Engine Performance and Emission Characteristics for a Blend of Petrol and Ethanol with Hydroxy gas

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Abstract - *This paper presents the results of experimentation carried out for studying performance on petrol engine using ethanol blends with oxyhydrogen gas by mass. Electrolysis of water with KOH electrolyte having 2 molar concentrations is carried out to produce oxyhydrogen gas. HHO gas is nothing but electrolyte from water having high specific energy per unit weight, good combustion characteristic, high flame propagation rate and also eco-friendly. From experimental data we can say that petrol with 5% ethanol blend and oxyhydrogen gas is best suitable for petrol engine. Using 5% ethanol blend with oxyhydrogen gas resulting in improvement in brake power and brake thermal efficiency when compared with engine running with petrol alone, also brake specific fuel consumption is reduced with modified fuel.*

Key Words: Oxyhydrogen, Electrolysis, Compression ratio, Brake power, Brake specific fuel consumption, Brake thermal efficiency

1. INTRODUCTION

As we all know, the petroleum reserves are limited, we are always trying to conserve petroleum fuels for future and due to this, there is a need of alternate and innovative fuel. Electrolysis of water can give us hydrogen in the form of oxy-hydrogen gas which can be used as an alternative fuel for any engine [1]. Oxyhydrogen gas is an enriched mixture of 'hydrogen' and 'oxygen' of which hydrogen contains high calorific value and oxygen aids combustion process. In present work blending different quantities of oxyhydrogen gas with petrol and ethanol is performed with different concentrations and corresponding engine performance characteristics are analyzed. With this, compatibility of oxyhydrogen gas as an alternative fuel for internal combustion engine has been checked.

Ethanol is a pure substance while gasoline is composed of Hydrocarbons. The ethanol contains an oxygen atom so that it can be viewed as a partially oxidized hydrocarbon. It helps in complete combustion. Ethanol blending is a procedure of adding ethanol to petrol. Because of growing economic concerns, use of ethanol as a motor fuel or as an additive is gaining rapid popularity. Properties of ethanol closely resemble to that of petrol.

2. METHODOLOGY

2.1 Engine Description

Fig.1 shows the setup used during the experimental work. It consists of a single cylinder, four stroke, Multi-fuel, research engine connected to eddy current dynamometer for loading. Set up is provided with necessary instruments for measurement of combustion pressure, Petrol line pressure and crank-timing. The setup has stand-alone panel box consisting of air box, transmitters for air and fuel flow measurements, indicated power, frictional power, BMEP, IMEP, BTHE, indicated thermal efficiency, Mechanical efficiency, specific fuel consumption, A/F ratio, heat balance and combustion analysis. Table 1 gives the detail specifications about the same.

Table -1: Engine Specification

Make	Maruti
Engine	single cylinder, 4 stroke water cooled, stroke 110mm, bore 87.5mm, 661cc.
Petrol mode	3.5 kW,1500rpm, CR 6-11
Speed range	1200-1800 rpm, CR range 6-10
Dynamometer Type	eddy current, water cooled, with loading unit
ECU	PF3 series ECU, Model PE3-8400P, full build.
Load sensor	Load cell, types strain gauge, range 0-50 kg

Fig -1: VCR petrol engine setup

2.2 Fuel Preparation

2.2.1 HHO generation

The HHO gas is nothing but the electrolyte form of water. It is also called as oxyhydrogen or brown gas. It is produced by electrolysis process, where an electrical power source is connected to two electrodes and which are placed in a mixture of water and electrolyte. Oxyhydrogen appears to be a favorable alternative fuel on account of its high specific energy per unit weight, its all-time availability as a component of water, good combustion characteristics and eco-friendly, fast burning and higher flame propagation rates are the attractive features of HHO gas. HHO gas is a mixture of hydrogen and oxygen gases, typically in a 2:1 atomic ratio; the same proportion as water. A source of DC voltage connected to the electrodes so that an electric current flow through the electrolyte from anode to cathode. As a result, water in the electrolyte solution is decomposed into H2 which is released at the cathode and oxygen at the anode.

