

Experimental Investigation of Performance of Acetylene Fuel Based Diesel Engine

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Abstract

People have been working seriously in the search for best alternative fuels to safeguard the environment ever since the transportation and industrial fields started growing widely. Among such alternatives acetylene has proved to be a better fuel for internal combustion engines due to its low cost, simplicity in manufacturing and excellent combustion characteristics. Moreover it has less carbon content compared to other fuels, which plays a central role in environmental degradation. However the fuel must be safe and environmentally friendly and also readily usable in existing engines without any significant design modifications. Acetylene is produced in parallel to the engine operation taking proper care to avoid back firing. We propose in the present study that acetylene be the safe and appropriate fuel for a compression ignition engine. Diesel engine is selected with a subsidiary mixing box for a homogeneous mixture of air and acetylene. The experiments are conducted with fixed acetylene flow rates from 0.1Lit/min to 5Lit/min with an increase of 0.5Lit/min in every step. The engine is tested at various loads, keeping track of combustion performance to find out the optimum fuel flow rates and also to have reduced emissions. The results show that the performance of the Acetylene enriched engine is nearer to the pure diesel engine with reduced emissions. It is concluded that acetylene could be the better alternative fuel without compromising brake thermal efficiency and safe operation with a moderate increment of smoke and NOx.

Keywords: Diesel engine; Acetylene; Combustion; Hc; Co; CO₂; NOx

Introduction

Among the internal combustion engines, compression ignition (CI) engines are widely used. These engines give superior power output and consistent performance at all loads. Diesel is the prime fuel for CI engines. In the search of alternative fuels for diesel engines many fuels were experimented and successfully replaced, but at the sake of performance and emissions. The self-ignition temperature of acetylene which is actually drawn from the energy sources that are renewable is really exceptional and therefore more explicitly suitable for spark ignition engines. But in case of compression ignition engines they are not generally designed for gaseous fuels. Nevertheless dual fuel suitability and design modifications are being done and implemented successfully. The Engines were also designed and used with gaseous fuels in dual fuel mode but were not successful. Emergent industrialization, limited reserves of fossil fuels and alarming environmental pollution necessitated to search for some more alternatives of conventional fuels. This ultimately resulted in fuels like CNG, LPG, Acetylene, ethanol, methanol, biodiesel, some vegetable oils and other such biomass resources. Alternative fuels should be easily available, should also have higher calorific value and should be non-polluting. Good quality fuel should fulfill environmental and energy needs without compromising the performance of the engine. Acetylene has many such qualities to be a good fuel among other alternative fuels because of its calorific value and combustion efficiency. NOx emission is a significant challenge for such an engine.

Lean-burn technology with conventional and modified diesel combustion strategies would give encouraging results. Recent technologies like advanced combustion strategies which makes use of high levels of intensity to reduce the in-cylinder NOx formation and post-combustion emissions control devices can be opted. Nevertheless, carrying cylinder and arresting the backfiring restricted the use of acetylene as a fuel in automobiles. We have worked out a system with which the acetylene can be used as an automobile fuel with better performance on par with Diesel engine.

Literature Review

Sharma et al. [1] explained the method to employ acetylene as an alternative energy source IC engines. They have conducted experiments on SI engine using acetylene as a primary and alcohol as a secondary fuel. Final results showed that alcohol can be introduced so as to reduce the in cylinder temperatures of the engine. Nagarajan and Lakshamanan [2] studied about the performance and also the emission quality of a compression ignition engine suitable for multi fuel operation, by timed manifold injection to induct acetylene at different flow rates. Results show that best possible condition as manifold injection with 10° ATDC with the injection interval of 90° crank angle. Fixed quantity of 3 L/m of acetylene is supplied to the inlet manifold in dual fuel mode. The results on the internal combustion engines with a primary fuel as diesel under different working loads during experiments were encouraging. The diesel engine working on dual or multi fuel system is noticed to give a lesser thermal efficiency at full load. The experiments conducted by Nagarajan and Lakshamanan on acetylene aspirated engine reported optimistic results. It was really

interesting under a dual fuel system operating at higher loads. The experiment was performed on a single cylinder engine with direct injection system at rated power at different loads. The air aspirated with acetylene resulted with lower thermal efficiency. But the amount of smoke declined, CO and HC emissions were comparable to the baseline diesel engine. The accelerated combustion rate and higher temperatures NOx formations are significantly increase as acetylene was inducted into the cylinder. As the flame travelled very rapidly the peak pressure rises in the case of the acetylene aspirated engine. It is experimentally proved that the emissions of such engines are quite encouraging since the smoke, hydrocarbon and carbon monoxide levels are noticed to be lower. However the efficiency of the engine is sacrificed in such case.

