Optimization of Injection Parameters For A Stationary Diesel Engine

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***Abstract*- Experiments were carried out on a 4 stroke single cylinder diesel engine at various injection pressures and injection timings to find the optimum values of the same towards obtaining better performance. The selected engine is made to run at rated speed and varying loads. All the readings were taken while maintaining the cooling water exit temperature at its optimum value. The results showed a better performance with the engine at an injection pressure of 200 bar and Injection timing 110 BTDC.**

Keywords-Diesel engine, optimum injection timing, optimum injection pressure, performance appraisal.

I. Introduction

Due to rapid depletion in the fossil fuel reserves, it is high time now to think about alternatives to the use of petroleum fuels in the diesel engines. Lot of research activities have been taking place in search of suitable alternative to the diesel oil in diesel engines. Before such an alternative is found, it's wise to look for improving the performance of the existing engine by suitable engine modifications. An attempt is made here to study the behavior of an existing diesel engine at various injection pressures and injection timings.

II. Literature review

Srithar Rajoo et.al **[12]** has conducted experiment to evaluate the coolant temperature effect on gasoline engine particularly the fuel consumption. Recent researches in automotive field have been concentrated on alternative fuel due to the fact that crude petroleum oil is becoming scarce. Apart from this, it is equally essential to study into currently available engines and improvise it to reduce fuel consumption. In this effort, an engine used in Malaysian made cars was tested under different coolant temperature and its corresponding fuel performance was recorded. In order to manually alter the coolant temperature, an independent cooling tower was built to be attached to the test engine via hose connection. It was found that, when coolant temperature increased from 70°C to 100°C, the fuel consumption of the engine decreases gradually and stabilizes after 90°C.

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Venkataramana Reddy, et.al **[2]** presented some findings of the use of honge oil and diesel fuel blend in direct injection diesel engine with increased injection opening pressure (IOP). The performance, emissions and combustion parameters of 20% honge oil and 80% diesel fuel (volume basis) were found very close to neat diesel fuel where as higher blend ratios were found inferior compared to neat diesel fuel. Improved premixed heat release rate were noticed with H30 when the IOP is enhanced. Performance and emissions with H30 are even better than neat diesel fuel at enhanced IOP. With increased injection pressure amount of honge oil in blend can be increased from 20% to 30%.

***M. Al-Hasan*, [5]** conducted experiment on a four-stroke four-cylinder spark ignition engine alternatively equipped with CIS and EIS. Fuel consumption; and exhaust emissions included hydrocarbon, carbon monoxide and carbon dioxide were measured as a function of ambient temperature; i.e. 7, 25 and 40ºC. In order to simulate engine operation condition during warm - up period under various ambient temperatures axillaries cooling water and cooling air systems were designed and coupled to the engine being tested. Results show that as the ambient temperature increases the concentration of both hydrocarbon and carbon monoxide and fuel consumption decreases while the carbon dioxide increases. Also, the time required for the engine to fully warm-up is shortened. Moreover, operating the engine when equipped with EIS has a greater effect on HC, CO and fuel consumption reduction compared to When equipped with CIS at the same operation conditions.

Rosli Abu Bakar, et.al **[9]** investigated effects of fuel injection pressure on engine performance. Experiments have been performed on a diesel engine with four-cylinder, two-stroke, direct injection. Engine performance values such as indicated pressure, indicated horse power, shaft horse power, brake horse power, break mean effective pressure and fuel consumption have been investigated both of variation engine speeds - fixed load and fixed engine speed – variation loads by changing the fuel injection pressure from 180 to 220 bars. According to the results, the best performance of the pressure injection has been obtained at 220 bars, specific fuel consumption has been obtained at 200 bars for fixed load – variation speeds and at 180 bar for variation loads – fixed speed. The results of the experiment have given as graphics in this pape

.***Cenk Sayin,*** et.al **[1]** investigated ethanol-blended diesel fuel from 0 to 15% with an increment of 5%. The engine has original injection pressure of 200 bar. The tests were conducted at three different injection pressures (180, 200 and 220 bar) with decreasing or increasing washer number. All tests were conducted at four different loads (5, 10, 15, and 20 N m) for constant engine speed of 2200 rpm. The experimental test results proved that brake thermal efficiency, heat release rate, peak cylinder pressure, smoke number, carbon monoxide and unburned hydrocarbon emissions reduced as brake-specific fuel consumption, brake specific energy consumption, combustion efficiency, and nitrogen oxides and carbon dioxide emissions increased with increasing amount of methanol in the fuel blend. When comparing the results to the original injection pressure, at the decreased injection pressure (180 bar), peak cylinder pressure, rate of heat release, combustion efficiency, and nitrogen oxides and carbon dioxide emissions decreased, whereas smoke number, unburned hydrocarbon, and carbon monoxide emissions increased at all test conditions. On the other hand, with the increased injection pressure (220 bar), smoke number, unburned hydrocarbon, and carbon monoxide emissions diminished, and peak cylinder pressure, heat release rate, combustion efficiency, and nitrogen oxides and carbon dioxide emissions boosted at all test conditions. With respect to brake-specific fuel consumption, brake-specific energy consumption, and brake thermal efficiency, changing injection pressure gave negative results in the all fuel blends compared to the original injection pressure.

