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Comparative Evaluation of Multi-Port Fuel Injection Petrol Engine Powered Using Gasoline-Ethanol-Methanol Blend on Performance and Emission Parameters

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Abstract

In today's world, energy security has become a major concern for most developing economies, including India. The nation's economy is hampered by high oil imports, volatile fuel prices, and poor air quality. Because of their liquid nature and similar physical and combustion properties to regular gasoline, Ethanol (E) and Methanol (M) have been appealing options to use as alternative fuels in automobiles. The focus of the article is to analyse the impact of adding alcohol (ethanol and methanol) at low rates (5 %, 20 %, and 25 %) to gasoline fuel on performance as well as emissions parameters. A 4-cyl, 4-s, water-cooled, multi-port fuel injection petrol engine was used for the experiments. It was running at various engine speeds (2100, 2800, 3500, and 4200 rpm) with a constant CR of 11:1. The research aimed to compare performance as well as emissions with three fuel blends, such as normal gasoline, ethanol (E), and methanol (M). In major trial instances, the performance reported higher BP, BSFC, and less BTE than the A20, A5, and A25 fuel blends. In addition, it represents a substantial decrease in CO2 and NOx exhaust emissions of the A5 with the rise in CO and HC for A5, A20, and A25 blends.

Major Findings: *A5, A20, and A25 blends increase the performance for brake power. (A5, A20, and A25) exhibit higher BSFC but enhance BTE for all speeds. The A5 blend has the minimum NOx and carbon dioxide emissions, while the A20 and A25 mixtures produce more emissions.*

Keywords: *Alternative Fuels, Ethanol, Emissions, Methanol, Performance, SI Engine*

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1.0 Introduction

Using fossil fuels would result in higher engine exhaust emissions, hence the future development of this is important[1]. Alternative fuels, which have lower production costs and are less polluting, dangerous, reusable, and environmentally friendly, can replace conventional fuels. A significant method to raise output energy, lower emissions, and improve the economy is to add alcohol to gasoline. The impact of alcohol on the performance was examined by blending different quantities of alcohol with gasoline fuel[2]. Alcohols are one of the most comprehensively examined options, whether they are used as a fossil fuel substitute or as an addition to enhance emissions, as well as combustion performance[3]. Since the two major concerns facing the world today are global warming plus the scarcity of fossil fuels, immense efforts have been made worldwide to seek renewable and ecologically friendly energy sources. It is most important that alternative fuels have lower exhaust emissions because the transportation sector adds significant amounts of global emissions[4]. Using non-traditional fuels from various renewable energy sources, including alcohol fuel, is growing in prominence due to the limited supply of conventional fuel. The growing demands for energy supplies that are mostly needed for manufacturing, transportation, and industrial facilities are becoming completely dependent upon modernization[5]. A combination of alternative fuels and conventional fuel is used to reduce vehicle emissions and the need to import crude oil. One of the possible alternative fuels is methanol (M), a possible energy carrier that could replace conventional fossil fuels. Today's IC engines can run directly on methanol with little or no modification. Many studies have been done on the properties of methanol as a fuel, encompassing its massive manufacture, transportation, and energy consumption[6]. Methanol provides various advantages when used as fuel in internal combustion engines. A low ignition temperature and a fast flame speed boost output power; some of these advantages are a substantial Hydrogen-to-Carbon (H/C) ratio that lowers hazardous emissions and Latent Heat of Vaporisation (LHV) that enhances volumetric efficiency[7]. Ethanol-based fuel can be mixed with gasoline to improve the Octane Number (ON) and emissions quality. It is compatible with SI engines. It is sometimes referred to as ethyl alcohol[8]. Through a fermentation process, agricultural products like sugar cane and potatoes that are regarded as biomass can be converted into ethanol. Since it can be made from biomass, it is regarded as a clean, sustainable, along renewable fuel[9]. The sole byproducts of burning Ethanol (E) are water and CO_2. Carbon dioxide emissions do not significantly affect the environment[10]. Vehicle emissions and the amount of petroleum and crude oil imported can be decreased by combining alternative fuels with conventional gasoline[11]. Iliev[12] evaluated the blending of gasoline-alcohol to decrease BP and boost BSFC when compared to regular Gasoline (G). Although the percentage of blends rises to 30 % (E30 or M30), the levels of CO as well as HC fall while the quantity of NO_x emissions improves significantly. Varol *et al.*[13] investigated mixed fuels with various alcohols tend to result in higher carbon dioxide pollutants plus fuel consumption rates, but lower HC and CO concentrations related to baseline Gasoline (G). Altun *et al.*[14] paper based on the results, a 10 per cent blend of Ethanol (E) or Methanol (M) to conventional Gasoline (G) works effectively under current engine design and operating conditions, in contrast to GEM mixtures. While BTE, CO, and HC pollutants decreased, BSFC increased. Syarifuddin Mohamed Zaharin *et al.*[15] studied the engine running on E15, reduced emissions of exhaust gases without sacrificing performance. Alcohols (ethanol and methanol) are added to ordinary Gasoline (G) as an alternative fuel formulation method to increase engine efficiency and minimise emissions. Mohammed Kamil *et al.*[16] in this paper, based on the outcomes, the BP, BTE, and BSFC are all higher than those of a basic gasoline engine. Alcohol additions are highly advised for improving performance, lowering emissions, along increasing mileage. Waluyo *et al.*[17] investigated that in comparison to conventional fuels, GEM blends have a lower energy content and will generate engine power that is either equal to or more if the combustion speed is faster. Because of its substantial enthalpy of evaporation, which promotes complete combustion as well as volumetric efficiency, Methanol (M) reduces emissions of CO and UHC when its percentage in the GEM fuel blend is increased. Balki *et al.*[18] performed for all compression ratios the SFC and BTE obtained using Ethanol (E) and Methanol (M) were generally highly related to baseline Gasoline (G). Alcohol (ethanol and methanol) fuels generally produce fewer

