SIGNIFICANCE OF INLET AIR TEMPERATURE ON REDUCING ENGINE-OUT EMISSIONS OF DI DIESEL ENGINE OPERATING UNDER THE INFLUENCE OF OXYGEN ENRICHED HYDROGEN GAS[*]

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Abstract– Increase in air pollution due to automotives is an important problem worldwide. Present experimental work concerns with the influence of inlet air temperature along with oxygen enriched hydrogen gas on reduction of exhaust emission and increasing the fuel economy of a DI diesel engine. Here, the oxygen enriched hydrogen gas was produced by the process of water electrolysis. When the potential difference is applied across the anode and the cathode electrodes of the electrolyzer, water is transmuted into oxygen enriched hydrogen gas. The produced gas was aspirated into the combustion process of petroleum diesel along with intake air at the flow rate of 4.6 liters per minute (lpm). The results are very promising. The fuel economy enhanced and simultaneously engine exhaust emissions by the addition of oxygen enriched hydrogen gas with change in inlet air charge temperature. In this investigation inlet air temperature was changed from normal operating temperature of 30^0C to 35^0C and 25^0C. When the flow rate of the gas mixture was 4.6 lpm with increased inlet air charge temperature of 35^0C, brake specific energy consumption of the test engine got decreased from 14.8 MJ/kWh to 12.72 MJ/kWh, by a decrease of 14.06%, and unburned hydrocarbon emission from 66 ppm to 51 ppm, by a decrease of 22.73%. Smoke emission reduced substantially from 42 HSU to 29 HSU, by a reduction of 30.95%. However; the NOX emission got increased from 420 ppm to 496 ppm, i.e., by 18.1%.

Keywords– Electrolysis, oxygen enriched hydrogen gas, inlet air temperature, engine-out emissions

1. INTRODUCTION

Advanced combustion methods and advanced fuels technologies are important in meeting the needs of sustainability in a manner that is technically feasible and economically viable [1]. The higher thermal efficiency of diesel engines compared with gasoline engines certainly has the advantage with regard to conserve energy and to solve the green house problems. Many engineers and scientists agree that the solution to these global problems would be to replace the existing fossil fuel system with the hydrogen energy system [2]. Hydrogen, as an energy medium, has some distinct benefits for its high efficiency and convenience in storage, transportation and conversion [3]. With its unique structure of non content of carbon molecules, hydrogen seems to significantly attract the attention of researchers towards it. Compared to pure petroleum diesel, hydrogen has wider flammability limits, higher flame speed and fast burning velocity, which enable engines to run on very lean mixtures [4-5]. Also, hydrogen is a renewable and clean burning fuel [6-7]. It can be produced from numerous resources; some of them are fossil fuels, biomass, water and industrial waste chemicals. Properties of hydrogen are shown in Table 1[8].

The use of hydrogen in dual fuel mode in the diesel engine has been investigated by several researchers. Since dual fuel mode is the most practical and efficient mode when compared to other modes

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[9], most of these researches are concerned with the use of pure hydrogen as a dual fuel, which creates storage problems for hydrogen. One of the viable solutions to this problem is to produce hydrogen instantly and use it immediately. The only process that fulfills the instant production of hydrogen is water electrolysis process. Water electrolysis is one of the most important industrial processes for hydrogen production today, and is expected to become even more important in the future [10].

Table 1 Important properties of hydrogen [8]

Properties of hydrogen	
Limits of flammability in air	4–75% vol.
Minimum energy for ignition	0.02 mJ
Auto-ignition temperature	858 K
Quenching gap in NTP air	0.064 cm
Burning velocity in NTP air	265–325 cm/s
Diffusion coefficient in NTP air	0.61 cm^2/s
Heat of combustion (LCV)	119.93 MJ/kg

Shrestha et al. conducted experiments on a Chevrolet Silverado 6.5 L turbocharged V8 diesel engine. They used 3 units of hydrogen generation system (HGS), each having a capacity of producing hydrogen - oxygen mixture of 690 cm^3/min by the process of water electrolysis. The results showed that there was an enhancement in combustion process and reduction in exhaust emissions when the hydrogen flow rate was increased. Particulate matter (PM) reduced up to 60%, reduction in CO was up to 30% and reduction in NO_X was up to 19% compared to the diesel combustion [11].

