Effect on Exhaust Gas Emission of Four Stroke IC Engine by Hydrogen Gas Addition to Gasoline Blend

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Abstract— Fossil fuels like coal, natural gases and petroleum depleted due to increasing energy demand. Its cost is also increasing day by day. Combustion product of these fossil fuel such as CO, CO2, SOX, NOX, HC and ashes have been causing many environmental problems and danger for the world. To avoid all these problem, it is necessary to replace fossil fuels by clean and renewable energy source. Hydrogen is a renewable, carbon free and light gaseous alternative fuels. It fulfills certain basic criteria such as availability, high specific energy, minimum pollution etc. Its high auto ignition temperature, high diffusivity and low ignition energy helps in enhancing engine performance. In this context, the work investigates dual fuel mode combustion using a four stroke petrol engine, operated using hydrogen and petrol. The effect of hydrogen energy share enhancement on exhaust emissions will be investigate. Various exhaust emission analysis have been done using exhaust gas analyzer. Test rig with short description of various components used in test rig is presented along with the performance parameters graph. During the practical, the engine is operated at part loads and substitution of petrol energy with hydrogen energy is done. We have supplied the HHO gas, produced by HHO kit, at the inlet manifold of the engine.

Keywords: Hydrogen Blending, SI Engine Emission, Dual Fuel, Alternative Fuel

I. INTRODUCTION

Indoor air pollution and poor urban air quality are listed as two of the world's worst toxic pollution problems. Air pollution in India is a serious issue with the major sources being fuel wood and biomass burning, fuel adulteration, vehicle emission and traffic congestion. In autumn and winter months, large scale crop residue burning in agriculture fields – a low cost alternative to mechanical tilling – is a major source of smoke, smog and particulate pollution. India has a low per capita emissions of greenhouse gases but the country as a whole is the third largest after China and the United States.

To avoid all these problem, it is necessary to replace fossil fuels by clean and renewable energy source. Hydrogen is a renewable, carbon free and light gaseous alternative fuels. The diffusivity and flame speed of hydrogen is higher than gasoline Hydrogen addition during combustion reduced cyclic variations. In short, Hydrogen is a long term renewable, recyclable and non-polluting fuel.

II. HYDROGEN

Hydrogen is a renewable, carbon free and light gaseous alternative fuels. It fulfills certain basic criteria such as availability, high specific energy, minimum pollution etc. Its high auto ignition temperature, high diffusivity and low ignition energy helps in enhancing engine performance.

Some properties of Hydrogen gas and petrol is listed below.

Property	Petrol	Hydrogen
Density	740	0.0824
Flammability limits	1.43-0.25	10-0.14
Auto ignition T in air (K)	550	858
Flame velocity	0.37-0.43	1.85
Adiabatic flame	2580	2480
Stoichiometric fuel/air ratio	0.068	0.029
Research Octane Number	91-99	>120

Table 1: Properties of Hydrogen & Petrol

III. UNCERTAINTY ANALYSIS

Uncertainty analysis involves systematic procedures for calculating error estimates for experimental data. When estimating errors in heat engine experiments, it is usually assumed that data is gathered under fixed (known) conditions and detailed knowledge of all system components is available.

S.n.	Measurement	Accuracy
1	Engine speed	± 30 r.p.m.
2	Temperatures	± 1^0c
3	Carbon Monoxide	± 0.03%
4	Hydro carbon	± 10 ppm
5	Carbon dioxide	± 0.04%

Table 2: Uncertainty Analysis

IV. HYDROGEN PRODUCTION

Electrolysis uses an electric current to split water into hydrogen and oxygen. The electricity required can be generated using any of a number of resources. However, to minimize greenhouse gas emissions, electricity generation using renewable energy technologies (such as wind, solar, geothermal, and hydroelectric power), nuclear energy, or natural gas and coal with carbon capture, utilization, and storage are preferred.

