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Performance of Hydroxy Gas on Diesel Engine

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Abstract: Limited reserves of petroleum products are turning to be a major problem in developing countries. Hydroxy gas can be a solution for this problem when enriched with Air & Diesel. Hydrogen's physical and chemical properties make it a good candidate for a supplement fuel. At normal atmospheric conditions, hydrogen is a colorless and odorless gas. It is stable and coexists harmlessly with free oxygen until an input of energy drives the exothermic (heat releasing) reaction that forms water. The cell plates have an anode and a cathode. The electric current enters the anode and then passes to the cathode through the electrolyte. The anode and cathode are made of the same materials. The quantity of HHO should be 50% of total air intake .it must be continuous in nature with higher safety precaution by carrying out all respective tests. Current supply should be adequate to generate a required quantity of HHO. When the Hydroxy gas is enriched with air in a diesel engine, the thermal efficiency for compression ratio 18 increases by 13.28% comparing to diesel combustion and the specific fuel consumption is reduced by 8.7% at full load condition.

Keywords: Hydroxy Gas, SFC, Indicated Power, HHO Kit, Diesel Engine.

I. INTRODUCTION

The increasing demand for petroleum fuel associated with limited non-renewable stored quantities has resulted in a huge instability in crude oil prices. In the last few years, ordinary people experienced this by paying more at the pumps. Consequently, we have seen a shift toward automobiles that consume less fuel. This has encouraged researchers to seek an alternative fuel that can be used in engines without the need for a dramatic change in the vehicle design. It has been shown that using pressurized hydrogen gas as a fuel in internal combustion engines (IC engines) has many advantages such as more engine power and lower pollutant concentrations in exhaust gasses [5].
Energy security is associated with national security and the availability of natural resources for energy consumption. Access to cheap energy has become essential to the functioning of modern economies. However, the uneven distribution of energy supplies among countries has led to significant vulnerabilities. According to WHO most large cities in the developing world are breaching global air pollution guidelines. Air pollution has been the reason by 8% globally in the last 5 years, estimating that it causes 3 million premature deaths in the year. It is estimated that 75% of carbon monoxide emission come from automobiles, where in urban areas harmful automotive emission are responsible for anywhere in between 50%-90% of air pollution. Hydroxy (HHO) gas contains two particles of hydrogen and one particle of oxygen. Hydrogen combustion reduces hydrocarbons, carbon monoxide and formation of NOx. [4]

Autoignition temperature of hydrogen is high and it has wide flammability range hence making it highly suitable for high compression engine. The only drawback to hydrogen is, it is having less density. Therefore a volume of hydrogen contains less energy. [1]

It is excepted that indicated power will increase by 10%. Also indicated thermal efficiency will increase by 15% and specific fuel consumption will be decreased by 10%.[1]

II. CHARACTERISTICS OF HYDROGEN GAS

Hydrogen has flammability limit of 4-75% by volume compared to 0.75% of diesel. The autoignition temperature of hydrogen is 858 K compare to 530 K of diesel. The flame velocity of hydrogen after injection is 265-325 cm/s compared to 30 cm/s of diesel. The high flame speed of hydrogen results in high cylinder pressure. The above parameters can reduce Co & HC. Due to high-temperature NOx will slightly increase. Table 1 gives properties of hydrogen and diesel.[1]

The net heat value of Hydrogen is 119.93 Mj/kg, whereas baseline diesel fuel hasn't heat value of 42.5 Mj/kg. Net heat value increases combustion process and fuel burns in a cleaner way. Results reduction in pollution.

Table I
Properties of hydrogen and diesel[1]

Sr.No.	Properties	Diesel	Hydrogen
1	Auto IgnitionTemperature (K)	530	858
2	Flammability Limits(volume % in air)	0.7-5	4-75
3	Stoichiometric air fuelRatio on mass basis	14.5	34.3
4	Density at 16 c and 1.01 bar (kg/m*3)	833-881	0.0838
5	Net heating value (MJ/kg)	42.5	119.93
6	Flame velocity (cm/s)	30	265-325
7	Diffusivity in air (cm*2/s)	---	0.63
8	Research octane number	30	130

III. THEORY

Oxygenated hydrogen (HHO) need to supply along with inlet Air-Fuel mixture of the engine. Hydrogen Generator is used to separate HHO from water as shown in fig 1.0. This separated HHO is then flowed through safety devices & finally supplied to Engine. Hydrogen has higher flame speed and its gasoline blend can be combusted faster. Still, as H2 addition widen the mixture flammability limit to leaner fuel equivalence, the reaction rate will be reduced and combustion would be prolonged in lean conditions[4].

