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Performance Analysis on 2.5 kW CI Engine Using Ethanol-Diesel Blends

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ABSTRACT

Diesel engines are one of the major contributors of air pollution as they emits exhaust gases like particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NOX); unburnt hydrocarbon (UHC) and other harmful compounds , which are very toxic for living beings as they can cause many diseases ,even cancer. They are even causing damages to our environment. So it is very important for us to switch to a cleaner fuel.

Ethanol secures a special place as it has a lot of advantages over others. Most important reason for using alcohols is: it is cheap, renewable and echo-friendly. In very small blend percentage it has an ability to drive the existing CI engines without modifications. Many researchers' have concluded that the brake thermal efficiency and brake power due to combustion process in diesel engines can be increased further by allowing the diesel fuel to combine with more oxygen atoms to form better combustion. As ethanol has oxygen atoms, when blended with diesel fuel it improves fuel characteristics. This whole process of addition of oxidants to the diesel fuel can reduce the smoke, carbon monoxide (CO) and unburnt hydrocarbon (UHC) emissions to a great extent.

The objective of this research work is focused mainly on performance analysis of diesel engine by using diesel- ethanol blends. The tests are conducted with a single cylinder, four-stroke, naturally aspirated, 2.5 kW air cooled diesel engine. Present research work is focused on the test conducted on a diesel engine using diesel – ethanol blends by having 5% & 10% ethanol blend with diesel. The performance tests are carried out under normal engine operating conditions and the evaluations are compared with that of diesel fuel. All experiments have been conducted at 0% to 50 % load conditions to study the performance of different proportions of ethanol on CI engine. Overall results of the methods show that with the increase in percentage of ethanol in diesel fuel, highest temperature in cycle kept on decreasing also exhaust gas temperature goes on decreasing. Power developed and torque also increases with increase in percentage blend.

Keywords: Diesel, Ethanol, Blending, Nitrogen Oxides, Particulate Emissions, Torque, Power.

I. INTRODUCTION

The world is facing major crises of fossil fuel depletion. Indiscriminate extraction and lavish consumption of fossil fuels have led to reduction in underground-based carbon resources. Due to their excessive extraction and very slow rate of replenishment, they are on verge of extinction in upcoming decade. On seeing the current scenario of fossil fuel utilization and rate of consumption, it is believed that they would be exhausted soon. In addition to that the fossil fuels are the primary source for the environmental degradation. More specifically, the continuous addition of greenhouse gases into the atmosphere by fossil fuel combustion is increases the threat of global warming.

One another issue is that the diesel engines emits higher percentages of nitrogen oxides, CO, particulate matter (PM) ,stinking odor and smoke which are hazardous to the earth's environment causing various global hazards such as acid rain, ozone layer depletion, global warming, smog and climatic changes etc. Researchers have found some alternatives to overcome these issues by employing various methods, namely - engine design modification, fuel blending and treatment of exhaust gases. So switching towards another fuel is one of the possibilities. After many researches ethanol occur as a new alternative fuel to overcome this problem.

Various tests suggested ethanol as an alternative fuel for conventional fossil fuels. Ethanol is considered widely as a replacement for diesel fuel due to its unique properties like biodegradability, non-toxic and reduced toxic emissions during combustion etc. some performance test suggested a result that power generation by ethanol blended diesel is somehow similar to conventional diesel engine. The blends of diesel with biofuels like alcohols, biodiesel can offer better solutions in reducing the fuel consumption without any modifications to the engines. Various studies concluded that by using diesel ethanol blends there is a significant reduction in particulate matter (PM) , NOx and CO emissions.

BENEFITS OF ETHANOL AS A FUEL

Ethanol is used as an automotive fuel nowadays by itself and can be mixed with gasoline to form "gasohol". Gasohol blend contains 15% ethanol and 85% gasoline. Over 1 billion gallons of ethanol has been used every year to produce gasohol in the United States. The greatest advantage of blending ethanol with gasoline reduces emission and gasoline usage. Since ethanol is produced from plants sources it is renewable and eco-friendly. It is used as renewable fuel because it can burn completely and cleanly when compared to gasoline and diesel fuel. According to the production process and feedstock used for manufacturing of ethanol, the Green House Gases emissions are reduced. These natural sources have less pollution to atmosphere.

