Experimental study on the effects of camphor ethanol petrol blends in a spark ignition engine: performance and emissions analysis

Sankar Shanmugasundaram [*1], Praveen Maruthur [2], Manivarma Kumaresan [3], Abhilash O. P [4], Akhil Das K [5] and Abdul Maluf [6]

[1,2,4,5,6] Department of Mechanical Engineering, Nehru College of Engineering and Research Centre, Pampady, Thrissur, India

[3] Department of Mechanical Engineering, Sri Krishna College of Engineering and Technology, Kuniamuthur, Coimbatore, India

[*1]shanmugasundaramsankar@yahoo.com

Abstract- **This paper discusses a detailed study on the performance of a SI engine fuelled with camphor-ethanol-petrol blends. In this study, a mixture consists of camphor and ethanol in weight percentage (20:80) was blended with petrol in three different ratios: 10%, 20% and 30%. A performance test was conducted in the SI engine at constant speed with varying torque using an eddy current dynamometer in order to evaluate the performance between the blended fuel and the sole fuel, such as brake power, specific fuel consumption, brake thermal efficiency and volumetric efficiency, among others. The study also includes viscosity measurements from a redwood viscometer, Calorific value measurements from a bomb calorimeter, density calculations and exhaust emission tests in a four gas analyser for both blended fuels as well as for pure petrol. It is inferred from the study that lesser specific fuel consumption, less emissions due to complete combustion of air fuel mixture and maximum volumetric efficiency were achieved in the blended fuel that results in efficient working of the spark ignition engine with less pollution. The main objective of this study is to increase the performance of SI engines, to reduce the emission rate and minimize the specific fuel consumption with the blended fuel to make the planet greener.**

Keywords- Camphor and ethanol mixture; Petrol; Spark ignition engine; Performance test; Exhaust emission test

I. INTRODUCTION

Internal Combustion (IC) engines are the major sources of energy for the automobile sector. These engines consume mainly petroleum products like petrol (gasoline) and diesel as fuels. It has been anticipated that the petroleum reserve will be exhausted soon if some alternative fuels do not replace at least partially petrol and diesel. The alternative fuel should have reasonably good thermal efficiency, low pollution level and should be available for a long time. Over the past decade, environmental concerns have increased significantly in the world. Excessive use of petrol fuel (gasoline) in the SIE (Spark Ignition Engine) shows that it is not environmentally friendly. Petrol leads to global environmental degradation effects such as climate change, the greenhouse effect, acid rain, and especially ozone depletion, among others. Day by day, the large amount of pollutants emitting from the exhaust of the automotive vehicles that run on fossil fuels are increasing, and these pollutants are proportional to the number of vehicles. In the meantime, the demand of energy is ever increasing for industries as well as automobiles. Either a slight modification in the IC engines or adding alcohols such as ethanol and methanol to petrol allows the fuel to combust more completely due to the presence of oxygen, which increases the combustion efficiency and reduces air pollution.

Bridgeman examined the utilization of ethanol-gasoline blends as a motor fuel and found an increase in power and reduction in gaseous pollutant emissions [1]. El-Eman and Desoky conducted a four-cylinder engine study to investigate the effect of using ethanol as an alternative fuel on a spark ignition engine [2].

Abdel-Rahman and Osman used 10%, 20%, 30% and 40% ethanol blended gasoline in a variable compression ratio engine. They reported that the optimum blend rate was found to be 10% ethanol with 90% gasoline [3]. Yüksel F and Yüksel B made a simple modification of the carburettor system and used 60% ethanol and 40% gasoline blend to test the engine performance and emission characteristics of a four-cylinder SI engine. They reported that the torque output of the engine increased slightly, whereas the CO, CO_2 and HC emissions decreased greatly with the use of ethanol-gasoline blended fuels [4]. The effects of ethanol addition to gasoline on SI engine performance and exhaust emissions were investigated experimentally and theoretically by Bayraktar. He carried out the experimental works with the blends containing ethanol up to 12% by volume. The best result was obtained for 7.5% ethanol experimentally and 16.5% ethanol theoretically without any modification to the engine design [5]. Adding alcohols such as ethanol and methanol to gasoline allows the fuel to combust more completely due to the presence of oxygen, which increases the combustion efficiency and reduces air pollution. Besides, alcohols can be promoted as alternative fuels in ICE since they do not contain sulphur or complex organic compounds; the organic emissions (ozone precursors) from alcohol combustion have lower reactivity, which can promote ozone formation substantially [6-8]. However, the presence of alcohols in the fuel causes corrosion to metallic fuel system components [9]. In order to diminish such corrosion problems and make the best use of alcohols in the ICE, the engine systems should be redesigned or low blend

DOI: 10.5963/IJEE0601003

rates could be used. The smaller the alcohol addition, the more easily typical blending problems (phase separation, corrosion, changed vapour pressure, changed air requirement etc.) can be solved [10]. It can be realized from the literature that many research papers are available for ethanol or methanol-gasoline blends [3-5] to reduce the pollutant emissions compared to the gasoline; but an attempt has not been made to analyse the effects of Camphor-Ethanol-Petrol blends on the performance and emissions analysis in SI engines to increase the mileage, performance of the engine and to reduce the exhaust emissions, to the best knowledge of the investigator. Therefore, it is imperative to investigate the emissions and performance analysis of Camphor-Ethanol-Petrol blends. In the present work, energetic and exergetic analysis is carried out on a Spark Ignition (SI) engine to investigate the effets of blended fuel on performance. The experiment was conducted at the NGI centre for Research in Engineering Design, Green Manufacturing and Computing (CRDGC) in Pampady, Thrissur, Kerala, India. The performance parameters of the engine for each fuel were computed and compared to one another, including the brake thermal efficiency, fuel consumption, specific fuel consumption, heat input, volumetric efficiency and engine emissions.

