EVALUATION OF PERFORMANCE AND EMISSIONS CHARACTERISTICS OF GASOLINE - PROPANOL BLENDS IN A NATURALLY ASPIRATED SPARK IGNITION ENGINE

P.Chaitanya Krishna[1], M. V. S. Pavan Kumar[2], Y.Raghu Ram[3]
[1,2,3] Assistant Professor, Department of Mechanical Engineering,
Sasi Institute of Technology & Engineering, Tadepalligudem

Abstract

Alcohols, basically Ethanol,Methonol are considered as a leading alternative fuel for automotive application because of its ability to reduce the air pollution and cost of the fuel. This paper investigates that the Gasoline-Propanol blends on performance and emissions characteristics of Gasoline-Propanol blend in a naturally aspirated spark ignition engine. In this regard, the four stroke, single cylinder naturally aspirated spark ignition engine is coupled with rope brake dynamometer and Auxiliary Fuel tank is used for measuring rate of fuel consumption. The Orset gas analyzer is also connected to muffler for measuring emissions in the exhaust gases. Experiments were conducted at different blends of gasoline-propanol such as 10:1, 7:1 and 5:1 proportions. Using these proportions, determined brake power, specific fuel consumption, break thermal efficiency and brake specific fuel consumption at 1 kg, 2kg, 3 kg with constant speed. The emissions of various Gasoline-propanol blends are analyzed by using gas analyses. The results of experimental investigation were compared with that of gasoline fuel.

Key words: Naturally aspirated spark ignition engine, Rope brake dynamometer, Orset gas analyzer, Performance, gas analyses

I NTRODUCTION

1.1 Introduction: Fuel additives are very important, since many of these additives when added to fuel improve engine's performance and emissions. One of the most important additive to improve combustion efficiency is oxygenates (oxygen containing organic compounds) which contribute oxygen for combustion of air-fuel mixture. Several oxygenates have been used as fuel additives, such as methanol, ethanol, propanol and methyl tertiary butyl ether. As a fuel for spark-ignition engines, alcohol has some advantages over gasoline, such as better anti-knock characteristics (higher octane number) and reduced CO and CO_2 emissions.[1]

An Experimental investigation of ethanol blends with gasoline on SI engine have been done by **Gaurav tiwari et.al [2]**. The authors were determined Performance parameters (brake thermal efficiency, brake specific energy consumption and brake specific fuel consumption) at various loads on engine with ethanol blended gasoline. The comparison was made on performance of conventional SI engine with pure gasoline operation. Brake thermal efficiency is increasing for a particular percentage of blending of alcohol. And the percentage is different for different alcohols. After a particular fixed percentage of blending the performance of alcohol blending decreases. The blending of ethanol in gasoline provide good combustion property.

Krishna Mohan Agarwal et.al [3] studied Performance Parameters Of Single Cylinder Four Stroke Spark Ignition Engine Using Gasoline - Ethanol Blends. Experiments were conducted using different blends of gasoline-ethanol such as E0, E20, E40, E60, E80 and E100 and its effect on brake power; specific fuel consumption, break thermal efficiency and brake mean effective pressure with respect to the engine speed (rpm) were reported. The results of experimental investigation were compared with that of gasoline fuel. Results show that alcohol like ethanol in pure form or if blended with gasoline increases the thermal efficiency. Blending mechanism works effectively and hence improved engine combustion performance and emission reduction using ethanol blends with gasoline. There is a fuel saving of 40 to 50 %, while using gasoline – ethanol fuel blends. There is also an improvement in thermal efficiency by 20 to 30 % using gasoline – ethanol blends. **Jing Gong et.al [4]** Explained "Emission Characteristics Of Iso-Propanol/Gasoline Blends In A Spark-Ignition Engine Combined With Exhaust Gas Re-Circulation". The various emission characteristics of the engine, including NOx, CO, CO2,and particulate matter emissions, were studied in a spark-ignition engine fueled with various iso-propanol/gasoline blends. The NOx emission and NOx emission gives the highest value at full load condition. The effects of load, EGR rate, blending ratio, and spark timing on the emissions. NOx em Analyzed vision gives the highest value at full load. The introduction of EGR reduces NOx emission and NOx emission indicates a first increase and late decrease trend with the increase of blending ratio. HC and CO emissions indicates no obvious difference in all the blending ratios except pure propanol while CO emission gives the lowest value.