Ethanol can reduce country's investment towards oil import. Also local farmers can generate some income by fulfilling demand of ethanol for fuel which will ultimately help to stabilize the price of fuel. Ethanol helps to improve quality of the environment as it reduces hazardous emissions emitted by convention fossil fuels. It also helps to generate employment in country by encouraging farmers to grow more grains to have an abundant supply for ethanol production.

PROPERTIES OF ETHANOL

Several studies have reported that Ethanol and diesel fuel have different chemical structures and characteristics but are inherently immiscible. Thus the addition of ethanol to diesel affects various properties of the blends like viscosity, lubricity, cetane number, energy content, volatility and stability.

Properties	Diesel	Ethanol
Chemical Formula	$C_{10}H_{22}$	C_2H_5OH
Self Ignition Temperature °C	210	420
Octane number	30	107
Centane number	45-55	8
Gross Heating Value kJ/kg	42500	26900
Flash point	56-65	13
Latent Heat of Vaporization ,kJ/kg	923	923
Stoichiometric air fuel ratio	14.7	9
Boiling Point	163-399	78
Density, kg/m^3	830	790
Ignition limit air-fuel ratio	1-5	3.57-17

Table 1.1: Various properties of Diesel and ethanol.

II. LITREATURE REVIEW

Cenk Sayin et al. (2010) found that there are considerable effects on the system's performance while using methanol–diesel (M5, M10) and ethanol–diesel (E5, E10) fuel blends. The results showed that brake specific fuel consumption and emissions of nitrogen oxides increased while brake thermal efficiency, smoke opacity, emissions of carbon monoxide and total hydrocarbon decreased with methanol–diesel and ethanol–diesel fuel blends with comparison to pure diesel.

Mukesh Kumar Saini et al. (2010) founds that ethanol blended petrol and diesel have enormous growth potential in India for use as fuels in transport sector as it provides cleaner and greener environment and less dependency on import of crude oil. In order to implement ethanol blending program (EBP) throughout the country, all the concerned stakeholders i.e. policy makers, regulators, producers and OMCs must agree on the point that while allocating ethanol as transport fuel we should not neglect its huge demand in chemical industries and its revenue potential in potable sector. Distilleries in India are not lagging behind in technology as well as capacity to produce the required ethanol to meet its demand in India, instead they struggles between the availability of raw material i.e. molasses and assured market for its product i.e. ethanol for fuel at right price. In addition, the present purchasing mechanism of ethanol by OMCs discourage distilleries to supply their product on lower bid price.

Mukesh Saxena et al. (2013) conducted the experiments for engine emission and performance with blendes of ethanol of 5% & 10% with diesel termed as fuel E5 & E10. The experiment was performed for 50% load condition & studies showed that with increase in the percentage of ethanol emissions were reduced significantly.

Yahuza et al. (2015) concludes that the properties of ethanol-diesel blends have a significant effect on safety, engine performance and durability, and emissions. It is accepted that the addition of ethanol to diesel fuel will have a beneficial effect in reducing the PM emissions at least. The amount of improvement varies from engine to engine and also within the working range of the engine itself. While there is considerable value in being able to use the fuel directly in an unmodified engine, small adjustments to fuel injection characteristics may result in further gains in reducing emissions.

Bhushan S Dalvi et al. (2017) conducts test with pure Diesel, and Diesel blended with ethanol 0%, 05%,7.5%,10%,12.5% and 15% by volume without any engine modifications. The results showed that blending ethanol with Diesel increases the Indicated power, brake thermal efficiencies and fuel consumption, while it decreases the brake specific fuel consumption and volumetric efficiency.

The CO and CO2 emissions concentrations in the engine exhaust do not vary substantially while NOx reduces up to 50%. The 15% ethanol in fuel blend gives the best results for all measured parameter at all engine speeds.

P.C. Seth et al. (2017) concludes that different type biodiesel in exhaust system directly affects the performance and the emission characteristics of the internal combustion engine. For improvement in the performance of an engine, it is necessary to control the temperature in automotive exhaust system. So it is economical and environment friendly to select biodiesel.