II. EXPERIMENTAL METHODS

Test engine and fuel preparation

Fig. 1 Photograph of the experimental setup

A spark-ignition engine with a bore of 70mm and a stroke of 66.7mm was used in this study. The engine is single cylinder, four strokes with a 4.67:1 compression ratio, water cooled and a carburettor fuel system. One may claim that a carburettor is hardly a current engine technology, but carburetted engines are still widely used and developed, e.g., [11-15]. The carburettor fuel system is very appropriate for use with fuel blends. This is due to its high quality of mixture preparation and mixing of different fuels [15]. Nowadays, carburettor-engine cars are being gradually phased out in favour of fuel injection, as injectors can do high quality mixture preparation much better than carburettors [16]. The orifice diameter of the greaves make means that computerized data acquisition of the single cylinder four stroke petrol engine test rig was 20mm, the speed was 3000 rpm, the Cubic capacity was 256.56 cc and the brake horsepower was 2.5 hp. It was rigidly mounted on the test rig with air and fuel intake lines. Fuel consumption was determined by measuring the fuel used (10cc) for a period of time. Further, the engine speed, voltage, current and manometer values were noted during each test. The dynamometer (self-exited DC compound generator of rated power 2.2 kW, 3000 rpm and 220 V DC) was connected with the engine shaft and mounted on rigid frame (Figure1). An rpm sensor was placed at the engine shaft to measure the speed of the engine. At the beginning, the engine was started in petrol mode at no load condition and allowed to warm up for a period of 15-20 minutes, and the other parameters such as engine speed, time for 10 cc petrol consumption, voltage, current and manometer readings were noted. Tests were performed when the engine reached its steady state operating temperature, and then the load was varied using 2.5 kW, air cooled, single phase resistance load bank from 500 Watts to 2500 watts (20% overload) in steps of 500 watts for different fuels. Before running the engine to a new fuel blend, it was allowed to run for sufficient time to consume the remaining fuel from the previous experiment. During fuel preparation, a Mixture (M) of Ethanol (E) having chemical composition of C_2H_6O [80% by weight] and Camphor (C), a waxy, flammable, white or transparent solid with a strong aromatic odour, soluble in ethanol, ethyl ester, turpentine and essential oils, having chemical composition of $C_{10}H_{16}O$ [20% by weight] as made that is $E_{80} + C_{20} = M$ (Figure 2), which is then mixed with petrol in three different ratios (weight percentages) as shown in Table 1. The reason that camphor is added (dissolved) in the ethanol is to reduce premature ignition and to provide uniform flame propagation.

DOI: 10.5963/IJEE0601003

Fig. 2 Preparation of camphor ethanol mixture

TABLE 1 SPECIFICATIONS OF THE FUEL USED IN THE EXPERIMENTS

Fuel % composition by weight	Density (Kg/m^3)	Calorific value (KJ/Kg)	Kinematic viscosity (Cm^2/s)	Absolute viscosity (Ns/Cm^2)
90% petrol + 10% Camphor and Ethanol Mixture	727	40693.5	0.0429	0.0312
80% petrol + 20% Camphor and Ethanol Mixture	735	51599.6	0.03986	0.02931
70% petrol + 30% Camphor and Ethanol Mixture	751	35500.0	0.02285	0.01716
100% petrol + 0% Camphor and Ethanol Mixture	715	38927.7	0.0513	0.03671

In addition, the blended fuels and sole fuel (petrol) were tested under a bomb calorimeter to determine its calorific value and the formula used to calculate the calorific value is given in Equation 1. Similarly, the kinematic viscosity of the test fuels and the petrol were determined using a redwood viscometer, and the formula used to calculate the kinematic viscosity is presented in Equation 2. Also, the density of the known volume of the test fuel (50 ml) was calculated after its weight was physically measured using an electronic physical balance, using Equation 4. The outcome of the test is presented in Table 1. Further, the formula used to calculate the absolute viscosity of the test fuel as well as pure petrol is given in Equation 3.

$$C_V = \frac{(T * 2332) - \left[(L_1 * C_{V1}) + (L_2 * C_{V2})\right]}{M} \tag{1}$$

Where, M is mass of the sample test fuel; T is rise in temperature; L_1 is length of the thread (8 cm); L_2 is length of the nichrome wire (5 cm); C_{V1} is calorific value of the thread (21 Calories/gram); C_{V2} is calorific value of the nichrome wire (2.33 Calories/length*gram).