Fig -2: Oxy Hydrogen gas generative cell

The HHO generator is basically an electrolyte cell. Here the kit is shown in Fig. 2 which has been used for electrolysis, whose reactor (container) is made of glass jar and the electrodes are made from SS 316 plate of thickness 1mm. These plates are immersed in the electrolyte solution of KOH (2 molar concentration) and kept 8 mm apart. A 5A electric current is passed through the electrolyte to initiate the electrolysis process. In the electrolysis process the oxygen is generated at anode & hydrogen is generated at cathode. A small free space at the top of the cylinder will allow the gases to mix together. The end cap houses the electrode terminals and also a hole for HHO gas outflow. The HHO gas generated from the kit is supplied to the engine via intake manifold.

For the anode reaction it is:

$4H_2O + 4e = 2H_2 + 4OH$

For the cathode reaction it is:

$4OH- = O_2 + 4e- + 2H_2O$

And finally, the overall reaction is:

$2H_2O = 2H_2 + O_2$

2.1.2 Fuel information

Table 2 shows thermal properties like density, calorific value, octane rating flash point and fire point of gasoline and its blend with ethanol. Higher calorific value and higher-octane rating is desirable for more efficiency.

Table -2: Fuel properties testing report

Sr	Test Description	Reference	Gasoline	Gasoline Oil + Ethanol Blends			
		Unit	E00	E5%	E10%	E15%	E20%
1	Density	*gm/cc*	0.75	0.75	0.76	0.76	0.77
2	Calorific Value	*MJ/Kg*	44	43	43	43	43.6
3	Octane Rating	-	91	92	94	96	97
4	Flash Point	oC	45	49	53	59	65
5	Fire Point	oC	49	56	61	67	74

3. EXPERIMENTAL PROCEDURE

Experiment is carried out on VCR engine. For comparative study compression ratio and ignition timing are varied. Compression ratio varies from 7:1 to 10:1 in step of one. Ignition timing varies from 25°BTDC - 40°BTDC in step of five. Experiment is carried out in 2 steps. In first stage pure gasoline and gasoline blend with ethanol was used and in second stage gasoline blend with HHO gas is taken for experimentation.

Experimental procedure is done in 2 steps. In first step

1) During experimentation on VCR engine the following parameters are varied

a. CR as 7:1,8:1,9:1,10:1 in step of one.

b. Ignition Timing 25°BTDC, 30°BTDC, 35°BTDC,40°BTDC in step of five. The normal range of CRs for petrol engine is 6-11.

2) Following blends of oxy hydrogen gas in petrol are tested.

a. NB1 (Pure petrol+200 ml/min)

b. B1 (5% Ethanol)

c. B2 (10% Ethanol)

d. B3 (15% Ethanol)

e. B4 (5% Ethanol+200 ml/min)

f. B5 (10% Ethanol+200 ml/min)

g. B6 (15% Ethanol+200 ml/min)

3) A pipe carrying Oxy-Hydrogen gas is attached to Air Intake manifold through nozzle.

4) Then the engine is run for few minutes.

5) Then by keeping the speed constant, the other parameters i.e. CR, Ignition timing & Blends are changed at full load conditions.

6) Performance results are recorded by software.

4. RESULT AND DISCUSSION

Various Performance parameter like brake power, break specific fuel consumption and break thermal efficiency are analyze at different compression ratio and different ignition timing. Both gasoline blend and blend with HHO gas is consider for comparative study.

4.1 PERFORMANCE READING

Sample reading showing speed, load, calorific value, break power, break specific fuel consumption and thermal efficiency for varying compression ratio and varying ignition timing is listed below in table 3.

