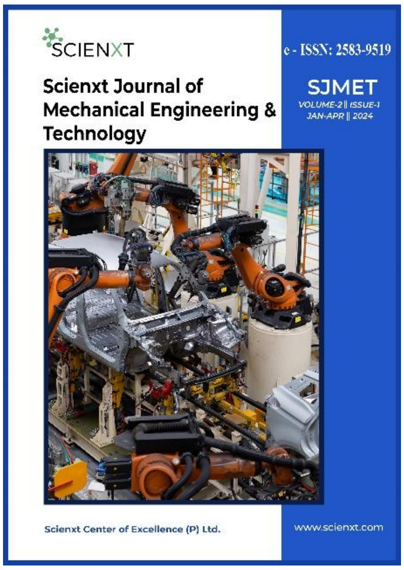

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Analysis on emissions of SI engine with variable ethanol-gasoline blends

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Abstract:

Global transportation sector is facing three major challenges, namely depletion of fossil fuels, volatility in crude oil prices and stringent environmental regulations. This research mainly focused on the use of biofuels, Ethanol is one of most suitable alternative blending fuel due to its better fuel quality and environmental benefits. In the present work, an ultrasonic bath was used to assure optimal mixing of ethanol and gasoline in various proportions (10% ethanol + 90% gasoline, 20% ethanol + 80% gasoline, 30% ethanol + 70% gasoline, and 40% ethanol + 60% gasoline). This will boost the fuel efficiency. A one-cylinder, four-stroke and spark ignition engine was used to study and analyze the effect of ethanol's/gasoline blend on exhaust gases. Result shows that adding ethanol reduces harmful exhaust gases (CO, CO2 NOx, and HC). Less exhaust emissions are seen to accompany higher ethanol levels. Ultimately, it is discovered that ethanol blends have a higher research octane number. Even though a higher heating value was discovered in gasoline compared to ethanol.

Keywords:

Ethanol, Octane Number, gasoline, SI Engine, Emissions etc.

1. Introduction:

Alternative fuels for automobiles are currently a topic of growing interest and an important issue all over the world due to negative effects of using traditional fuels on climate change, air pollution and global warning which is contributed by the combustion of fossil fuel. Day by day the large number of pollutants emitting out from the exhaust of the automotive vehicles run on fossil fuels are increasing and these pollutants are proportional to number of vehicles. As the number of vehicles increases the demand of fuel also increase. Hence the Government must spend huge amount of money for importing crude petroleum to meet the fuel demand for the automotive vehicles. Fast depletion of fossil fuels, emission of harmful gases and heavy consumption of gasoline due to individual transport, the search for alternative fuels has become compulsory. Ethanol considers one of the most important alternative fuels which have the potential to replace fossil fuels because it is liquid, higher octane no. and has similar chemical properties to that of conventional fuel properties. In this study, the first approach was selected with the aim of improving the combustion and emission characteristics of gasoline, which will be reflected in improving the engine Performance and that is done by mixing ethanol as an additive which is integral part of today's fuel. They can have surprisingly large effects even when added in little amount. In recent years several research have been carried out to the influence of ethanol on the performance of spark ignition engines. We have reviewed the below mention research paper to complete our study. [1] Mortadha k. mohammed et. al (2021) they experiment on single cylinder four stroke engine ethanol was mixed in different proportions (10%, 20%, 30%, 40%, 60%) with gasoline by utilizing ultrasonic bath to ensure perfect mixing. Results showed that power, brake specific Fuel consumption and thermal efficiency are improved with the increase of ethanol concentration. On the other hand, ethanol was found to have negative effect on volumetric efficiency. [2] Hatte, Prafulla., et. al (2019). VCR engine is tested for its performance under different operating conditions with ethanol-gasoline fuel fractions. They recommended running the engine at high speed and high compression ratio. Ethanol blend improves this efficiency, and it is recommended to use E10 for improved efficiency. [3] Ze Liu, Ping Sun, et. al (2021), Test platform for ethanol port injection plus gasoline direct injection was built to explore the effects of different ethanol-gasoline ratios, direct injection timing and ignition timing on the combustion and emissions of a SI engine. Results clearly show that when the total fuel contains more ethanol, the ignition timing corresponding to the maximum torque is smaller than the ignition timing when the total fuel contains more gasoline.[4] Wibowo, C. S., et. al. (2018). The effect of bioethanol blending on fuel showed an increase in the octane number values for all three fuels tested in this research.