Mahla et al. [3] Experimented on diesel engine with acetylene aspiration and blended it with diethyl ether at a rate of 12 L/m into the inlet manifold. In search engine the source of ignition was diesel, which was the primary fuel. The functioning of the diesel engine which used pilot fuel and Di Ethyl Ether (DEE) showed better thermal efficiency and hence the performance was better compared to the standard diesel engine. Acetylene as a sole fuel in HCCI mode resulted in higher thermal efficiencies, and it is also better suited for a wide spectrum of brake mean effective pressure. If the inlet charge temperature is increased the brake thermal efficiency reaches its maximum at certain exhaust gas recirculation condition in addition to the temperatures of the inlet air. At higher brake mean effective pressures the re-circulated exhaust gas is normally at higher temperatures, and that in turn causes uncontrolled combustion or detonation. Therefore the amount of EGR is controlled accordingly. The experiments conducted on direct injection single cylinder engine by Gunea, Razavi and Karim et al. [4] has been verified experimentally. Another important case is the nature of the pilot fuel system and its importance on the delay period of engine. This was also investigated for wide ranges of cetane numbers. The ignition delay time, mainly depends on fuel quality and quantity of the pilot fuel in the engine. If high cetane number fuels are used, then the performance of the engine improves.

John et al. [5] described the explosion of a cylinder containing acetylene gas, which occurred in 1993 in Sydney. In this paper, he describes the failure and the conditions that affected with it. The assessment says that the explosion, which occurred, needs an explanation of the events. In the experimental investigations by Swaminathan, et al. [6] mainly on HCCI engine with charge consisting acetylene has shown better thermal efficiency for a wide spectrum of mean effective pressure. It has been proved that such an engine is able to reach the same efficiency levels as that of the baseline diesel engine. With exhaust gas recirculation it has been experimentally proven that there is an improvement in the thermal efficiency of such HCCI engines. In accordance of the output of the engine at high BMEP and EGR, the temperature of the intake charge and quantity of EGR can also be controlled which generally leads to knocking. However, it is clear that acetylene is used as a homogeneous charge in CI engines and that it reduces the smoke and NOx. However, when there is an increase in hydrocarbons in the flue gases as compared to the standard diesel engine.

Possible Alternative Fuels

Many fuels are tested and made available to replace the fossil fuels in IC Engines. Fuels can be Classified into 3 forms, viz. Solid, liquid and gaseous fuels.

Acetylene gas

Acetylene is a colourless and highly combustible gas with a pungent odour. If it is compressed, heated or mixed with air, it becomes highly explosive. It is produced by a straightforward chemical process in which calcium carbide reacts with water and generates acetylene gas and slurry of calcium carbonate. It needs no sophisticated apparatus or equipment and the reaction is spontaneous. It was widely used in acetylene lamps, to light homes and mining tunnels during 1980s. It is a gaseous hydrocarbon highly combustible and unstable. It also produces high flame temperatures ranging from 3000°C to 5400°C when combined with oxygen. Acetylene has been commonly utilized for lighting in mine areas by street vendors, besides which industrial uses of acetylene are many out of which it is used as a fuel for motors or lighting sources. The use of acetylene as a fuel has been largely limited in the recent times to acetylene torches for welding or welding-related applications. The easy availability of economical and effective fuel which has better calorific value and effective flame speeds motivated to study and experiment on acetylene engine.

Methodology

The specifications of the engine which has been selected for the experimentation are tabulated in Table 1 and Table 2 lists the physical properties of acetylene. The experimental setup is as shown in Figure 1 which illustrates the setup clearly.

Properties	Acetylene	Hydrogen	CNG
Composition	C ₂ H ₂	H ₂	CH ₄ :86.4-90% C ₂ H ₆ :3-6% C ₃ H ₈
Density (kg/m ³) at 1 atm & 200°C	1.092	0.08	0.72
Autoignition temp (K)	598	845	723
Stoichiometric A/F ratio (kg/kg)	13.2	34.3	17.3
Flammability limit (vol %)	2.5-8.1	4-74.6	5.3-15
Lower Calorific Value (kJ/kg)	48,225	120000	45800
Ignition energy (mJ)	0.019	0.02	0.28

Table 1: Properties of gases.

The tests were conducted on naturally aspirated single cylinder, four-stroke, direct-injection, water cooled engine. The nominal injection timing of the engine is 19 crank-degrees before top dead center and fixed throughout the test. The experimental setup also comprises a data acquisition system to measure the in cylinder pressure. Diesel injected and acetylene was supplied separately with air through the flow control valve in order to attain the controlled flow. Chemical reaction of Calcium Carbide with water resulting in acetylene (C₂H₂) and lime sludge. This can be done on site. Proper acetylene to diesel ratio could give better performance characteristics and thus leads to higher thermal efficiency.