Table -3: Sample of performace reading

Blends	CR	IA	Speed (N)	Load (w)	CV (kJ/kg)	BP (kW)	BSFC (kg/kWh)	ηbthe (%)
B1	7	25	1524	10.86	43900	3.14	0.394	20.8
B1	7	30	1530	10.85	43900	3.15	0.437	18.7
B1	7	35	1540	10.90	43900	3.19	0.416	19.6
B1	7	40	1537	10.90	43900	3.18	0.417	19.6
B1	8	25	1513	11.29	43900	3.24	0.397	20.6
B1	8	30	1528	10.72	43900	3.11	0.398	20.5
B1	8	35	1513	10.49	43900	3.01	0.411	19.9
B1	8	40	1548	10.60	43900	3.11	0.413	19.8
B1	9	25	1540	11.50	43900	3.36	0.421	19.4
B1	9	30	1558	11.81	43900	3.50	0.419	19.5
B1	9	35	1527	11.20	43900	3.25	0.436	18.7
B1	9	40	1540	10.93	43900	3.20	0.415	19.7
B1	10	25	1528	13.93	43900	4.04	0.340	24.0
B1	10	30	1489	13.73	43900	3.88	0.354	23.1
B1	10	35	1450	12.89	43900	3.55	0.362	22.5
B1	10	40	1487	12.84	43900	3.63	0.391	20.9

4.2 SAMPLE CALCULATION

Sample calculation is carried out for blend with 5% ethanol (B1) where compression ratio is 7 and ignition timing is 25 BTDC. From table 3, speed(N)= 1524, load(W)=10.86, calorific value (CV)=43900. Arm length for engine is 185 mm.

1) Brake Power = $\frac{2\pi N*(W*g*Arm\ length)}{60000}$

$=\frac{2*3.14*1524*(10.86*9.81*0.185)}{60000}$ = 3.14 kW

2) Break Specific Fuel Consumption = $\frac{m_f}{Brake\ Power}$

$=\frac{1.24}{3.14}$ = 0.3941 kg/ kWhr

3) Break Thermal Efficiency= $\frac{Brake\ Power}{(m_f*CV)} * 100$

$$=\frac{3.14*3600}{1.24*43900}*100 = 20.80\ \%$$

4.3 Performance Parameter

Plots for performance parameter like break power, break specific fuel consumption and thermal efficiency for varying compression ratio and varying injection timing are used for comparison. For deciding most efficient blend performance parameter of blend with HHO gas and without HHO gas are compare.

4.3.1 Performance reading without HHO gas

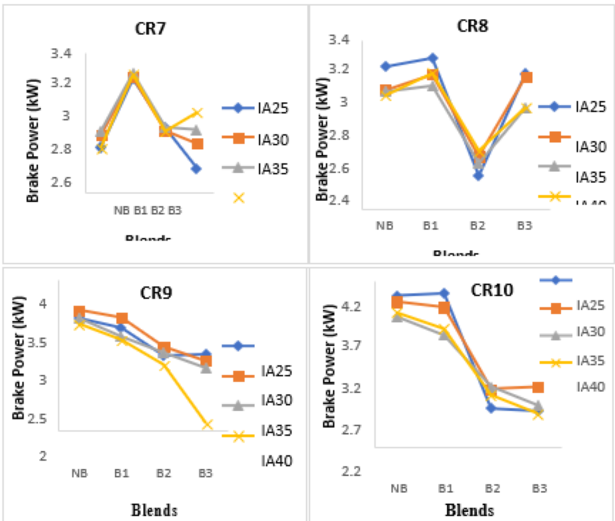

Chart -1: Graph of Brake Power V/s Blends without HHO

Chart 1. Shows effect of Ignition timing on Brake Power V/s blends. As shown in the figure brake power increases at B1 but reduces further at B2, B3 as calorific value of fuel goes on decreasing. As the compression ratio is increased gain in BP is observed, at CR10 maximum BP is achieved. With the increase in Ignition Timing 25°BTDC to 40°BTDC brake power decreases. At CR7 peak value of brake power is 3.18kW for blend B1 and IA40. The least value observed at CR7 was 2.23kW for blend B3 and IA25. At CR8 peak value of brake power is 3.24kW for blend B1 and IA25. The least value observed at CR8 was 2.23kW for blend B2 and IA35. At CR9 peak value of brake power is 3.50kW for blend B1 and IA30. The least value observed at CR9 was 2.08kW for blend B3 and IA40. At CR10 peak value of brake power is 4.04kW for blend B1 and IA25. The least value observed at CR10 was 2.26kW for blend B2 and IA25.