emissions. Yusuf *et al.*[19] based on this research work, the impact varies depending on the blend ratio and the methanol and ethanol added to gasoline. Agama *et al.*[20] presented that GEM decreased CO and HC levels by 43 % and 18 %, respectively, in the E15M5 mixture compared to the E10M10 blend, whereas nitrogen oxide levels rose by 30 % in both fuel blends. The test results demonstrate that GEM surpasses. Elfasakhany[21] paper evaluated that the BP, volumetric efficiency, and engine torque of GEM mixtures were moderately higher than those of GM and GE fuel mixtures. Related to baseline gasoline, the quantity of UHC and CO pollutants was considerably reduced when the vehicle was driven by GEM blends. Canakci *et al.*[22] presented at all wheel powers at 80 kilometres per hour, and the testing outcomes indicated that carbon monoxide, CO_2, hydrocarbon, and NOx pollutants dropped as the engine was running with GE or GM mixtures. In contrast to the context of regular Gasoline (G), the A/F equivalence ratio improved as the amounts of Ethanol (E) as well as Methanol (M) in fuel blends increased. Eyidogan *et al.*[23] assessed that BSFC was obtained to be more related to pure Gasoline (G) as the vehicle was driven by GE (E5/E10) and GM (M5/M10) fuel mixtures. Since the alcohol's Heating Value (HV) is 37–53 % lower than that of baseline gasoline. Usman *et al.*[24] in this paper the research revealed that enhancing the blend percentage of Methanol (M) and Ethanol (E) fuels in gasoline (E+M) improved BTE and BP. E2, E5M5, and regular Gasoline (G) were used to determine the minimal BSFC. EM, E, and gasoline can be ordered in decreasing order of CO_2 and NO_x pollutants, whereas HC emissions are increasing. Özcan *et al.*[25] This paper compared GE, GEM, and GM fuel blends to have a significantly higher BSFC. Alcohol has been added to Gasoline (G) to boost combustion, which has decreased NO_x, HC, and CO exhaust emissions. Iorio *et al.*[26] studied that increasing alcohol levels in the blend reduces NO_x, CO, and HC, exhaust pollutants with varying contributions throughout the cycle. For E25 and E10, particle emissions drop even more. Particulate emissions are higher when methanol is added to the blend than when E25 is used. Balki *et al.*[27] paper based on the results, that alcohol fuels improved BSFC, brake torque, and BTE. Furthermore, emissions of CO_2 increased while the hydrocarbons, carbon monoxide, and nitrogen oxide pollutants dropped. Li *et al.*[28] reported, in contrast, that GEM mixtures indicated the least nitrogen oxide pollutants. The Methanol (M) and Ethanol (E) mixtures caused a drop in BTE because the engine was operating with the SI of the gasoline's MBT. Carbon monoxide exhaust emissions rose under stoichiometric conditions and declined at rich conditions with the addition of Methanol (M) as well as Ethanol (E). HC emissions were lower for GE blends and higher for GM mixtures as compared to Gasoline (G). The present experimental work evaluates exhaust emissions as well as performance parameters of Gasoline-Ethanol-Methanol (GEM) fuel mixtures on a 4-cylinder, 4-s multiport fuel injection petrol engine. The comparative analysis covers a wide range of engine speeds (2100, 2800, 3500, and 4200 rpm) with compression ratios (11:1). This investigation is novel in that it analyses both performance as well as emissions at various blend ratio levels (A20, A5, and A25).