The experiment was conducted for different compression ratio starting from 6.5 with fixed acetylene gas flow rates at 0.1 L/m, 0.5 L/m, 1.0 L/m, 2.0 L/m, 3.0 L/m, 4.0 L/m and 5.0 L/m. The optimum

flow rate was experimentally found and based on the nature of proper combustion and emission characteristics at different loads for optimum performance is noted. Acetylene flow was controlled and gauged by a flow control valve and was calibrated by a gas flow meter. Diesel was measured by noting the times at regular intervals in the fixed quantity or amount of diesel sent to the engine. The flow meter is used to measure the flow of acetylene the range of flow meters are 0 lpm – 1 lpm and also 1 lpm – 40 lpm. Air From the atmosphere and acetylene from the generator is mixing in the mixing box and directed to engine cylinder during suction. The purpose of mixing box is to mix air and acetylene properly.

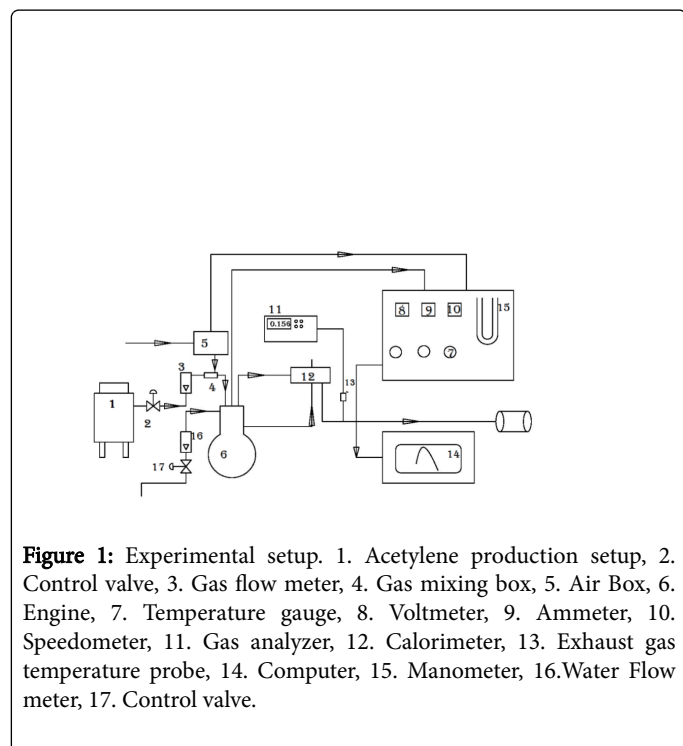


Figure 1: Experimental setup. 1. Acetylene production setup, 2. Control valve, 3. Gas flow meter, 4. Gas mixing box, 5. Air Box, 6. Engine, 7. Temperature gauge, 8. Voltmeter, 9. Ammeter, 10. Speedometer, 11. Gas analyzer, 12. Calorimeter, 13. Exhaust gas temperature probe, 14. Computer, 15. Manometer, 16. Water Flow meter, 17. Control valve.

Equipment	Specification
Engine	Single Cylinder 4-stroke Diesel Engine Kirloskar AV- 1
Rated Power	3.7 KW, 1500 RPM
Bore-Stroke	80mm x 110mm
Compression Ratio	16.5 : 1 range 14.3 to 20
Cubic Capacity	553 CC
Dynamometer	Alternator
In Cyl-Pressure	Piezo Sensor, Range : 2000 PSI
Software Used	Lab View
Type	4-Stroke Single Cylinder Diesel Engine, Water cooled

Table 2: Specifications of the engine.

To determine the pressure variation, a transducer was used. With a thermocouple we found out the temperature of exhaust gases from the

engine. The heat release rate and other combustion parameters were calculated using software in order to get the accurate results. Using the smoke meter, engine exhaust smoke was determined from the combustion chamber. The engine performance and emission characteristics of acetylene enriched modified engine was evaluated and compared with the basic diesel engine working on the simple diesel engine.

Results and Discussions

Peak pressure

The in cylinder pressure and its variation along the engine combustion process is a matter of greater importance to really understand the nature of the engine. Figure 2 is presented which is obtained from P-θ diagram. The peak pressure is more or less reaching to 58bar when the engine is running at full load. As the charge is enriched with acetylene gradually starting from 210 g/h to 280 g/h to 351 g/h the pressures were also found gradually raising from 61bar to 73bar and 78bar respectively when experimented on full load. It was noticed that the pressure is declined when compared to the baseline diesel engine in the same way at regular intervals even gradually at a rate of 4% to 3% at 110 g/h and 180 g/h of charge flow into the chamber respectively and brought the diesel efficiency at 240 g/h of charge flow. If the charge supplied to the engine is advanced little bit the peak pressure is also restricted to that of the diesel engine. The advancement of 30 CA, 40 CA and 50 CA at 210 g/h, 280 g/h and 351 g/h of charge were supplied respectively. The reason for high in cylinder pressures in acetylene enriched combustion engine is possibly due to sudden and instantaneous burning of mixture.

