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FUEL FLOW ANALYSIS OF AN ECU-CONTROLLED MPFI ENGINE USING IAA AND IBA BLENDS TO ASSESS THEIR ENVIRONMENTAL IMPACT

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Abstract. There has always been a way to lessen the amount of greenhouse gases, including carbon dioxide, that are emitted by cars and trucks, which account for a significant share of all emissions. New sources of energy are superior alternative for existing outdated fuels derived from fossils many of the years they minimize oil imports, pollution, and can be produced responsibly. Several tests on the MPFI engine running with wire throttle positions were done in this study. In order to show the maximum return that can be habitual in terms of air need, fuel requirement, AFR, and volumetric outputs, various Loads and various blends of gasoline with IAA and IBA are tested. The results and justifications for this study are then described. Additionally, it was demonstrated that at lower speeds, both gasoline and blends have higher AFR and volumetric efficiency. Air and fuel flow, however, increase as speed does. The results of this study show that energy use, as well as fuel flow and airflow consumption, are reduced in order to protect the environment.
Keywords: *IAA, IBA, MPFI, Proportions, SI engines, Fuel flow.*

1 Introduction

As soon as the load demand changes, the fuel flow decreases before the air flow, and it is vice versa to airflow, ensuring that an excess of air or an air rich condition prevails at all times to guarantee safe and full combustion.

AFR regulation and estimate is one of the most crucial parts of combustion management. Several factors, including the intake air mass flow rate, the amount of fuel injected, and the EGR flow rate, have an impact on the AFR's magnitude[1].

Vehicle engine exhaust emissions account for half of all air pollution.. Vehicles release a variety of pollutants, including CO, HC, NO_X, and others. There is a propensity to create engine control systems that operate quickly. Lower emissions from completing this job, together with improvements to the fuel's composition, will lead to the engine of the vehicle operating at its best.

Controlling the AFR is essential ,It has a significant impact on the efficiency of the fuel and the reduction of pollutants[2].

The AFR is measured by a lambda sensor in the exhaust manifold. As a result, there is a variable transit latency in the model under study. A non-linear control strategy is utilised, which is based on a Takagi–model Sugeno's of the system. Then, two control law architectures based on parallel distributed compensation control laws that account for variable time delay are compared.

several simulations are provided to demonstrate the effectiveness of the devised control legislation[3].

The performance of a cylinder hydrogen-fueled port injection engine as affected by AFR and engine speed GT-Power was used to construct the port injection engine's computational model. The flow and heat transmission in the engine components were simulated by a one-dimensional gas dynamics model. The AFR was changed throughout the trial, from stoichiometric to lean. Engine speeds ranged from 2500 to 4500 rpm. Port injection hydrogen engines have a serious problem with volumetric efficiency that lowers overall engine performance. This demonstrated how conventional engines could be easily converted to run on hydrogen fuel. [4].

The BSFC has been found to be improved by raising engine speed and AFR while lowering BMEP and BTE. While engine speed rises, the cylinder temperature falls even as the AFR rises. As the engine speed and equivalent ratio increase, the volumetric efficiency increases. The volumetric efficiency of hydrogen engines with port injection is a serious problem that lowers the engine's overall performance. This demonstrated how conventional engines could potentially be converted to run on hydrogen fuel with minimal changes. [5].

This in-depth analysis' main objective is to summarise all previous work on plastic oil and additives in terms of performance, combustion, emissions, and other factors. The disparity between worldwide waste plastic manufacture and waste plastic consumption necessitates prompt chemical action transformation of renewable waste plastic authorities, direct rise, and gradual complete implementation of plastic oil in hydrocarbon engines. Reactants included kaolin, silica, alumina, ZSM-5, and others[6].

Pyrolysis is recognised as a useful process for recycling used tyres because it produces liquid, gases, carbon black, and steel wires. This technology produces fuel that can help to ease the energy crisis in addition to disposing of used tyres and tubes in a responsible and environmentally friendly mannerIt talks about the primary and secondary uses of gas, char, and oil. In the end, it is found that tyre oil is a good substitute fuel for the effective operation of gasoline engines[7].

One alternative fuel with a high octane rating and low emissions is alcohol. Despite efficient resource management, fuel consumption in heavy- and light-duty engines is higher. One of the unwelcome byproducts of sugar mills is isoamyl alcohol, which is present in large quantities[8].

The use of fossil fuels, especially gasoline engines, releases harmful pollutants into the atmosphere and contributes to global warming on a global scale. In an effort to outperform SI engines, CI engines claim to have improved performance and consistent particulate interns of CO, HC limits, as well as significant smoke and NOx emissions. A new form of IC engine, such as RCCI, is one of the most cost-effective choices for lowering NOx and smoke emissions. The current study sought to ascertain the particulate matter and consequences of the RCCI engine.