Dilip Borkar et al. (2019) concludes that Nitrogen oxide (NOx) emissions decreased by 17% by using ethanol-diesel blend as fuel compared to pure diesel. There was a reduction of 77 % of hydro carbon (HC) emissions by using ethanol-diesel blend as fuel when compared to pure diesel. The minimum carbon dioxide (CO2) emission was observed for ethanol-diesel blend with the introduction of 20 % EGR.

Ho Young Kim et al. (2020) states that the maximum combination pressure and maximum heat release rate of ethanol-blended fuels were higher than those of pure diesel fuel. The BSFC increased when ethanol was blended, and increased with the blend ratio; however, the BTEs of ethanol-blended fuels were lower than when pure diesel fuel was used. When ethanol was blended and the blending ratio increased, the NOx and soot opacity decreased, but CO emissions increased. The levels of HC showed a tendency to increase as the ethanol blending ratio increased, although the HC emissions of ethanol–diesel blended fuels are lower than those of pure diesel fuel. As the ethanol blending ratio increased, the mean size of the soot particles decreased, and the distribution of small particles increased.

Ajay Sharma et al. (2021) concludes that the emissions for carbon monoxide were recorded to be lower for all dual biodiesel samples than that of mineral diesel at maximum compression ratios. Further, the exhaust emissions of hydrocarbons were also reduced significantly for all dual biodiesel samples. The carbon dioxide gas emission was higher for all dual biodiesel samples in comparison with mineral diesel at all compression ratios.

The fuel parameters tested on the engine in terms of combustion, efficiency, and emissions reported better results for dual biodiesel samples.

EXPERIMENTAL SETUP

This experimental work is to investigate the performance of single cylinder 4-stroke diesel engine using ethanol- diesel blends. The test bench used is a computer controlled test bench for single-cylinder engine, power output of 2.2 kW, model no: TBMC3, designed by EDIBON. The unit has an element to exert the braking torque, an asynchronous motor fed by a variable frequency drive. The shaft of the motor is connected to the shaft of the engine by means of an elastic coupling. The unit also includes:

Instrumentation: several sensors that provide us measurements of the variables under study.

Start system: engine includes its own electric starter motor that facilitates its operation.

Fuel supply system: it carries the required fuel to the internal combustion engine.

Cooling system: The refrigeration is obtained by the passing of ambient air through the fins of the engine.

Air intake system: it allows the intake of fresh air in the engine. It contains the oxygen required to generate the combustion.

System to remove the exhaust gases: it removes from the engine the substances generated during the combustion and reduces the noise inherent to the gases flow.

ENGINE SPECIFICATIONS

Test bench for single-cylinder combustion engines up to 2.2 kW. It has a computer controlled electric motor to generate the load having braking torque: 8 Nm & maximum speed of 3600 rpm. The motor also works as the engine starter. Transmission between the engine and the brake is through elastic couplings. Acceleration/deceleration of the combustion engine through the computer controlled fuel valve. It has a capacity of fuel tank nearly 5 Liter. Speed (rpm) of the engine varies in range: 0 – 6000 rpm. Fuel consumption ranges from : 2 – 30 ml/min. Inlet air flow as well as exhaust gases outflow both ranges from: 0 – 300 m^3/h.

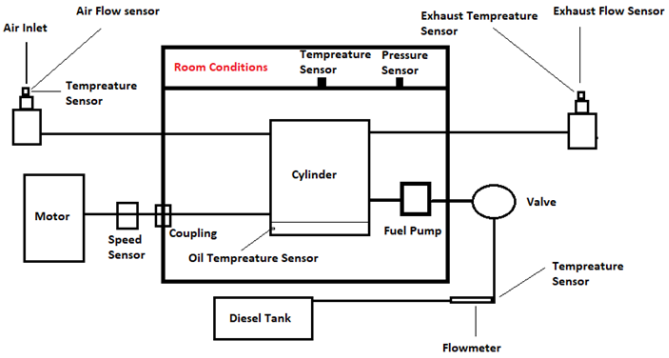


Diagram Showing various Sensors

Number of Cylinders	1
Number of Strokes	4
Type of Cooling	Air Cooled
Bore	69 mm
Stroke	60 mm
Compression Ratio	21:01
Maximum Torque	10.4 Nm/2400 rpm
Rated Output	4.2 HP

Table shows Specifications of Engine

Make	Edibon
Type Of Air Intake	Naturally Aspirated

III. EXPERIMENTAL RESULTS & DISCURSSION

Two blends were prepared with 5% & 10 % ethanol with diesel.