Birtas et al. carried out an investigation using hydrogen rich gas on a naturally aspirated direct injection, tractor diesel engine with four cylinders in-line having the total capacity of 3759 cm^3, nominal power of 50 kW at 2400 rpm. The HRG (Hydrogen Rich Gas) produced by the water electrolysis process was introduced along with the air stream into the cylinder. The results showed that by adding HRG, smoke emission was reduced up to 30%, while NO_X concentrations varied up to 14%, depending upon the engine operational mode [12].

Recently, Wang et al. investigated the effects of introducing a hydrogen and oxygen mixture (H_2/O_2) to a heavy-duty diesel engine (HDDE) on the performance, fuel consumption and emission characteristics. HDDE was tested at 24.5% of the maximum load using pure petroleum diesel and seven H_2/O_2 mixtures: 10–70 L/min, with the increment of 10 L/min. The results showed that brake thermal efficiency increased from 31.1% for pure petroleum diesel to 39.9% for 70 L/min of H_2/O_2 mixture. For 10–40 L/min of H_2/O_2 mixture addition, the brake specific fuel consumption (BSFC) was higher than that of pure petroleum diesel. However, for 50, 60 and 70 L/min of H_2/O_2 mixture addition, the BSFC was lower than that of pure petroleum diesel by about 3.2%, 9.9% and 10.5% respectively. Due to improved combustion efficiency, the emissions such as UBHC, CO and CO_2 were lowered, while those of the oxides of nitrogen were increased. The NO_X concentration was 60.05 ppm for pure petroleum diesel, and was increased to 67.22 ppm for 70 L/min of H_2/O_2 addition [13].

When hydrogen is used to enrich the combustion process of the diesel engine; due to the higher degree of constant volume combustion, higher flame speed associated with high diffusivity through the fuel-air mixture resulting in high-grade combustion. Increasing the inlet air temperature resulting in enhanced pre-mixed burning phase. Owing to this, the pressure and the temperature of combustion increase. The atmosphere of high temperature present in the combustion chamber results in more thermal NO_X and reduction in all engine-out emissions such as CO, CO_2, UBHC and Smoke.

Alam et al. conducted experiments with a commercially available six cylinder, water cooled, turbocharged, direct injection diesel engine operated over a range of inlet air temperatures. When the engine was operated with an increase in inlet air temperature, it resulted in decreased air flow rate, increased fuel flow rate, and decreased air-fuel ratio of the engine. Apart from these effects, the engine efficiency was also decreased with increase in exhaust gas temperature. The change in inlet air temperature affects the ignition delay due to its effect on overall charge conditions during the ignition delay period. When the temperature of inlet charge air is increased, ignition delay decreases. This is because higher inlet air temperature reduces the time to vaporize the fuel to make a combustible mixture [14].

The increase in inlet air temperature also results in increase in NO_X emissions and this increase is due to increase in average cylinder temperature [15]. Hydrocarbon emissions also tend to decrease when the inlet air temperature is increased. This might be due to the decrease in the air-fuel ratio [14].

The high burning velocity causes rapid flame propagation in hydrogen combustion engines resulting in an intense convection of the burning gas and a large heat transfer from the burning gas to the combustion chamber walls [16]. The exhaust emissions coming out from the engine depend upon the combustion operational temperature. The smoke emission can be reduced by increasing the inlet air charge temperature [17]. When the inlet air charge temperature increases, it results in reduction in the ignition delay period [14].

Li et al. did an investigation in marine diesel engine having a compression ratio of 13. They concluded that the effective power of the engine decreased when the ambient temperature was increased. When the ambient temperature was increased by 10K, the effective power of the engine decreased by 0.49%. The maximum combustion pressure of the engine also decreased when the ambient temperature was increased. When the ambient temperature was increased by 10K, maximum combustion pressure of the engine decreased by 1.55% [18].

When going through the vast literature of hydrogen usage in diesel engines, significant work on the effect of inlet air temperature was not found to have been carried out. Hence, an attempt is made during this investigation to fill this void.

