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"Emission Control Using Hydrogen As An Additive With Diesel"

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***Abstract**: -* Hydrogen is used an additive with diesel to calculate the performance characteristics and the emission characteristics. The enhancement is also achieved in Engine performance. like brake power and indicated power at different load conditions. There was also achievement in bsfc (Brake Specific fuel consumption). I have taken the trial on 4 stroke, 4 cylinder diesel engine with hydraulic dynamometer at flywheel side for measurement of torque.

***Keywords**: - Study of performance characteristics; emission characteristics; enhancement in Engine performance*

I. LITERATURE REVIEW

Most of these work focused on the use of pure hydrogen as an additive which brings on board storage problem of hydrogen into consideration. Hydrogen has a high specific energy and very low density entailing high storage volume unless it is compressed (typically 70Mpa)or combined chemically with a metal alloy. To store hydrogen on-board in forms of a compressed gas, a cryogenic liquid or a gas dissolved in metal hydrides, a large amount of hydrogen is required to be stored and carried which leads to increase in the overall weight of the vehicle. Alternatively, in terms of liquid

hydrogen storage, not only the cost of onboard cryogenic containers is high, but also a high level of energy is required to convert the gaseous hydrogen into liquid. Therefore, the use of small and light hydrogen containers are respected which need to be filled in short distances of driving. However, hydrogen supply infrastructures are not still available and need to be developed in the near future. In addition, the wide flammability range of hydrogen makes it is hazardous fuel to be stored which can be combusted at atmosphere pressure at concentrations from 4% to 74.2% by volume. One of the viable solutions to this problem is to generate hydrogen on-board through electrolysis of water and use it in the form of hydrogen-oxygen($H2/O2$) mixture. However, no significant work has been carried out in testing diesel engine with the addition of $H2/O2$ mixture. The aim of this study is to investigate the impacts of adding $H2/O2$ mixture on the performance parameters of a diesel engine coupled to a generator producing electricity. The engine was tested at a constant speed of 2200 rpm with the addition of varying amount of $H2/O2$ mixture(1-6%) under three different load levels of 20 KW,25KW, and 30KW.

II. EXPERIMENTAL SETUP AND PROCEDURE

A Four Stroke, four cylinder, and water cooled diesel engine Fitted with Hydraulic Dynamometer was used in this experiment. The detail of the engine is listed in Table 1 and the properties of diesel and hydrogen is listed in Table 2.

Table 1

Engine Type	Max.RPM	Max.Power	Cc Of Engine
4-Cylinder,4 stroke, water cooled With Hydraulic Dynamometer	5500	39 KW	1396 CC

Table 2

Sr.No.	Properties	Diesel	Hydrogen
1	Density(Kg/m^3)	840	0.082
2	Calorific Value(MJ/Kg)	42.7	119.80
3	Flame Velocity (m/s)	0.3	2.70
4	Auto ignition Temp.(^{0}C)	280	585
5	Carbon Residue(%)	0.1	0.0
6	Boiling Point at 1 atm.(^{0}C)	- 252 ^{0}C	180 to 345 ^{0}C

The engine was mounted `to an Electrical generator and the generator was then connected to an adjustable load cell to put load on the engine. A schematic diagram of the experimental set up is shown in Fig.1. The mixture of H2/O2 was generated by electrolyzing water using an Oxy-Hydrogen generator machine, Epoch-500. In order to simplify the set up, the H2/O2 mixture was generated using 24 V external power supply. But in reality it will be produced from the battery/alternator arrangement of the engine.

Fig.1.Experimental Set Up With Hydraulic Dynamometer.

The power needed to produce the H2/O2

Mixture is included as an input energy to the engine. The generated mixture is then passed through a drier container and a flow meter before it is introduced to the engine via the air intake manifold mounted on the engine. The flow line of H2/O2 mixture was connected to the ground using a normal wire to prevent concentration of static electricity which may cause explosion. Two flame arrestors were installed in to H2/O2 line. A Dwyer model RMC gas flow meter was used to measure the H2/O2 mixture flow rate flowing into the engine with an accuracy of ± 0.5 l/min. Also, A nozzle mounted to the air inlet duct of the engine was used to measure the air-flow rate. The pressure difference across the nozzle was measured with an accuracy of ± 0.01 KPa using a U tube manometer. To enable measuring the diesel fuel, a digital weighing scale with an accuracy of ± 1 g and a stop watch were used. The CO and CO_2 Emissions were measured by non – dispersive infrared (NDIR) gas analyser with an accuracy of ±0.1 %. The Chemiluminescence's method was used for detection of oxides of nitrogen (NO_X) with an accuracy of ±1 ppm. The flame iodization detection (FID) methodology was used to measure HC with an accuracy of
±1 ppm. Engine speed was measured with an accuracy of ±1 rpm using a digital tachometer.