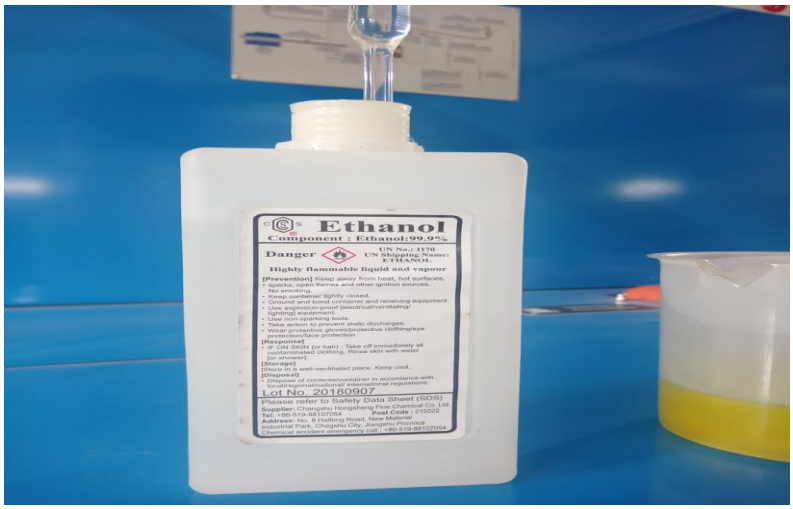
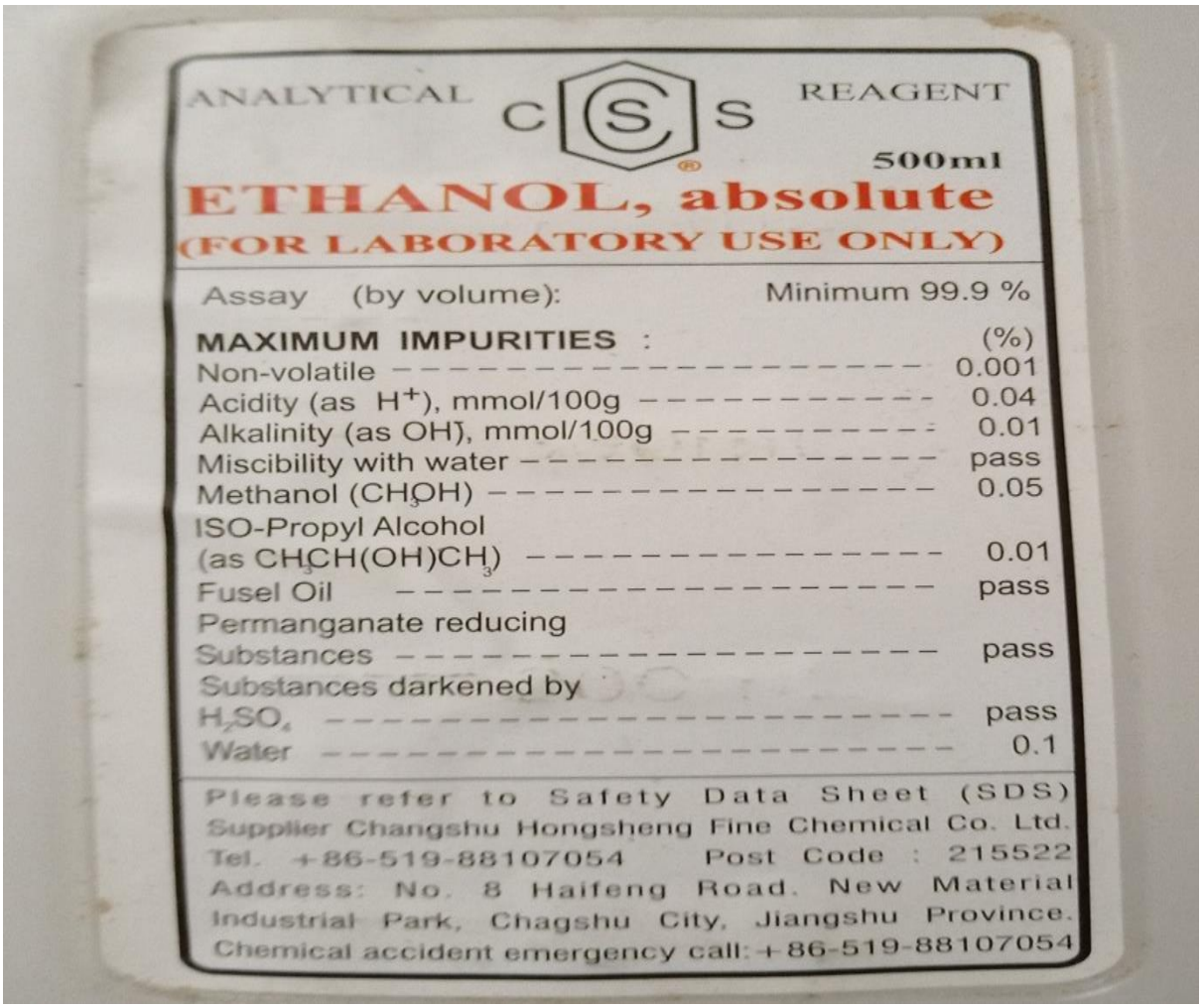