The significant increase occurred when using the gasoline blended with 20% volume of bioethanol. [5] P. Sakthivel, K.A. Subramanian, (2020)] Experimental study on unregulated emission characteristics of a two-wheeler with ethanol-gasoline blends (E0 to E50), Fuel, it is observed emissions increased with ethanol blends beyond E20. Unburned ethanol emissions were higher with E30, E40 & E50 compared to neat gasoline and the blends. All the unregulated emission components decreased with the increase in vehicle speed. [6] A. A. Yusuf et. al (2019), Studied on the Single- cylinder, four-stroke TD201 SI engine, equipped with efficient Electronic Fuel Injection systems. They used fuels were pure gasoline (E0), and bio ethanol produced from Mbwazirume bio-mass peels was blend ratios which contained 5%, 10%, and 15% ethanol. Results showed lower emissions when the engine is running on E10 and E15.[7] Battal Do?an, et. al (2017), Investigate the effect of ethanol- gasoline blends on performance and exhaust emissions of a spark ignition engine through exergy analysis, fuels prepared by blending it with gasoline in various ratios (E0, E10, E20, and E30). Theoretical calculations showed that ethanol added fuels show reduction in carbon monoxide (CO), carbon dioxide (CO2) and nitrogen oxide (NOX) emissions without significant loss of power compared to gasoline. But it was measured that the reduction of the temperature inside the cylinder increases the hydrocarbon (HC) emission. [8] Lan Li, Yunshan et. al (2015), the emission characteristics of motorcycles using gasoline and E10 were investigated in this article. The experimental results showed that the emission factors of total hydrocarbons (THC) and carbon monoxide (CO) from E10 fuelling motorcycles decreased by 26%-45% and 63%-73%, while the emission factor of NOx increased by 36%-54% compared with those from gasoline fuelling motorcycles. [9] Gaurav Tiwari & Dr. Nitin Shrivastava (2014), Experimental investigation of ethanol blends with gasoline on SI engine. In this study they have evaluated the performance of two stroke single cylinder spark ignition engine with ratio of 10% 20% and 30% of ethanol and gasoline by volume. Performance parameters (BTE, BSEC and BSFC) were determined at various loads on engine with ethanol blended gasoline. Performance of E10 shows better result, it shows least brake specific fuel consumption and better engine performance. [10] Rudra Nandan Pramanik, (2013), determined that Impact of ethanol blends on various technical Parameters of a four stroke 4- cylinder IC engine. Result shows CO emissions for E10 are much lower and NOx and CO2 emissions for E10 and gasoline are similar. NOx emissions for E20 are like those of pure gasoline. CO2 emissions are higher for E20 than for what is produced by gasoline. In this present work the engine emission was measured at a variety of engine operating conditions. With keeping in mind, the financial and environmental considerations an attempt has been made to increase the performance satisfactory results were obtained and the work carried out is presented.

2. Experimental setup:

The Experimental setup comprises a computerized single cylinder, 4 strokes, multi fuel; variable compression ratio engine makes by Kirloskar and AVL digas 444 gas analyzer. The system stores the readings using high speed data skills system. Eddy current dynamometer used to apply load. Load on the engine was changed by controlling the current given to the electromagnets. Scaled tube was used to measure fuel consumption with the help of stopwatch.

Table. 2.1: Exhaust gas analyser

Make	AVL
Model	Digas 444
Type	Pipe in Pipe
Display type	Digital
Measured value output	(CO, CO_2, HC, NOx and O_2)