Purushothamana K. et.al **[8]** investigated the effect of injection pressure on the combustion process and exhaust emissions of a direct injection diesel engine fueled with Orange Skin Powder Diesel Solution (OSPDS). In the present investigation the injection pressure was varied with 30% OSPDS and the combustion, performance and emissions characteristics were compared with those of diesel fuel. The different injection pressures studied were 215 bar, 235 bar and 255 bar. The results showed that the cylinder pressure with 30% OSPDS at 235 bar fuel injection pressure, was higher than that of diesel fuel as well as at other injection pressures. Similarly, the ignition delay was longer and with shorter combustion duration with 30% OSPDS at 235 bar injection pressure. The brake thermal efficiency was better at 235 bar than that of other fuel injection pressures with OSPDS and lower than that of diesel fuel. The NO_x emission with 30% OSPDS was higher at 235 bar. The hydrocarbon and CO emissions were lower with 30% OSPDS at 235 bar. The smoke emission with 30% OSPDS was marginally lower at 235 bar and marginally higher at 215 bar than for diesel fuel. The combustion, performance and emission characteristics of the engine operating on the test fuels at 235 bar injection pressure were better than other injection pressures.

***Murari Mohon Roy*, [6]** investigated the effect of fuel injection timing and injection pressure on combustion and odorous emissions in a direct injection diesel engine. Injection timings from 15 deg before top dead center (BTDC) to top dead center (TDC) and injection pressures from 20 Map to 120 Map were tested. In emissions, exhaust odor, irritation, aldehydes, total hydrocarbon, and hydrocarbon components are compared in different injection timings and injection pressures condition. Injection timings where main combustion takes place very close to TDC are found to show minimum odorous emissions. Moderate injection pressures (60–80 MPa) showed lower emissions including odor and irritation due to proper mixture formation. Below the injection pressure of 40 MPa, and over 80 MPa, emissions become worse. Combustion analysis is performed by taking cylinder pressures after engine warm-up for different injection timings and injection pressures and analyzing cylinder temperatures and heat release rates. Cylinder pressures and temperatures are gradually decreased when injection timings are retarded. Ignition delay becomes shortest at 5–10 deg BTDC injection timings. The peak cylinder pressure and temperature are increased with higher injection pressures. The shortest ignition delay and minimum emissions is found at around 60 MPa of injection pressure.

C J Brace, et.al **[3]** conducted the experiments on effects of cooling system hardware changes on diesel engine emissions and fuel economy. Experiments were performed under both steady state and transient conditions and complemented by statistical assessments. Techniques for assessing the thermal integrity of the engine as a consequence of such changes are also presented. An experimental design was constructed to investigate the effect of water pump throttling, coolant flow control through the oil cooler, and the adoption of a pressure resistive thermostat (PRT). Use of these thermal controls offers a useful trade-off between NO_x and fuel economy, with a saving of around 3 per cent in b.s.f.c. for a 10 per cent NO_x penalty at low load, where NO_x output is less of a concern. However, these benefits were not observed during drive cycle testing.

Ns Bari, et.al **[10]** examined the changes in the behaviour of waste cooking oil (WCO) with changes in injection timing of a direct injection (DI) diesel engine, compared with those of diesel. The aspects taken into consideration were the effects of injection timing on combustion, performance and emissions. The results reveal that WCO and diesel responded identically to injection timing changes. To reduce NO_x emission, one of the methods is to retard the injection timing from MBT timing. The engine used in this research follows this technique and had its original injection timing set at 15Â° before top dead centre (BTDC). With injection timing advanced by 4Â°, the engine produced better e ciency by 1.6 per cent for WCO and by 1.1 per cent for diesel, reduced CO emission, by averages of 9.9 per cent for WCO and 44.9 per cent for diesel, but su ered increased NO emission of 76.6 per cent for WCO and 91.4 per cent for diesel. In all instances, WCO had shorter ignition delays than diesel, but the ignition delay for WCO was more sensitive to load and injection timing than that for diesel.

The test engine could run on WCO with the original injection timing, and altering the timing could result in a trade-o between performance and emission. ***M. I. Nwafor***, **[7]** examined the advanced injection timing on the performance of natural gas used as primary fuel in dual-fuel combustion has been examined. Satisfactory diesel engine combustion demands self-ignition of the fuel as it is injected near the top dead centre (TDC) into the hot swirling compressed cylinder gas. Longer delays between injection and ignition lead to unacceptable rates of pressure rise (diesel knock) because too much fuel is ready to burn when combustion eventually occurs. Natural gas has been noted to exhibit longer ignition delays and slower burning rates especially at low load levels hence resulting in late combustion in the expansion stroke. Advanced injection timing is expected to compensate for these effects. The engine has standard injection timing of 30Â° before TDC (BTDC). The injection was first advanced by 5.5Â° given injection timing of 35.5Â° BTDC. The engine ran for about 5 minutes at this timing and stopped. The engine failed to start upon subsequent attempts. The injection was then advanced by 3.5Â° (i.e. 33.5Â° BTDC). The engine ran smoothly on this timing but seemed to incur penalty on fuel consumption especially at high load levels.

