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Experimental Analysis on single cylinder Diesel Engine by varying injection pressure

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ABSTRACT

Aim is to study single cylinder diesel engine to a CRDI (common rail direct injection) and see how the injection pressure affects the performance of the CRDI engine. Diesel engines are used at larger extent for agricultural applications in India. However, performance of these engines are not much improved over the period of time. Hence, a stationary constant speed agricultural based diesel engine was selected for study. The advanced technology in CRDI system was used to control the performance and emission parameters in the stationary constant speed diesel engine, as these engines are slightly neglected for their performance and emission. Thus the engine was converted to CRDI and then the performance was enhanced by increasing injection pressure.

Keywords: Injection Pressure, Diesel Engine, ECU (Engine Control unit), CRDI unit (common rail direct injection).

I. INTRODUCTION

The common rail system prototype was developed in the late 1960s by Robert Huber of Switzerland and the technology further developed by Dr. Marco Ganser at the Swiss Federal Institute of Technology in Zurich, later of Ganser- Hydromag AG (est.1995) in Obergeri. The rest successful usage in a production vehicle began in Japan by the mid-1990s. Dr. Shohei Itoh and Masahiko Miyaki of the Denso Corporation, Japanese automotive parts manufacturer, developed the common rail fuel system for heavy duty vehicles and turned it into practical use on their ECD-U2 common-rail system mounted on the Hino Rising Ranger truck and sold for general use in 1995. Denso claims the rest commercial high pressure common rail system in 1995. Modern common rail systems, whilst working on the same principle, are governed by an engine control unit (ECU) which opens each injector electronically rather than mechanically. This was extensively prototyped in the 1990s with collaboration between Magneti Marelli, Centro Ricerche Fiat and Elasis. After re-search and development by the Fiat Group, the design was acquired by the German company Robert Bosch GmbH for completion of development and refinement for mass-production. Ordinary diesel direct fuel-injection systems have to build up a new pressure for each and every injection cycle, the new common rail (line) engines maintain constant pressure regardless of the injection sequence. This pressure then remains permanently available throughout the fuel line. The engine's electronic timing regulates injection pressure according to engine speed and load. The electronic control unit

(ECU) modifies injection pressure precisely and as needed, based on data obtained from sensors on the cam and crankshafts. This technique allows fuel to be injected as needed, saving fuel. Also, electronic injection allows the injector to have a pilot injection which significantly reduces the noise level and the vibrations in the engine making it smoother and silent in operation. More accurately measured and timed mixture spray in the combustion chamber significantly reducing unburned fuel gives CRDI the potential to meet future emission guidelines such as Euro V. CRDI engines are now being used in almost all Mercedes-Benz, Toyota, Hyundai, Ford and many other diesel auto mobiles.

The Diesel engine, due to its associated fuel consumption efficiency and durability, has become a popular power source for many vehicles. The market share for Diesel powered passenger cars is increasing in world and more than a third of the car buyers choose Diesel-powered cars. Unfortunately, compared to the conventional, catalyst equipped, gasoline engine Diesel engine is notorious for being a source of particulate matter and nitrogen oxides (NOx) emissions in more amount. In order to improve air quality, legislation regarding emissions from mobile sources has tightened considerably over the past 20 years.

The combustion efficiency of an engine improves if the injection pressure increases. This is due to the better atomization and mixing of fuel and air. Also, the combustion chamber geometry effects the mixing of air and fuel and contributes to the performance of the engine. The emissions such as NOx need to be controlled as they are dangerous to humans as well as the nature, thus EGR in the system can limit the NOx emissions. The project deals with converting a single cylinder four stroke diesel engine used for agricultural application to a CRDI engine. This needs addition of some components such as ECU, fuel rail, wiring harness, high pressure fuel pump and different sensors to the conventional engine.

II.LITERATURE REVIEW

2.1 Avinash Kumar Agarwal et al [1] conclude that, a simple and cheaper version of CRDI FIE system for single cylinder, constant speed engines was successfully developed. The ECU and large number of sensors of conventional CRDI system were replaced by simpler electronic circuits and basic sensors in order to control the cost of the system. Effect of SOI timings on this new engine's performance, emissions and combustion characteristics was experimentally investigated. Advanced SOI timings showed higher in-cylinder pressures, higher pressure rise rates and higher heat release rates, primarily due to relatively longer ignition delays. As the engine load increases, relative contribution of premixed combustion phase to the total heat release decreases due to reduction in ignition delay and mixing controlled combustion phase starts to dominate the engine combustion and total heat release process. Maximum heat release rate and peak cylinder pressure shifts away from TDC. For retarded SOI timings, due to the late combustion, peak pressure occurs later in the expansion stroke of this CRDI engine. 34◦ BTDC SOI gives best thermal efficiency. Any variation in SOI timings in either direction leads to a fuel penalty.