Kinematic viscosity, (in stokes 34<T<100)

$$\upsilon = 0.0026T - \frac{1.79}{T} \tag{2}$$

Absolute viscosity,

$$\mu = \upsilon * \rho \tag{3}$$

Where, ρ is density of the test fuel.

$$\text{Density} = \text{Mass} / \text{Volume} \tag{4}$$

III. RESULTS AND DISCUSSION

The effects of camphor ethanol addition to petrol on SI engine performance at constant engine speeds were investigated. The sample data obtained in experiments for various dynamometer loads, such as time for 10cc of fuel consumption, dynamometer voltage and current for constant engine speed (3000 rpm) are presented in Tables 2, 3, 4 and 5 respectively. Similarly, the calculated parameters, such as brake thermal efficiency, mass of fuel supplied, specific fuel consumption, heat input and volumetric efficiency against various brake power for blended fuel as well as for sole fuel (petrol), are depicted in Figures 3, 4, 5, 6 and 7 respectively.

DOI: 10.5963/IJEE0601003

TABLE 2 SAMPLE DATA OBTAINED IN EXPERIMENT FOR 100% PETROL + 0% MIXTURE

Load	Engine speed (rpm)	Dynamo meter Load (Watts)	Time for 10cc fuel consumption (Sec)	Dynamometer Voltage (V)	Dynamo meter Current (I)
No Load	3000	0	9.73	206	0
25%		500	7.26	175	1.74
50%		1000	6.92	148	2.96
75%		1500	6.89	126	3.8
100%		2000	6.84	110	4.54
125%		2500	6.69	100	5.12

TABLE 3 SAMPLE DATA OBTAINED IN EXPERIMENT FOR 90% PETROL + 10% MIXTURE

Load	Engine speed (rpm)	Dynamo meter Load (Watts)	Time for 10cc fuel consumption (Sec)	Dynamometer Voltage (V)	Dynamo meter Current (I)
No Load	3000	0	6.5	177	0
25%		500	6.43	154	1.58
50%		1000	6.15	143	2.89
75%		1500	6.11	130	4.0
100%		2000	5.8	119	4.82
125%		2500	5.6	108	5.49

TABLE 4 SAMPLE DATA OBTAINED IN EXPERIMENT FOR 80% PETROL + 20% MIXTURE

Load	Engine speed (rpm)	Dynamo meter Load (Watts)	Time for 10cc fuel consumption (Sec)	Dynamometer Voltage (V)	Dynamo meter Current (I)
No Load	3000	0	8	170	0
25%		500	7.03	150	1.51
50%		1000	6.98	135	2.71
75%		1500	6.55	120	3.78
100%		2000	6.45	108	4.32
125%		2500	6.04	98	5.08

TABLE 5 SAMPLE DATA OBTAINED IN EXPERIMENT FOR 70% PETROL + 30% MIXTURE

Load	Engine speed (rpm)	Dynamo meter Load (Watts)	Time for 10cc fuel consumption (Sec)	Dynamo meter Voltage (V)	Dynamo meter Current (I)
No Load	3000	0	8.78	173	0
25%		500	7.8	158	1.88
50%		1000	7.5	141	2.83
75%		1500	7.48	127	3.87
100%		2000	7.3	115	4.64
125%		2500	7.06	105	5.3

Brake thermal efficiency

The effect of the camphor-ethanol-petrol blends on the brake thermal efficiency at constant engine speed (3000 rpm) against various brake powers is shown in Figure 3. It is evident from Figure 3 that the brake thermal efficiency of fuel with

DOI: 10.5963/IJEE0601003

70% petrol plus 30% camphor and ethanol mixture is higher starting from the beginning up to 0.5 kW brake power, and also a marginal increase of brake thermal efficiency is observed, with an increase in brake power when compared with other sample as well as 100% sole fuel (petrol). In addition, the observed maximum brake thermal efficiency for the above fuel is 2.14%, but it was only 1.77% for the sole fuel (petrol). Among all the test fuels, the fuel with 70% petrol plus 30% camphor and ethanol mixture shows the maximum brake thermal efficiency (2.14%). This happened due to the lower calorific value of the blended fuel (35500 KJ/Kg) than the sole fuel (38927 KJ/Kg), almost equal brake power and mass of fuel supplied that increases the brake thermal efficiency of the engine.

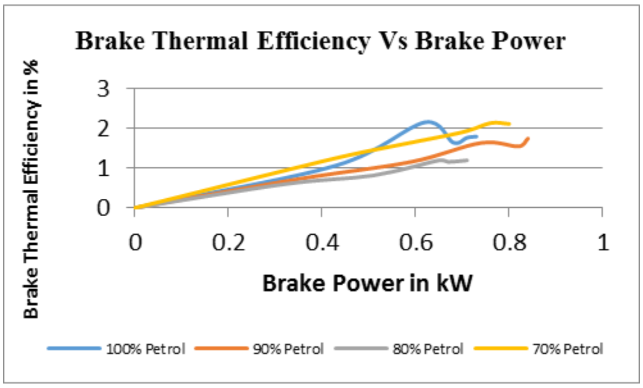


Fig. 3 Variation of brake thermal efficiency with brake power at 3000 rpm

Fuel consumption

The variation of fuel consumption with brake power for different percentages of the camphor–ethanol mixture with petrol has been plotted in Figure 4. It is inferred from Figure 4 that the fuel consumption increases as the engine power increases. Also, it is noted that among the entire sample, the fuel consumption was less for the fuel with 70% petrol and 30% camphor and ethanol mixture for the same brake power. This behaviour is attributed to the lower heating value per unit mass of the fuel that is distinctly lower than that of the sole fuel. Also, this happens due to an increase in density of the blended fuel (751 Kg/m^3) when compared with pure petrol (715 Kg/m^3).