The engine was operated at a constant speed of 2200 rpm with three different power levels of 20 KW,25KW, and 30KW applied by a load cell. Under each load condition, the flow rate of diesel fuel and other parameters were first recorded without any induction of H2/O2 mixture into the engine. Then, with no change in experimental conditions, a small amount of H2/O2 mixture was introduced to the engine. The impacts of the induction of H2/O2 mixture on engine performance parameters such as output power, diesel specific fuel consumption, exhaust temperature, air-flow rate, H2/O2 mixture flow rate, engine speed and emissions were recorded. Then, the flow rate of H2/O2 mixture was increased and the required data were collected until the optimum fuel saving was achieved.

3.Results And Discussion

In the investigation, the performance and emission characteristics of a diesel engine were studied using the hydrogen/oxygen mixture enrichment at a constant speed of 1500 rpm. The flow rate of H2/O2 mixture was varied to obtain optimum performance and the engine was tested at three different powers of 20 KW,25KW, and 30KW. In this experiment, the H2/O2 mixture was generated using 24 V external power supply and the power needed to produce the Hydrogen/Oxygen mixture is included in the input energy of the engine.

3.1 Brake Thermal Efficiency

The variation Brake Thermal Efficiency at different % of H2/O2 mixture is presented in figure 2. It can be observed from the figure that, regardless of the level of load, increasing the induction of Hydrogen/Oxygen mixture the brake thermal efficiency of the engine increases.

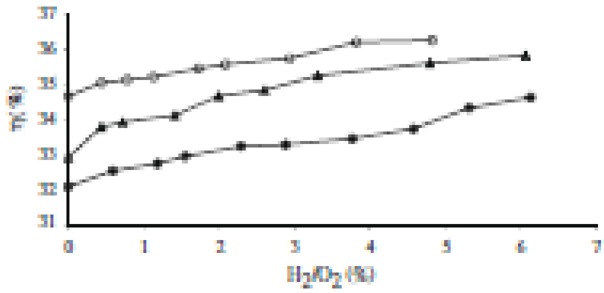

Fig.2.Graph Of Efficiency Vs.Percentage Of H2/O2

The flame speed of hydrogen is nine times faster than the flame speed of diesel. Therefore , burning diesel in the presence of hydrogen will result in overall faster and more complete combustion. This will result in higher peak pressure closer to TDC and therefore, will produce a higher effective pressure to do work. These have contributed to improve the efficiency. However, the increase in efficiency diminishes after 5% total diesel equivalent of H2/O2 mixture (flow rate of 25 l/min), and therefore, the flow rate of H2/O2 mixture kept to a maximum of 6% total diesel equivalent of H2/O2 mixture (30 l/min). At 20 kw, the maximum brake thermal efficiency (BTE) increased to 34.5 % from 31.8. when running on diesel. Similarly, the BTE increased to 35.8 % from 32.9 % at 25 kw and at 30 kw, the efficiency increased to 36.5 % from 35.1 %. Fig.3 shows the actual flow rate of Hydrogen/Oxygen mixture needed to produce those increases in efficiency, which were 30.5 l/min, 29.75 l/min, and 31.7 l/min corresponding to 4.85%, 6.00% and 6.10% of the total diesel equivalent flow rate at 20 KW,25KW, and 30KW respectively.

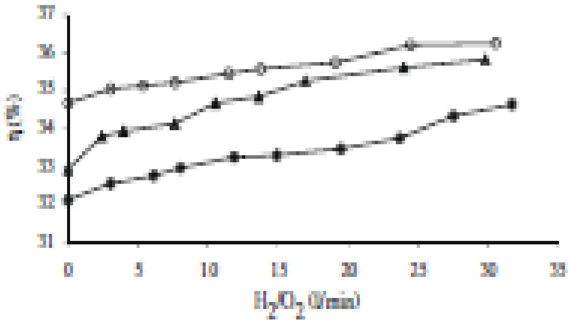

Fig.3Graph Efficiency Vs.H2/O2 (Lit./min)

These low percentage of H2/O2 mixture acted as an additive to improve the combustion process which is the result of higher flame speed of hydrogen compared to diesel. The outcome of this study follows the logic of the experimental study . This study was carried out with diesel as the main fuel and pure hydrogen as an additive injected in to the air intake manifold during the intake stroke.