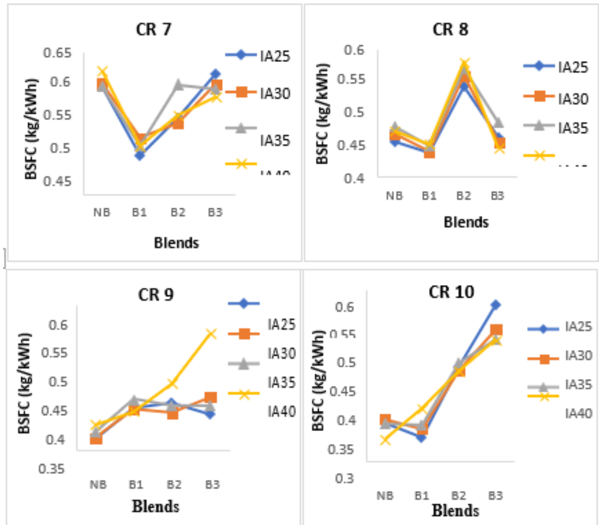

Chart -2: Graph of BSFC V/s Blends without HHO

Chart 2. Shows effect of Injection Advance on Brake Specific Fuel Consumption vs blends. As shown in the figure BSFC decreases at B1 but increases further this is due to increase in brake thermal efficiency and decrease in air-fuel ratio. With the increase in CR, BSFC increases & the lowest BSFC was achieved at CR7 IA25 for 5% Ethanol blend. At CR7 peak value of BSFC is 0.56 kg/kWh for blend B3 and IA30. The least value observed at CR7 was 0.41 kg/kWh for blend B1 and IA40. At CR8 peak value of BSFC is 0.57 kg/kWh for blend B2 and IA40. The least value observed at CR8 was 0.41 kg/kWh for blend B1 and IA40. At CR9 peak value of BSFC is 0.55 kg/kWh for blend B3 and IA40. The least value observed at CR9 was 0.37 kg/kWh for blend NB and IA35. At CR10 peak value of BSFC is 0.57kg/kWh for blend B3 and IA25. The least value observed at CR10 was 0.33kg/kWh for blend NB and IA40.

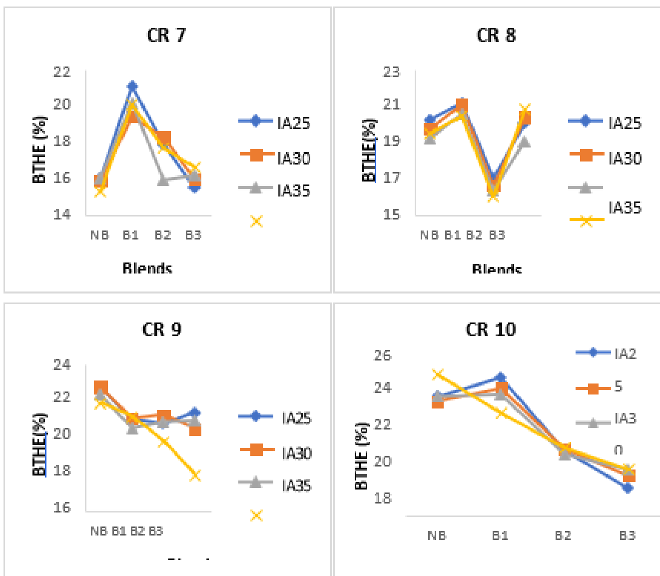

Chart -3: Graph of Brake Thermal Efficiency V/s Blends without HHO

Chart 3. shows effect of Injection Advance on Brake Thermal Efficiency vs blends. As shown in the fig 4.3, E% increases in the fuel blend the pressure and temperature decreases at the beginning of combustion. Also, A/F ratio increases i.e., decrease in heat transfer to the cylinder walls due to incomplete combustion. BTHE decreases with the increase in CR. At CR7 peak value of BTHE is 20.80% for blend B1 and IA25. The least value observed at CR7 was 14.73% for blend B3 and IA35. At CR8 peak value of BTHE is 19.95% for blend B1 and IA35. The least value observed at CR8 was 14.29% for blend B2 and IA40. At CR9 peak value of BTHE is 21.53% for blend NB and IA35. The least value observed at CR9 was 14.95% for blend B3 and IA40. At CR10 peak value of BTHE is 24.05% for blend B1 and IA25. The least value observed at CR10 was 14.40% for blend B3 and IA25.