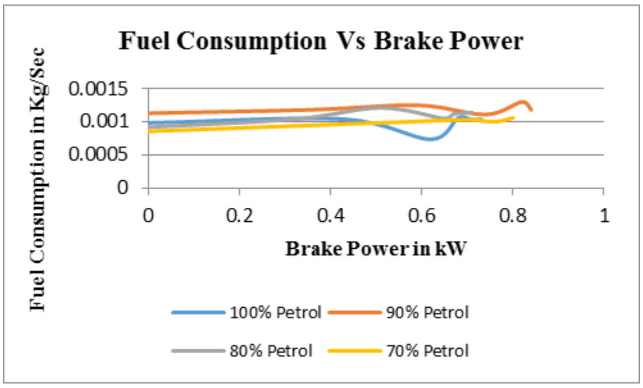


Fig. 4 Variation of fuel consumption with brake power at 3000 rpm

Specific fuel consumption

The effect of the camphor–ethanol-petrol blends on specific fuel consumption against various brake powers at constant engine speed (3000 rpm) is summarized in Figure 5. As shown in the Figure 5, at the beginning stage, the specific fuel consumption increased gradually for all the model fuels with an increase in brake power and then decrease gradually with an increase in brake power. This is a normal consequence of the behaviour of the engine brake thermal efficiency. Also, it is observed from figure 5 that among all the fuels, the specific fuel consumption was less for the fuel with 70% petrol and 30% of camphor and ethanol mixture, and, more or less, it followed the curve of the sole fuel (petrol).

DOI: 10.5963/IJEE0601003

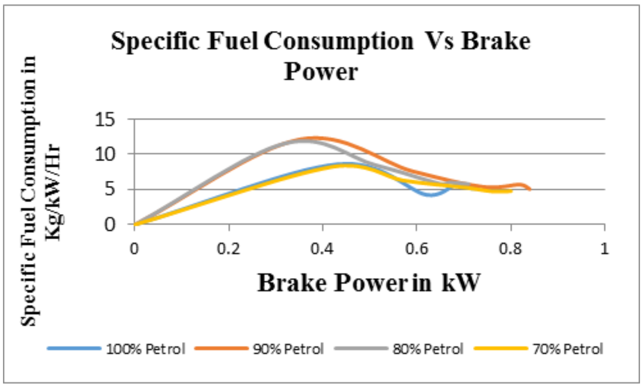


Fig. 5 Variation of specific fuel consumption with brake power at 3000 rpm

Heat input

Figure 6 demonstrates the effect of the camphor–ethanol-petrol blends on the heat input against various brake powers at a constant engine speed (3000 rpm). It is very clear from Figure 6 that the heat required for complete combustion of air/fuel mixture was lower for fuel with 70% petrol plus 30% camphor and ethanol mixture for almost same amount of fuel supply, when compared with sole fuel (petrol). It is because of the lower calorific value of the fuel (35500 KJ/Kg). Also, it is greater for fuel with 80% petrol plus 20% camphor and ethanol mixture.

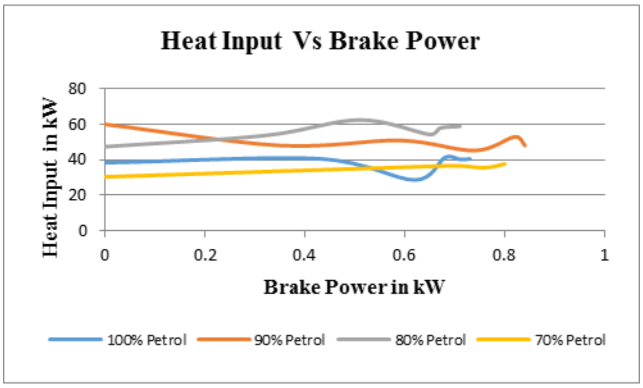


Fig. 6 Heat input vs Brake power at 3000 rpm

Volumetric efficiency

The variation of volumetric efficiency with brake power for different percentages of camphor and ethanol mixture with petrol has been presented in Figure 7. Volumetric efficiency is the ratio of volume of charge admitted at normal temperature and pressure to the swept volume, and it indicates the measure of the degree to which the engine fills its swept volume. It puts a limit on the amount of fuel that can be effectively burned in an engine. From analysing the plots, it is evident that the volumetric efficiency increased as the brake power increased. The maximum volumetric efficiency is noted for fuel with 80% petrol plus 20% camphor and ethanol mixture followed by fuel with 70% petrol plus 30% camphor and ethanol mixture. It is also seen that the volumetric efficiency of test fuel having 70% petrol plus 30% camphor and ethanol mixture and 90% petrol plus 10% camphor and ethanol mixture are almost parallel and showed the least variation with brake power.