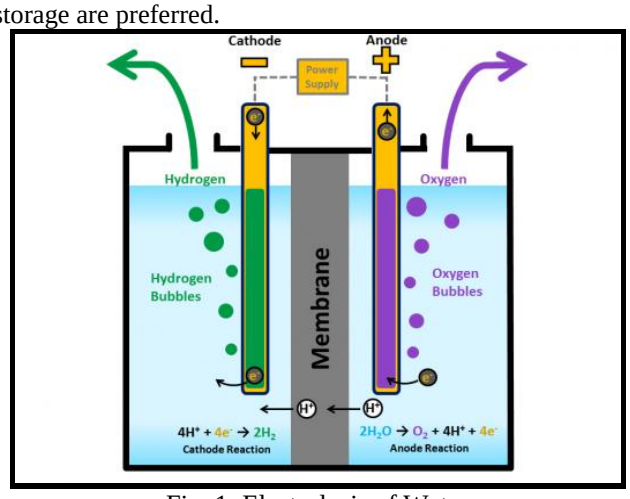

Fig. 1: Electrolysis of Water

	Acidic Conditions
Anode	$H_2O \rightarrow \frac{1}{2}O_2 + 2H^+ + 2e^-$
Cathode	$2H^+ + 2e^- \rightarrow H_2$
Total Reaction	$H_2O \rightarrow H_2 + \frac{1}{2}O_2$

Table 3: Reaction on anode and cathode

V. ENGINE SPECIFICATION

Engine Description	149.2 cm^3 ATFT (CBZ)
Displacement	149.2 cm^3
Type of Cooling	Air Cooling
Maximum Power	14.2 bhp @ 8500 r.p.m.
Maximum Torque	12.8 N-m @ 6500 r.p.m.
No. of Cylinders	1
Bore	57.3 mm
Stroke	57.8 mm

Table 4: Engine specification

VI. TEST RIG

For this experiment single cylinder 149.2 cc ATFT engine with Electrical dynamometer was used. Petrol gas analyzer is used to measure the concentration of various emissions in exhaust gas.

Fig. 2: Four stroke petrol engine test rig

Fig. 3: Test rig with Petrol analyzer

VII. OBSERVATION TABLE

The various readings of the exhaust gas emission has been noted down by changing load on engine from 1.5 kW to 9 kW. The observations of exhaust gas emissions when only petrol is supplied and when petrol is supplied with hydrogen gas are shown below in the table.

Load Bank			Engine RPM	Exhaust Emission			
Load (kW)	Volt	Amp.		CO (%)	HC ppm	CO_2 (%)	NO_X (%)
0	-	-	810	0.08	24	4	6
1.5	226	1.4	755	0.09	28	4.3	12
3	226	2.9	680	0.1	39	4.5	19
4.5	227	4.3	630	0.09	35	4.7	24
7.5	226	6.9	538	0.07	55	4.6	27
9	227	8.8	402	0.06	65	4.4	35

Table 5: Observation table (Only petrol)

Engine RPM	Load	Exhaust Emission			
		CO (%)	HC ppm	CO_2 (%)	NO_X (%)
810	0	0.07	23	5	10
755	1.5	0.08	27	5.3	23
680	3	0.09	36	5.6	34
630	4.5	0.08	33	5.8	43
538	7.5	0.05	50	5.7	53
402	9	0.04	61	5.9	57

Table 6: Observation table (Petrol + Hydrogen gas)

VIII. CHARTS

The effect on carbon monoxide, hydro carbon, nitrogen oxides and carbon dioxide is shown in figure when load on engine is changed from 0 kW to 9 kW.