A. F. Kheiralla et.al [5] Explained on "Experimental Determination of Fuel Properties of Ethanol/Gasoline Blends as Bio-fuel for SI engines". Fuel properties of tested ethanol/gasoline blends such as density and viscosity increased continuously and linearly with increasing percentage of ethanol while API gravity and heat value decreased with decreasing percentage of ethanol increase. These blends were namely E10, E15, E20, and E25, E30 and E35.Furthermore, cloud point, flash and fire points were found to be higher than gasoline fuel, while distillation curves were lower. The tested blends Octane rating based Research Octane Number (RON) increased continuously and linearly with increasing percentage of ethanol. **Sankar Shanmugasundaram et.al [6]** studied on the effects of camphor ethanol petrol blends in a spark ignition engine performance and emissions analysis." 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. 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. 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.

II PROPERTIES OF PROPANOL

Propionaldehyde or propanol is the organic compound with the formula CH_3CH_2CHO. It is a saturated 3-carbon aldehyde and it is a isomer of acetone. It is a colourless liquid with slightly irritating, fruity flovour.

Table 1: Properties of propanol

Chemical formula	C_3H_6O
Molar mass	58.08 g·mol^{-1}
Appearance	Colourless liquid Pungent, fruity odour
Density	0.81 g cm^{-3}
Melting point	−81 °C (−114 °F; 192 K)
Boiling point	46 to 50 °C (115 to 122 °F; 319 to 323 K)
Solubility in water	20 g/100 ml
Magnetic susceptibility (χ)	-34.32·10−6 cm^3/mol
Viscosity	0.6 cP at 20 °C

III EXPERIMENTAL METHODOLOGY

3.1 Experimental Setup:

The experimental setup as is shown in figure 1 It consists of Air Filter, which supplies cleaned air to the engine, similarly fuel supplied through auxiliary fuel tank for measuring fuel consumption and naturally aspirated SI engine coupled with rope brake dynamometer for measuring torque, brake power.

Figure 1: Experimental Setup

The gas analyser consists essentially of a calibrated water-jacketed gas burette connected by glass capillary tubing to three absorption pipettes containing chemical solutions that absorb the gasses it is required to measure. For safety and portability, the apparatus is usually encased in a wooden box as shown in figure 2.

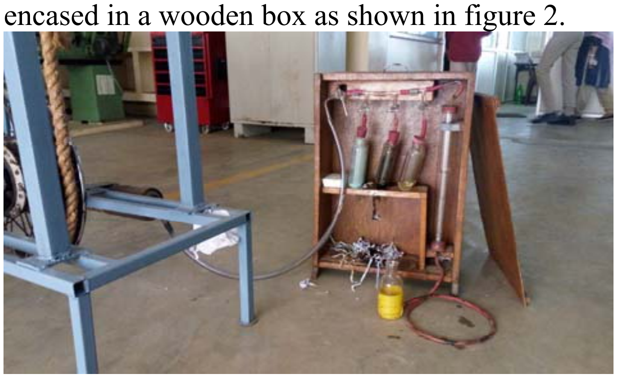


Figure 2: Gas analyser

3.2 Experimental procedure for conducting performance:

Initially the fuel supply system is Connected to the engine and tighten the pipe clamps for preventing any leakage from the pipes.conducted test with petrol as a fuel. At constant speed i.e. 2000 rpm measured fuel consumption in kg/s. Varied the loads on the engine, (at 1kg, 2kg, 3kg) measured fuel consumption in kg/s. Measured rated speed, applied load, time taken for 10 ml fuel consumption. Repeated the same operational procedure and taken consumption of Gasoline-Propanol blends at 10:1, 7:1 and 5:1 proportions.

3.3 Experimental procedure for conducting Gas Analysis:

Collected 100 cm3of gas whose analysis is to be made is drawn into the bottle by lowering the leveling bottle. Opened the stop cock, then the whole flue gas is forced to pipette-1. The gas remains in this pipette for some time and most of the carbon dioxide is absorbed. The leveling bottle is then lowered to allow the chemical to come to its original level.Measured the volume of gas thus absorbed on the scale of the measuring bottle. Repeated the same for a number of times to ensure that the whole of the CO_2 is absorbed. Further, the remaining flue gas is then supply to the pipette-2 which contains pyrogallic acid to absorb whole of O_2. The reading on the measuring burette will be the sum of volume ofCO_2 and O_2. The oxygen content can then be found out by subtraction. Finally, as before, the sample of gas is supply through the pipette-3 to absorbed carbon monoxide completely. Volume of gas is the sum of CO_2, CO and O_2 contents. Orsat apparatus gives an analysis of the dry products of combustion. Steps may be taken to remove the steam from the sample by condensing, but as the sample is collected over water it becomes saturated with water. The resulting analysis is nevertheless a true analysis of the dry products. This is because the volume readings are taken at a constant temperature and pressure, and the partial pressure of the vapour is constant. This means that the sum of the partial pressures of the remaining constituents is constant. The vapour then occupies the same proportion of the total volume at each measurement. Hence the vapour does not affect the result of the analysis.