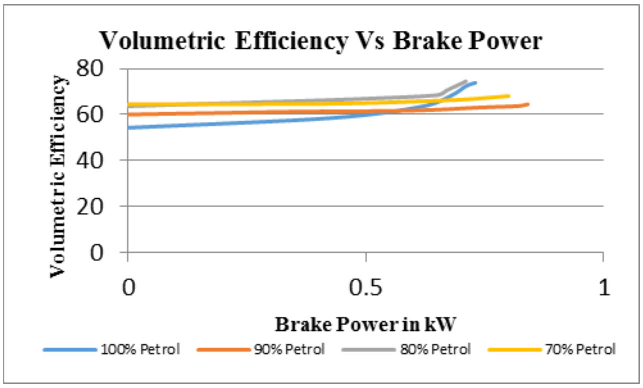
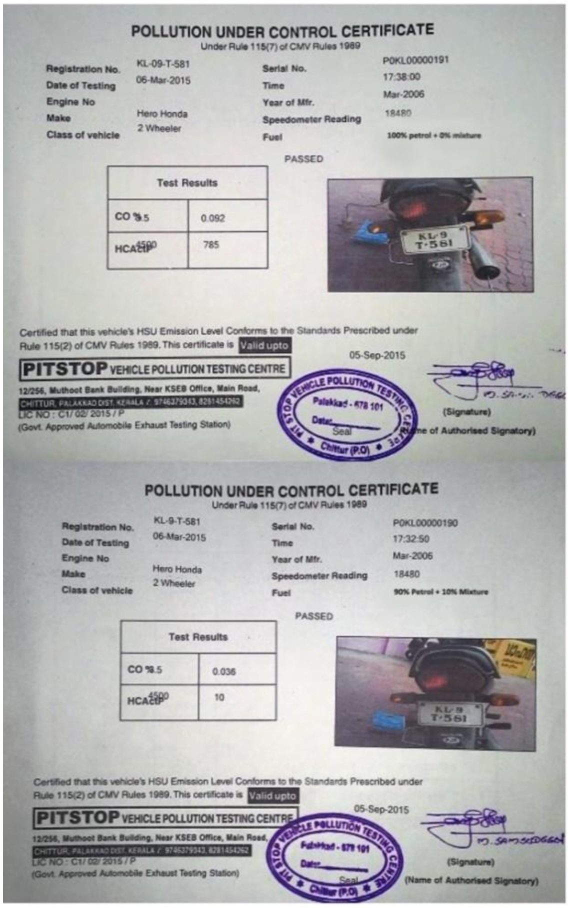


Fig. 7 Volumetric efficiency vs Brake power at 3000 rpm

DOI: 10.5963/IJEE0601003

CO, CO_2, O_2 and HC emission test results



POLLUTION UNDER CONTROL CERTIFICATE
Under Rule 115(7) of CMV Rules 1989

Registration No.	KL-09-T-581	Serial No.	P0KL00000191
Date of Testing	06-Mar-2015	Time	17:38:00
Engine No		Year of Mfr.	Mar-2006
Make	Hero Honda	Speedometer Reading	18480
Class of vehicle	2 Wheeler	Fuel	100% petrol + 0% mixture

PASSED

Test Results	
CO % 3.5	0.092
HC 4500	785

Certified that this vehicle's HSU Emission Level Conforms to the Standards Prescribed under Rule 115(2) of CMV Rules 1989. This certificate is Valid upto 05-Sep-2015

PITSTOP VEHICLE POLLUTION TESTING CENTRE
12/256, Muthoot Bank Building, Near KSEB Office, Main Road,
CHITTUR, PALAKKAD DIST. KERALA Ph: 9746379343, 8281454262
LIC NO : C1/ 02/ 2015 / P
(Govt. Approved Automobile Exhaust Testing Station)
(Signature)
(Name of Authorised Signatory)

POLLUTION UNDER CONTROL CERTIFICATE
Under Rule 115(7) of CMV Rules 1989

Registration No.	KL-9-T-581	Serial No.	P0KL00000190
Date of Testing	06-Mar-2015	Time	17:32:50
Engine No		Year of Mfr.	Mar-2006
Make	Hero Honda	Speedometer Reading	18480
Class of vehicle	2 Wheeler	Fuel	90% Petrol + 10% Mixture

PASSED

Test Results	
CO % 3.5	0.036
HC 4500	10

Certified that this vehicle's HSU Emission Level Conforms to the Standards Prescribed under Rule 115(2) of CMV Rules 1989. This certificate is Valid upto 05-Sep-2015

PITSTOP VEHICLE POLLUTION TESTING CENTRE
12/256, Muthoot Bank Building, Near KSEB Office, Main Road,
CHITTUR, PALAKKAD DIST. KERALA Ph: 9746379343, 8281454262
LIC NO : C1/ 02/ 2015 / P
(Govt. Approved Automobile Exhaust Testing Station)
(Signature)
(Name of Authorised Signatory)

Fig. 8 Pollution test certificate of P100 & P90

POLLUTION UNDER CONTROL CERTIFICATE
Under Rule 115(7) of CMV Rules 1989

Registration No.	KL-09-T-581	Serial No.	P0KL00000189
Date of Testing	06-Mar-2015	Time	17:28:01
Engine No		Year of Mfr.	Mar-2003
Make	Hero Honda	Speedometer Reading	18480
Class of vehicle	2 Wheeler	Fuel	80% petrol +20% mixture