A. Effect on CO emission

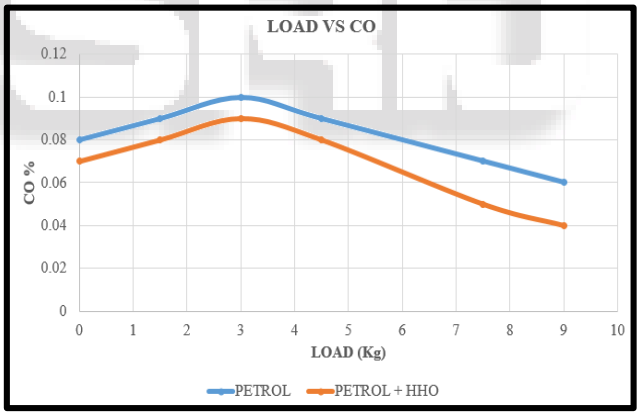

Fig. 4: Load vs CO Emission

B. Effect on NOx emission

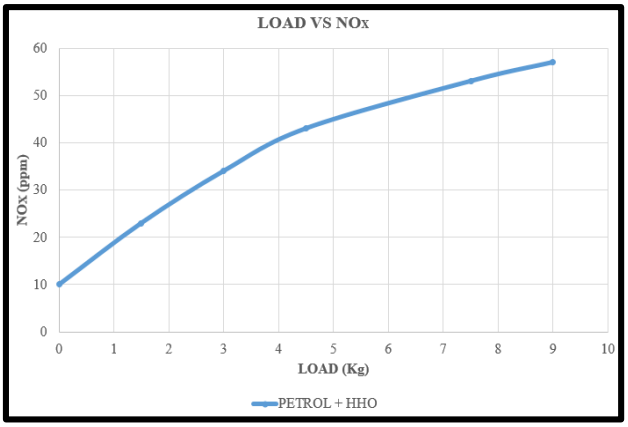

Fig. 5: Load vs NOx Emission

C. Effect on HC emission

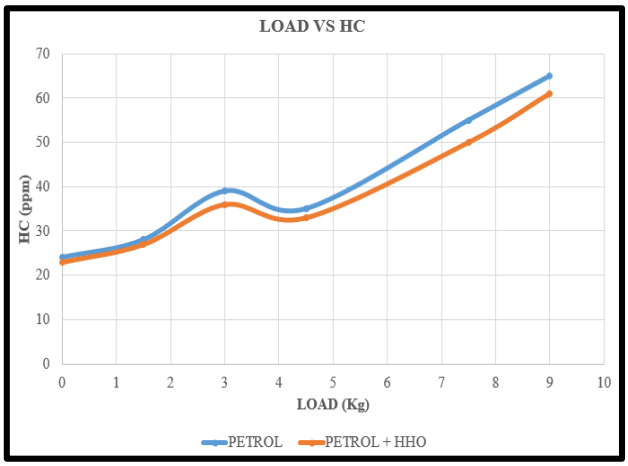

Fig. 6: Load vs HC Emission

D. Effect on CO_2 emission

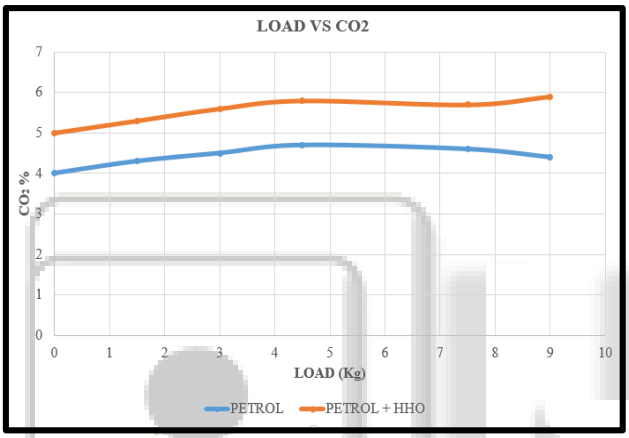

Fig. 7: Load vs CO_2 Emission

IX. CONCLUSION

An experimental study was conducted to investigate the effects of hydrogen addition to petrol on four stroke SI engine emission. During the experiment SI engine was operated at no load, part load and full load. Hydrogen which was produced by an alkaline water electrolyser was introduced into the intake manifold along with petrol and air.
The effect on various exhaust gas emission are discussed below.

A. CO Emission:

Carbon monoxide emission has been reduced when some amount of hydrogen is induced in the engine. As the amount of hydrogen in mixture increases, CO emission has been decreases.

B. HC Emission:

Hydro carbon emission has been reduced when hydrogen is supplied to the engine.