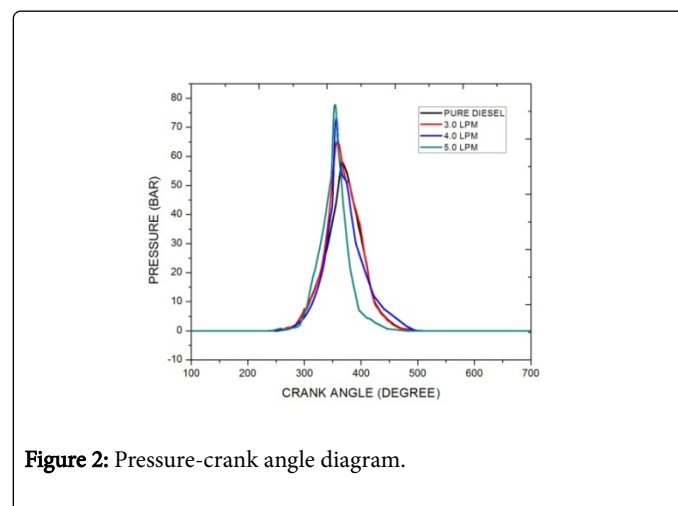


Figure 2: Pressure- crank angle diagram.

It is certainly much higher compared to a diesel engine under normal working conditions. The polytropic compression index is diverse altered from 1.27 to 1.29 at 210 g/h to 280 g/h of flow rate of the mixture. The deviation is due to the presence of acetylene which is a gaseous fuel as subsidiary to the diesel engine.

Heat release rate

The Heat release rate is another most important parameter which can give an idea about the amount of heat released during combustion of acetylene enriched fuel of an engine.

In Figure 3 it has been shown that at full load the maximum rate of flow of charge, i.e. mixture of acetylene and air is around 240 g/h. The heat release rate at such flow rates can be evaluated from P-θ such calculations are performed for 100 cycles of engine operation. The power output mainly depends on the rate of burning of the charge in the cylinder during the combustion. The rate of burning of the charge is categorized into phases, the heat release rate diagram would elaborate about such phase as delay period phase, premixed combustion phase, mixing and regulated combustion phase and late or delayed combustion phase in diesel engine operation. In the same way acetylene combustion also goes through four stages. The Pre-oxidation reaction of the charge is the first stage, the actual burning of the charge is second stage. However the third stage/phase is quite similar to the primary charge burning, which is premixed combustion phase. Particularly in gaseous fuels the fourth stage is more or less a kind of diffusion based combustion phase. The energy availability after combustion is based on the heat release rate (Hrr) of acetylene. Acetylene based engine shows a combination of premixed combustion phase and diffusion combustion as well. However the premixed combustion is for a brief time period, but prolonged diffusion combustion is the noticeable fact which really deviates from the baseline diesel engine.

Figure 3 clearly elaborates that at a rate of flow of charge at 240 g/h gives out the maximum heat, which is measured as 72 J/°CA. On the other hand, for smooth diesel engine operation, it is found to be only 64 J/°CA.

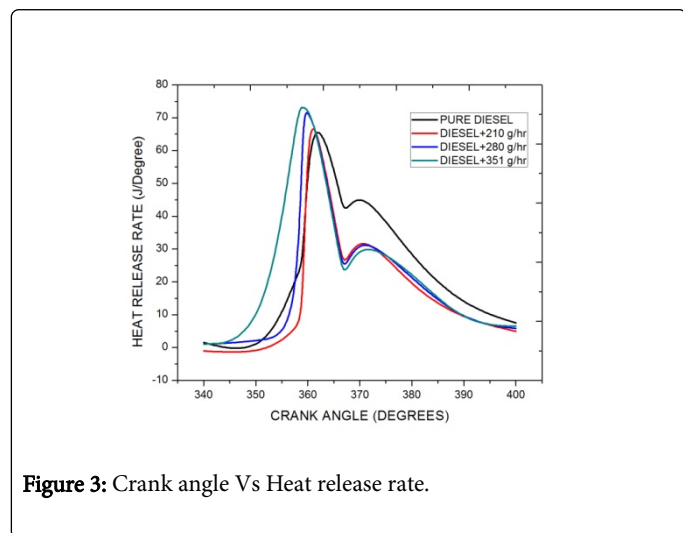


Figure 3: Crank angle Vs Heat release rate.