PASSED

Test Results	
CO % 3.5	0.041
HC 4500	10

Certified that this vehicle's HSU Emission Level Conforms to the Standards Prescribed under Rule 115(2) of CMV Rules 1989. This certificate is Valid upto 05-Sep-2015

PITSTOP VEHICLE POLLUTION TESTING CENTRE
12/256, Muthoot Bank Building, Near KSEB Office, Main Road,
CHITTUR, PALAKKAD DIST. KERALA Ph: 9746379343, 8281454262
LIC NO : C1/ 02/ 2015 / P
(Govt. Approved Automobile Exhaust Testing Station)
(Signature)
(Name of Authorised Signatory)

POLLUTION UNDER CONTROL CERTIFICATE
Under Rule 115(7) of CMV Rules 1989

Registration No.	KL-09-T-581	Serial No.	P0KL00000188
Date of Testing	06-Mar-2015	Time	17:18:23
Engine No		Year of Mfr.	Mar-2006
Make	Hero Honda	Speedometer Reading	18480
Class of vehicle	2 Wheeler	Fuel	70% petrol + 30% mixture

PASSED

Test Results	
CO % 3.5	0.042
HC 4500	10

Certified that this vehicle's HSU Emission Level Conforms to the Standards Prescribed under Rule 115(2) of CMV Rules 1989. This certificate is Valid upto 05-Sep-2015

PITSTOP VEHICLE POLLUTION TESTING CENTRE
12/256, Muthoot Bank Building, Near KSEB Office, Main Road,
CHITTUR, PALAKKAD DIST. KERALA Ph: 9746379343, 8281454262
LIC NO : C1/ 02/ 2015 / P
(Govt. Approved Automobile Exhaust Testing Station)
(Signature)
(Name of Authorised Signatory)

Fig. 9 Pollution test certificate of P80 &P70

In this study, due to safety and other reasons, as in the normal method, the emission test was not conducted at the exhaust of an engine itself. Instead of that, an idling emission test was carried out at one of the government authorised 2 wheeler vehicle pollution testing centres (Figures 8 and 9). During this idling test, initially, the two wheeler engine was warmed up after a run of 20 minutes and then the sampling probe (part of an instrument) was inserted in to the vehicle exhaust system to a depth of 350mm for the idling speed exhaust emissions measurements. Initially, the idling emission test was conducted for pure petrol and then for other blended fuels. This exhaust gas emission test was conducted with four gas analyser i3 sys equipment, and the outcome of the test results is depicted in Figure 10 -13. According to Indian Central Motor Vehicle Rules (CMVR) 1989, under rule number 115/2, the allowable idling speed emission of Carbon Monoxide (CO) is 3,5% and Hydrocarbon (HC) is 4500 ppm for 2 and 3 wheelers (4 stroke) operated with petrol/CNG/LPG.

Carbon monoxide (CO)

The effect of camphor–ethanol-petrol blends on Carbon monoxide (CO) emissions is shown in Figure 10. The Carbon monoxide (CO) will be produced from the partial oxidation of carbon-containing components; it forms when there is not sufficient oxygen to produce carbon dioxide (CO_2) such as when operating a stove or an Internal Combustion engine. In the presence of oxygen, carbon monoxide burns with a blue flame and produces carbon dioxide. It is seen from Figure 10 that the CO emissions were less for all the test fuels when compared with the sole fuel (petrol). This is due to the increase in the percentage of ethanol and camphor mixture that has resulted in leaner combustion, and also due to the presence of oxygen in ethanol. Due to leaning, CO emissions decreased tremendously. The percentage of carbon monoxide (CO) was less (0.036%) for fuel with 90% petrol plus 10% camphor and ethanol mixture. Further, it is obvious from the Figure 10 that the CO emission for all the test fuels follows very close trends.

DOI: 10.5963/IJEE0601003

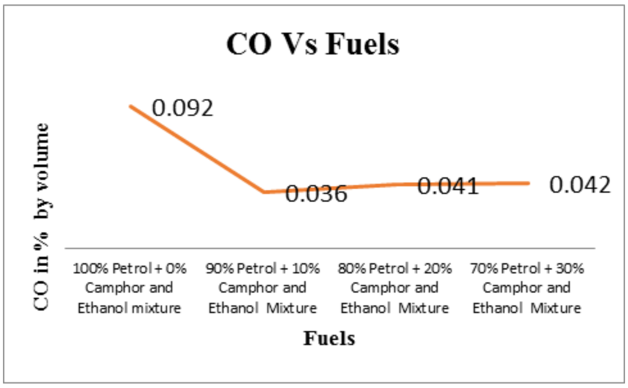


Fig. 10 Effect of camphor ethanol petrol blends on the CO

Carbon dioxide (CO_2)

The effect of the camphor–ethanol-petrol blends on the CO_2 is shown in Figure 11. It is evident from Figure 11 that the CO_2 emission decreased from 2.56% to 0.51%, 0.42% and 0.40% for the test fuels. This indicates the complete combustion of the fuel in the combustion chamber. In addition, there was an appreciable reduction (0.40% by volume) to fuel with 90% petrol plus 10% camphor and ethanol mixture when compared to other samples. This is due to the maximum blend of the air-fuel mixture.