2. PRESENT EXPERIMENTAL WORK

In the present method, an electrolyzer decomposed distilled water into a new fuel composed of hydrogen, oxygen and their molecular and magnecular bonds, called oxygen enriched hydrogen gas. The produced gas was aspirated into the combustion process along with intake air at the flow rate of 4.6 lpm with change in inlet air temperature of 35^0C (IAT35) and 25^0C (IAT25) from normal operating temperature of 30^0C. Thereby, the effectiveness of oxygen enriched hydrogen gas on reduction of exhaust emission and fuel economy of the engine was determined under various brake power conditions of the engine. The generation quantity of gas was controlled by an electronic control unit namely, electronic control unit of oxygen enriched hydrogen gas (ECOEHG).

3. TEST ENGINE SETUP

The present investigation of using oxygen enriched hydrogen gas with change in inlet air temperature was carried out in a Kirloskar make SV1 model single cylinder, water-cooled, four stroke, DI diesel engine, developing the rated power of 5.9 kW at a speed of 1800 rpm and having a compression ratio of 17.5:1. The engine specification is given in Table 2. Eddy current dynamometer was used to load the engine. The oxygen enriched hydrogen gas was metered through a digital mass flow controller (MFC) of Aalborg

make for precision measurement. The engine in-cylinder pressure was measured using a Kistler make piezoelectric pressure transducer with an in-line charge amplifier. The amplified analogue signal was converted to a digital signal using an analogue - to - digital converter (ADC). The exhaust gas emissions such as CO_2, CO, UBHC, NO_X and Excess oxygen (O_2) available in exhaust were measured using Crypton 290 EN2 five gas analyzer. The smoke opacity was measured using AVL smoke meter in Hatridge Smoke Unit (HSU). The schematic arrangement of experimental setup is shown in Fig. 1.

Table 2   Engine specifications

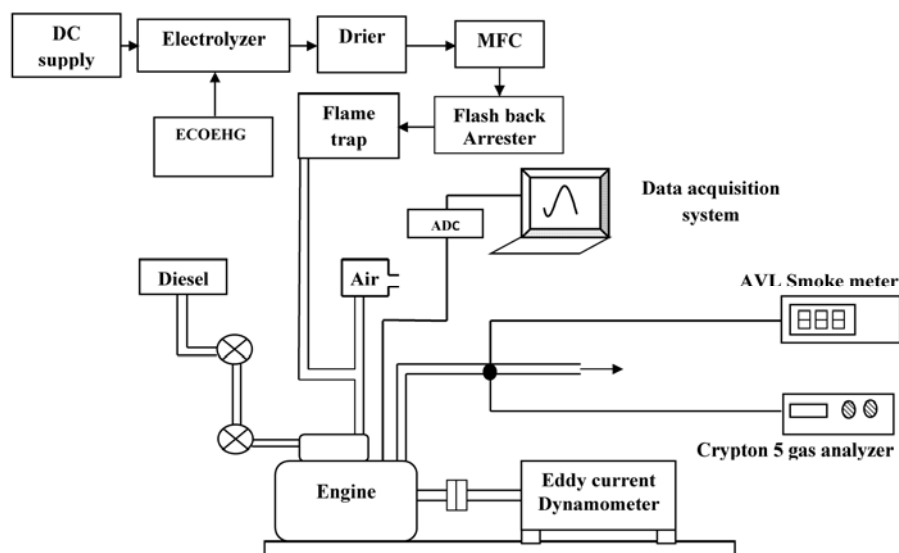| Specifications of test engine	
Make and Model	Kirloskar, SV1
General	4-Stroke / Vertical
	Compression
Type	Ignition
Number of Cylinder	One
Bore	87.5 mm
Stroke	110 mm
Cubic capacity	661 cc
Clearance Volume	37.8 cc
Compression Ratio	17.5: 1
Rated Output	5.9 kW
Rated Speed	1800 rpm
Combustion Chamber	Hemispherical Open
Type of Cooling	Water Cooled

Fig. 1. Schematic arrangement of experimental setup

4. EXPERIMENTAL PROCEDURE

When the DC power of 12V was supplied, the potential difference across the anode electrodes and the cathode electrodes along with the aqueous electrolyte solution of the sodium hydroxide present in the electrolyzer produce oxygen enriched hydrogen gas by the process of water electrolysis. The produced gas was then passed through a drier, flashback arrestor and flame trap before being enriched with the inlet air

supplied to the engine. Drier was used to remove the moisture content present in the gas mixture. Flashback arrestor and flame trap were used to suppress the flame if a back fire from the engine occurred. In this experiment, pure petroleum diesel combustion with the ambient air temperature of 30^0C was taken as a base reading to compare the performance and emission characteristics of the test engine with varied ambient air temperatures operating under the influence of oxygen enriched hydrogen gas with a flow rate of 4.6 lpm at different brake power conditions of the test engine, i.e., from no load (0%) condition to full rated load (100%) condition. All experimental data were collected thrice, after the engine reached the steady state.