2.2 Zhao Jinghua et al [2] concluded that Advanced angle of fuel injection and increased common-rail pressure would result in increased NOx emissions, However, the output of the Soot decreases accordingly; in addition, the increase of the common rail pressure will be helpful to get a appropriate performance between NOx and Soot. Also Different pre-injection strategies would result in different conclusions, if the pre/main interval angle and the quantity of pre-injection are small , the fuel of pre-injection will get the cold-flame, and the timing of combustion will get advanced; if the advance angle of pre-injection and the quantity of pre-injection are large, the fuel of pre-injection will get the exothermic reaction obviously , and the timing of the combustion will get advanced evidently, In addition, the pressure in-cylinder and the temperature profile will get apart from the curve group , and it will result in the increase of NOx.

2.3 LIU Yongfeng et al [3] concluded that one of these new injection systems is the Common Rail System. The CR-System is one in which the high injection pressure is available at all times and not only during the injection periods. The pressure level itself can be freely

selected throughout the complete engine operation range. Another advantage is the benefit of the pilot injection which has a significant effect on reducing noise of direct injection Diesel engines.

2.4 Gyung-Man Kim et al [4] concluded that the characteristics of input sensors and their interface circuits in the engine ECU are analyzed, and the simulator for generating waveforms of all input sensors is implemented by both the 16-bit DSP TMS320LF2407 and host computer. The signals generated in the simulator are nearly the same as those

of actual sensors. The operating conditions and fault situations of engine ECU with a variation of input sensors can be easily observed.

III. OBJECTIVE

- Study of Experimental setup.
- Base data generation of given engine on experimental setup.
- Analysis the engine performance by varying injection pressure.

IV. CONVERSION OF CONVENTIONAL ENGINE TO CRDI ENGINE

As the project involved the changes in the CRDI engine operation through ECU we needed to convert the conventional single cylinder direct injection diesel engine to a CRDI engine as there is no such setup available for testing. The engine that was chosen for the conversion to the CRDI engine is an agricultural based constant speed diesel engine. The engine shown in the Figure 4.1 below is used for the setup and is single cylinder direct injection diesel engine and its specifications can be seen in Table 4.1

Figure 4.1

“TABLE"

4.1 Engine Specifications

Make	Kirloskar
Type	4 stroke, Direct injection, Water cooling
No. of cylinders	01
Bore	87.5mm
Stroke	110mm
Compression Ratio	17.5:1
Capacity	3.73kW (5HP)
Speed	1500rpm
Injection Timing	23^0 BTDC
Type of Loading	Electrical Resistance

V. RESULT AND DISCUSSION

First we take the test on Single cylinder CRDI diesel engine with maximum injection pressure 700bar.The highest brake thermal efficiency was found at 600bar and it decreases for higher pressure at 12 kg load. The quantity of fuel injected increased due to the higher injection pressure and the brake thermal efficiency is decreasing. The variation of brake thermal efficiency at all loads at injection pressure 400, 500,600,650 and 700 bar are shown in Figure-5.1 The brake specific fuel consumption at different loads at injection pressure 400, 500,600,650 and 700 bar are shown in Figure-5.2. At 600 bar pressure we get the less SFC as compared to other injection pressure. As the injection pressure increases the SFC decreases up to certain load and then it increases. The SFC increases and BTE decreases when the fuel injection pressure is increased.

“Graph1”

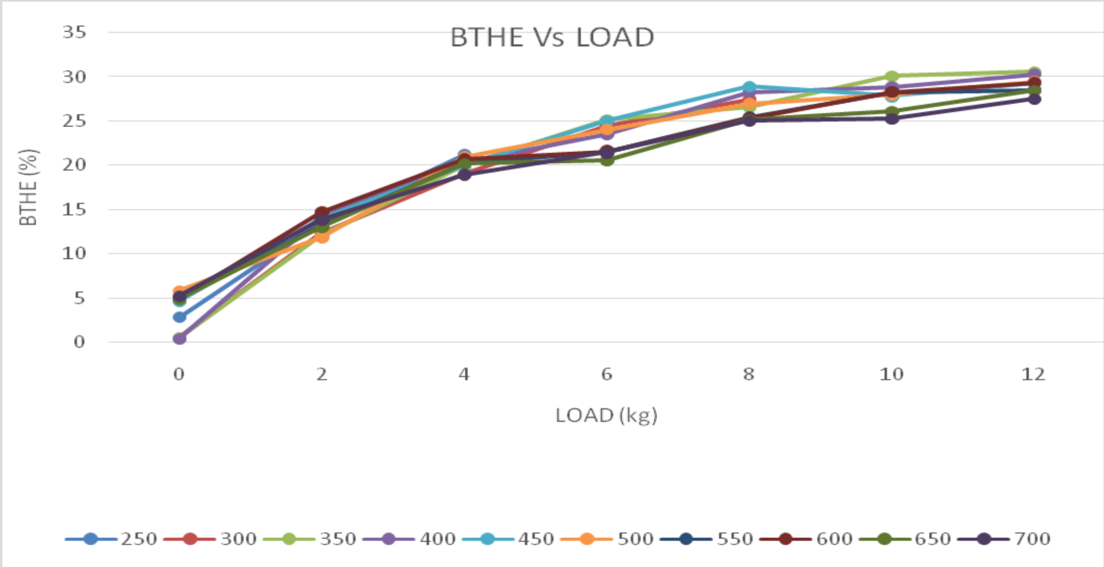

Figure 5.1

For Break Thermal Efficiency

As load increases BTHE also increases. But for the pressure range 350-400 Bar the BTHE is greater.