IV PERFORMANCE OF A NATURALLY ASPIRATED S.I ENGINE

4.1 Formulae:

Mass of petrol Consumed in kg/s,

$$m_p = \frac{\rho \times V}{t}$$

where

ρ=Density of the fuel = 0.75 g/ml

The density of the petrol = 0.73 g/ml and density of the propanol = 0.78 g/ml so the average density of the fuel considered as 0.75 g/ml for both the fuels

V = Volume of the petrol consumed = 10 ml

t = time taken for 10 ml of petrol consumed in sec.

Mass of petrol Consumed in kg/s,

$$m_p = \frac{\rho \times V}{t}$$

Brake Power (B.P),

$$B.P = \frac{2\pi NT}{60 \times 1000} \text{kw}$$

Brake Specific Fuel Consumption,

$$BSFC\ (\text{kg/KW-hr}) = \frac{mf \times 3600}{B.P}$$

Brake Thermal efficiency, $\eta_{bth} = \frac{BP}{mf \times C.V}$

4.2 Observations:

The following observation table gives some detailed readings that were taken during the testing when petrol as a fuel. Now as it can be seen that readings at different loads like that of 1kg, 2kg, 3kg and are taken at maximum speed 2000rpm condition.

Table 2: Observations for Petrol as a fuel.

S.No.	Load (Kg)	RPM	Time for 10ml fuel consumption (s)
1	1	2000	53
2	2	2000	38
3	3	2000	27

Similar to that of petrol- propanol blends at 10:1, 7:1 and 5:1 readings were obtained as well, with the same rpm and similar load put to test.

Table 3: Observations for petrol blends with propanol at different ratios

S.No.	Load (Kg)	RPM	Time for 10ml fuel consumption (s)		
			Gasoline-Propanol (G/P) blend at 10:1	Gasoline-Propanol (G/P) blend at 7:1	Gasoline-Propanol (G/P) blend at 5:1
1	1	2000	51	72	61
2	2	2000	40	60	53
3	3	2000	30	55	27

4.3 Sample Calculations (at 1 kg load and at 2000rpm):

4.3.(a) For Petrol:

Mass of petrol consumption = $m_f = \frac{\rho \times V}{t}$

$= \frac{0.75 \times 10}{t}$ g /s

$= \frac{0.75 \times 10}{53}$ g /s

$= 1.41 \times 10^{-4}$ kg /s

Mass of petrol Consumed in kg/s = $m_f = 1.41 \times 10^{-4}$ kg /s

Mass of petrol Consumed in kg/hr = $m_f \times 3600$ = 0.5094 kg/hr

Torque = $T = (w\text{-}s) \times g \times r$ N-m

$= 1 \times 9.81 \times 0.5$

$T = 4.90$ N-m

Brake Power (B.P) = $\frac{2\pi NT}{60 \times 1000}$ kw

$= \frac{2\pi \times 2000 \times 4.90}{60 \times 1000}$ kw

B.P = 1.02kw

$BSFC = \frac{mf \times 3600}{B.P}$ kg/kw-hr

$= \frac{1.41 \times 10(-4) \times 3600}{1.02}$

$BSFC$ = 0.66kg/kw-hr

Brake Thermal efficiency, $\eta_{bth} = \frac{BP}{mf \times C.V}$

$\eta_{bth} = \frac{1.02}{1.41 \times 10(-4) \times 44000}$

η_{bth} = 16%

4.3. (b) For Gasoline-Propanol Blends at 10:1 proportion:

Mass of petrol consumption = $m_f = \frac{\rho \times V}{t}$

$= \frac{0.75 \times 10}{51}$ g /s

$= 1.47 \times 10^{-4}$ kg /s

Mass of petrol Consumed in kg/s = $m_f = 1.47 \times 10^{-4}$ kg /s

Mass of petrol Consumed in kg/hr = $m_f \times 3600$ = 0.5294 kg/hr

Torque = $T = (w\text{-}s) \times g \times r$ N-m

$= 1 \times 9.81 \times 0.5$

$T = 4.90$ N-m

Brake Power (B.P) = $\frac{2\pi \times 2000 \times 4.90}{60 \times 1000}$ kw

B.P = 1.02kw

$BSFC = \frac{mf \times 3600}{B.P}$ kg/kw-hr

$= \frac{0.5294}{1.02}$

BSFC = 0.51kg/kw-hr

Thermal efficiency, $\eta_{bth} = \frac{BP}{mf \times C.V}$

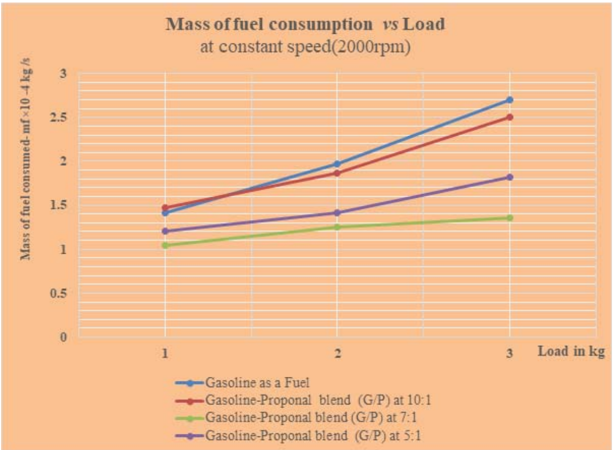
$\eta_{bth} = \frac{0.76}{1.47 \times 10(-4) \times 44000}$

η_{bth} = 15 %

V RESULTS AND DISCUSSION

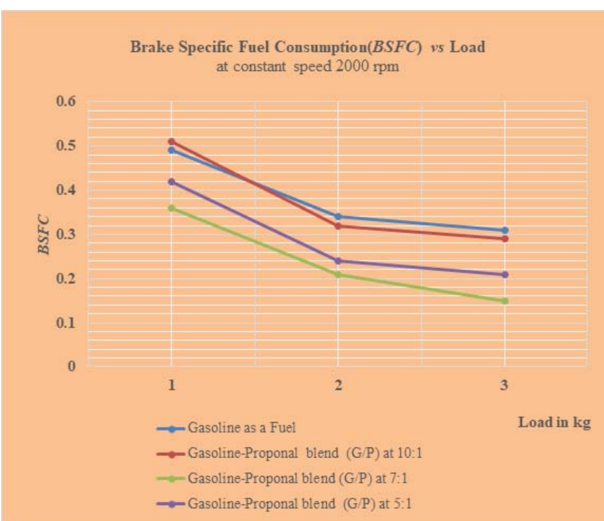
Taking into similar standards as consideration, the difference in the brake thermal efficiency is evident with the increasing load, the brake thermal efficiency is increases. Similarly with the increasing load, the fuel consumption also increases.

Graph 1: Mass of Fuel Consumption Verses Load



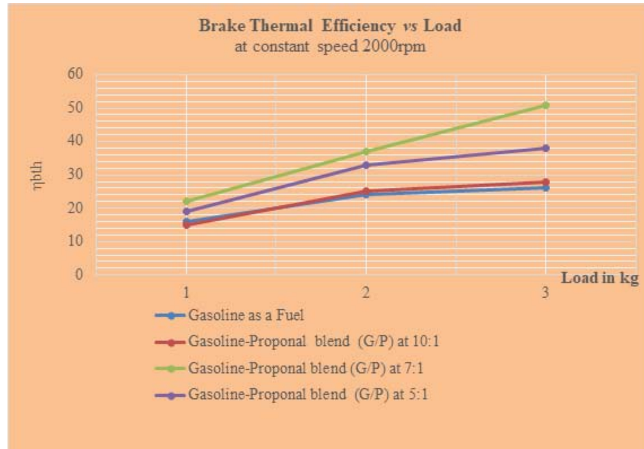
The above graph shows that mass of fuel consumption at different loads. It is clear evident that the fuel consumption increases by increasing load. The optimal fuel consumption obtained at Gasoline-Propanol blend at 7:1. The graph clearly shows that Gasoline-Propanol blend at 7:1 is the optimal blend as compared with 10:1, 5:1 Gasoline-Propanol blends.

Graph 2: Brake Specific Fuel Consumption Verses Load



The above graph shows that mass of fuel consumption at different loads. It is clear evident that the Brake specific fuel consumption increases by increasing load. The optimal Brake specific fuel consumption obtained at Gasoline-Propanol blend at 7:1. The graph clearly shows that Gasoline-Propanol blend at 7:1 is the optimal blend as compared with 10:1, 5:1 Gasoline-Propanol blends.

Graph 3: Brake Thermal Efficiency Verses Load



The above graph shows that Brake Thermal Efficiency at different loads. It is clear evident that the Brake Thermal Efficiency increases by increasing load. Higher Brake Thermal Efficiency obtained at Gasoline-Propanol blend at 7:1. The graph clearly shows that Gasoline-Propanol blend at 7:1 is the optimal blend as compared with 10:1, 5:1 Gasoline-Propanol blends.