Figure Shows preparation of diesel-ethanol blends

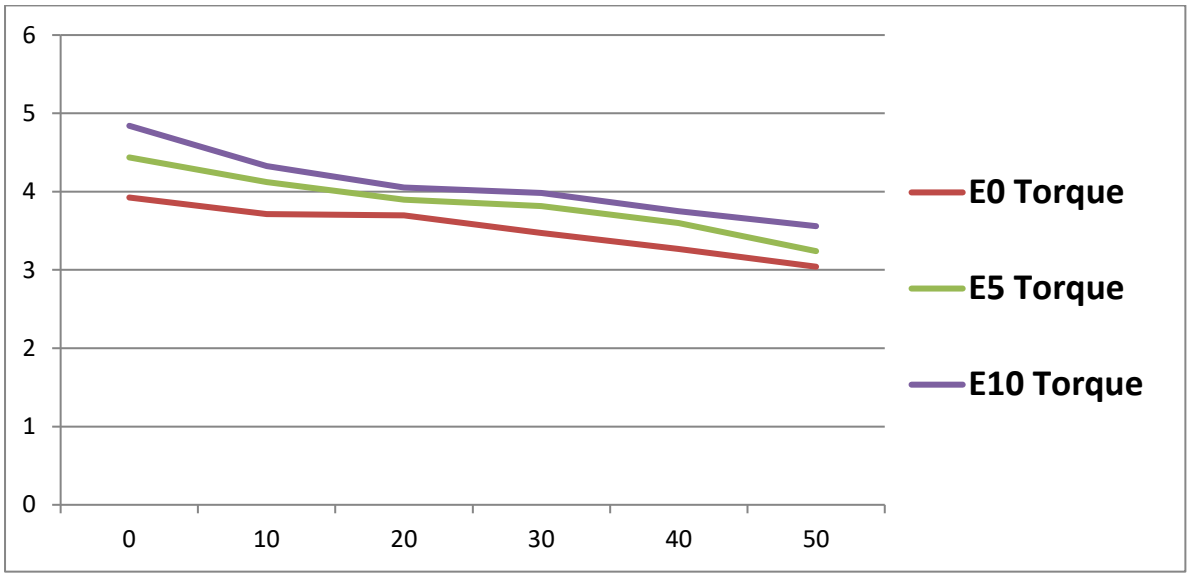


Ethanol used for experiment is 99.99 % pure. Its constituents are shown in figure.