Brake thermal efficiency

The nature of change of brake thermal efficiency with respect to brake power at different flow rates of acetylene is shown in Figure 4. The ratio of brake power to energy input is accounted as a familiar brake thermal efficiency; obviously the brake thermal efficiency of the base line diesel engine and the engine sourced with acetylene enriched charge should be evaluated. The results were quite corroborative to the previous discussion and at full load the efficiency is about 24% with the supply of 351 g/h of enrichment. Though the efficiency is decreased to 23% at the 280 g/h of acetylene, it has stabilized at 23%, even if the enrichment of the air is decreased to 210 g/h. If the efficiency of the diesel engine is noted on the other hand it is about 25%, without the enrichment of air with acetylene. The nature of thermal efficiency in acetylene charged engine is quite peculiar in view of the fact that it

decreases at lower loads, but eventually increases to more than the standard diesel engine at full loads.

Here it is noticed that the engine is not equally efficient at all loads. The part load efficiency is poor and the reason for that might be due to rapid rate combustion. To counter it the charge is ignited at little advanced crank angles and the maximum pressure is higher at such angle. It can be explicitly observed that the replacement of diesel is not uniform throughout the engine loadings. But varies during part loads and full load, it is experimentally observed that the engine efficiency is also increasing as the charge is rich in acetylene.

The enrichment is to be increased as the air flow rate is increasing, this is due to the acetylene rich charge in the combustion chamber. When the charge is rich the combustion is normal at full loads and it can be inferred that the additional acetylene is active in the cylinder.

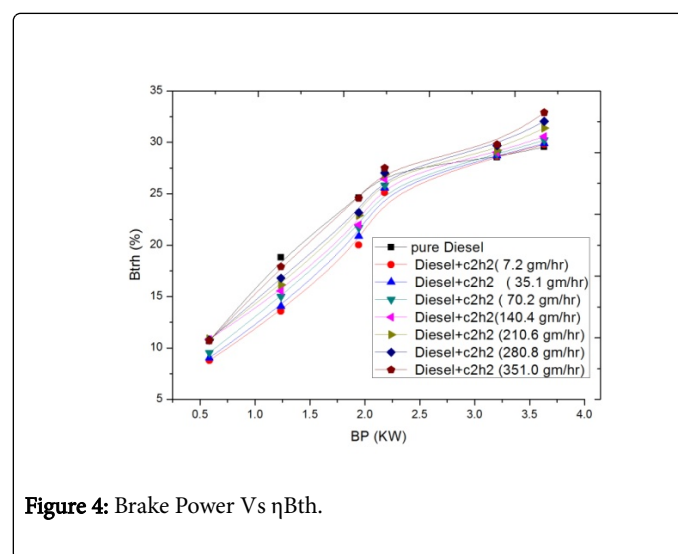


Figure 4: Brake Power Vs η_{Bth} .

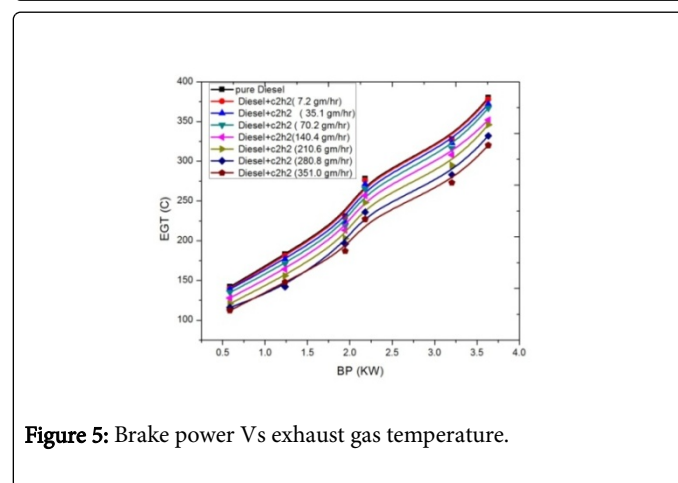


Figure 5: Brake power Vs exhaust gas temperature.

If we see the exhaust gas temperature of the base line diesel engine. P-θ diagram gives the maximum in-cylinder pressure and the rate of combustion energy released into the enriched engine can be obtained with the appropriate heat release rate calculations. It is also noticed that the in cylinder pressure increases at the same rate as the rate of intake of air into the engine. The heat loss from the cylinder increases due to higher thermal conductivity of gases this might be one of the reasons for lower exhaust gas temperature.

Temperature (Exhaust gas temperature)

The Majority of the engine emission implicitly or explicitly depends on the combustion temperature and the prominent parameter that can be measured in experimentation is the exhaust gas temperature. In the present case the combustion behavior is concentrated mainly at full load which is depicted in Figure 5. At about 210 g/h of acetylene that is

added to the air the measured exhaust gas temperature is 3800°C. The temperature decreases to 3700°C if the acetylene supply is increased to 280 g/h. This goes on decreasing till 3600°C as the acetylene enrichment is raised to 351 g/h. The energy ratios have been calculated as the energy of acetylene is divided by the energy of total fuel and tabulated in Table 3.