C. NOx Emission:

As the load on engine increases, nitrogen oxides emission is also increases. This is due to the presence of excess oxygen and high combustion temperature that is responsible for oxidation reaction. When hydrogen is supplied to the engine, NOx emission increases.

Further studies are required to know the effect of various proportions of hydrogen and petrol on exhaust emission. Some research is also required to reduce the nitrogen oxides emission when hydrogen is supplied with petrol. Research should also be done various production methods of hydrogen so that economical and best methods can reduced overall cost of manufacturers.

Finally, hydrogen gas has the potential to reduce exhaust emissions from IC engine, and the instantaneous production and consumption method is a safe means of integration into petrol engine-powered vehicles.

REFERENCES

[1] A Review on Performance of the IC Engine Using Alternative Fuels Mr. Venkata Sundar Rao. Ka*, Dr. S.N. Kurbetb, Dr. Vinay V. Kuppastc ScienceDirect PMME 2016
[2] Application of hydrogen enriched natural gas in spark ignition IC engines: from fundamental fuel properties to engine performances and emissions by Fuwu Yana, Lei Xua, Yu Wanga
[3] Development of hydrogen fuelled transport engine and field tests on vehicles by Jayakrishnan Krishnan Unni, Premakumara Govindappa, Lalit Mohan Das, ScienceDirect 2016 I-9
[4] Dilution of fresh charge for reducing combustion knock in the internal combustion engine fueled with hydrogen rich gases by Stanislaw Szwaja, ScienceDirect
[5] Experimental and modelling investigations on the performance and emission characteristics of a single cylinder hydrogen engine by Jayakrishnan Krishnanunni, Divesh Bhatia b, Lalit Mohan Das, ScienceDirect, 2017 I-11
[6] Investigation of hydrogen addition to methanolgasoline blends in an SI engine by Ilker Yilmaz, Murat Tas,tan, ScienceDirect 2018 I-10
[7] Production and use of HHO gas in IC engines by Balaji Subramanian, Saleel Ismail 2018 I-15
[8] An experimental analysis of ic engine by using hydrogen blend by Chetan N. Patel, Prof. Maulik A. Modi, Dr. Tushar M. Patel, IJRTER
[9] Combustion Performance and Emission Characteristics of Hydrogen as an Internal Combustion Engine Fuel by Aritra Chatterjee, Suhail Dutta, Bijan Kumar Mandal, JAAE Volume 1, Number 1; September, 2014 pp. 1-6
[10] Effect of hydrogen addition on exhaust emissions and performance of a spark ignition engine by Yasin Karagöz, Emre Orak, Levent Yüksek, Tarkan Sandalcı, Environmental Engineering and Management Journal, March 2015, Vol.14, No. 3, 665-672
[11] Performance analysis of IC engine using hydrogen fuel by Pandurang Ingle and Prof. Chaudhari, P.N. Asian Journal of Science and Technology Vol. 08, Issue, 11, pp.6312-6315, November, 2017
[12] Hydrogen as a petrol additive in 4 stroke i c engine by Ritesh Dhanotiya, Nitesh Kumar, Naveen S patil, Nikhil Kumar C, T Venkate Gowda, Anil Kumar P R, IRJET Volume: 04 Issue: 06 June -2017
[13] A review paper on the Analysis of Hydrogen Fueled Engine by Akhileshpati tiwari, Manoj kumar yadav,

Surender kumar, Ramnaresh yadav, IJETT – Volume 46 Number 5 April 2017

[14] Effect of using hydrogen mixed gases as a fuel in IC engines – A Review by Dr. Premkartikkumar. SR, Dr. Pradeepkumar. A.R, IJIRA Issue 9, Volume 2 (September 2015)

[15] Hydrogen use in IC engine: A review by Murat ciniviz, Hüseyin kose, International Journal of Automotive Engineering and Technologies Vol. 1, Issue 1, pp. 1 – 15, 2012

[16] Efficiency Analysis of a Copper Coated SI Engine using Normal and HHO blended Gasoline under Various Loads by P.T.Aravindhan, P.T.Anandhan, International Journal of Innovative Research in Science, Engineering and Technology Volume 3, Special Issue 3, March 2014