The experiments used diesel as the base fuel and ETBE as the replacement fuel. The compositions of the fuels ranged from 0% to 10%, 20%, and 30%. [12].

This experimental work investigates the impacts of various blend proportions at various loads, and it estimates the features of air and fuel consumption, volumetric efficiency, and air fuel ratio at various speeds in MPFI mode..

Nomenclature

Symbol	Abbreviation	Symbol	Abbreviation
AFR	Air fuel ratio	HC	Hydrocarbon
AI	Auto Ignition	IC	Internal Combustion
BMEP	Brake Mean Effective	IAA	Isoamyl Alcohol
BSFC	Brake specific fuel	IBA	Isobutyl Alcohol
BTE	Brake thermal	MPFI	Multi point Fuel injection
CO	Carbon monoxide	RCCI	Reactivity controlled
CI	Compression Ignition	SI	Spark ignition
ECU	Engine control unit	VE	Volumetric efficiency
ETBE	Ethyl Tertiary Butyl	WT	Wire Throttle
EGR	Exhaust Gas		

2 Methodology

- selecting a 3 cylinder, 4 stroke, MPFI Research Engine test. To examine how much air, fuel, and vol. eff. are used by Petrol, IAA, and IBA by using an MPFI engine and WT method in the following manner.
- By varying the blend ratio from B 0 to B 20 in relation to the speed from (2500,3000,3500, 4000 & 4500)
- The purpose of the study is to identify the ideal fuel, air, and volumetric efficiency ratios for each scenario in relation to blend and speed.

Total Count of Experimentations for air consumption = CR x RPM x Blend = (1 X 4 X 4) = 16

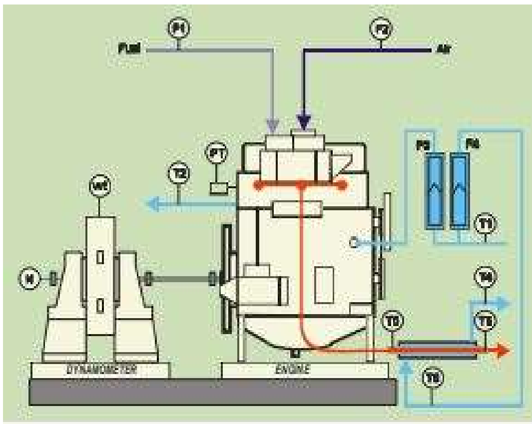
Total Count of Experimentations for fuel consumption = CR x RPM x Blend = (1 X 4 X 4) = 16

Total Count of Experimentations for volumetric efficiency = CR x RPM x Blend = (1 X 4 X 4) = 16

Total Count of Experimentations for air fuel ratio = CR x RPM x Blend = (1 X 4 X 4) = 16

3 Experimental Procedure

Fuels now have a significant impact on how future generations will live. Several alternative fuels are used around the world. One alternative fuel that has a high octane rating and emits less emissions is alcohol. Fuel consumption is higher in heavy-duty and light-duty engines even though resources are typically employed efficiently. In this experiment, primary alcohols like isoamyl alcohol and isobutyl alcohol are used as fuels instead of gasoline as the base fuel. Wire throttling allows us to vary the speed and load of the MPFI research engine. In this research engine, various



B0, B5, B10, B15, and B20 proportions are used with varying speeds. An internal combustion engine can be fuel-injected utilising the MPFI technique by using numerous ports on the intake valves of each cylinder. It distributes the precise amount of gasoline to each cylinder at the precise moment. Fig.1. Engine Schematic Diagram Fig.2 .MPFI Engine test rig

EngineSoft is a Lab view-based software suite developed by Apex Innovations Pvt. Ltd. for monitoring engine performance. EngineSoft can handle the vast majority of the monitoring, reporting, data entry, and data logging needs of engine testing applications. The programme evaluates fuel use, heat emission, power, and efficiency.

At Apex Laboratories in Shangli, Maharashtra, the experiment was carried out, and all the facts were recorded. The general layout of the experiment is described in Table 1. Depending on the engine configuration, it might be configured. Different graphs are produced under various working conditions.

During on-line testing of the engine in RUN mode, the relevant signals are scanned, saved, and shown in a graph. To view the data in graphical and tabular formats, the stored data file is accessed.