M. Pandian et.al, **[4]** conducted the experiment on Twin Cylinder CIDI Engine Using Bio-diesel Blend as Fuel. Stringent emission norms and environment degradation due to pollutants from the automotive vehicles lead us to find the suitable alternative for the petro-diesel. Among the alternatives the non-edible vegetable oil seems to be most promising one. The transesterification process has proved as one of the best method to achieve the same. It is evident from the literature that the major problem on utilization of blends of bio-diesel is the increase in NOx emission from diesel engines. To reduce the NOx emission from the diesel engines employing biodiesel blend as fuel, the injection timing of fuel is altered by either addition or removal of shims in the pump. The effect of changing the injection timing on BSEC, Brake Thermal Efficiency, CO, HC and NO emissions are studied at different injection timings such as 18°, 21°, 24°, 27° and 30° CA BTDC. From the experiments it is found that on retarding the injection to 18°CA BTDC from 24° CA BTDC, the original injection timing, the NOx emission reduced to about 35% while advancing to 30°CA BTDC, the NOx increased by 25%. The BSEC, CO, HC have been found to increase by about 3%, 12.65% and 10% respectively on retarding to 18°CA BTDC while decrease by 6.27%, 32%,and 14.44% respectively on advancing the injection to 30° CA BTDC. The brake thermal efficiency is reduced by 3.08% on retarding to 18°CA BTDC whereas it is improved by 5.09% on advancing the injection timing to 30° CA BTDC.

III. EXPERIMENTATION

An experimental test rig with necessary instrumentation is selected for test purpose. The engine is mounted on a sturdy mild steel chasis and is coupled with rope brake dynamometer. Fuel consumption is measured with the help of a standard burette and air consumption with orifice fitted to an air box. The rate of coolant flow is measured by a turbine flow meter. The layout of the setup is shown in the Fig.4.1. The technical specifications of the engine were presented in Table4.1.

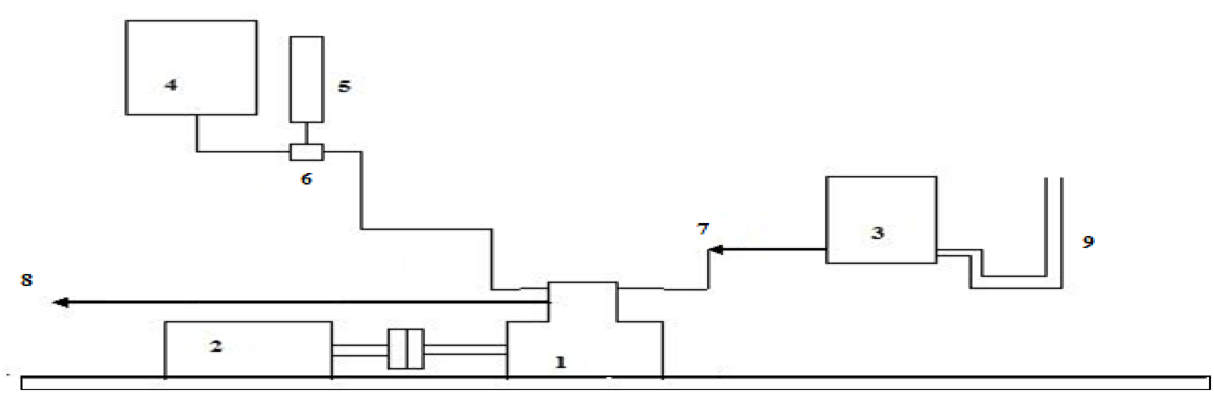

Fig 3.1 Layout of Experimental setup

1. Engine
2. Brake drum dynamometer.
3. Air box
4. Fuel tank
5. Burette
6. Three way valve.
7. Air flow direction.
8. Exhaust flow.
9. Manometer

Table 3.1: specifications of the engine

Power	3.7KW
Speed	1500rpm
S.F.C	247gms/kw hr/182gms/bhp
Compression Ratio	20:1

IV. Results and Discussion

A. *Experimentation at various injection pressures:*

Fig.4.1 shows the variation in BTE with BP at different injection pressures. It can be noted that highest brake thermal efficiency is obtained at an injection pressure of 200bar. The brake thermal efficiencies obtained at full load at an injection pressure of 160bar is 23.43%, at 200bar it is 31.12%, while at 250bar injection pressure, the brake thermal efficiency obtained is 24.45%.

Fig.4.2 shows the variation in mechanical efficiency with Brake power at various injection pressures. It can be observed that the highest mechanical efficiency at full load is obtained with an injection pressure 160bar.

The variation in Exhaust gas temperature with Brake power at different injection pressures is shown in the Fig.4.3. It can be seen that minimum Exhaust gas temperature is obtained at 200bar injection pressure.

From the Fig.4.4 it can be observed that the brake specific fuel consumption is less at 200 bar injection pressure.