5. RESULTS AND DISCUSSION

a) Brake thermal efficiency

Brake thermal efficiency is an important metric in analyzing the engine performance, and can be defined as the rate of energy required to produce unit kilowatt of power [19]. Figure 2 displays the variation of brake thermal efficiency with brake power for oxygen enriched hydrogen gas of 4.6 lpm of flow rate with IAT25 and IAT35. From the graph, it is concluded that the brake thermal efficiency increases, when the combustion process is influenced by oxygen enriched hydrogen gas. When the inlet air temperature is IAT35 and at rated brake power of the engine, the brake thermal efficiency increases from 24.32% to 28.30%, a 16.37% increase compared to pure petroleum diesel combustion. When the inlet air temperature is IAT25 at the same rated brake power of the engine, the brake thermal efficiency increases from 24.32% to 28.46%, an increase of 17.02%.
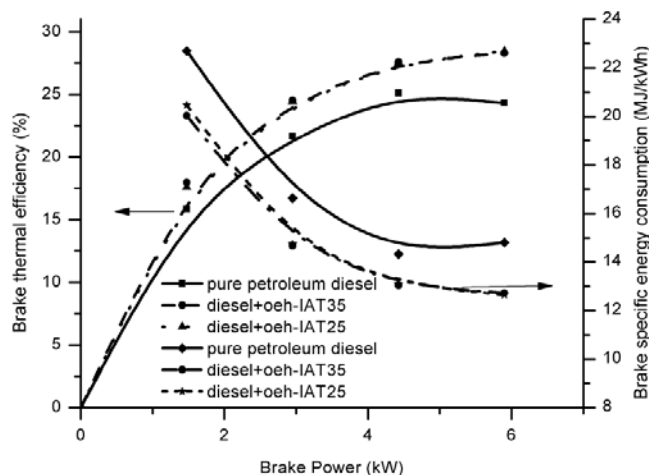

Fig. 2. Variation of brake thermal efficiency & brake specific energy consumption with varied brake power

This increase in brake thermal efficiency is due to the dual effect of catalytic action of oxygen enriched hydrogen gas and the increase in vaporizing rate of fuel droplets due to change in inlet air temperature [14]. Increasing the inlet air temperature along with hydrogen gas mixture makes the combustion of higher grade and causes a reduction in exhaust emissions. Higher heat content of hydrogen present in the gas mixture, its high flame velocity and also, due to the presence of atomic hydrogen and oxygen in the gas mixture, as they are highly energetic compared with their dual molecule counterparts [20]. Because of this quality, when the ignition is initiated by petroleum diesel, they immediately start to fracture the heavier hydrocarbon molecules of diesel fuel and initiate the chain reactions. This resulting in high-temperature atmosphere combustion and higher brake thermal efficiency than petroleum diesel.

On the other hand, oxygen enriched hydrogen gas with IAT25, when introduced at 25% of rated brake power of the engine results in reduction of brake thermal efficiency compared to IAT35 for the

same rated brake power. This reduction is due to, at low load conditions the combustion of hydrogen-air mixtures is dependent on the local temperature around parcels of air-fuel mixtures [21].

b) Brake specific energy consumption (BSEC)

Figure 2 represents the effectiveness of oxygen enriched hydrogen gas of 4.6 lpm of flow rate with IAT25 and IAT35 on the brake specific energy consumption (BSEC) of the test engine at various brake power conditions. At rated power of the test engine, and for inlet air temperature of IAT35, the BSEC decreases from 14.8 MJ/kWh to 12.72 MJ/kWh; when 4.6 lpm of oxygen enriched hydrogen gas is introduced in the combustion of petroleum diesel, it decreases by 14.06% compared to pure petroleum diesel combustion. At the same time, when the inlet air temperature is IAT25, the BSEC decreases by 14.55% compared to pure petroleum diesel combustion.