Table 1 Experiment Setup Specifications

Manufacturing ID	230	Stroke (mm)	79.5
Make	Maruti	Bore (mm)	73
Type	BS-VI,	CC	998
No. Cylinders	3	CR	11.0:1
No of Strokes	4	Dynamometer	EC
Engine Cooling Type	Water	PS	Capacity 5000 PSI

Maximum Power (Kilowatt)	50 Kw @ 5500 rpm,	CAS	Rev 10 with 5500 RPM
TS	Make Radix, Type RTD,	Thermocouple	Type K
LI	Digital	Range (Kg)	0 to 500
Load sensor	LC	Type	SG
Range (Kg)	0 to 50	No. of Valves	Two
Fuel flow transmitter	DP	Range (mm)	0 to 500
Air flow transmitter	Pressure based	Range (mm)	250
Rota meter Capacity (LPH)	100 to 1000	Calorimeter Capacity (LPH)	25 to 250

Here the properties of fuels are find out in Apex Laboratories, Shangli , Maharastra. shows the Characteristics .In table 2 shows the fuel properties of Gasoline , Isoamyl alcohol & Isobutyl alcohol.

Table 2 Fuel Properties

Properties	Gasoline	Isoamyl alcohol	Isobutyl Alcohol
Chemical Formula	C_8H_{18}	$C_5H_{12}O$	$C_4H_{10}O$
MW,g?mol	95.18	87.99	73.97
Density(kg/m^3)	719-776	802.3	801
Oxygen content (%weight)	2.1	17.89	0.817
Viscosity (mm^2/s)	0.5-0.6 (at 25^{0}C)	3.69	Not Pertained
Stoichiometric air fuel ratio	14.19-15.0	11.69	20.19
Boiling Point (^{0}C)	209.58	130.89	106.89
LHV(MJ/kg)	43.99	34.64	33.84
LH of vaporization (kJ/kg)	381.89-399.58	620.79	579
RON	90-102	112	113
MON	83-91	85	95

To ascertain the oil's capacity, range, speed, and temperature, data is currently being gathered based on experiments.

Table 3 Range/Accuracy/Resolution

Capacity	Range	Retention	RPM	Temp. of the Oil
	0 to 100 Percentage	0 to (1/10) m	400 to 6000 (1/min)	0 to 150degrees

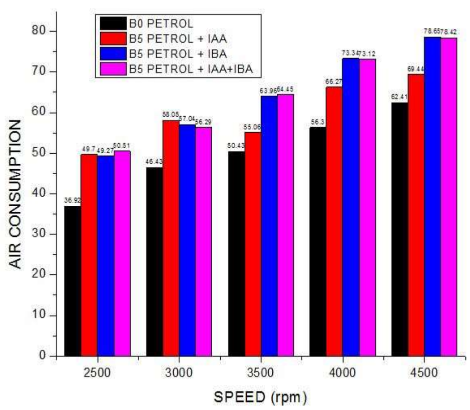
Precession & Repeatability	±1% of full measuring range	Better than ± (1/10) m	±10	±2degrees
Accuracy	0.1 %	(1/1000) m	±1	±1 degrees

4 Findings and Discussion

Air Consumption

Air Consumption is one of the important factor in IC Engines and also it is known as dead air volume. Air pressure, the number of bottles actually generated, and the air that needs to be evacuated after each blow cycle are all factors that affect air consumption. The parts connecting the blow valves and the hollow contain this air. To ensure that there is no pressure left in the blown bottle, all air between the exhaust valve and the cavity must also be drained when the exhaust valve is opened. In order to increase air density, which facilitates better combustion in less time and leads to increased power output, exhaust emissions, and fuel economy, a higher air intake pressure is required.

Figure 3 demonstrates how the varied speeds are taken into account in the X axis and the various mix proportions in this experiment. B0(100% gasoline) ,B5(95%gasoline + 5%IAA), B5(95%gasoline + 5%IBA) , B5(90%gasoline + 5%IAA+5%IBA) are considered in Y axis.



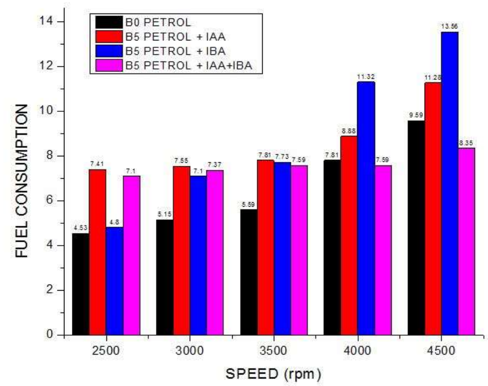
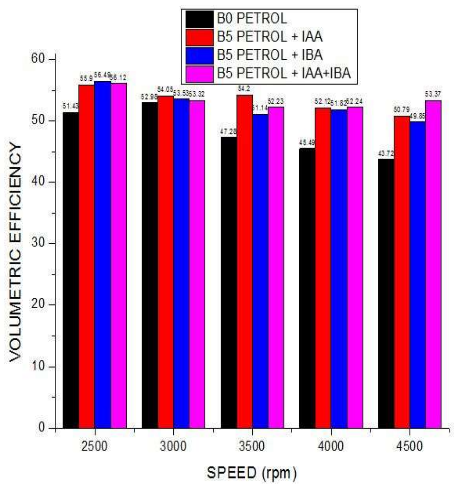