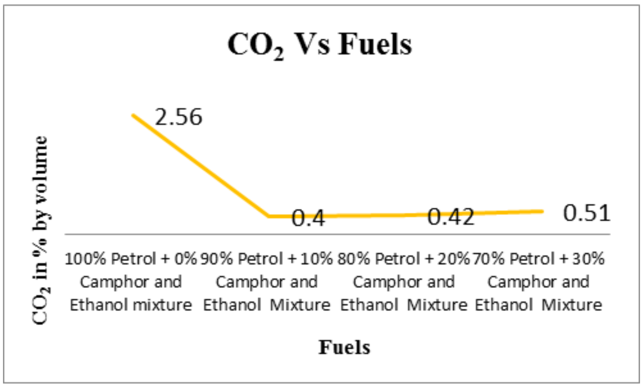


Fig. 11 Effect of camphor ethanol petrol blends on the CO_2

Oxygen (O_2)

Figure 12 presents the variation of oxygen for different test fuels, as well as for sole fuel (petrol). From Figure 12, oxygen increase with an increase in camphor-ethanol mixture and it was at its maximum (19.98% by volume) for fuel with 70% petrol plus 30% camphor and ethanol mixture. The reason for the increase in oxygen content in the exhaust gas is due to the increase in alcohol and camphor percentage in the mixture.

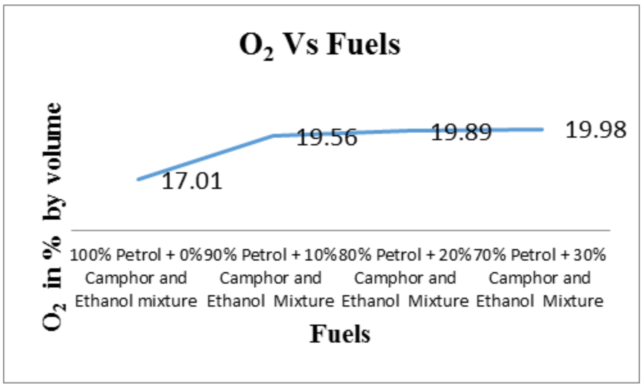


Fig. 12 Effect of camphor ethanol petrol blends on the O_2

Hydrocarbons (HC)

A hydrocarbon (HC) is an organic compound consisting entirely of hydrogen and carbon. Unburned hydrocarbons are the hydrocarbons emitted after petrol is burnt in an engine. In piston engines, some of the air-fuel mixture “hides” from the flame

DOI: 10.5963/IJEE0601003

in the gaps provided by the piston ring grooves. Also, some portions of the combustion chamber may have a very weak flame and low combustion temperature. Thus, when unburnt fuel is emitted from a combustor, HC is formed. Hydrocarbon emitted for different test fuels as well as for sole fuel (petrol) is presented in Figure 13. It is obvious from Figure 13 that there were steep reductions in hydrocarbon emissions (from 785 ppm to 10 ppm) for all the test fuels when compared with sole fuel (petrol). This is because of the complete combustion of the air-fuel mixture in the engine, uniform distribution of flame and sufficient combustion temperature inside the engine.

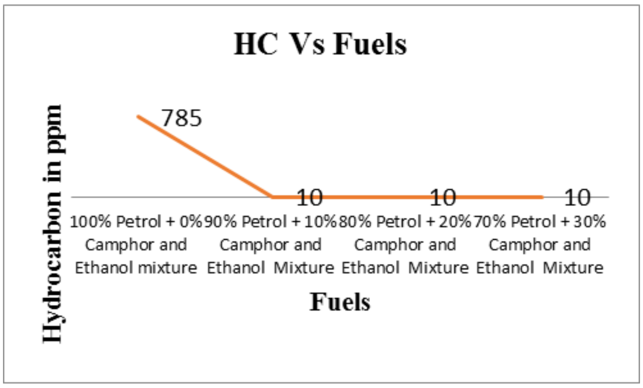


Fig. 13 Variation of HC emission for different camphor ethanol petrol blends

IV. CONCLUSION

In this study, spark ignition engine performance and pollutant emissions from camphor ethanol petrol blended fuels have been investigated experimentally. From the above study, the following conclusions can be deduced.

Camphor and ethanol mixture with petrol caused improvement in engine performance and reduced exhaust emissions. For all the test fuels, the values of CO, CO_2 and HCs were found to be reduced. On the other hand, O_2 emissions have increased significantly. The CO emissions were reduced to 0.042% by volume to fuel with 70% petrol plus 30% camphor and ethanol mixture from 0.092%, which belongs to pure petrol. Similarly, it is reduced to 0.036% by volume to fuel with 90% petrol plus 10% camphor and ethanol mixture. The CO_2 emission was reduced to 0.4% by volume to fuel with 90% petrol plus 10% camphor and ethanol mixture from 2.56% belongs to pure petrol. The HC emission was drastically reduced from 785 ppm to 10 ppm uniformly to all the test fuels due to the complete combustion of fuel because of uniform heat distribution inside the engine. The addition of camphor and ethanol mixture to petrol resulted in an increase of brake thermal efficiency (0.37%; Figure 3) for the fuel with 70% petrol plus 30% camphor and ethanol mixture when compared with sole fuel (petrol). Among all the fuels, the fuel consumption (Figure 4) and specific fuel consumption (Figure 5) against the brake power were less for fuel with 70% petrol plus 30% camphor and ethanol mixture. Further, it is understood from the above study that the heat input against the brake power was also least (35.50 kW) for fuel with 70% petrol plus 30% camphor and ethanol mixture (Figure 6) when compared with sole fuel (40.09 kW). Also, it is very clear from Figure 7 that the volumetric efficiency was higher for fuel with 80% petrol plus 20% camphor and ethanol mixture followed by fuel with 70% petrol plus 30% camphor and ethanol mixture. Finally, this study demonstrates that if we aim to get less emission of CO, CO_2 and HC and higher brake thermal efficiency with less specific fuel consumption from SI engine, we should use 70% petrol plus 30% camphor and ethanol mixture.