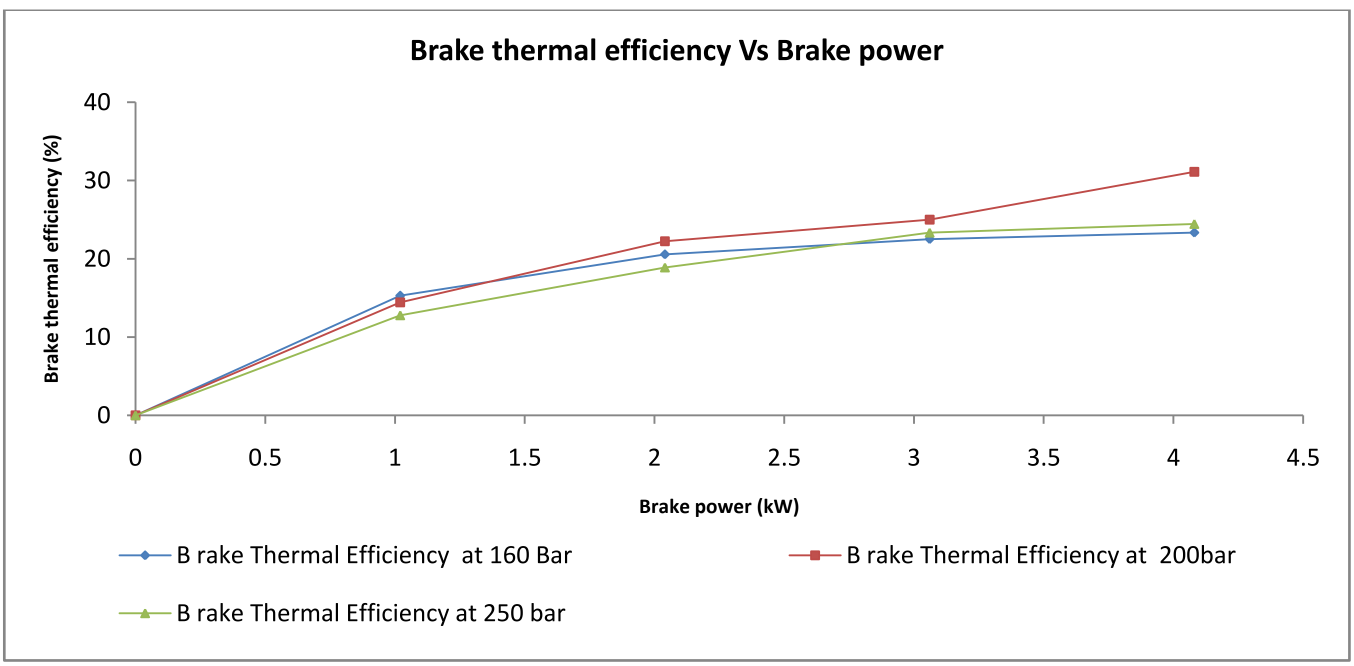

Fig4.1 Brake thermal efficiency Vs Brake power at different injection pressures

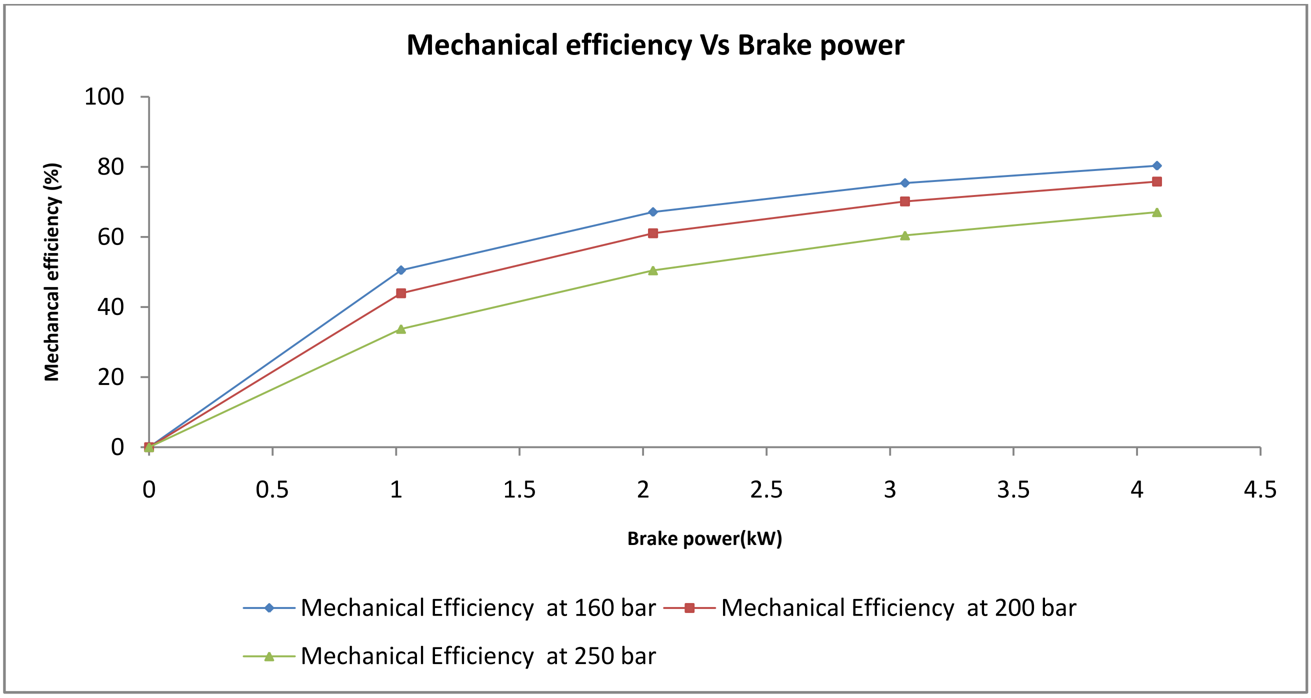

Fig4.2 Mechanical efficiency Vs Brake power at different injection pressures

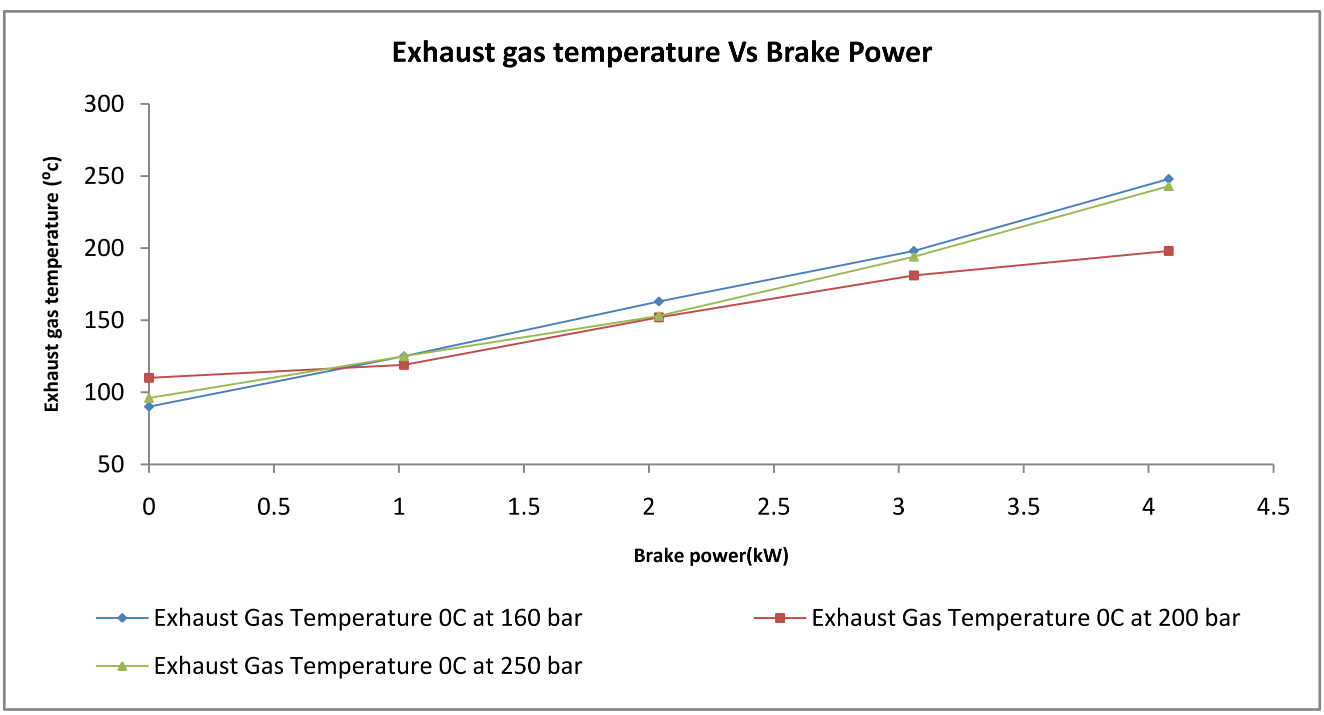