Fig.3.Air Consumption vs Speed at Blend B5 Fig.4.Fuel Consumption at Blend B5

The maximum air consumption was measured at a speed of 4500rpm with B5 (99% gasoline + 5% IBA), while the lowest air consumption was seen at a speed of 2500rpm with B0 (100% gasoline). Figure 4 shows the various speeds taken into account along the X axis and the various mix proportions taken into account along the Y axis. B0 (100 percent gasoline), B5 (90 percent gasoline + 10 percent IAA), B5 (90 percent gasoline + 10 percent IBA), and B5 (80 percent gasoline + 10 percent IAA + 10 percent IBA). As compared with the gasoline lower fuel flow is occurred at a speed of 2500rpm with B0(100%gasoline) and the highest is recorded at a speed of 4500rpm with B5(95%gasoline + 5%IBA).

Fuel Consumption

The fuel flow control system distributes the gasoline in the precise amount necessary to fulfil the fuel firing rate demand. It works in tandem with the air flow management system to make sure that the combustion process maintains the stoichiometric ratio with some increased air flow[9]. Figure 5 illustrates how different speeds are taken into account in the X axis while varied blend proportions—B0 (100 perc gasoline), B5 (95 perc gasoline + 5% IAA), B5 (95 perc gasoline + 5% IBA), and B5 (90 perc gasoline + 5% IAA+5% IBA)—are taken into account in the Y axis. In terms of volumetric efficiency, B0 (100 percent gasoline) has lesser volumetric efficiency at 4500 rpm, whereas B5 (95 percent gasoline plus 5 percent IBA) exhibits the best volumetric efficiency at 2500 rpm. In Figure 6, various speeds are taken into account together with the blends B0 (100 percent gasoline), B5 (90 percent gasoline plus 10 percent IAA), B5 (90 percent gasoline plus 10 percent IBA), and B5 (80 percent gasoline plus 10 percent IAA plus 10 percent IBA). The largest fuel flow was observed at a speed of 2500 rpm with B5(90%gasoline + 5%IAA+5%IBA), while the lowest occurred at a speed of 4500 rpm with B5(95%gasoline+ 5%IBA).



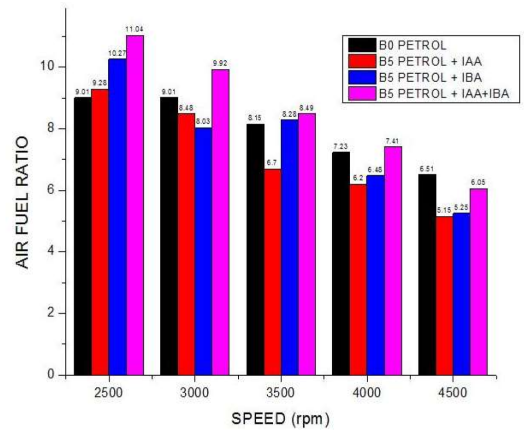
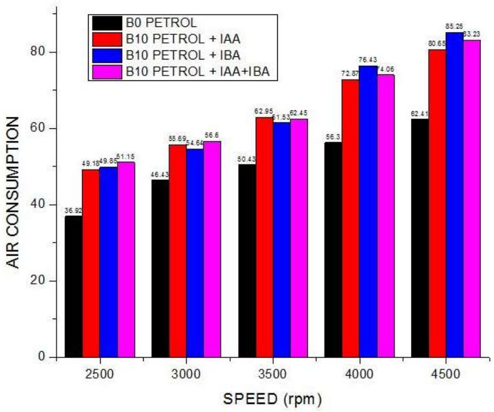


Fig.5.Volumetric Efficiency vs Speed at Blend B5 Fig.6.Air fuel ratio at Blend B5 proportions

Volumetric Efficiency

A compressor cylinder's volumetric efficiency displays how much gas it can compress. It is described as the volume of gas actually supplied divided by the piston displacement, with suction temperature and pressure taken into account. Figure 7 shows the varying speeds are taken into account in the X axis and the various proportions of blends B0 (100 percent gasoline), B10 (90 percent gasoline + 10% IAA), B10 (90 percent gasoline + 10% IBA), and B10 (80 percent gasoline + 10% IAA+10% IBA) are taken into account in the Y axis. With B0 (100 percent gasoline), the lowest air consumption is observed at a speed of 2500 rpm, while B5 (90 percent gasoline plus 10 percent IBA), the highest, is observed at a speed of 4500 rpm. Figure 8 illustrates how various blends, such as B0 (100 percent gasoline), B10 (90 percent gasoline + 10 percent IAA), B10 (90 percent gasoline + 10 percent IBA), and B10 (80 percent gasoline + 10 percent IAA + 10 percent IBA), are taken into account in relation to different speeds. With B0 (100 percent gasoline), the fuel flow is lower at 2500 rpm, and with B10 (90 percent gasoline plus 10 percent IAA), the fuel flow is highest at 4500 rpm.