Load (Kw)	0.1 lpm	0.5 lpm	1.0 lpm	2.0 lpm	3.0 lpm	4.0 lpm	5.0 lpm	6.0 lpm
0.5	0.018	0.0948	0.0037	0.0084	0.0141	0.0161	0.0211	0.0231
1	0.0146	0.0731	0.0027	0.006	0.011	0.0159	0.0209	0.0259
1.5	0.012	0.0633	0.002	0.0044	0.0081	0.0118	0.0155	0.0192
2	0.0098	0.0498	0.0017	0.0036	0.0059	0.0082	0.0105	0.0128
2.5	0.0088	0.0445	0.0015	0.0031	0.005	0.0069	0.0087	0.0106
3	0.0077	0.0394	0.0013	0.0028	0.0043	0.0058	0.0072	0.0087

Table 3: Energy ratios calculated as the energy of acetylene is divided by the energy of total fuel.

Oxides of nitrogen (NOx)

It could be clearly observed from Figure 6 that NOx emission is 5.38 g/kWh. The NOx is about 4.38 g/kWh, which is recorded when the supply of acetylene is 351 g/h. It is 4.12 g/kWh if the supply is reduced to 280 g/h. 4.66 g/kWh at 210 g/h of acetylene enriched charge. However the equivalence ratio was not kept constant throughout the experiment, but actually varied from 0.63 to 0.68 and finally to 0.71 respectively. It is explicitly clear that there is a significant drop in the NOx emission compared to the diesel engine. If we observe from the experimental facts the amount of NOx constantly dropping from 12% at 210 g/h, 9% at 280 g/h and 7% at 351 g/h enriched charge in contrast with the standard diesel engine.

can also be corroborated with the phase duration and also premixed combustion data from the heat release rate (HRR) diagram.

Smoke

The reason for the emission of engine smoke is attributed to the proper burning of the fuel. The fuel is basically hydrocarbon and any improper combustion leads to the emission of smoke from the engine. Mainly at part load conditions if the fuel rich zone is present in the cylinder it leads to the pyrolysis of the hydrocarbon which is the major source of smoke. Generally, if the engine is operated under heterogeneous mixtures conditions which are similar to the mixture condition used in CI engines, charge consumption will be there due to the diffusion flame therefore smoke is formed during such a phase. Its quality is also a key criteria for the engine designers which depend on the key parameters viz. Fuel injection timing and the process of combustion during the preparation phase and actual burning phase.

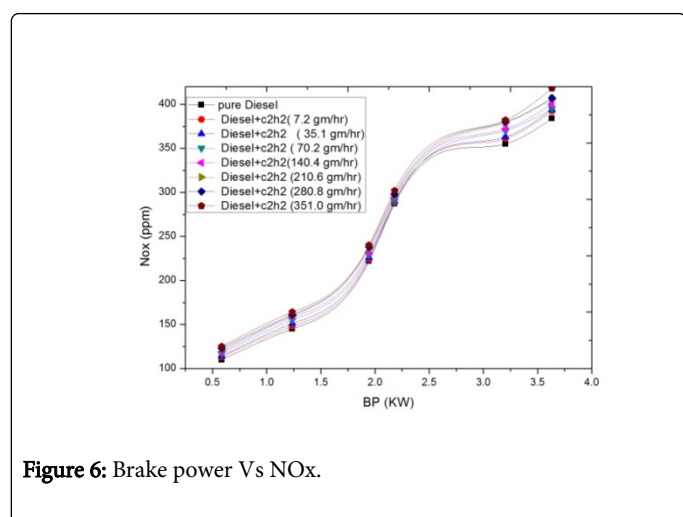


Figure 6: Brake power Vs NOx.

The Zeldovich mechanism infers that actually NOx formation is primarily because of the reaction temperatures in the combustion chamber. Not only the reaction temperature, but it also depends on the availability of oxygen in the combustion chamber for the proper reaction and the formation of the products. Therefore the decrease of the nitrous oxides is clearly attributed to lean mixture combustion. It

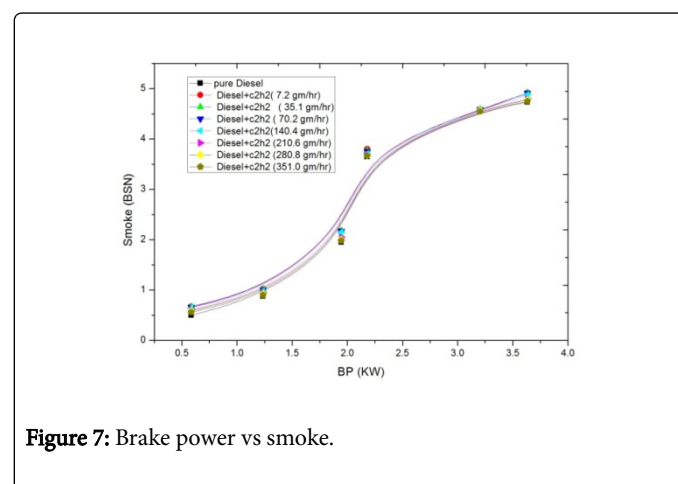


Figure 7: Brake power vs smoke.