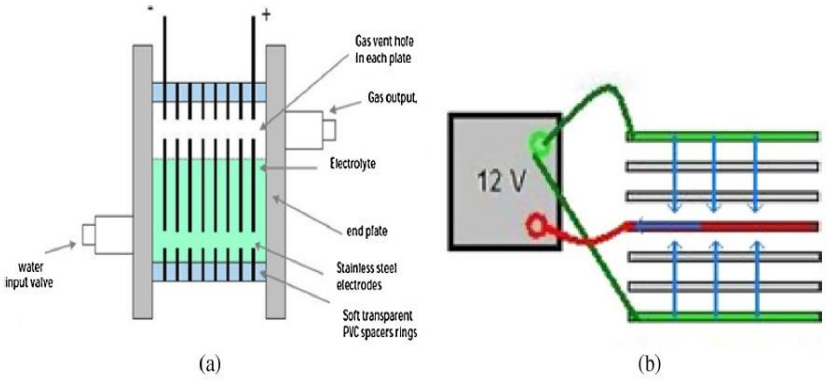

Figure 1.0 HHO generator setup.[6]

Advantages of CO2, CO, and HC reduction, while NOx increased, with higher H2 %, would be reasoned as follows: reduction of these 3 was attributed to enhanced combustion kinetics, as H2 combustion produces the oxidizing species of OH and O radicals that benefit the chemistry of Hydrocarbons (HCs) combustion. Besides, gasoline fuel flow was reduced with H2 enrichment to maintain constant global mixture equivalence and compare the engine performance with pure gasoline so, lesser HCs content is in the fuel, which cuts the formation of CO, CO2, and HC and promotes economic fuel consumption. Furthermore, hydrogen has a higher diffusion coefficient than that of the gasoline, and so, the gaseous H2 can disperse thoroughly in the charge and allow for greater mixture homogeneity and combustion completeness. On the other hand, NOx increase was attributed to the higher adiabatic flame temperature of hydrogen [8].

IV. TEST SETUP

In this report, HHO kit is tested for single cylinder Diesel Engine. Hydroxy (HHO) gas needs to supply along with inlet Air to the engine. Hydrogen Generator is used to separate H2 & O from the water. This separated HHO is then flowed through safety devices & finally supplied to Engine. Hydrogen has higher flame speed and its flammability will help in faster combustion.

Figure :2.0 :- Test setup

Figure 2 shows experimental setup. Dry type HHO generator is used to supply constant flow Hydroxy (HHO) gas as supplementary fuel in the diesel engine. The engines specifications are given in table 2.0. Eddy current dynamometer is coupled with the engine and is used for loading. Test data is generated on engine soft software package. Testing of the engine was carried as per ISO3046 std. Initially the Engine was tested on various load condition as 0%, 25%, 50%, 75% & 100% loads & performance was recorded for these loading conditions. Then HHO gas is allowed to flow through Air Inlet pipe in the engine, 100 gm KOH powder is used to control electrolysis process. HHO kit consumed 120Watt power to supply HHO at 0.6 *lpm.*

Table 2.0
Engine Specification

Engine Specification	Parameters
Type	Water cooled diesel engine
Make	Kirloskar
Power (HP)	4.76
Maximum speed (RPM)	1500
Bore diameter (mm)	87.5
Stroke (mm)	110
Compression ratio	18:1
Number of cylinder	Single
Swept volume (cc)	661.5
Test Standard	ISO 3046

V. RESULT AND DISCUSSION

The performance characteristics of diesel with HHO gas enrichment is compared with baseline diesel as a fuel to the engine.

4.1 Performance Parameters:

4.1.1 Indicated thermal efficiency

Figure 3 shows indicated thermal efficiency for baseline diesel engine with 1 *lpm* enrichment of HHO. The indicated thermal efficiency of baseline diesel engine was 31.42%. As hydrogen is having high flammability & flame velocity it will increase combustion rate. This results in an increment in thermal efficiency by 13.28%. Indicated thermal efficiency is maximum at 50% load & at full load, it is 36.23%.

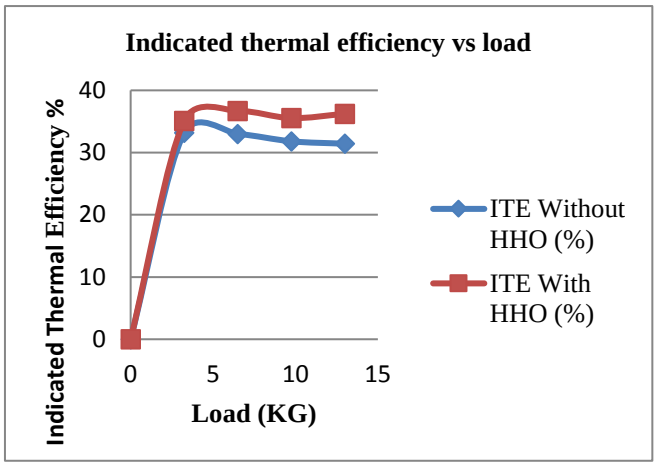

Figure:3.0 Variation of Indicated thermal efficiency with load

4.1.2 Indicated Power

Figure 4 Shows variation of indicated power with load. Indicated power is increasing with increase in load. For baseline diesel fuel indicated power at full load was 6.2 HP. With the addition of Hydroxy gas, this power is increased by 6.6 HP. As Hydrogen is having high calorific value it will help in the pure combustion of fuel, hence combustion will e cleaner. It results in 6% increment in indicated power.