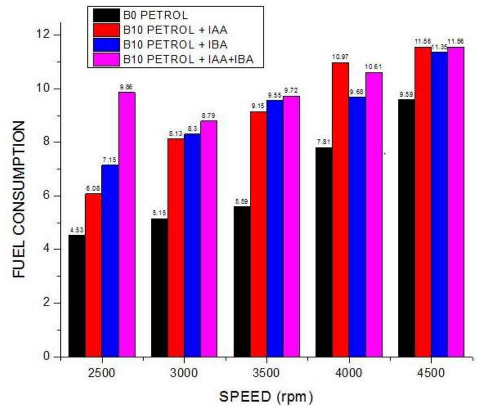
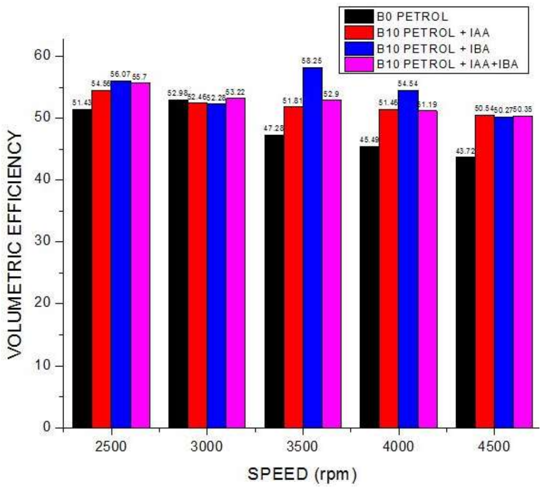


Fig.7. Air Consumption vs Speed at Blend B10 Fig.8.Fuel Consumption at Blend B10

Air Fuel Ratio

The stoichiometric mixture is the ideal air-to-fuel ratio for a gasoline engine because it burns all the fuel completely without any extra air. The stoichiometric air-fuel ratio for gasoline is roughly 14.7:1, which means that 14.7 grammes of air are needed for every gramme of fuel. The air-fuel ratio determines how much energy is released, how many unwanted pollutants are produced during the reaction, and whether a mixture is combustible. There is typically a range of fuel to air ratios above which ignition will not take place. The terms "lower explosive limit" and "upper explosive limit" are used.

Figure 9 explains how various blend proportions and speeds are taken into account. B0(100% gasoline), B10(90% gasoline + 10% IAA), B10(90% gasoline + 10% IBA), and B10(80% gasoline + 10% IAA+10% IBA) are taken into account in the Y axis. In terms of volumetric efficiency, B0 (100 percent gasoline) exhibits lower volumetric efficiency at 4500 rpm, while B10 (90 percent gasoline plus 10 percent IBA) exhibits the highest volumetric efficiency at 3500 rpm. Figure 10 illustrates how various blends, such as B0 (100 percent gasoline), B10 (90 percent gasoline + 10 percent IAA), B10 (90 percent gasoline + 10 percent IBA), and B10 (80 percent gasoline + 10 percent IAA + 10 percent IBA), are taken into account in relation to different speeds. In terms of fuel flow, B10 (80% gasoline + 10% IAA + 10% IBA) produces the lowest at 4500 rpm and B0 (100% gasoline) produces the highest