It is quite obvious that the fuel flow rate is directly proportional to the smoke and it is noticed that 4BSN (Bosch smoke number) is the baseline diesel engine smoke reading. The smoke and soot level obviously increases because acetylene is the forerunner in the

formation of soot during the combustion. As the enriched gas flows at a rate of 240 g/h it is noticed that the smoke is increased by 5%. This continued still further and at 180 g/h smoke was found to be 8% and it was 12% at 180 g/h of supply of acetylene. All the measurements were made on full load conditions only and the enrichment of acetylene was through inlet manifold and also during the suction stroke itself which is totally different from the baseline diesel engine Figure 7.

The other prominent engine emission is Hydro-Carbons (HC). These emissions are essentially due to the unburned fuel particles in the vicinity of engine cylinder near the walls and crevices. At moderately low temperatures such emissions are more and become dormant. Hydrocarbons stay unburned at such narrow passages and settles on the surface as the fire does not entirely spread into these territories and consume the charge. Compression Ignition engines produce lesser HC emission compared to SI engines because they are work with lean fuel charge. The HC in emission is constantly lower in acetylene fuelled engine than diesel fuel operation at all charges. At part loads the HC emissions are comparatively more compared to full loads. In case of acetylene enriched engine the variation is almost in the same manner; however, it alters in accordance with the charge flow rates. At normal charge flow rates the HC emission is noted as 0.31 g/kWh for the load of 0.5 whereas it decreases to 0.07 g/kWh at full load in the baseline diesel engine. On the other hand, in case of acetylene enriched engine the HC emission is found to be shifting from 0.26 g/kWh at intermediate loads and falls to 0.06 g/kWh at full load. However it prominently depends on the charge flow rate into the combustion chamber. If noted the charge flow rate of the above emissions of acetylene enriched engine is around 210 g/h, and the equivalence ratio (ϕ) is 0.71. For the ratio of 0.68 and the charge flow rate of 280 g/h the HC emission almost changing from 0.23 to 0.05 g/kWh, if noted at part load and full load. This trend is again repeated for the higher charge flow rates as well. It can be verified from the Figure 8 that at the flow rate of 351 g/h, the emission is noted to change from 0.68 to 0.22 g/kWh whereas the ϕ , the ratio is 0.63.

This clear cut experimental result confirms that the complete combustion of the charge is taking place in the combustion chamber. It is appropriate to widen the limits of the ignition temperatures and leaner operation of the engine and the specific energy content released is quite practical and constructive to operate such an engine.

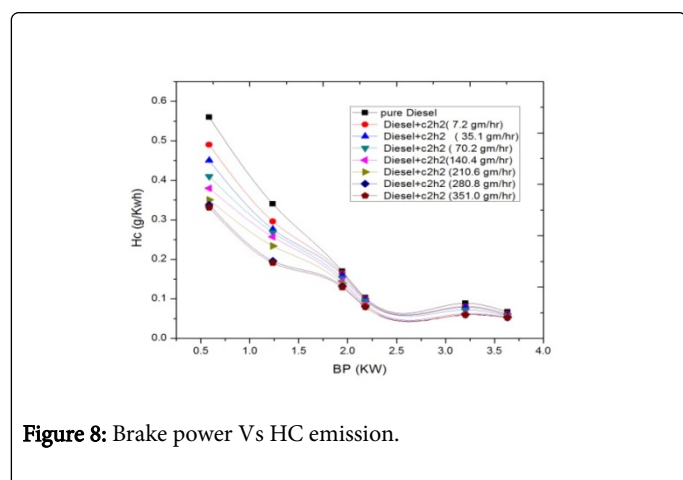


Figure 8: Brake power Vs HC emission.

Carbon monoxide (CO)

An observation of Figure 9 shows that carbon monoxide emission also exhibits a similar trend as that of hydrocarbon emissions. Under full load conditions the CO emissions were lower compared to the baseline diesel engine. No matter what rate of charge flow, the maximum CO emitted is found to be 0.54-0.56 g/kWh with respect to the variation of equivalence ratio (ϕ) through 0.71 to 0.63.

It is quite obvious that CO emission is noticed to be comparatively higher for rich mixtures due to insufficient oxygen availability for the combustion which properly converts from carbon into carbon dioxide. The emission of CO is a bit lower in the case of acetylene enriched engine operation; this might be due to the operation of modified engine on a lean mixture. However the exhaust gas temperatures are comparatively lower.