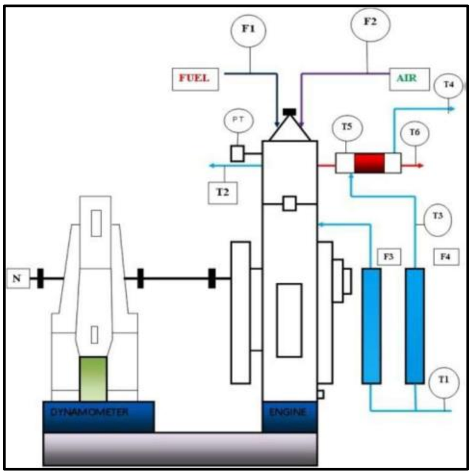

Figure. 2.1: line diagram of engine setup

Table. 2.2: Description of line diagram

F1	Fuel consumption kg/hr
F2	Air consumption kg/hr
F3	Engine water flow (litre per hour)
F4	Calorimeter water flow (lph)
T1	Jacket water inlet tem. (°C)
T2	Jacket water outlet tem. (°C)
T3	Calorimeter water inlet tem. (°C)
T4	Calorimeter water outlet tem. (°C)
T5	Exhaust gas to calorimeter inlet temperature (°C)
T6	Exhaust gas from calorimeter outlet temperature (°C)
PT	Cylinder pressure transducer (bar)
N	RPM Decoder

Table. 2.3: Physical and chemical properties of ethanol/gasoline blend

S. No.	Fuel Blends	Pour Point °C	Fire Point °C	Flash Point °C	Stoichio-metric ratio (A/F)	Density Kg/m3	Octa ne No.	Self-ignition Temp. °C	Boiling Point °C
1	E0	14	70	69	14.60	836	88	68	58
2	E5	13.5	68	67	14.20	832	94	64	55
3	E10	13	66	65	14.05	828	90	62	55
4	E20	12.5	65	64	13.50	826	88	59	50
5	E100	14	69	68	09.00	842	97	63	76

Table. 2.4: Engine Specification

Make	Kirloskar
Model	TV1
No. of Cylinder	Single
Bore	87.5mm
Stoke	110mm
Displacement	661CC
Connecting Rod Length	234mm
Normal Compression Ratio	17.5:1
Variable Compression Ratio	6:1 to 18:1 for Petrol and Diesel
Rated output	5HP@ 1500 rpm
Type of Cooling	Water
Type of Starting	Self-Start with battery
Type of lubricant	Forced
Petrol mode output 6:1 to 9:1	5KW @ 1500-1800rpm
Diesel mode output 14:1 to18:1	5 KW at 1500 rpm
Fuel	Petrol/Diesel

2.1. Experimental procedure:

Onset, it's required to mix 2 L of ethanol and gasoline mixture with a various ratios of ethanol addition to gasoline, which are (10%, 20%, 30% and 40%), to achieve the steady state and homogeneity of the mixture, a 30 min period was given to the mixture to attain this state. Then it fed to the engine tank and the experimentation are ready to commence.

The ultrasonic bath used here is CT BRAND ultrasonic bath 5 liter each sonication run of the devices is set to be 30 min and, the amount of energy was set to be zero to avoid the evaporation of the fuel.

The first run was conducted on pure gasoline for comparison reason, thereafter four tests were performed with the prepared ethanol/gasoline mixture. The initial inlet air temperature was measured by one k-type thermocouple, while the exhaust gases was measured by another thermocouple. The rotary speed of the engine was measured by optical sensor pulse, while the engine torque was measured by load cell instrument.

The exhaust emissions were differentiated and analyzed by exhaust gas analyzer type Techno (MOD 488) (NOx), (HC), (CO) and (CO2). The fuel consumption was measured by recording the time required to pass through scaled tube. The engine has a fixed compression ratio of (8.5:1), variable speed of (1500-2500 rpm) in increments of (250 rpm) for each reading. The collected measured signals are acquired by data acquisitioned and fed to the computer to where the VDAS software package displays these signals to temperature, speed, or torque.

Engine used in the current experimentations is Kirloskar (TV 1) it has a schematics and specification depicted in both Figure 1 and Table 2.2. The current rig is computerized which would help to get a reliable and Fidel outcomes. Such arrangement gives accurate readings and minimize the human errors. Table (2.3) shows some physical properties for different mixing ratio of gasoline/Ethanol blend fuel used (see Table 2.3). Applying load has been utilized using hydraulic dynamometer, which used to dissipate the energy generated, as well as to measure braking torque generated by the engine.

3. Results and discussion emissions characteristics:

Engine emission has presented over a convenient graphical method. These graphs are based on data collected from the AVL DIGAS 444 gas analyzer at different loads. In this research paper some of the important emission from SI engine is discussed.