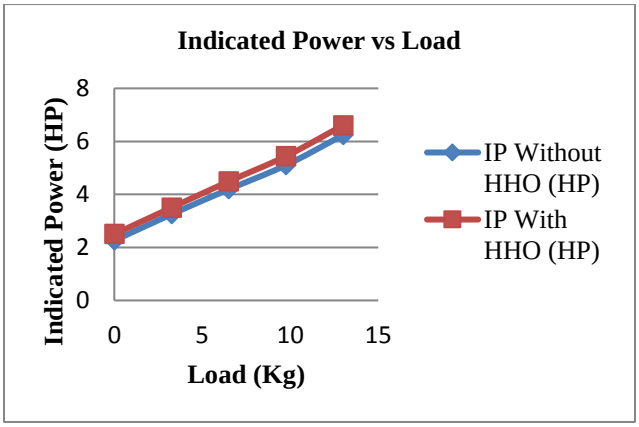

Figure: 4.0 Variation of Indicated power with load.

4.1.3 Specific fuel consumption

Figure 5 shows the variation of specific fuel consumption with the load. It is observed that specific fuel consumption is maximum at 3.25 kg load and then it decreases towards a full load of 13 Kg load. With addition HHO gas there is a reduction in specific fuel consumption. Hydrogen is having high diffusivity with diesel & air. Hydrogen gas also assists the combustion process and yields better combustion due to high flame speed & flammability. The addition of Hydroxy gas would help the fuel to burn faster.

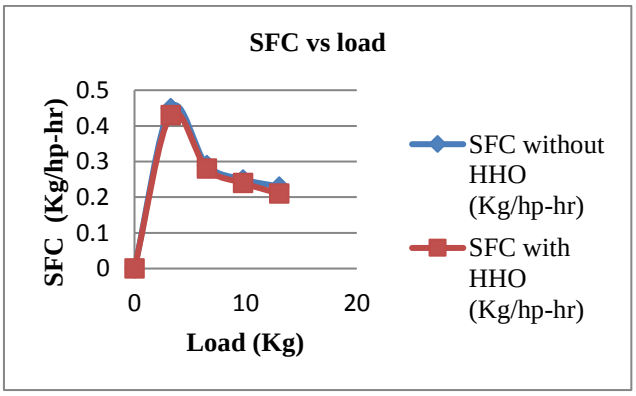

Figure: 5.0 variation of specific fuel consumption with the load.

The specific fuel consumption is reduced by 8.7% at full load condition.

4.1.4 Exhaust gas temperature

The variation of exhaust gas temperature for various loads is as shown in figure 6. The trend shows that the exhaust gas temperature is increased from 262°C to 273°C when enriched with hydroxy gas. The maximum exhaust gas temperature 273°C is reached at full load condition. The Figure 5 shows that a better combustion was taking place after enrichment of hydroxy gas into the engine. Hydrogen has high auto-ignition temperature hence more gas gets accumulated in the cylinder contributes to increasing in exhaust temperature.

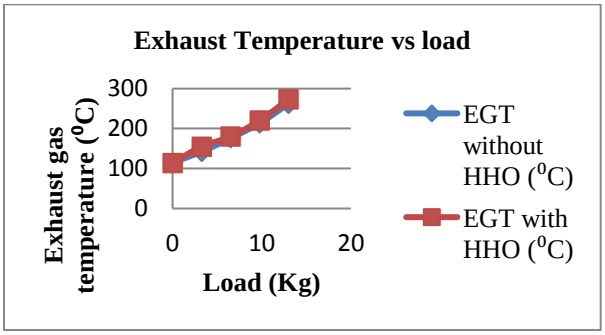

Figure: 5.0 Variation of exhaust gas temperature with the load.

CONCLUSION

From the results obtained on single cylinder four stroke diesel engine, it is seen that the hydroxy gas enrichment results in improvement in performance of the engine. Exhaust gas temperature increases due to high flammability hence Nox will increase. Indicated thermal efficiency increased by 13.28% compared with baseline diesel fuel. Indicated power increased by 6% compared with baseline diesel fuel. Specific fuel consumption reduced by 8.7% compared with baseline diesel fuel. And Exhaust temperature increased by 4% compared with baseline diesel fuel. HHO kit can be used in addition with EGR system to reduce exhaust gas temperature & other constituents.

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