When analyzing the graph of BSEC, it is clear that the BSEC decreases when oxygen enriched hydrogen gas with IAT25 and IAT35 is used in the engine. This decrease in BSEC is due to the combined effect of oxygen enriched hydrogen gas and the change in inlet air charge temperature. When the inlet air charge temperature is increased, the vaporization rate of fuel droplets is high [14]. When the temperature is reduced such as IAT25, the mass of air inducted into the combustion process increases [18]. It results in more oxygen concentration which results in enhanced combustion. Also, due to high heating value of the hydrogen present in the gas mixture, operation of the hydrogen-fueled engine at the leaner equivalence ratio [22] and also the rate of combustion is high due to faster chain reactions initiated by atomic hydrogen and oxygen present in the gas mixture after the start of diesel ignition resulting in decreased BSEC.

On comparing the BSEC at IAT25 and IAT35 at rated brake power of the test engine, the BSEC is low when the engine is operated with IAT25. Since with IAT35 the mass of air inducted into the combustion process is less due to its high temperature and low density, it decreases overall concentration of oxygen in the mixture and ultimately results in high BSEC and low efficiency compared to IAT25.

c) Carbon monoxide (CO)

The effectiveness of oxygen enriched hydrogen gas on Carbon monoxide (CO) emission of the test engine is represented by Fig. 3. This graph is made for 4.6 lpm of flow rate of oxygen enriched hydrogen gas with inlet air temperature of IAT35 and IAT25 at various brake power of the test engine. When the combustion is incomplete, carbon monoxide forms during the combustion process. When oxygen enriched hydrogen gas with change in inlet air charge temperature is used in the engine, it results in lower quantity of carbon monoxide emission.
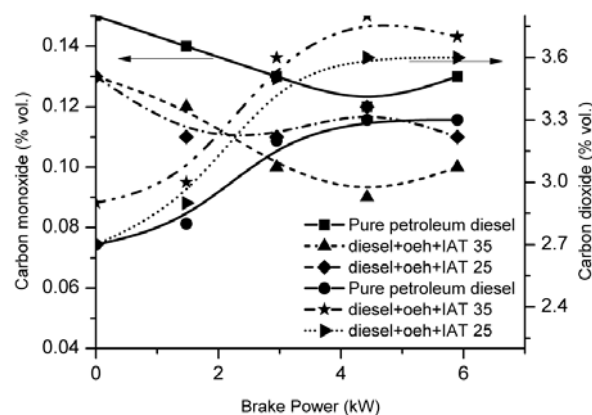

Fig. 3. Variation of carbon monoxide emission & carbon dioxide emission with varied brake power

At rated power of the test engine, 4.6 lpm of oxygen enriched hydrogen gas with inlet air temperature of IAT35, the CO emission decreases from 0.13% vol. to 0.10% vol., by a decrease of 23.08% compared to pure petroleum diesel combustion. This decrease in CO emission is due to higher efficiency combustion of oxygen enriched hydrogen gas, and the faster oxidation reactions resulting due to increased vaporization rate of fuel-air mixture along with atomic hydrogen and oxygen present in the gas mixture. This further enhance the combustion process and overall ratio of H/C when oxygen enriched hydrogen gas is used in the combustion of petroleum diesel.

d) Carbon dioxide (CO$_2$)

The CO$_2$ emission of the test engine is shown by Fig. 3, for 4.6 lpm of flow rate of oxygen enriched hydrogen gas with inlet air temperature of IAT35 and IAT25 at various brake power conditions. If the degree of combustion of fuel and air mixture is high, the CO$_2$ emission will be more. Probably, the same thing happens during the combustion influenced by the oxygen enriched hydrogen gas with change in inlet air charge temperature.