2.0 Research Methodology

2.1 Preparation of Different Fuel Blends

Three sets of fuel blends were made using Methanol (M), Ethanol (E), and Gasoline (G). The commercial petrol pump owned by Bharat Petroleum Corporation Limited (BPCL) provided the gasoline used in this work. The supplier of both methanol and ethanol was Impression Chemicals Enterprises in Sangli, Maharashtra. For safety reasons, alcohol and gasoline were stored in the experimental lab after use. Fuel mixtures are made using different quantities of Ethanol (E), Gasoline (G), and Methanol (M). Table 1 provides a summary of the formulation of the blends and their designation. Fuels are blended using agitators or mechanical stirrers in a mixing tank. In this research work, a 4-s, 4-cyl multi-port fuel injection petrol engine was employed to test three different types of fuel samples. The first fuel sample mixture, designated F1, consists of only typical gasoline plus ethanol. The remaining two fuel samples, designated F2 and F3, are gasoline-methanol and gasoline-ethanol-methanol mixtures. Adding both Ethanol (E) as well as Methanol (M) into regular gasoline with a volumetric basis of 5 %, 20 %, and 25 % to produce a fuel blend. The blends are designated by A5 (M 5 % + G 95 %), A20 (E 20 % + G 80 %), and A25 (E 20 % + M 5 % + G 75 %). To prevent phase separation, the blended gasoline should be used shortly after preparation (about 5–10 minutes). The blend

Table 1. Formulation of fuel blends and their designation

Fuel Name	Blends	Gasoline (ml)	Ethanol (ml)	Methanol (ml)
F1	A5	9.5	-	0.5
F2	A20	8.0	2.0	-
F3	A25	7.5	2.0	0.5

Table 2. The fuel properties of gasoline, methanol, and ethanol[3]

Properties	Gasoline	Methanol	Ethanol
Auto ignition temperature (°C)	257	423	425
Freezing point (°C)	-40	-97.5	-11
Carbon mass (%)	87.5	37.5	52.2
Hydrogen mass (%)	12.5	-	34.7
Oxygen mass (%)	0	49.93	34.7
Boiling temperature (°C)	27-225	78	78.25
Reid Vapor Pressure (kPa)	53-60	32.4	17
Research Octane Number (RON)	90-100	108.7	108.6-110
Motor Octane Number (MON)	82-92	86.6	92
Latent Heat of Vaporization (kJ/kg)	349	920	923
Lower Heating Value (MJ/kg)	44	20.1	26.9
Chemical Formula	C_8H_{18}	CH_3OH	C_2H_5OH
Auto ignition temperature (°C)	257	423	425

separates into layers after preparation because alcohol and regular gasoline fuel evaporate at different rates. To prevent Ethanol (E) reaction to water vapour in the air and to assure that the mixture of fuel was homogeneous, the trial fuels were made just before the experiment. Table 2 lists the fuel properties of the Gasoline (G), Ethanol (E), and Methanol (M) employed in the experiment. Table 3 summarises the Calorific Value (CV) and fuel density of each blend.

Table 3. The fuel density and Calorific Value (CV) of each blend

Test blends	Fuel density (kg/m^3)	Calorific value (KJ/kg)
A5	742.6	42795
A20	749.8	40540
A25	752.4	39335

2.2 Experimental Set-Up

The experimental engine is a Maruti BS-VI water-cooled, 4-cyl, 4-s petrol engine at a constant CR (11:1). For testing loads, it has an Eddy Current Dynamometer (ECD). The system has a number of sensors that can record fluid flow, engine loads, Temperature (T), and Pressure (P). A 16-bit multipurpose input/output device is connected to a high-speed data collection system in order to acquire data. Both engine cooling water as well as calorimeter water flow are measured using rotameters.

Table 4. The engine specifications (Apex Innovations Pvt. Ltd.)