Fig4.3 Exhaust gas temperature Vs Brake power at different injection pressures

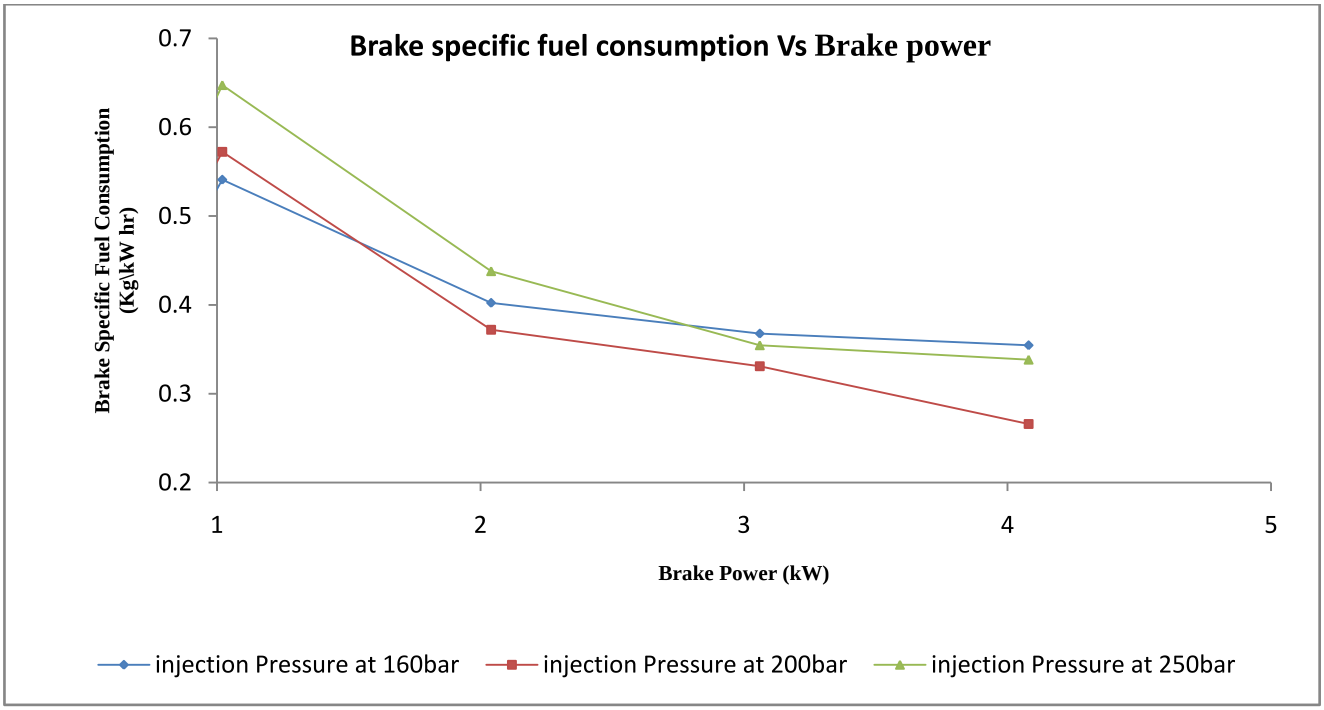

Fig4.4 Brake specific fuel consumption Vs Brake power at different injection pressures

B. Experimentation at various injection timings

Experiments were carried out on the engine test rig at various injection timings namely 11oBTDC and 140BTDC. The results were shown in the Fig 5.5, 5.6,5.7 and 5.8. From the figures it can be observed that 11o BTDC is the injection timing at which we obtain better Brake thermal efficiency, low Brake specific fuel consumption and Low exhaust gas temperatures.