ACKNOWLEDGMENT

The authors would like to thank the technical staff of the Internal Combustion Engine laboratory at the Mechanical Engineering Department of Nehru College of Engineering and Research Centre. Also, the authors appreciate the proprietor and management of PITSTOP vehicle pollution testing centre for assistance in carrying out an emission test.

REFERENCES

[1] O. C. Bridgeman, "Utilization of ethanol gasoline blends as motor fuels", *Industrial Engineering Chemistry*, Vol. 28, pp. 1102-1109, 1936.

[2] S. H. EI-Emam and A. A. Desoky, "A study on the combustion of alternative fuels in Spark-ignition engines", *International Journal of Hydrogen Energy*, Vol. 10, pp. 497-504, 1985.

[3] A. A. Abdel-Rahman and M. M. Osman, "Experimental investigation on varying the compression ratio of SI engine working under different ethanol-gasoline fuel blends", *International Journal of Energy Research*, Vol. 21, pp. 31-40, 1997.

[4] F. Yüksel and B. Yuksel, "The use of ethanol-gasoline blends as a fuel in an SI engine", *Renewable Energy*, Vol. 29, pp. 1181-1191, 2004.

[5] H. Bayraktar, "Experimental and theoretical investigation of using gasoline-ethanol blends in spark-ignition engines", *Renewable Energy*, Vol. 30, pp. 1733-1747, 2005.

DOI: 10.5963/IJEE0601003

[6] A. Elfasakhany, “Investigation on performance and emissions characteristics of an internal combustion engine fuelled with petroleum gasoline and a hybrid methanolegasoline fuel”, *IJET-IJENS*, Vol. 13, 2013.

[7] A. Elfasakhany , “The effects of ethanol gasoline blends on performance and exhaust emission characteristics of spark ignition engines”, *International Journal of Automotive Engineering*, Vol. 4(1), pp. 608-620, 2014.

[8] Y. Akutsu , F. Toyoda , K. Tomita , F. Yoshizawa , M. Tamura and T. Yoshida , “Effect of exhaust from alcohol fuel on ozone formation in the atmosphere”, *Atmospheric Environment Part A General Topics*, Vol. 25(7), pp. 1383-1389, 1991.

[9] A. N. Ozsezen and M. Canakci, “Performance and combustion characteristics of alcohol-gasoline blends at wide-open throttle”, *Energy*, Vol. 36(5), pp. 2747–2752, 2011.

[10] F. Pischinger, “Alcohol fuels for automotive engines”, *11th World Petroleum Congress, RTD*, Vol. 6 (3), 1983, London.

[11] N. R. Banapurmath and P. G. Tewari, “Comparative performance studies of a 4-stroke CI engine operated on dual fuel mode with producer gas and Honge oil and its methyl ester (HOME) with and without carburettor”, *Renewable Energy*, Vol. 34(4), pp. 1009–1015, 2009.

[12] V. S. M. Krishna, V. R. S. Rao, K. K. Reddy and V. K. Murthy, “Performance evaluation of medium grade low heat rejection diesel engine with carburetted methanol and crude jatropha oil”, *Renewable and Sustainable Energy Reviews*, Vol. 34, pp. 122–135, 2014.

[13] V. S. M. Krishna, V. R. S. Rao, K. K. Reddy and V. K. Murthy, “Comparative studies on performance evaluation of DI diesel engine with high grade low heat rejection combustion chamber with carbureted alcohols and crude jatropha oil”, *Renewable and Sustainable Energy Reviews*, Vol. 36, pp. 1-19, 2014.

[14] M. T. Muslim, H. Selamat, A. J. Alimin, N. M. Rohi and M. F. Hushim, “A review on retrofit fuel injection technology for small carburetted motorcycle engines towards lower fuel consumption and cleaner exhaust emission”, *Renewable and Sustainable Energy Reviews*, Vol. 35, 2014.

[15] M. Abu-Qudais, K. R. Asfar and R. Al-Azzam, “Engine performance using vaporizing Carburettor”, *Energy Conversion and Management*, Vol. 42(6), pp. 755–761, 2001.

[16] B. Saud, I. M. Taib, A. Ahmed, A. Abdullah and A. Ibrahim , “The effects of research octane number and fuel systems on the performance and emissions of a spark ignition engine: A study on Saudi Arabian RON91 and RON95 with port injection and direct injection systems”, *Fuel*, Vol. 158, pp. 351–360, 2015.

DOI: 10.5963/IJEE0601003