Table 4: Emissions of Gasoline and Gasoline-Propanol (G/P) blends

S. No.	Speed (rpm)	Load (Kg)	Emission gases	Gasoline	Gasoline-Propanol (G/P) blends		
					10:1	7:1	5:1
1	2000	2	CO_2	29	26.6	20.2	15.6
2			O_2	3.5	19	25.4	29.7
3			CO	11	6	4.5	2
4			N_2	56.5	48.4	49.9	52.7

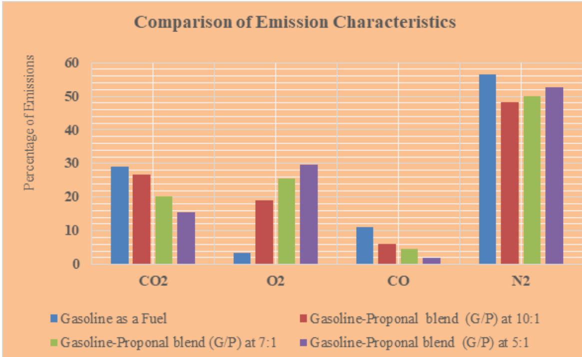


Figure 2: Brake Specific Fuel Consumption Verses Load

The emissions have also been reduced gradually by increasing propanol concentration. From the Fig.4.3.the emissions has been low at Gasoline-Propanol blend at 5:1 when compared with 10:1, 7:1 Gasoline-Propanol blends and Gasoline as fuels. If the emissions are as major considerations, the Gasoline-Propanol blend at 5:1 is the optimal blend.

VI CONCLUSION

This work was taken up with the objective of conducting extensive investigations on performance test and emission characteristics of SI engine using propanol-gasoline blends in varying volumetric ratios. Experiments were carried out to collect data on performance test and emission characteristics of spark ignition engine for a range of test decided on the basis of practical considerations of the system and operating conditions. Under similar conditions results have been compared with the Gasoline.

The data has been presented in the form of variation of load with gasoline -Propanol blends in different proportions 10:1,7:1 and 5:1 at a constant engine speed to bring out clearly the effect of these parameters on the enhancement in performance test and subsequent reduction in the regulated emissions. From the investigation, the optimal brake specific fuel consumption, best brake thermal efficiency have been obtained at Gasoline-Propanol blend with 7:1 proportion. The emissions have also been reduced gradually by increasing propanol concentration i.e. low emissions have been obtained at 5:1 Gasoline-propanol blend. By using these results, one can easily figure out that the best possible Gasoline-Propanol blend at 7:1 proportion, that may yield the best performance and lowest regulated emissions from the spark ignition engine.

REFERENCES

1. A. Samuel Raja, A. Valan Arasu, T. Sornakumar, “Effect of Gasoline - Ethanol Blends on Performance and Emission Characteristics of A Single Cylinder Air Cooled Motor Bike SI Engine”, Journal of Engineering Science and Technology, Vol. 10, No.12 (2015) 1540 – 1552
2. Gaurav tiwari, Dr. Nitin shrivastava, “Experimental investigation of ethanol blends with gasoline on SI engine”, IJERA,vol-4,issue-10(2014) 108-114
3. Krishna Mohan Agarwal, Mayank Chhabra, “Study Of Performance Parameters Of Single Cylinder Four Stroke Spark Ignition Engine Using Gasoline - Ethanol Blends”, IJTEEE,vol-3,issue-2 (2015) 44-46
4. Jing Gong, Yingjia Zhang, Chenglong Tang, and Zuohua Huang, “Emission Characteristics Of Iso-Propanol/Gasoline Blends In A Spark-Ignition Engine Combined With Exhaust Gas Re-Circulation”,THERMAL SCIENCE: vol-18, issue-1, (2014) 269-277
5. A. F. Kheiralla, Mohamed M. El-Awad, Mathani Y. Hassan, Mohammed A. Hussen, “Experimental Determination of Fuel Properties of Ethanol/Gasoline Blends as Bio-fuel for SI engines”, International Conference on Mechanical, Automobile and Robotics Engineering(ICMAR), vol-2, issue-1 (2012)
6. Sankar Shanmugasundaram, Praveen Maruthur, Manivarma Kumaresan, Abhilash O. P, Akhil Das K and Abdul Maluf, “Experimental study on the effects of camphor ethanol petrol blends in a spark ignition engine: performance and emissions analysis”, IJEE,vol-6,issue-1 (2016) 19-28