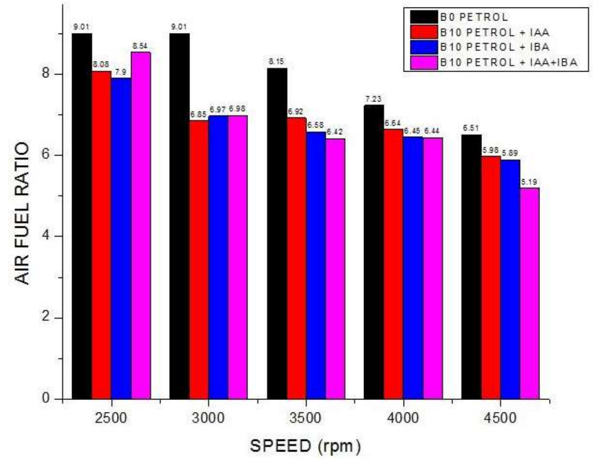
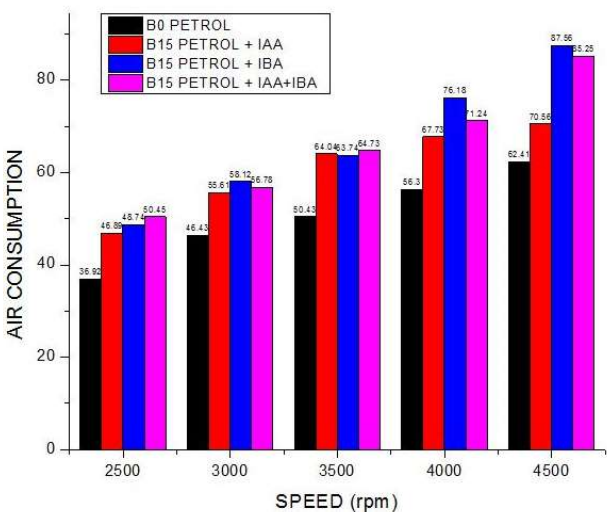


Fig.9.Volumetric Efficiency vs Speed at Blend B10 Fig.10.Air fuel ratio at Blend B10

According to Figure 11, various blends, such as B0 (100 percent gasoline), B15 (85% gasoline + 15% IAA), B15 (85% gasoline + 15% IBA), and B15 (70 percent gasoline + 15% IAA+15% IBA), are taken into account in accordance with different speeds. The highest air consumption was recorded at a speed of 4500rpm with B5 (85% gasoline + 15% IBA), while the lowest air consumption was seen at a speed of 2500rpm with B0 (100% gasoline). Figure 12 illustrates how various blends, such as B0 (100 percent gasoline), B15 (85% gasoline + 15% IAA), B15 (85% gasoline + 15% IBA), and B15 (70 percent gasoline + 15% IAA+15% IBA), are taken into account in relation to different speeds. The highest fuel flow is recorded at a speed of 4500rpm with B15 (85% gasoline + 15% IAA), while the lowest fuel flow is observed at a speed of 2500rpm with B0 (100% gasoline)



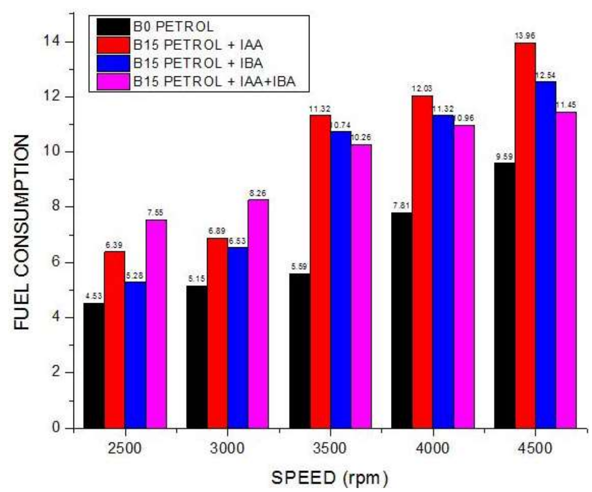


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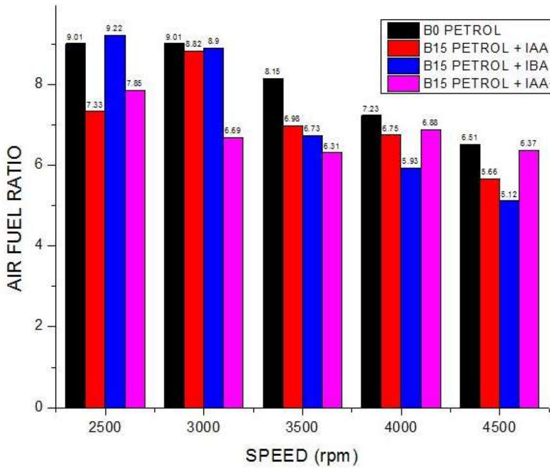
Fig.11. Air Consumption vs Speed at Blend B15 Fig.12.Fuel Consumption at Blend B15

Figure 13 illustrates how various speeds are taken into account in the X axis while different blend proportions—B0 (100 percent gasoline), B15 (85% gasoline + 15% IAA), B15 (85% gasoline + 15% IBA), and B15 (70 percent gasoline + 15% IAA+15% IBA)—are taken into account in the Y axis. The best volumetric efficiency with B15(85%gasoline + 15%IBA) was recorded at a speed of 2500rpm, whereas the lowest volumetric efficiency with gasoline occurred at a speed of 4500rpm. Figure 14 illustrates how various speeds are taken into account in the X axis, and blends such as B0 (100 percent gasoline), B15 (85% gasoline + 15% IAA), B15 (85% gasoline + 15% IBA), and B15 (70 percent gasoline + 15% IAA+15% IBA) are taken into account in the Y axis. The highest fuel flow was measured at a speed of 2500rpm with B15 (85% gasoline + 15% IBA), while the lowest was observed at 4500rpm with B0 (100% gasoline).