The engine was run for E0 blend, E5 blend and E10 blend and various reading were taken for exhaust gas temperature, oil temperature , fuel temperature, exhaust and air inlet flow, torque , power developed etc. by varying load from 0% to 50%.

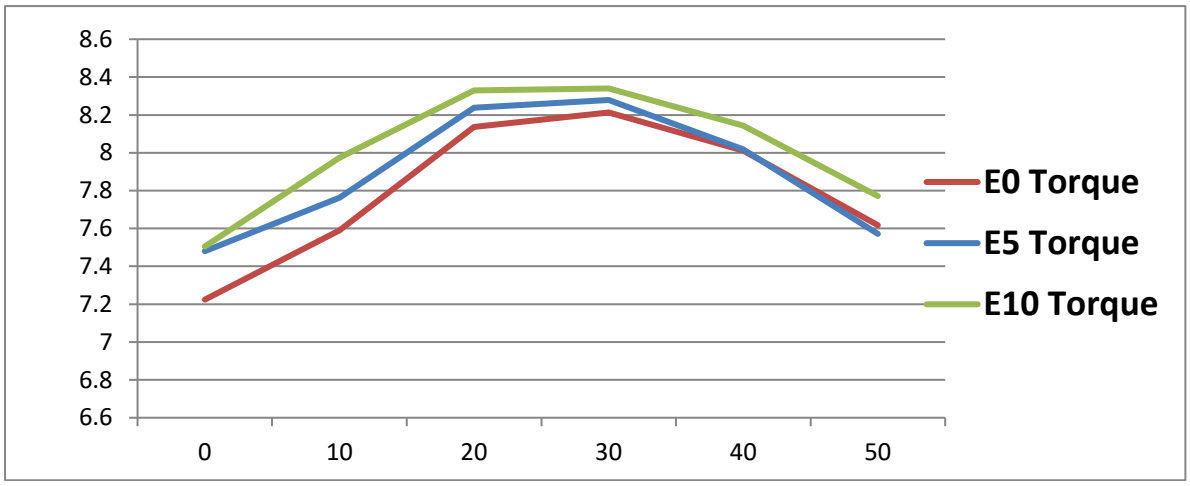
Torque Vs Load Curve

A. Closed Throttle (Idle Rpm)



Torque in Nm (Y Axis) vs Load in %age (X Axis)

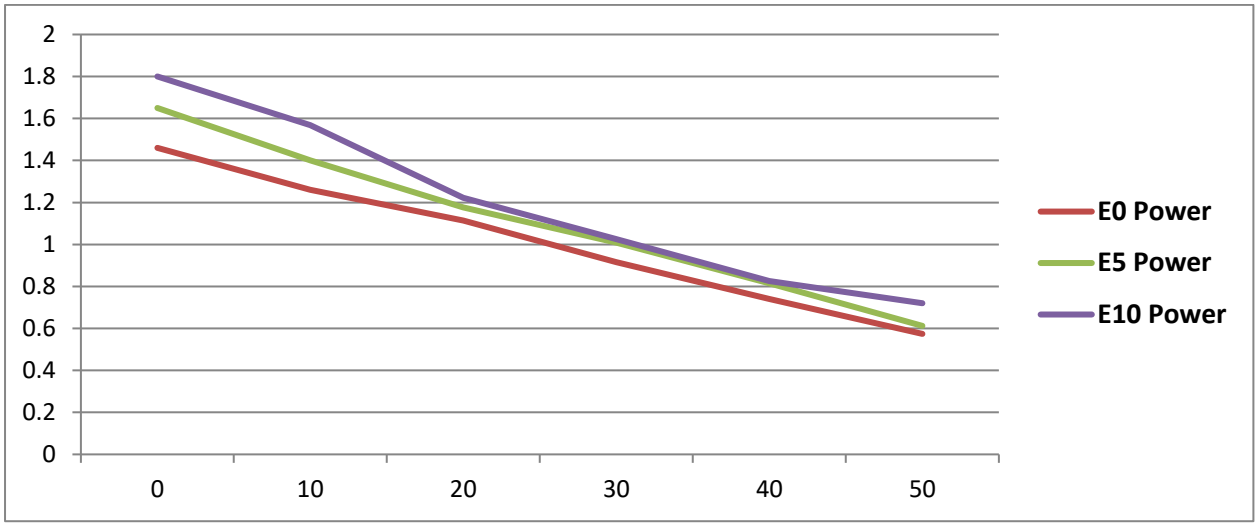
B. Open Throttle (Full RPM)