4.3.2 Performance reading with HHO gas

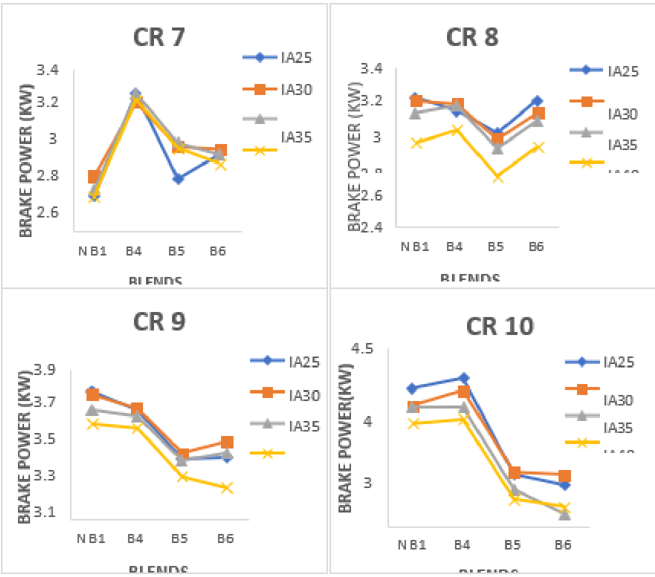

Chart -4: Graph of Break Power V/s Blends with HHO

Compared to blends without gas we found that value of BP of blend with gas was higher for the same configuration. As the compression ratio is increased gain in BP is observed in Chart 4., at CR10 maximum BP is achieved. The optimum configuration found was CR7 IA25 for 5% ethanol blend with addition of HHO. Brake power increases up to 31% compared to that of pure petrol. At CR7 peak value of brake power is 3.17kW for blend B4 and IA40. The least value observed at CR7 was 2.58kW for blend B5 and IA25. At CR8 peak value of brake power is 3.19kW for blend NB1 and IA30. The least value observed at CR8 was 2.71kW for blend B5 and IA40. At CR9 peak value of brake power is 3.65kW for blend NB1 and IA30. The least value observed at CR9 was 2.78kW for blend B6 and IA40. The least value observed at CR10 was 2.71kW for blend B6 and IA40.