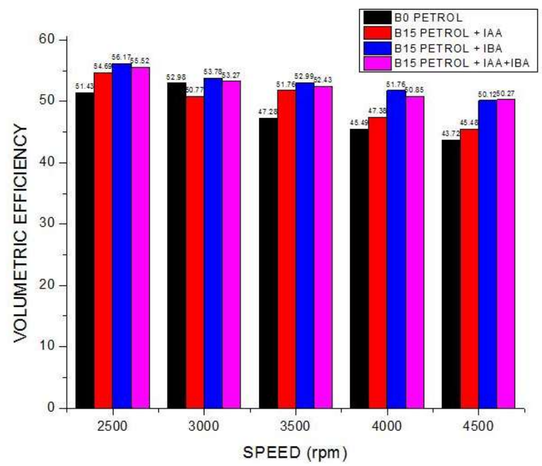
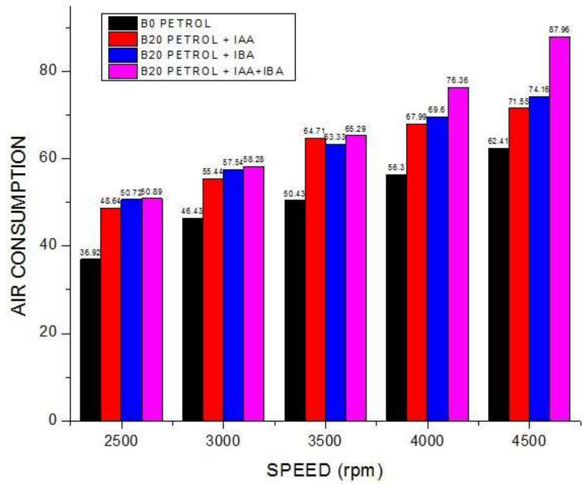


Fig.13.Volumetric Efficiency vs Speed at Blend B15

Fig.14.Air fuel ratio at Blend B15

Figure 15 shows that different speeds are taken into account in the X axis while varied blend proportions—B0 (100 percent gasoline), B20 (80% gasoline + 20% IAA), B20 (80% gasoline + 120% IBA), and B20 (60% gasoline + 20% IAA+20% IBA)—are taken into account in the Y axis. With B0 (100 percent gasoline), the lowest air consumption is observed at a speed of 2500 rpm, while B20 (60 percent gasoline plus 20 percent IAA plus 20 percent IBA), the maximum, is observed at a speed of 4500 rpm. Figure 16 illustrates how various speeds are taken into account in the X axis, while blends such as B0 (100 percent gasoline), B20 (80% gasoline + 20% IAA), B20 (80% gasoline + 120% IBA), and B20 (60% gasoline + 20% IAA+20% IBA) are taken into account in the Y axis. The highest fuel flow was measured at a speed of 4500 rpm with B20(80%gasoline + 20%IAA), while the lowest was seen at 2500 rpm with B20(80%gasoline + 20%IAA).



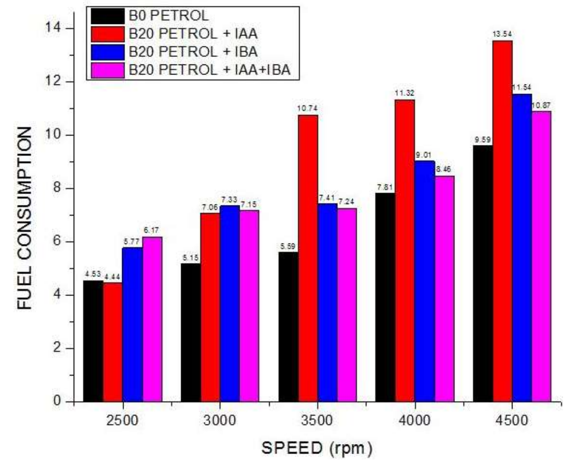
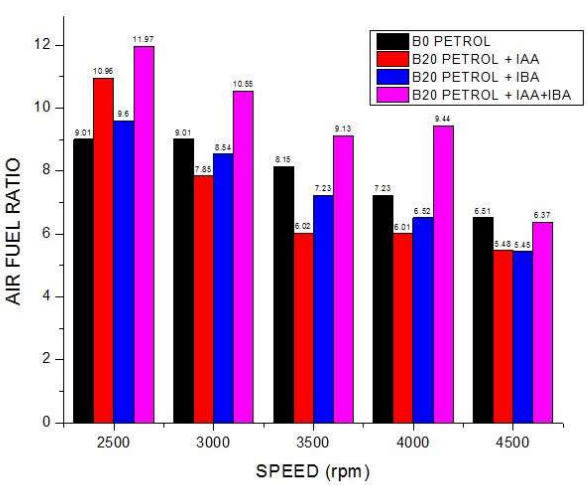


