying ethanol blends at different engine speed. Carbon monoxide is formed during engine combustion processes with rich air fuel mixtures and when there is insufficient oxygen present in fuel it burns all the carbon in fuel which leads to $CO_2$. The effect of ethanol petrol blends on carbon monoxide is shown in above fig by varying ethanol blends. It shows that a CO emission gets decreased with increase in percentage of ethanol petrol blends. When we are increasing ethanol percentage in fuel it leads to decrease in CO emission. This occurs due to ethanol contains higher oxygen content than petrol which causes complete combustion. Fig. also shows that CO emission increases with increase in engine speed. This increase in CO emission is because at higher engine speed, there is insufficient time for full or complete combustion which leading to higher CO emission.

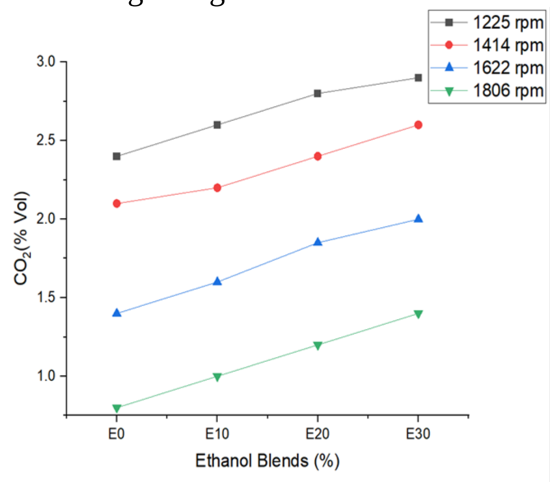
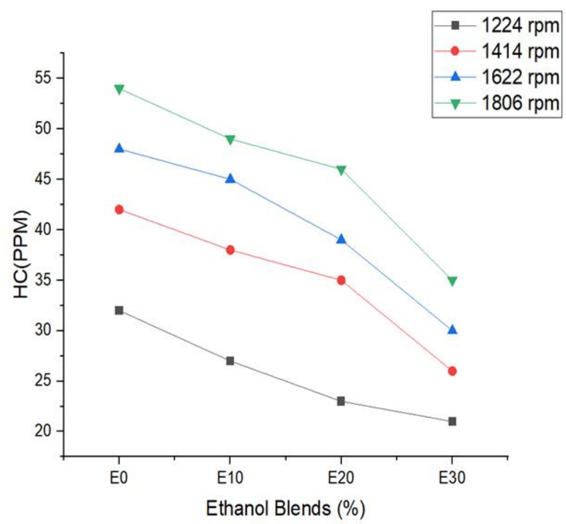
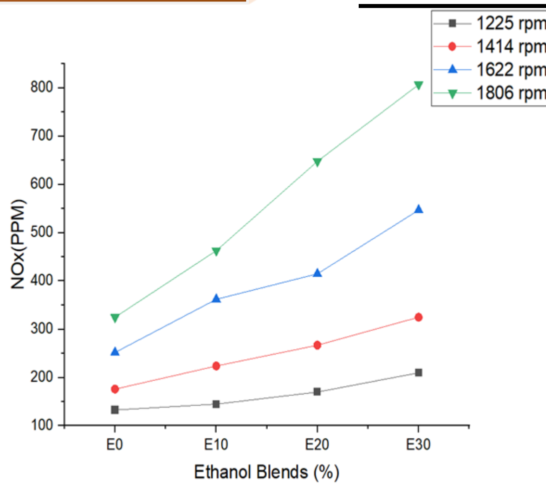



Fig. shows that $CO_2$ emissions with respect to various ethanol petrol blends. A $CO_2$ emission increases as percentage of ethanol blends gets increased and an emission gets decreased with increase in engine speed. The $CO_2$ have an opposite behaviour compared to CO emissions. This is because of improved combustion process which is result of greater oxygen content of ethanol fuel.




The effect of ethanol blends with respect to HC emission is shown in fig. From above fig., we can see that HC emissions are reduced as percentage of ethanol in the blend increases gradually. This is because of higher oxygen content in ethanol blends which leads to complete combustion thus it reduces HC emissions.




NOx emission with respect to various proportion of ethanol blends are shown in fig. From above fig. it can showed that NOx emission are increases gradually with increase in proportion of ethanol blends. Higher percentage of ethanol blends leads to higher NOx emissions. NOx emissions increase with increase in speed.

**Conclusion:**

The performance, exhaust emission and combustion analysis of Single cylinder four stroke spark ignition engine fuelled with various range of ethanol blends (E0, E10, E20 and E30) were carried out successfully at various speed conditions and from the results we get following conclusions:

1] Ethanol – petrol blends gives a reduction in CO and HC emissions and due to complete combustion of fuel at higher ethanol-petrol blends gives increase in $CO_2$ emission.

2] Addition of ethanol with petrol leads to increase in pressure and temperature of combustion at low engine speed.

3] Using ethanol as fuel substitute with petrol i.e. ethanol-petrol blend leads to improvement in combustion characteristics and significant reduction in exhaust gas emissions of engine. Ethanol blended petrol gives higher combustion efficiency, higher maximum pressure at low engine speed and improved CO and HC emission characteristics.

4] By use of ethanol blended petrol at different proportions, octane number of produced blends is increased which leads to increase in compression ratio and power output. Break thermal efficiency of ethanol blend also increases.

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