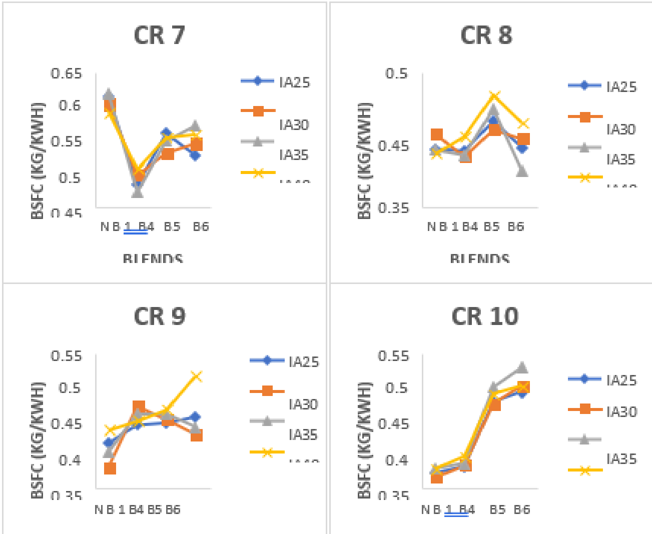

Chart -2: Graph of BSFC V/s Blends with HHO

In Chart 5. We found that value of BSFC of blend with gas was lower for the same configuration as HHO helps in proper combustion. From the figure we can see that BSFC decreases at B1 but increases further this is due to decrease in air-fuel ratio. With the increase in CR, BSFC increases. The lowest BSFC was achieved at CR7 IA25 for 5% Ethanol blend & the percentage decrease noted was 26% compared to that of pure petrol. At CR7 peak value of BSFC is 0.60 kg/kWh for blend NB1 and IA35. The least value observed at CR7 was 0.38 kg/kWh for blend B4 and IA35. At CR8 peak value of BSFC is 0.47 kg/kWh for blend B5 and IA40. The least value observed at CR8 was 0.39 kg/kWh for blend B6 and IA35. At CR9 peak value of BSFC is 0.50 kg/kWh for blend B6 and IA40. The least value observed at CR9 was 0.36 kg/kWh for blend NB1 and IA35. At CR10 peak value of BSFC is 0.52kg/kWh for blend B6 and IA35. The least value observed at CR10 was 0.33kg/kWh for blend NB1 and IA40.

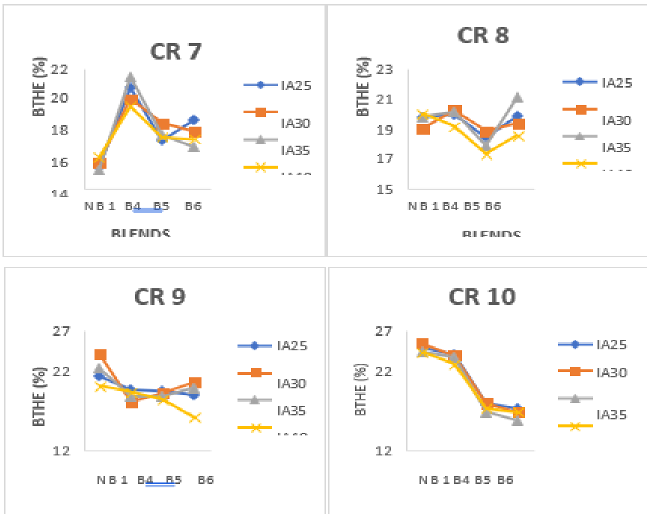

Chart -6: Graph of Brake Thermal Efficiency V/s Blends with HHO

Chart 6. Shows addition of HHO shows significant increase in BTHE due to proper combustion of fuel blend. With the increase in CR the BTHE goes on decreasing. With the increase in IA BTHE decreases. The maximum value of BTHE was observed at CR 10 IA25 and the percentage change observed was 40%. At CR7 peak value of BTHE is 21.30% for blend B4 and IA35. The least value observed at 13.58% for blend NB and IA35. At CR8 peak value of BTHE is 21.05% for blend B6 and IA35. The least value observed at CR8 was 17.29% for blend B5 and IA40. At CR9 peak value of BTHE is 24.12% for blend NB1 and IA30. The least value observed at CR9 was 16.14% for blend B6 and IA40. At CR10 peak value of BTHE is 25.39% for blend NB1 and IA30. The least value observed at CR10 was 15.68% for blend B6 and IA35.

5. CONCLUSION

In this paper blend with HHO gas and without HHO gas are compare for different performance parameter. Brake power in case of 5% Ethanol blend with HHO gas at CR 7 & IA 25 is increased by 31.095% compared to that of pure petrol. Brake Specific Fuel consumption at same operating condition is decreases by 28.694% compared to that of pure petrol. Brake Thermal Efficiency in case of 5% Ethanol blend at CR 7 & IA 25 increases by 40.561% compared to that of pure petrol. Brake Power in case of 5% Ethanol blend without HHO gas at CR 7 & IA 25 is increased by 28.231% compared to that of pure petrol. Brake Specific Fuel consumption in case of E5 blend at CR7 & IA25 decreases by 29.927% compared to that of pure petrol. Brake Thermal Efficiency for same operating condition is increases by 43.034% compared to that of pure petrol.

From above discussion it is found that 5% Ethanol +petrol + HHO is the optimum blend.

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