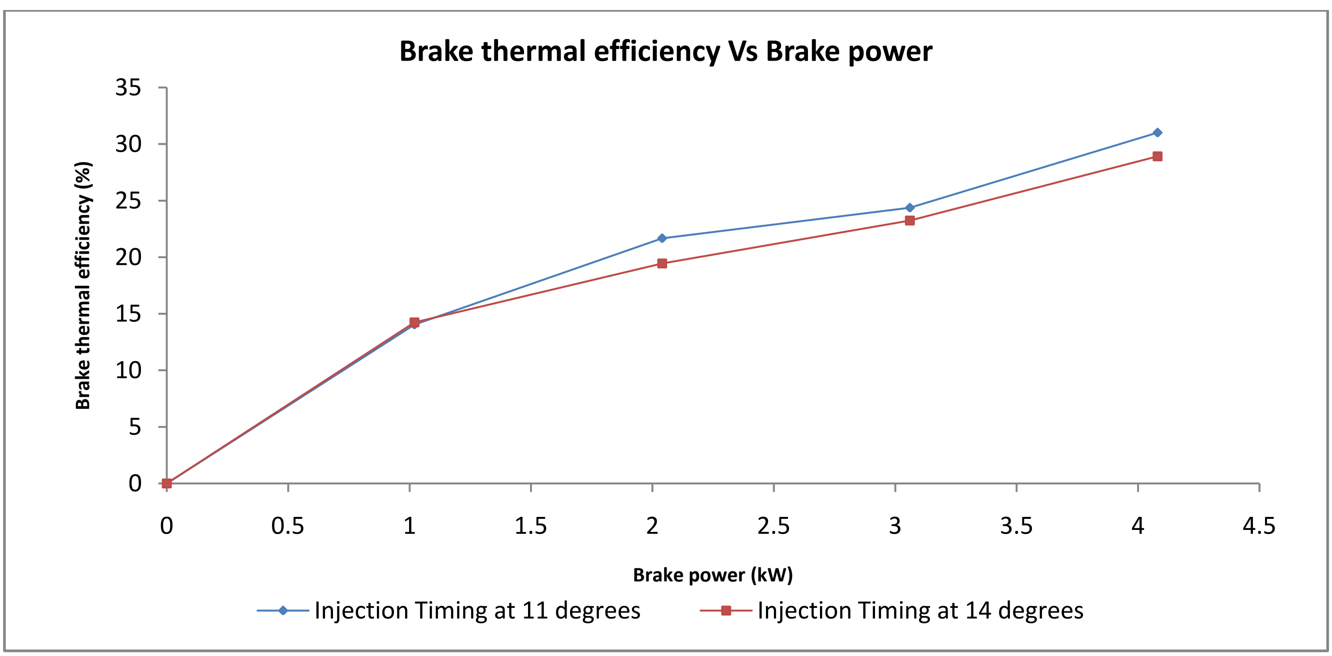

Fig4.5 Brake thermal efficiency Vs Brake power at different injection timings

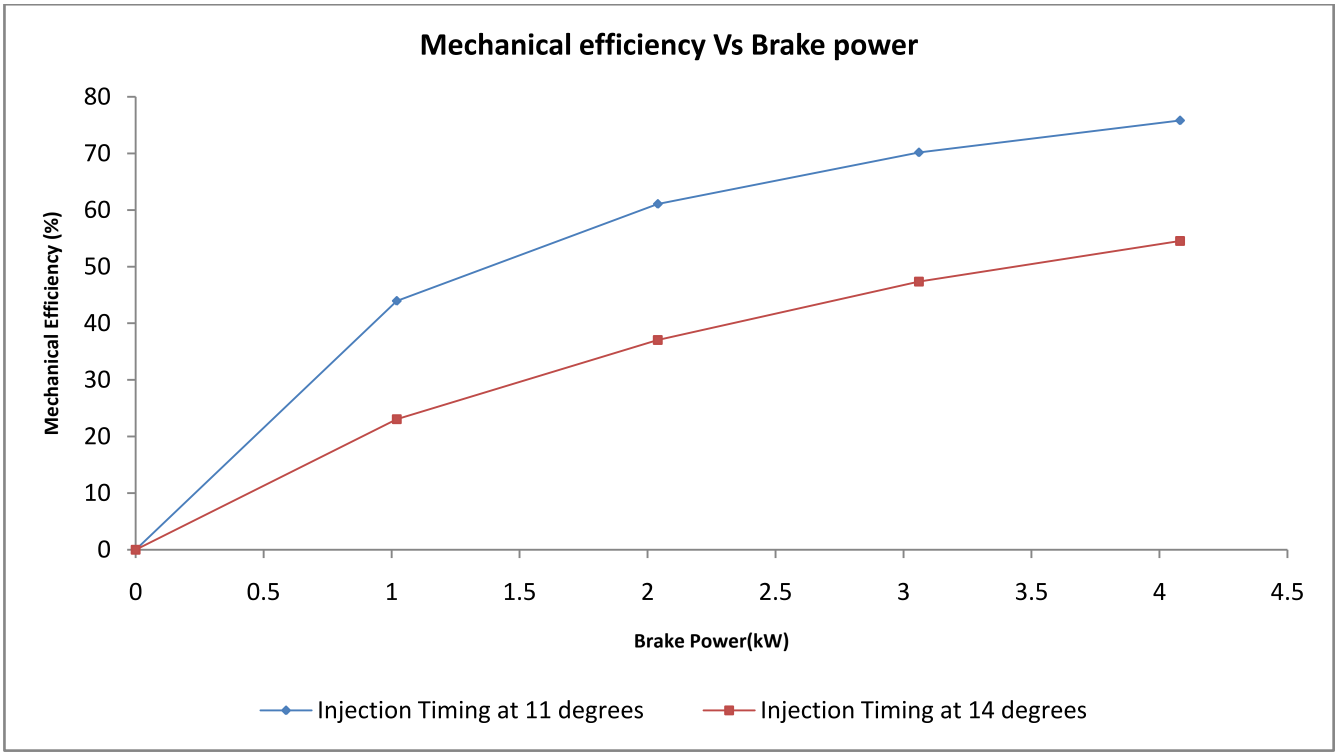

Fig 4.6 Mechanical efficiency Vs Brake power at different injection timings.