Parameter	Description
Engine	Make Maruti, Type BS-VI, 4 Cylinder, 4 Stroke, water-cooled, Petrol (MPFI)
No. of cylinders	4
No. of strokes	4
Rated power	61.00 Kw @ 6000 rpm
Cylinder diameter	73.0 mm
Stroke length	71.5 mmm
Connecting rod length	155 mm
Compression ratio	11:1
Orifice diameter	48 mm
Dynamometer arm length	255 mm

The panel box contains an air box, a piezoelectric powering unit, manometers, and transmitters to monitor air and fuel, as well as a dual fuel reservoir. BTE, BP, and BSFC are some of the performance parameters. The analysis of exhaust emissions was done with a smoke detector and an AVL-five gas analyser. Figure 1 depicts a photographic view of the engine test setup. Table 4 lists the engine specifications. "ICEngine Soft" is a laboratory-based software designed for online engine combustion and performance analysis. Data entry, reporting, recording, and logging are among the most common engine testing program requirements that it can handle. The software assesses the consumption of fuel, heat release, and power efficiency. It can be adjusted to suit the engine configuration. Distinct charts are generated under various operating conditions. Table 5 represents AVL DIGAS 444 gas analyser specifications

2.3 Experimental Procedure

A series of tests was performed on the MPFI engine to assess the effects of different engine speeds. Experiments

Table 5. Technical specifications of AVL DIGAS 444 exhaust gas analyser

Measured parameters	Measuring range
CO (%)	0-10 % volume
HC (ppm)	0-20000 ppm
CO_2 (%)	0-20 % volume
NO (ppm)	0-5000 ppm
O_2 (%)	0-22 % volume
Display	LCD
Interface	RS232
Operating Voltage	100-300VAC,50-60Hz,11-22 VDC (Optional)
Power Consumption	Max.25W
Dimensions (wxhxl)	270x85x320mm
Weight	4.5kg
Engine Speed	400- 6000 rpm
Oil Temperature	- 30 to 125 ^{0}C
Lambda (λ)	to 9.999



Figure 1. Engine test setup.

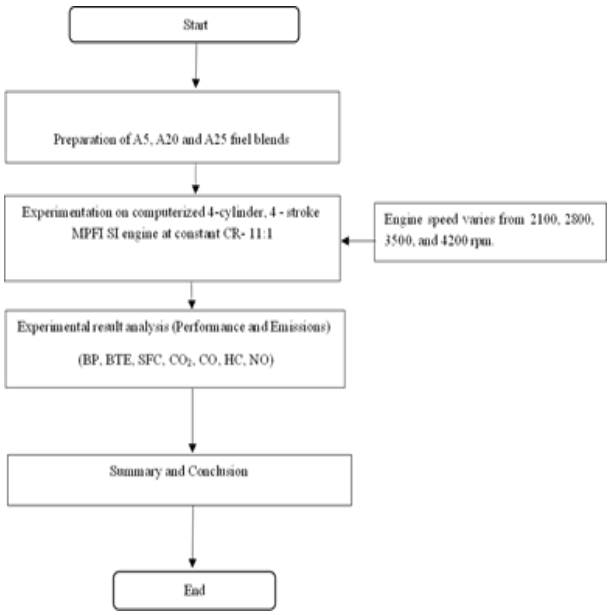


Figure 2. Flow Chart for experimentation.

were performed at a constant CR of 11:1 for speeds of 2100, 2800, 3500, and 4200 rpm. Three test fuel blends (A5, A20, and A25) were run through the same series of tests, a high-speed data collection system was used to record various output parameters, including SFC, BP, and BTE at each speed, as well as constant CR under full throttle conditions. In addition, an Exhaust Gas Analyser (EGA) was employed to monitor the emission parameters (CO, HC, CO_2, and NOx). Figure 2 indicates the flow chart of experimentation.

2.4 Uncertainty Analysis

Various factors, such as the test design, surrounding factors, recording methods, and the selection, condition, and calibration of test equipment, can lead to uncertainties and errors even when the essential measures are taken throughout the experimental tests. To evaluate the reliability and correctness of the experiments, uncertainty analysis is required. Because Experimental Errors (EE) are unavoidable. Initial measurements are employed to determine the result of a trial. Performance measurements, including BTE and BSFC as well as BP, along with emission parameters like NOx, carbon monoxide, CO_2, and hydrocarbon, were evaluated in this study to assess the engine test's results. This uncertainty analysis ensures a comprehensive assessment of the experimental results and makes it easier to understand any variations in the outcomes. Three sets of testing, or repeatability tests, were carried out in the present research with the same operating parameters and conditions to measure the variation in the output data. Equation (1) evaluates the overall uncertainty of the emission characteristics and engine performance. Table 6 shows the estimated percentage uncertainty of performance and emissions parameters.