3.2 Brake Specific Fuel Consumption and Fuel Saving

Fig.4 shows the variation of brake specific fuel consumption (bsfc) with percentage of H2/O2 mixture.

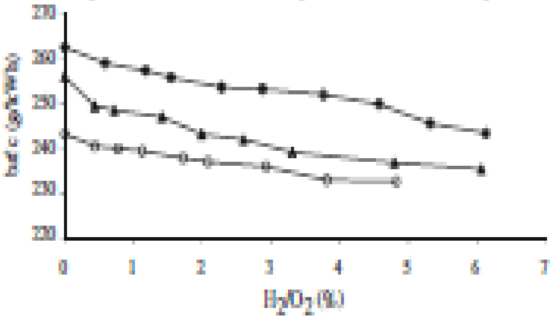

Fig.4 Graph Of bsfc Vs. Percentage Of H2/O2

The fuel consumption is the sum of diesel, diesel equivalent hydrogen flow rate and diesel equivalent energy needed to produce the H2/O2 mixture. The figure reveals that addition of a small amount of H2/O2 into air inlet manifold to enhance diesel combustion decreases the bsfc regardless of the level of load. This is due to uniformity in hydrogen mixture formation with air resulting in better combustion.

3.3 Air-Fuel Ratio

Fig.5 shows the variation of air-fuel ratio with H2/O2 percentage. As the H2/O2 mixture is introduced through the air intake manifold the mixture replaces some air that could result in reduced air-fuel ratio. The figure indicates that the with increase in hydrogen /oxygen percentage the air fuel ratio increases. This is due to the mixture containing oxygen as well. This increase in Air-Fuel ratio improves the combustion resulting lower fuel consumption and better efficiency. The increase in air-fuel ratio at the maximum flow rate of hydrogen /oxygen mixture were from 95.5 to 105.5 for 20 kw power, 92.6 to 103.7 for 25 kw power and 75.3 to 80.8 at 30 kw power.

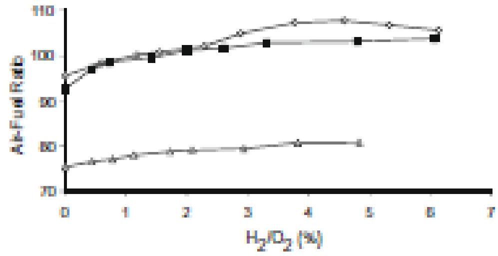

Fig.5 Variation Of Total Fuel Flow Rate With Percentage Of H2/O2

3.4 Hydro-Carbon (HC)

Fig.6 depicts the variation of HC with percentage of Hydrogen/Oxygen under different load conditions. Though the graph shows some overlapping, but regardless of the load level by introducing Hydrogen/Oxygen to diesel the HC emission reduced. The reduction of HC emissions is due to the absence of carbon in hydrogen fuel and also due to the better combustion of diesel fuel with the aid of hydrogen which has a higher speed of flame.

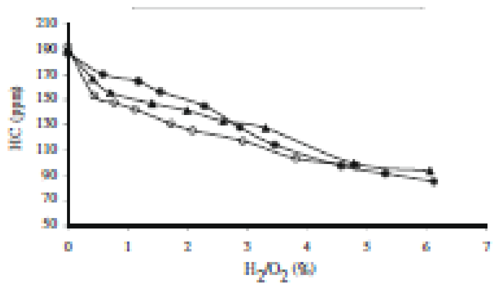

Fig.6 Variation Of HC With Percentage of H2/O2

In detail speaking the HC emission dropped from 187 ppm to 85 ppm with 31.75 l/min induction of Hydrogen/Oxygen at 20 kw, from 189 ppm to 93 ppm by adding 30.6 l/min of H2/O2 for 25 kw and 192 ppm to 97 ppm by adding 30.6 l/min induction of H2/O2 for 30 kw.

3.5 Oxides Of Nitrogen (NO_X)

The variation of NO_X emission with percentage of H2/O2 is shown in figure7.