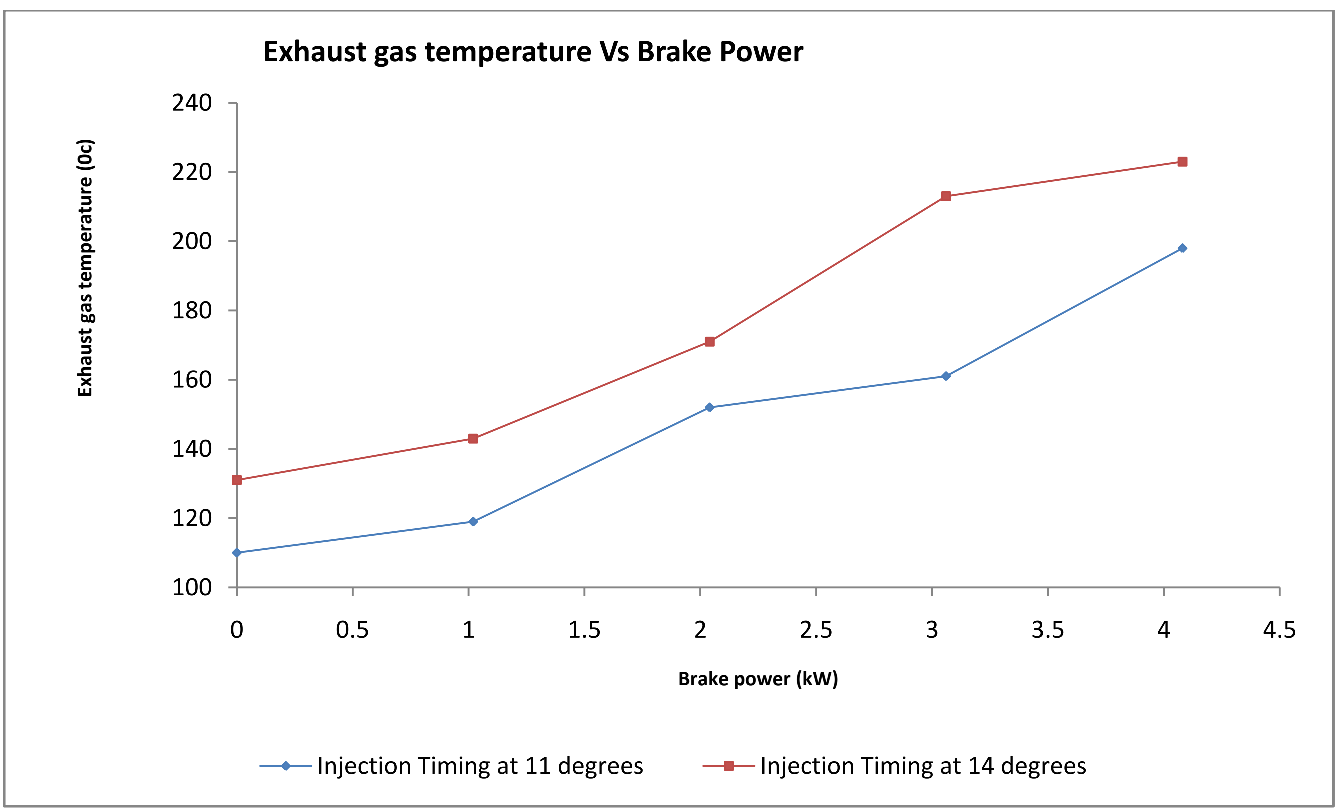

Fig 4.7 Exhaust gas temperature Vs Brake power at different injection timings.

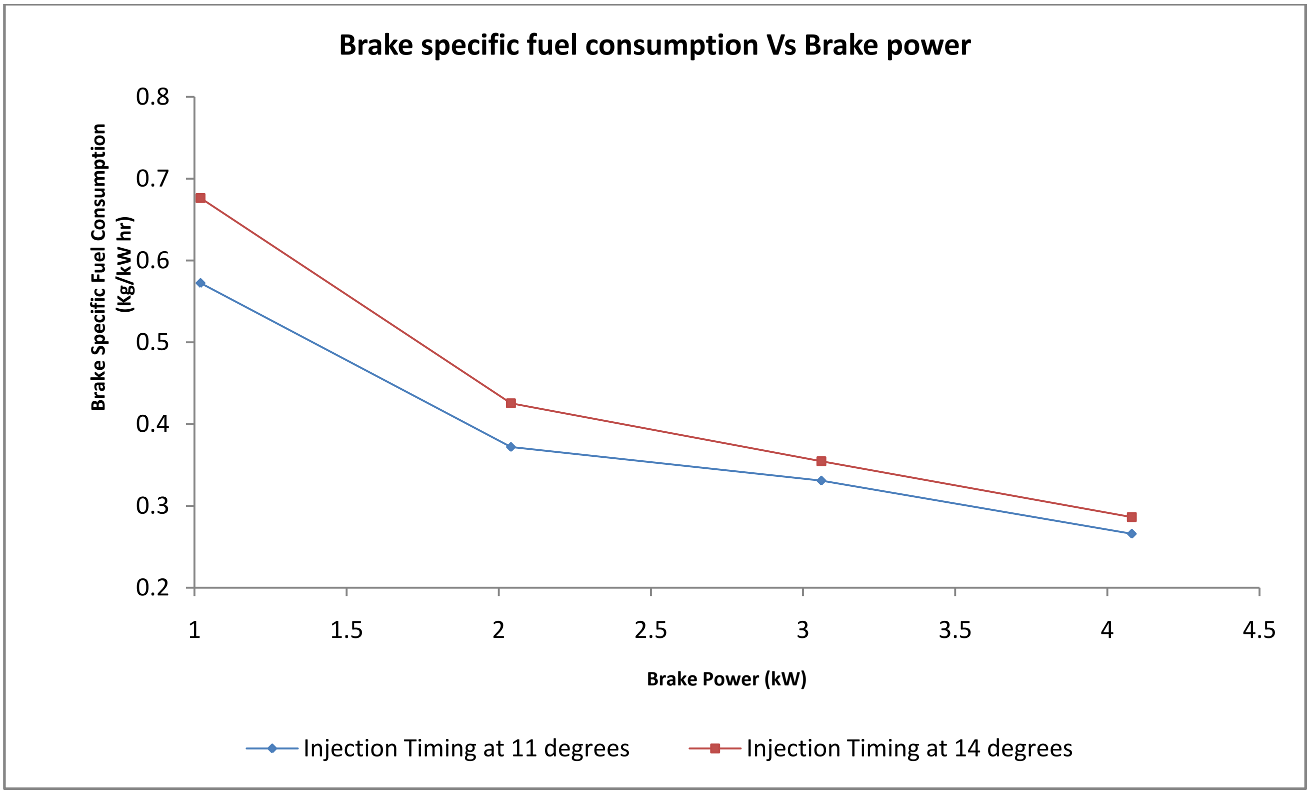

Fig 4.8 Brake specific fuel consumption Vs Brake power at different injection timings.

V. Conclusions

From the experiments carried out on the engine at various injection pressures and injection timings, Following conclusions can be drawn.

At an injection pressure of 200bar and injection timing 11^0BTDC, the brake thermal efficiency is better

The specific fuel consumption is found to be less at 200 bar injection pressure and injection timing 11^0BTDC. However there is a slight increase in frictional power at 200bar pressure.

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