Table 6. Percentage uncertainty of performance and emissions parameters

Parameters	Accuracy	Uncertainty (%)
CO emission (%)	±0.01 %	±0.1
CO_2 emission (%)	±5 %	±0.1
HC emission (ppm)	±10 ppm	±0.5
NO_x emission (ppm)	±50 ppm	±1
BTE (%)	-	±2
BSFC (kg/kWh)	-	±0.1
Engine speed (rpm)	±1 rpm	±0.1
Temperature (^{0}C)	±1	±0.5

Overall uncertainty =

$$\pm \text{ Uncertainty \% of } [BTE^2 + BSFC^2 + CO_2{}^2 + NO^2 + HC^2 + CO^2]^{1/2} \quad (1)$$

$$\pm \text{ Uncertainty \% of } [(2)^2 + (0.1)^2 + (0.1)^2 + (1)^2 + (0.5)^2 + (0.1)^2]^{1/2} = \pm 2.29$$

The present experiment is well within the acceptable range of 5 % uncertainty, which results in an overall uncertainty of ±2.29 %[29].

3.0 Results and Discussion

In addition, gasoline-alcohol mixtures were employed to assess both performance and emissions. A 4-s, 4-cyl

MPFI gasoline engine was used for the experimental work, and it run at different speeds for A20, A5, and A25 blends within 2100 to 4200 rpm. At a constant CR of 11:1 engine performance as well as emissions parameters for using A25 blends in comparison to A5, and A20, under various operating conditions. The impact of A25 blends in different percentages (5 % to 25 %) on exhaust emissions parameters (CO_2, CO, HC, and NO_x) and performance parameters (BP, BSFC, and BTE) about engine speed is shown in the following sections.

3.1 Engine Performance Parameters

3.1.1 Brake Power

In Figure 3, the brake power trend from an MPFI SI engine running with varying speeds (2100– 4200 rpm) is presented. As the speed is raised, the BP increases, as seen in the above figure. The highest brake power produced by A25 at 3500 rpm is 12.36 kw, followed by 12.06 kw and 11.31 kw for A5 and A20, respectively. The main cause of the higher BP in the fuel blends is that alcohol has a higher LHV related to gasoline. To increase the output power and density of the charge, it additionally provides A/F charge cooling. Since Ethanol (E) is partially oxidised, adding it to the mixed fuel increases combustion in engines. Therefore, because oxygen causes ethanol-gasoline blends to burn more completely, the presence of oxygen (O2) in the mixtures causes a leaning effect. Consequently, the use of alcohol will lead to better combustion, which raises BP. The impacts of Gasoline (G), Ethanol (E), and Methanol (M) mixtures on BP are presented in Figure 3. Brake power is one of the key parameters affecting an engine's performance. For all engine speeds, BP has increased for A5, A25, and A20. Brake Power (BP) improved slightly as the quantity of Methanol (M) in the blended fuel (M5) increased. The higher engine combustion efficiency of oxygenated fuels is presented in this article. Enhancing the quantity of Methanol (M) fuel in the blended fuel to M5 led to an elevated BP at all speeds.

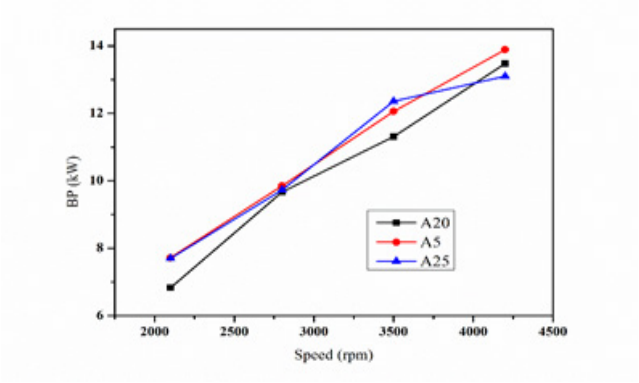


Figure 3. Change of brake power with engine speed.