3.1. Carbon monoxide:

The variation of carbon monoxide emission versus the speed of the engine (rpm) and different blending ratio in the test engine. CO is produced when the fuel does not burn completely, the carbon in the fuel will be converted to CO. Note from Figure (4.1) that emissions of CO decrease with increasing of engine speed. For the same speed, it is seen that CO emissions with blending fuel be lower at all the speeds of an engine compare with that produced by gasoline. The maximum of percentage deviation CO contains in gasoline fuel compare with blending fuel reported is 26.33% at blending ratio E30 at engine speed 2500 rpm. The stratified blending fuels ratio is leaner to the cool cylinder wall and close to the sparking plug, which causes the flame propagation to quench closer and ignites the blend easily. Further, a wide lean burn limit tends for accelerating the flame propagation and higher combustion temperature that able to increase the heat release rate in a less period at the next combustion phase, thus lessening the CO emissions.

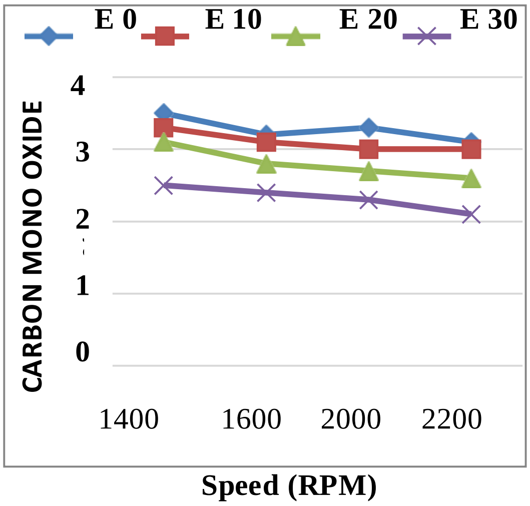

Figure. 4.1: Speed Vs CO

3.2. Carbon dioxide:

The variation of CO_2 emission versus engine speed (rpm) and different blending ratio in the test engine are illustrated in Figure (4.2). CO_2 is produced when the fuel does burn completely, the carbon in the fuel will be converted into CO_2. When increases engine speed so the CO_2 emissions follow a minor increase. For the same engine speed, CO_2 emissions blending fuel were found to be lower than that for gasoline fuel since ethanol contains less carbon than gasoline and produces less CO_2, which plays a key role in global warming during combustion. CO_2 emissions have been measured lower for blending fuel were used compared with gasoline fuel. The maximum of percentage deviation CO_2 content in gasoline fuel compares with another fuel used reported is 42.5% for E40 for engine speed 1500 rpm. It can be noted that using blending fuel causes a reduction in carbon dioxide concentration. This is due to a low carbon-to-hydrogen ratio to mix fuel, also it burns more efficiently with a more homogenous mixture which leads to a decrease in CO2 emissions compared with pure gasoline.

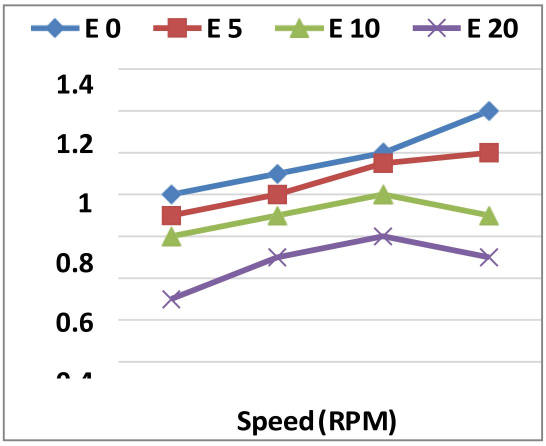

Figure. 4.2: Speed Vs CO2

3.3. Hydrocarbon:

The variation of HC emission versus engine speeds (rpm) and different blending ratio in the test engine are presented in Fig. (4.3). the presence of HC in the exhaust gases indicates that the fuel was not completely burned. It was found that the HC decreases with increase of engine speed. The main causes of complete combustion failure and HC formation are Lack in the oxygen, the temperature is low, and mixture heterogeneity. The maximum of percentage deviation HC content in gasoline fuel compares with blending fuel reported is 31.05% for E40 at engine speed 2500 rpm. HC emissions decrease as ethanol level use increases. Because of a mixture be more homogeneous with increasing level of ethanol use, the HC emissions are reduced, and the combustion becomes better. Blended fuel contributes to further complete combustion and advances the wall quenching by decreasing the hydrocarbon emissions. As the engine speed increases, HC emissions increasing due to the mixture's enrichment. The results shown that HC concentration decrease as engine speed increase at constant load due to the longer valve overlap period at low speed and this reduction more significant at higher speed. The difference in the emission of hydrocarbons is the function of the brake means effective pressure as there is a decrease in hydrocarbons with an increase in the brake means effective pressure due to the increase in the cylinder temperature which makes the engine run hotter and thus facilitating improved combustion.