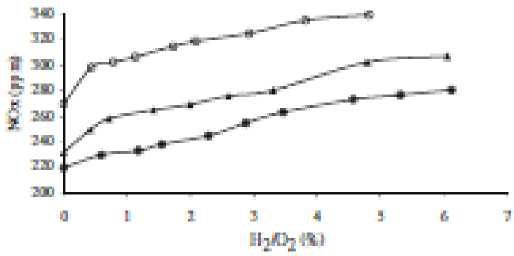

Fig.7.Graph Of Variation Of NO_X Emission Vs. Percentage Of H2/O2

At all loads, induction of H2/O2 resulted in increase in the amount of NO_X emission. Higher air-fuel ratio coupled with better combustion due to higher flame speed of hydrogen might have caused the peak pressure and temperature to rise. Both high temperature and more available oxygen in the formed mixture might have caused NOx emission to rise. The NOx emission is found to be increased from 220 ppm to 280 ppm at 20 kw power, 232 ppm to 307 ppm at 25 kw power and 270 ppm to 339 ppm at 30 kw power.

3.6 Carbon dioxide

Fig.8 shows the variation of carbon dioxide (CO_2) with the percentage of H2/O2 from figure it is observed that at all load levels CO_2 is reduced. The reduction in CO_2 is due to less carbon concentration in the formed mixture of fuels.

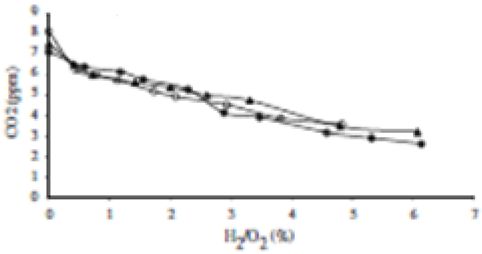

Fig.8. Variation Of Carbon-Dioxide (CO_2) Vs. Percentage Of H2/O2

Hydrogen is a carbon less fuel and when substituted to diesel the formed mixture produces less carbon dioxide. The reduction of carbon dioxide is achieved at all load conditions. The minimum amount of CO_2 is 2.06 ppm at 20 kw with flow rate of 31.5 l/min of H2/O2.

3.7 Carbon monoxide

Fig.9 shows the variation of Carbon monoxide with percentage of H2/O2. Although the CO values for neat diesel operation is relatively lower, by inducing H2/O2 into diesel the CO amount is again decreased.

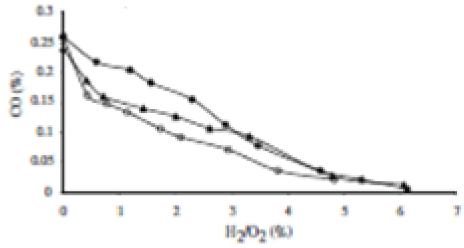

Fig.9.Graph Of Carbon-Monoxide(CO) Vs. Percentage Of H2/O2

This is achieved due to absence of carbon in the hydrogen fuel. For higher air fuel ratio (i.e. for leaner mixture). CO is reduced from 0.26 % to 0.021 % at 30 kw power.

III. CONCLUSION

Using small amount of H2/O2 mixture as an additive with diesel, the performance of 4 cylinder engine which is located at PVPIT is evaluated. The required amount of H2/O2 mixture was generated by electrolysis of water considering on board production of H2/O2 mixture. In observation following conclusions were noted.

1. Hydrogen has 9 times higher flame speed than pure diesel.
2. It has ability to enhance overall combustion generating higher peak pressure closer to TDC which results in more output from the engine.
3. Due to Hydrogen/Oxygen mixture as an additive there is enhancement in overall efficiency of the engine.
4. Experimental results shows that the introduction of 6.05% total diesel equivalent to H2/O2 mixture into diesel, BTE (Brake Thermal Efficiency increases. Details are shown in tabular form below.
5. Brake specific fuel consumption also increases so that economy is achieved.

Table 3

Sr No.	Kw	Increase in BTE %	% Increase in BSFC Kg/KW-Hr.
1	20	2.5	7.2
2	25	3.0	8.0
3	30	1.5	5.0

6. However addition of H2/O2 mixture beyond 5 % does not have significant effect in enhancing the engine performance.
7. The emissions of HC, CO_2 and CO were found to be reduced due to better combustion while NO_X increased due to the higher temperature reached during the combustion.

REFERENCES

[1] S.Bari,M.Mohammad Esmaeil- Effect of H2/O2 Addition In Increasing The Thermal Efficiency Of A Diesel Engine- Journal Fuel 89 (2010).
[2] U.S.Department Of Transportation-November 2007.
[3] Hydrogen Fuel Cell Vehicle Study-June 12,2003.
[4] Cooling Of The Desert-Revision '0'-December-2001-Hydrogen Use In IC Engines.