3.1.2 Brake Specific Fuel Consumption

Changes in SFC values for combined fuels A20, A5, and A25 with varying engine speeds are demonstrated in Figure 4. From the graphs, comparisons of BSFC for different test fuels. SFC was shown to decrease as engine speed increased for all blended fuels, although specific fuel consumption rose as engine speed increased.

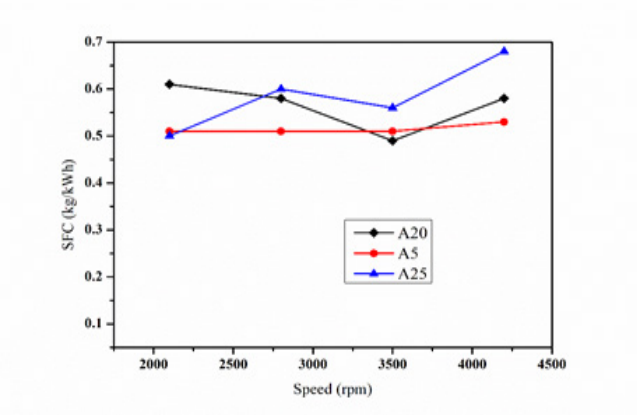


Figure 4. Change of brake-specific fuel consumption with speed.

All of the tested fuels show the same pattern, hence, operating conditions rather than fuel type should be attributed to this variation. Blended fuels consisting of Gasoline (G), Ethanol (E), and Methanol (M) exhibit higher SFC. The Heating Value (HV) of methanol is the lowest of the three fuels. SFC for Methanol (M) blends was higher under specific operating conditions because Methanol fuel (M) has an LCV related to baseline gasoline. Because methanol had a 50 % O2 content, which prevents heat development during in-cylinder combustion, its CV was lower. The BSFC values are obtained using engine speeds between 2100 and 4200 rpm in Figure 4. M5, A20, and A25 were rising by 0.56 %, 0.51 %, and 0.58 % in the overall test condition. The BSFC values increase as the alcohol contents grow. This is mostly because both

Methanol (M) and Ethanol (E) fuel have fewer LHVs than pure Gasoline (G), which are 22.7 as well as 29.7 MJ/kg, respectively.

3.1.3 Brake thermal efficiency

Figure 5 demonstrates the impact of gasoline-alcohol fuel mixtures on BTE. When raising speed through 2100 - 4200 rpm, the BTE decreases. At full throttle conditions, the BTE is presented in Figure 5 at various engine speeds (2100 rpm to 4200 rpm) and fuel blends (A20, A5, and A25). When the engine is running at 3500 rpm, the A5 has the highest BTE value (16.56 %). It may be caused by the increased O_2 content and LHV of methanol fuel.

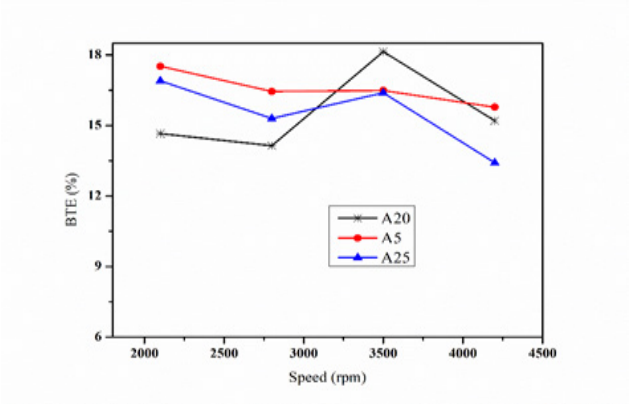


Figure 5. Change of brake thermal efficiency with engine speed.

The higher the alcohol percentage, the better the BTE. This is because partially oxygenated alcohol burns more efficiently. In addition, Methanol (M) has a higher LHV than Ethanol (E) and Gasoline (G). Therefore, it will enhance the cooling effect. The higher the LHV, the faster the fuel will vaporise during the compression stroke. BTE values for alcohol-gasoline mixtures were generally slightly less since the BTE is inversely proportional to the LHV as well as BSFC.