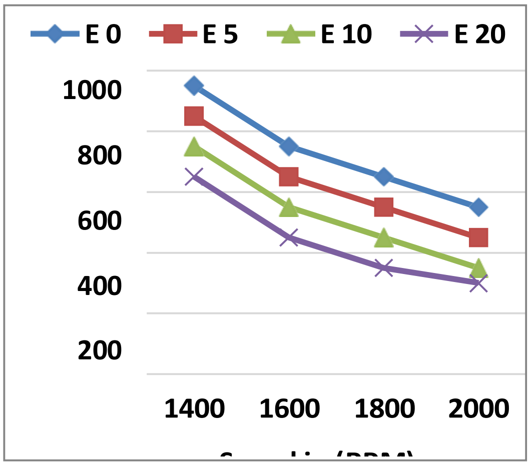

Figure. 4.3: Speed Vs HC Nitric Oxide

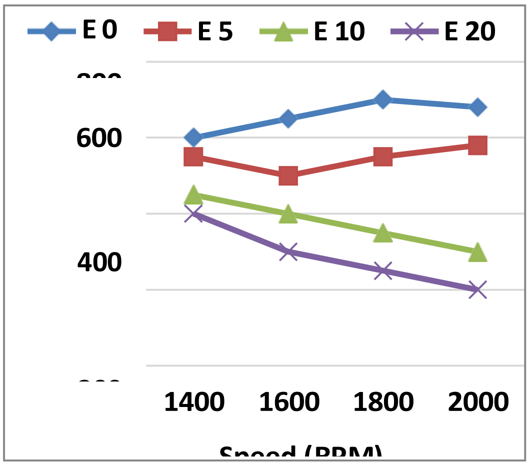

Figure. 4.4: Speed Vs NOx

3.4. Nitric oxide:

The variation of NOx emission versus engine speed (rpm) and different blending ratio in the test engine are illustrated in Fig. (4.4). In general, with increased engine speed, NOx emissions as well shows the increasing trend. For the same engine speed, it is seen NOx emissions with gasoline fuel was found higher at all engine speeds compared with blending fuel. This can be attributed to increase in fuel consumption as load increases, which lead to increase in temperature during combustion process thus increase NOx. Also, this is attached to the increase in the cooling energy flow effect of blended fuel, which lightly reduces cylinder gas pressure and the combustion duration. Moreover, low NOx emissions can be supported at a greater level by delayed ignition timing without decreasing the enhanced thermal efficiency, as rapid flame propagation of hydrogen allows steady combustion. The maximum of percentage deviation NOx content in gasoline fuel compares with another fuel used reported is 20.91% for E40 and at engine speed 2500 rpm.

4. Conclusion:

1. In this study, the performance characteristics and emissions characteristics for ethanol fuel were examined pilot-grade in the single- cylinder SI engine without any adjustments at different engine speeds (1500-2500) rpm. Following conclusion has been drawn from based on this study: Significant increase in RON and MON for all blending fuels but has a lower heating value for pure gasoline.

2. The best increase in thermal efficiency at the E40 mixture was (25.8%) compared to gasoline.

3. Volumetric efficiency appears negative behaviour with increasing in engine speed and ethanol blending percentage decreases.

4. The maximum reduction in brake specific fuel consumption in blending fuel were for blending (E40) was equal and that show decreases by (17.21%) compared with gasoline fuel.

5. There is a significant reduction in exhaust gas emissions in (HC, NOx, CO2, CO) with an increase in ethanol ratios compared to gasoline fuel. The maximum drop CO emissions were found in E30 by (26.33%), in CO2 emissions was found at E40 by (25%), in HC emissions was found at E40 by (31.05%) and in NOx emissions was found at E40 by (20.91%).

As we increase the ethanol percentage in gasoline the harmful emission CO, CO2, NOx, HC decreases because ethanol as biofuel has low carbon emission as compared to pure gasoline. Hence, we can conclude that using ethanol blend can help in controlling the air pollution and we can preserve petrol fuel for future.

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