When oxygen enriched hydrogen gas of 4.6 lpm with IAT35 is introduced at the rated brake power of the engine, CO$_2$ emission increases from 3.3% vol. to 3.7% vol., by an increase of 12.12%. The CO$_2$ emission increases because of the high degree combustion obtained due to higher catalytic action of gas mixture. The high flame velocity of oxygen enriched hydrogen gas associated with high diffusing property and the high oxidation reactions initiated due to change in inlet air charge temperature makes the fuel-air mixture more homogeneous and resuls in more CO$_2$ emission when the combustion is initiated by diesel combustion. At rated brake power of the test engine at IAT25, the CO$_2$ emission increases from 3.3% vol. to 3.6% vol., by an increase of 9.09%.

e) Oxides of nitrogen (NO$_X$)

Figure 4 displays the graphical representation of the NO$_X$ emission during combustion assisted by oxygen enriched hydrogen gas, supplied to the engine at 4.6 lpm of flow rate with inlet air charge temperature of IAT35 and IAT25 at various brake power conditions of the engine. NO$_X$ is formed in the combustion process because of three factors; high temperature, sufficient oxygen concentration, and residence time. If these three factors are present in a combustion process, the NO$_X$ formation is more. On analyzing Fig. 4, the NO$_X$ emission increases when oxygen enriched hydrogen gas with change in inlet air charge temperature is used in the combustion process of pure petroleum diesel.
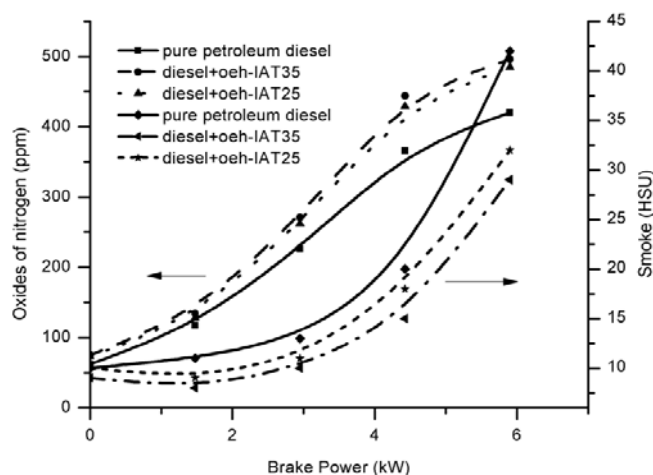

Fig. 4. Variation of oxides of nitrogen emission & smoke emission with varied brake power

When the flow rate of oxygen enriched hydrogen gas of 4.6 lpm with IAT35 is inducted at full rated brake power of the engine, the NO_X emission increases from 420 ppm to 496 ppm compared to pure petroleum diesel combustion, it results in an increase of 18.1%. At IAT25, the NO_X emission increases from 420 ppm to 485 ppm, resulting in an increase of 15.48%. This increase in NO_X emission is due to high temperature produced by change in inlet air charge temperature associated with high flame velocity of the hydrogen present in the gas mixture. It results in a spontaneous combustion as a result of enhanced pre-mixed combustion phase of oxygen enriched hydrogen gas when ignition is assisted by pilot diesel fuel. When the pre-mixed combustion phase is enhanced, the temperature and the pressure developed during the combustion process are high. Because of this, the rate of heat release and rate of pressure increase are also higher in case of oxygen, enriched hydrogen gas with change in inlet air charge temperature influenced diesel combustion.

f) Smoke

Figure 4 analyzes the amount of smoke emitted by the test engine during its combustion, when pure petroleum diesel is combusted and when petroleum diesel with 4.6 lpm of flow rate of oxygen enriched hydrogen gas with inlet air temperature of IAT35 and IAT25 is combusted, at different brake power conditions of the test engine.

When oxygen enriched hydrogen gas with change in inlet air charge temperature is inducted into the combustion process, the smoke reduces substantially. If the heavier structure of fuel molecules is fractured into lighter and smaller hydrocarbon structures in quick time, the homogeneous mixture can be formed. This is what probably happens when oxygen enriched hydrogen gas with change in inlet air temperature is aspirated into the combustion process of the diesel engine. When oxygen enriched hydrogen gas of 4.6 lpm with IAT25 is inducted at rated brake power of the engine, the smoke is 32 HSU compared to pure petroleum diesel combustion of 42 HSU, by a decrease of 23.81%. At IAT35, the smoke emission decreases from 42 HSU to 29 HSU, by a decrease of 30.95%. On comparing the smoke emission at IAT25 and IAT35, the smoke emission at IAT25 is higher because of the low oxidation reactions. It results in low adiabatic temperature prevailing in the combustion chamber, due to inferior grade combustion compared to IAT35 combustion.

g) Unburned hydrocarbon (UBHC)

Figure 5 represents the variation of UBHC emission, when the test engine is operated under the influence of oxygen enriched hydrogen gas of 4.6 lpm with inlet air charge temperature of IAT35 and IAT25. When 4.6 lpm of gas mixture with IAT35 is inducted into the combustion process, it results in 51 ppm at rated brake power of the engine, at the same time the pure petroleum diesel combustion results in the UBHC emission of 66 ppm, i.e., by a reduction of 22.73%. At IAT25, it results in the reduction of 18.18% of UBHC emission.