3.2 Exhaust Emissions Evaluations

3.2.1 Carbon Monoxide Emission

The impact of alcohol added to Gasoline (G) fuel on Carbon Monoxide (CO) emissions is seen in Figure 6. CO exhaust emissions are the result of partial combustion, which occurs when there is not enough air in the AFR or

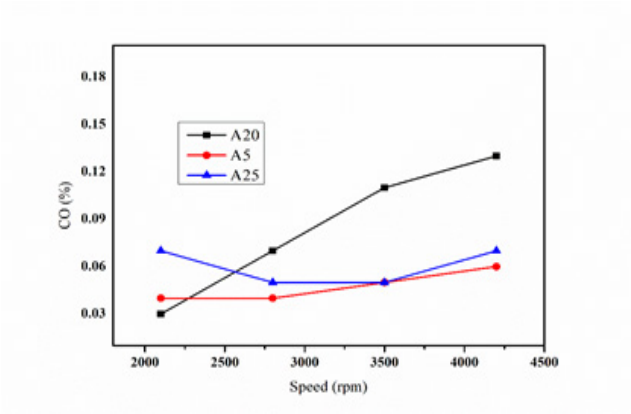


Figure 6. Change of carbon monoxide with engine speed.

inadequate time in the cycle for full combustion. Carbon monoxide emissions rise as engine speeds increase due to a lack of available oxygen for Combustion. Figure 6 indicates that carbon monoxide emission changes with speed from 2100-4200 rpm during full throttle conditions. The CO emissions increased as the engine speed rose. However, the overall carbon monoxide exhaust emissions for alcohol-gasoline mixtures are rising. On average, gasoline-ethanol-methanol fuels A20, A5, and A25 result in CO emissions increases of 8.5 %, 4.7 %, and 6 %, respectively.

3.2.2 Carbon Dioxide Emission

Figure 7 indicates that A25 produces the highest CO_2 emissions, followed by A20 and A5. The carbon dioxide exhaust emissions using A25, A20, and A5 were raised by approximately 10.25, 9.35, and 8.37 % on average. Lean burning, which is attributed to a rise in oxygen

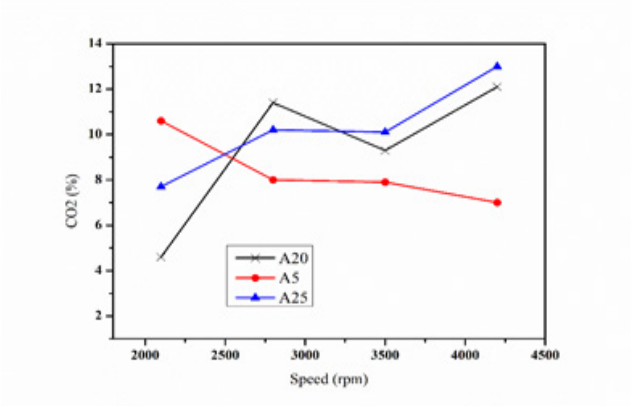


Figure 7. Change of carbon dioxide with engine speed.

(O_2) content, led to an increase in CO_2 emissions. This is because more complete combustion and higher CO_2 exhaust emissions are the outcomes of leaner engine conditions. The C-H ratios of gasoline are the main cause of CO_2 emissions

Methanol's (M) lower C-H ratio or C content, which indicates lower CO_2, is the cause of the results. According to the data, for each fuel used, the proportion of CO_2 increased as rpm rose until it reached a limit and then started to decline. It was also observed that, up to A20, carbon dioxide rose roughly linearly proportional to the percentage of E blend. Furthermore, a higher O_2 proportion and octane number are relevant for the higher CO_2 emissions produced by alcoholic fuels (ethanol and methanol). As a result, the octane rating causes fuel to acquire antiknock characteristics. This led to enhanced combustion at the cost of reduced friction and higher carbon dioxide exhaust emissions.

3.2.3 Hydrocarbon Emission

Figure 8 demonstrates that both ethanol and methanol, with gasoline mixtures, affect HC exhaust emissions at varying engine speeds. Blended fuels tend to raise hydrocarbon pollutants. Alcohols-gasoline mixtures have an effect on emissions of hydrocarbons for different speeds, as demonstrated in Figure 8. In the engine cylinder, incomplete or insufficient combustion is the main cause of HC emissions. The overall considerably richer charge's lack of oxygen raises HC mass emissions at high engine speeds. All of the blended fuels in this experiment showed higher measured HC emissions. At A20, A5, and A25, the maximum HC emission was measured at 4200 rpm. Due to the results of the experiments, using A20, A5, and A25 fuels leads to significantly increased HC emissions.