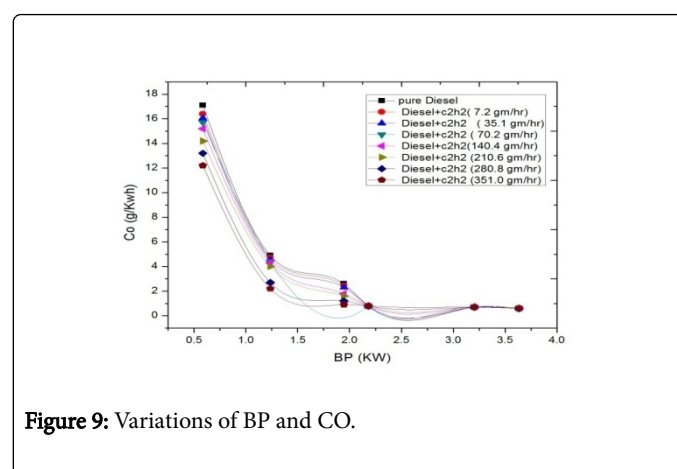


Figure 9: Variations of BP and CO.

Carbon dioxide (CO₂)

Another most important engine emission is carbon dioxide CO₂, in the modified diesel engine operation CO₂ emissions are comparatively lower viz. 778 g/kWh to 675.86 g/kWh for the charge flow rates of 210 g/h to 351 g/h, respectively, and it has been proved experimentally. However the variation depends on the charge flow rate as well. Since the charge flow rate is 210 g/h, CO₂ emission is lowered by 5% in comparison with the baseline diesel engine. The same trend continues to even the higher charge flow rates of 280 g/h and 351 g/h where the CO₂ is decreased by 11% to 18% respectively. Nevertheless, the lower C-H ratio of the fuel acetylene gives out lower carbon dioxide emission in the acetylene enriched modified engine Figure 10.

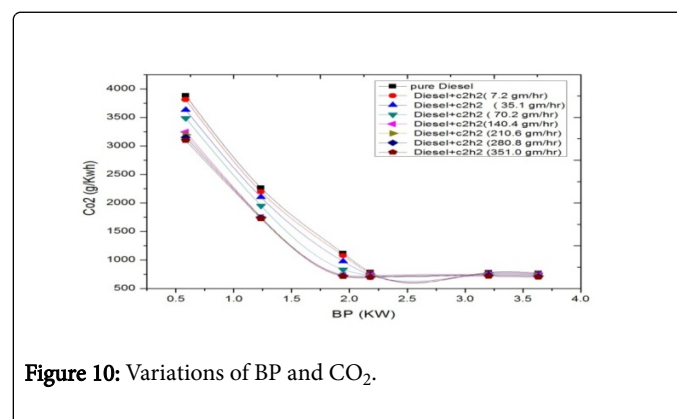


Figure 10: Variations of BP and CO₂.

Conclusions

The experimental work was conducted to study and recognize the capability to execute and run such an engine which uses acetylene enhanced charge by blending acetylene with the air that is supplied amid suction stroke into the chamber, and moreover the quality of emission gases of such modified diesel engine. The following conclusions were drawn after careful analysis and observation.

The essential conclusion that we make is that it is promising to work a diesel engine of the direct infusion sort easily with stable ignition utilizing acetylene as an improved fuel to the engine air and by changing the acetylene stream rate from 7.2 g/h to 280 g/h with no unusual burning in the engine. In the event of faster stream rates it further increases and there is a tendency of knocking inclination in the ignition.

With little modifications in the diesel injection timing and quantity of acetylene added to the inlet air the optimum fuel flow rate is 5Lpm and better brake thermal efficiency can be achieved. It is experimentally verified and proved that the optimum injection timing is 60bTDC and correspondingly the acetylene enrichment is about 280 g/h for the modified engine. Therefore, it can be concluded that compared to the standard diesel engine the modified engine is 8% more efficient. However the NOx emission comparatively increases by 6.4% at 110 g/h and continuously scales up to 6.5% at 210 g/h, and stays steady at 6.5% for further increase of charge which is quite dissimilar to the standard engine which works at full load.

On the other hand the smoke levels do not follow the same trend as the NOx are but they steadily grow. At a charge input of 280 g/h it was only 1.04%, which rose up to 3.07%. Hydrocarbon emissions were noticed to be diminishing to be marginal in comparison with standard

diesel engines. It is almost 17% less in acetylene enriched engine when compared to a diesel engine.

The CO in engine exhaust was seen unimportant when compared with the benchmark diesel engine. However, CO₂ also decreased from 4.8% to 7.65% of the charge flow rates of 140 g/h to 280 g/h respectively.

At last it is reasoned that the acetylene rich diesel engine is constructible and safe to operate without major design modifications, with reduced hydrocarbon and carbondioxide emission, but in contrast with more NOx emissions and with no noteworthy change in CO emission levels. The thermal efficiency of an engine can be improved with an interesting possibility of acetylene as an IC engine fuel in the years to come.

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