This reduction in percentage of UBHC emission is due to more oxygen concentration present in the overall fuel mixture, the high burning velocity causes rapid flame propagation in hydrogen combustion engines resulting in an intense convection of the burning gas and a large heat transfer from the burning gas to the combustion chamber walls [16]. Also, the flame quenching distance of the hydrogen present in the gas is 0.064 cm [8], the high fracturing action of heavier hydrocarbon molecules by atomic hydrogen and oxygen present in the gas mixture [20], and increased vaporization rate of fuel due to change in inlet air temperature resulting in high-grade combustion and less UBHC emission compared to petroleum diesel.
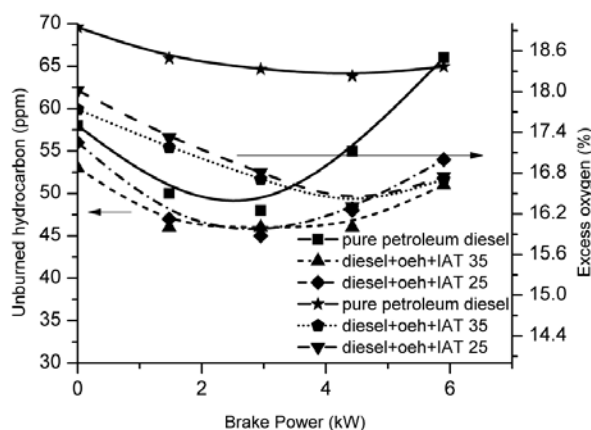
Fig. 5. Variation of unburned hydrocarbon emission & excess oxygen in exhaust with varied brake power

h) Excess oxygen (O₂)

Figure 5 displays the effect of oxygen enriched hydrogen gas addition on the excess oxygen present in the exhaust emission of a test engine at different engine brake power conditions and for flow rate of 4.6 lpm of gas mixture with inlet air charge temperature of IAT35 and IAT25. On analyzing the graph, the 4.6 lpm of oxygen enriched hydrogen gas with change in inlet air temperature resulting in reduction in oxygen percentage in the exhaust of the diesel engine.

When 4.6 lpm flow rate of oxygen enriched hydrogen gas with IAT25 is aspirated into the combustion process at rated brake power of the test engine, the excess oxygen present in the exhaust is 16.75%, whereas the pure petroleum diesel combustion results in 18.37%, i.e., by a reduction of 8.82%. At the same time, when oxygen enriched hydrogen gas with IAT35 is introduced in a combustion process of petroleum diesel it results in decrease of the excess oxygen in the exhaust as 9.04%.

This is due to the strong oxidizing ability of oxygen enriched hydrogen gas associated with change in inlet air charge temperature, because of the higher vaporizing rate of fuel molecules due to the high-temperature atmosphere present in the combustion chamber, overall high percentage of oxygen, high rate of fracturing capability of atomic hydrogen and oxygen present in the oxygen enriched hydrogen gas mixture, and subsequent increase in the oxidation rate of lighter hydrocarbons resulting in reduction in oxygen emission.

i) Heat release rate (HRR)

Figure 6 compares the heat release rates of oxygen enriched hydrogen gas of flow rate of 4.6 lpm with inlet air temperature of IAT35 at rated brake power of the engine and pure petroleum diesel combustion at the same rated brake power. The heat release rate during oxygen enriched hydrogen gas with change in inlet air charge temperature influenced combustion of petroleum diesel is more compared to pure petroleum diesel combustion. The heat release pattern of oxygen enriched hydrogen gas displays a peculiar characteristic of more premixed type combustion compared to typical diffusion type combustion of diesel fuel. The pure petroleum diesel combustion results in 80 J/CAD, whereas the peak heat release rate of 92 J/CAD is achieved when the combustion is influenced by oxygen enriched hydrogen gas of flow rate of 4.6 lpm with IAT35. This increase in heat release rate is due to high flame speed associated with high diffusivity of hydrogen and higher vaporizing rate of fuel molecules due to high temperature as a result of change in inlet air charge temperature. These facts make the fuel-air mixture more homogeneous and creates spontaneous combustion when oxygen enriched hydrogen gas is ignited by pilot petroleum diesel. The maximum heat addition also occurs nearer to TDC in oxygen enriched hydrogen gas with