Fig.15. Air Consumption vs Speed at Blend B20 Fig.16.Fuel Consumption at Blend B20

Figure 17 illustrates how different speeds are taken into account in the X axis while different blend proportions—B0 (100 percent gasoline), B20 (80% gasoline + 20% IAA), B20 (80% gasoline + 120% IBA), and B20 (60% gasoline + 20% IAA+20% IBA)—are taken into account in the Y axis. In terms of volumetric efficiency, B20 (80% gasoline + 20% IAA) has lower volumetric efficiency at 2500 rpm than gasoline and the highest volumetric efficiency is obtained at 4500 rpm. Figure 18 illustrates how different speeds are taken into account in the X axis while varied blend proportions—B0 (100 percent gasoline), B20 (80% gasoline + 20% IAA), B20 (80% gasoline + 120% IBA), and B20 (60% gasoline + 20% IAA+20% IBA)—are taken into account in the Y axis. In comparison to gasoline, the fuel flow is lowest at 4500 rpm with B20 (80% gasoline + 20% IBA), and maximum at 2500 rpm with B20 (60 % gasoline + 20 % IAA + 20 % IBA).



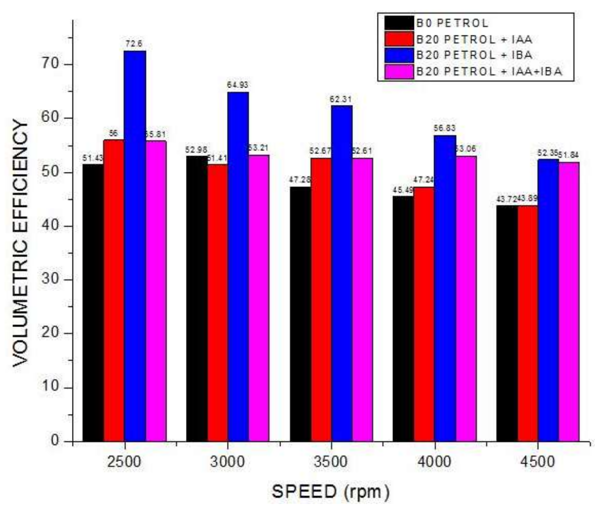


Fig.17.Volumetric Efficiency vs Speed at Blend B20
Fig.18.Air fuel ratio at Blend B20

5 Conclusions

The influence of IAA& IBA proportions on MPFI Engine to analyse Air Consumption, Fuel flow, Air fuel ratio, and Volumetric efficiency was recorded in this experiment.

- Referring to the data, it can be seen that as speed rises, the ternary blend B20 (Petrol + IAA+ IBA) produces the largest air flow, with a value of 87.96 kg/hr at a speed of 4500 rpm. The B15 mixture (85% gasoline + 15% IAA) has the lowest fuel flow, measuring 46.89 kg/hr at a speed of 2500 rpm. The lowest number for 100% gasoline is 36.92 kg/hr at 2500 rpm, while the greatest fuel flow is 62.41 kg/hr at 4500 rpm.
- The greatest fuel flow is noted at B15 (85% petrol + 15% IAA) with a value of 13.96kg/hr at a speed of 4500rpm in the case of the fuel flow category as speed increases. The B20 (80% gasoline + 20% IAA) mixture, with a flow rate of 4.44kg/hr at a speed of 2500rpm, has the lowest fuel flow. The lowest figure for 100% gasoline is 4.53 kg/hr at a speed of 2500 rpm, while the highest value is 9.59 kg/hr at a speed of 4500 rpm.
- The lowest AFR is found at B20 (80% petrol +20%IAA), with a value of 4.44 at a speed of 2500rpm, while the greatest AFR is observed at ternary blend B20 (Petrol +IAA+IBA), with a value of 11.97 at a speed of 2500rpm. The lowest value for 100% gasoline was 9.01 at a speed of 2500 rpm, and the highest value for B0 is 6.51.
- The best volumetric efficiency is noted at B20 (80% petrol +20%IBA) with a value of 72.6 at a speed of 2500rpm, whereas the lowest were recorded at B20 (80% petrol +20%IAA) with a value of 43.89 at a speed of 4500rpm. This is true for the volumetric efficiency category as well. The lowest reading for 100% gasoline was 43.72 at 4500 rpm, and the highest reading for that same fuel was 51.43 at 2500 rpm.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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