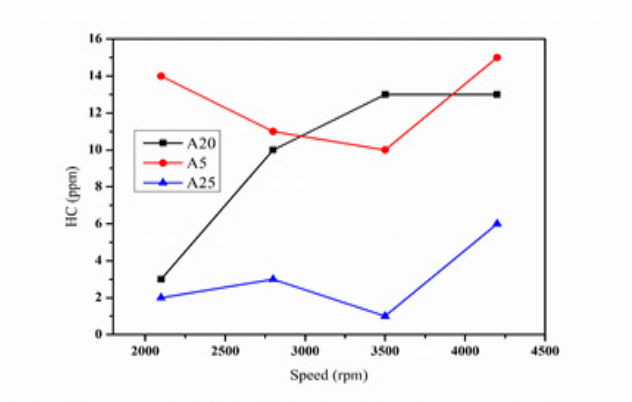


Figure 8. Change of hydrocarbon with engine speed.

The HC exhaust emission may rise quickly when there is a misfire or insufficient combustion during a portion of the engine's working cycles.

3.2.4 Nitrogen Oxide

Figure 9 depicts the pattern of NOx exhaust emissions by changing the engine speed through 2100 rpm - 4200 rpm under full throttle conditions. The graph indicates that when the speed is raised, nitrogen oxide emissions increase. The highest NOx emissions, 22 ppm, are produced by the A25 at a speed of 4200 rpm.

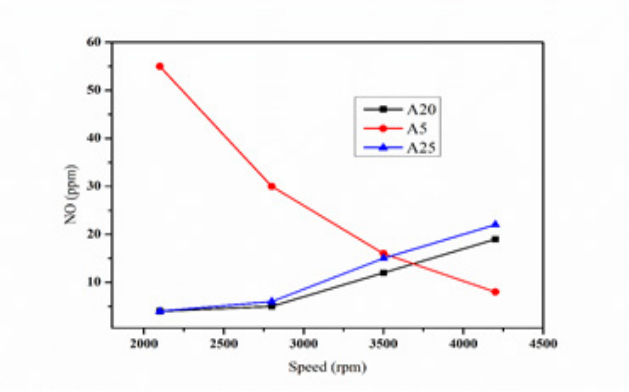


Figure 9. Change of Nitrogen oxide with speed.

NOx is formed by several parameters, including the temperatures inside the cylinder and the availability of oxygen. The NOx formation rises with the amount of alcohol blends. The rise in flame temperature is the cause of this. Alcohol will have a leaner effect since it will reduce the equivalence air-fuel ratio. Based on the results, NOx emissions rose as engine speed climbed and the ethanol to gasoline percentage increased to 20 %. Depending on engine operating conditions, NOx emissions can either rise or fall, irrespective of increased alcohol blends. NOx emissions were found to be lowest for A5 and highest for A25 and A20, respectively.

Exhaust Gas Temperatures (EGT) and higher consumption of fuel in the presence of blended fuels may be the cause of the larger percentage rise in NOx that was seen in the present study.

4.0 Conclusions

The experimental study compares exhaust emissions as well as performance with regular Gasoline (G) and various blend ratios (A20, A5, and A25) under varying engine operating conditions. The engine performance as well as emissions parameters were assessed for this objective at four different engine speed levels (2100, 2800, 3500, and 4200 rpm) and compression ratios (11:1). Variations in engine speed and compression ratio were examined for their impact on emissions and performance. Here, the experimental results are summarised:

The methanol (M) content in combined fuels increased to 5 % (A5), and the BP rose marginally, while the ethanol level in the mixed fuel was raised to 20 % (A20), with BP improved for all speeds. As alcohol (ethanol and methanol) percentage ratios in Gasoline (G) were increased up to 25 % (A25), BP was enhanced at all engine speeds. The SFC is raised in proportion to the ethanol or methanol content. Brake-specific fuel consumption levels are higher in gasoline blended fuels (A5, A20, and A25). BTE has increased for all engine speeds as a result of Gasoline-Ethanol (GE), Gasoline-Methanol (GM), and GEM fuel blends. The highest HC (hydrocarbon) and CO (carbon monoxide) emission levels are obtained by using gasoline blended fuel containing both methanol and ethanol (A20, A5, and A25) for all engine speeds. For all engine speeds, the A5 blend ratio yields the lowest CO_2 and NOx exhaust emissions, while the A20 and A25 blend ratios produce the highest.

The A20, A5, and A25 blends exhibit better performance in terms of BP. However, the blends have a poor emission profile, particularly when the engine speed is increased. There is potential for improving alcohol emission performance in the future by using particular additives to minimise emissions.

5.0 References

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