change in inlet air charge temperature of IAT35 assisted combustion process, which results in higher brake thermal efficiency also.
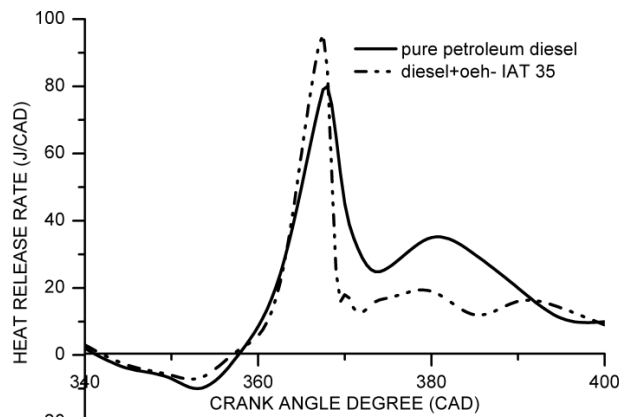

Fig. 6. Variation of heat release rate with crank-angle

j) In-cylinder pressure

Figure 7 shows, the in-cylinder pressures developed during 4.6 lpm of oxygen enriched hydrogen gas with IAT35 assisted petroleum diesel combustion and in-cylinder pressure developed during the combustion of pure petroleum diesel. When oxygen enriched hydrogen gas with IAT35 is added into the combustion process of petroleum diesel, the ignition delay decreases by 1^0. When the inlet air charge temperature is increased, ignition delay period decreases due to increase in the vaporization rate of the fuel-air mixture [14].
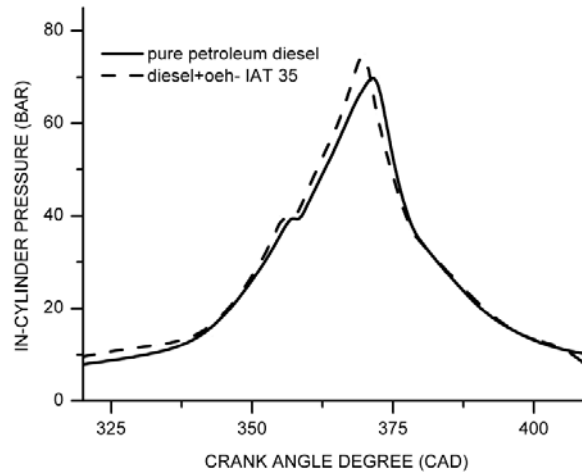

Fig. 7. Variation of in-cylinder pressure with crank-angle

When oxygen enriched hydrogen gas with IAT35 enhance the combustion of petroleum diesel, the combustion is spontaneous and intense. As the pre-mixed burning phase enhances, it creates high pressure and high temperature inside the combustion chamber resulting in higher thermal NO_X also. From the graph, it is evident that a small drop followed by an immediate hike in the pressure curve is due to the heat observed by fuel droplets during their vaporization from surrounding heated air presented in the combustion chamber. When oxygen enriched hydrogen gas of 4.6 lpm with IAT35 is introduced to the combustion process at rated brake power of the engine, it results in the peak pressure of 75 bar. In pure petroleum diesel combustion, the peak pressure results in 70 bar, by an increase of 5 bar. The rate of pressure rise is also higher, as a result of spontaneous combustion of the gas mixture.

6. CONCLUSION

From the data of the present investigation of using oxygen enriched hydrogen gas of 4.6 lpm with change in inlet air charge temperature in the combustion process of DI diesel engine, it is concluded that the engine fuel economy can be increased considerably, and the all engine-out emissions except NO_X emission can be reduced effectively. On analyzing the practical perspective of the above enhancement, it still needs improvement. Since, when the electrolysis process runs continuously, the temperature of electrolyte increases which in-turn draws more power. Hence temperature control/and cooling of electrolyte is important temperature for sensors can be incorporated in the setup.

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