Torque in Nm (Y Axis) vs Load in %age (X Axis)

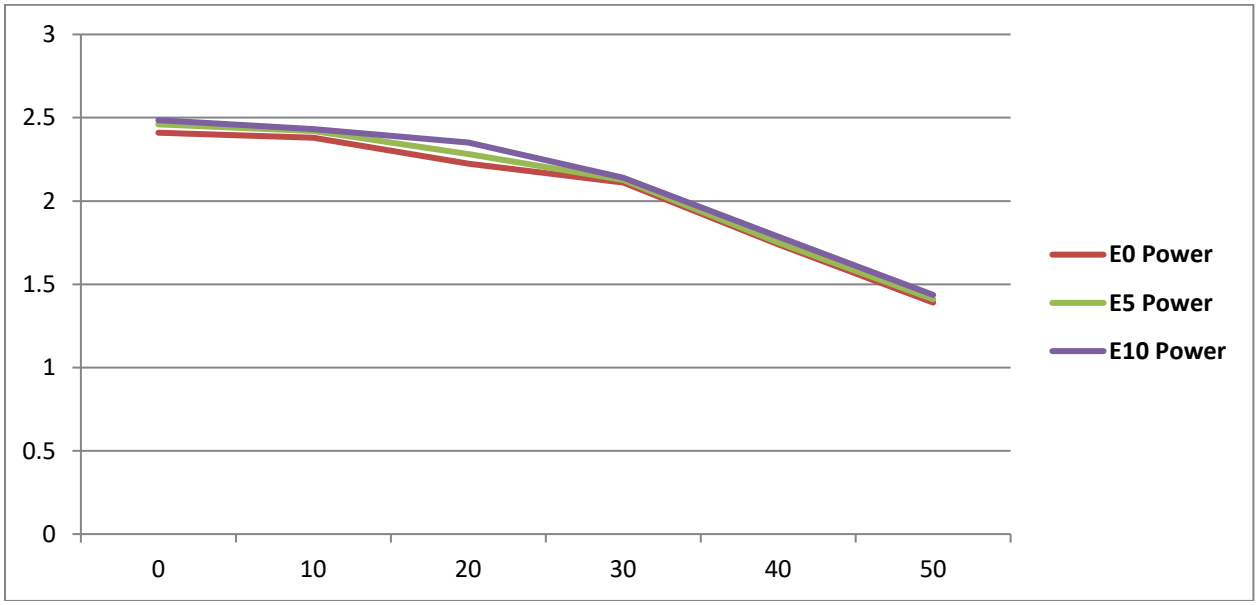
Power Vs Load Curve

A. Closed Throttle (Idle Rpm)



Power in kW (Y Axis) vs Load in %age (X Axis)

B. Open Throttle (Full RPM)



Power in kW (Y Axis) vs Load in %age (X Axis)

IV.CONCLUSION

Highest Temperature in engine never raised beyond 1200 k therefore Exhaust Gas Recirculation system was not introduced. Maximum Value for Highest Temperature in cycle was found to be of pure Diesel fuel while it kept on decreasing with increase in percentage of blend. Exhaust gas Temperature was found to be more for pure diesel and kept on decreasing while increasing blend percentage. Power Developed goes on increasing by increasing the blend %age of ethanol in diesel. Torque Developed goes on increasing by increasing the blend %age of ethanol in diesel.The Brake Specific Fuel Consumption increases from pure diesel to increase in blending %age in diesel. This is because more fuel was consumed due to the lower calorific value of ethanol. Brake Thermal Efficiency goes on increasing from pure diesel to increase in blend %age because of high Oxygen content, combustion become more complete or more stoichiometric therefore, flame temperature and cylinder pressure rise to their higher values. Thus mean indicated work and mean indicated pressure increases because of the increases in cylinder pressure. Therefore, engine power output and thermal efficiency increases.

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