“Graph2”

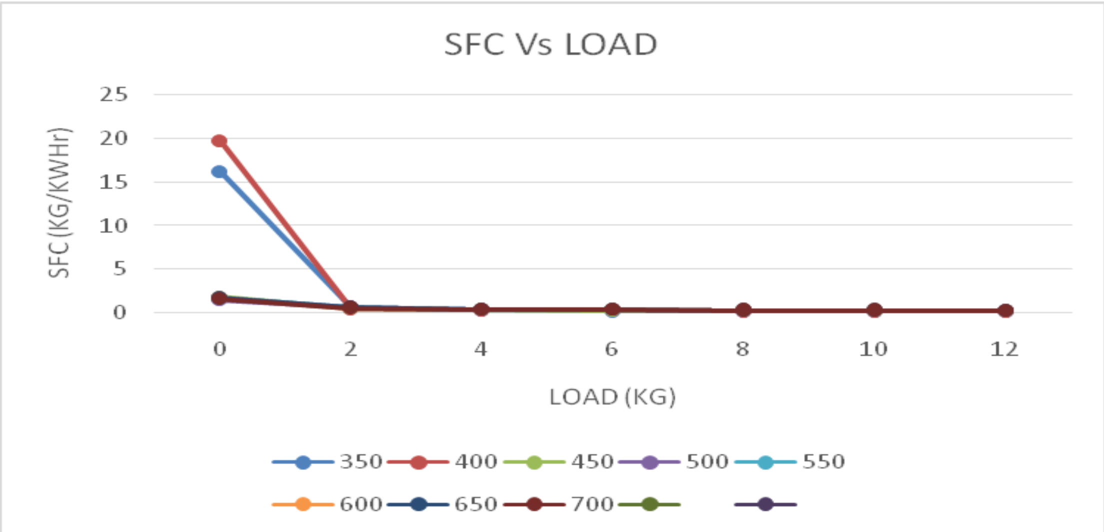

Figure 5.2

For Specific Fuel Consumption

For prssure range 350-400 Bar SFC is about 15-20(kg/kwh) which is maximum at no load and as the load increases SFC decreases.

“Graph 3”

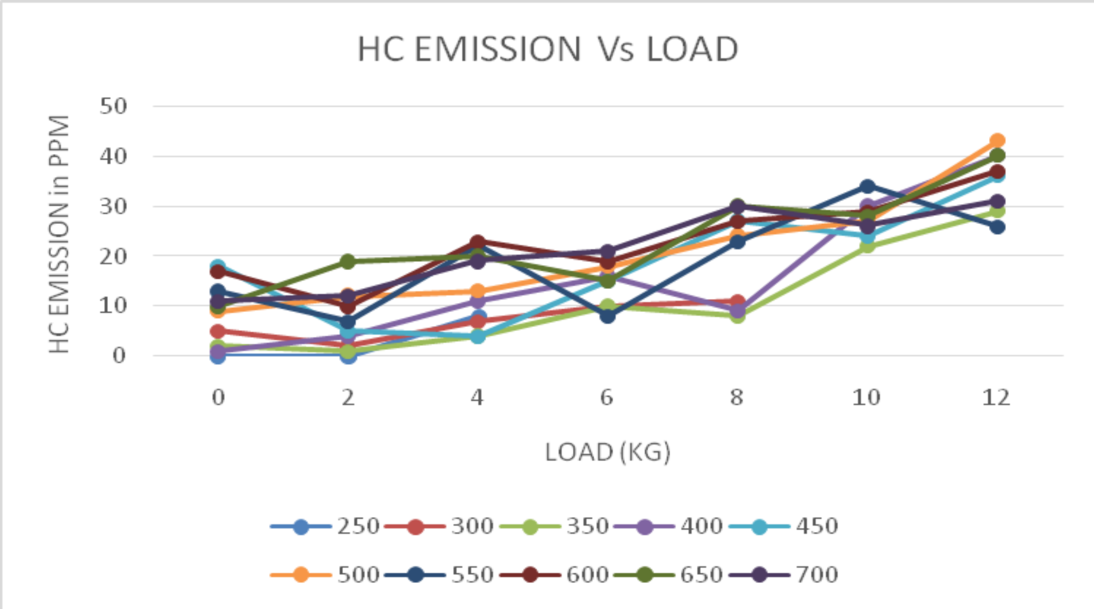

Figure 5.3

For HC Emission

For the pressure range 550 bar the HC emission found lowest at the load 12kg. And HC emission increases as the load increases.

"Graph 4"

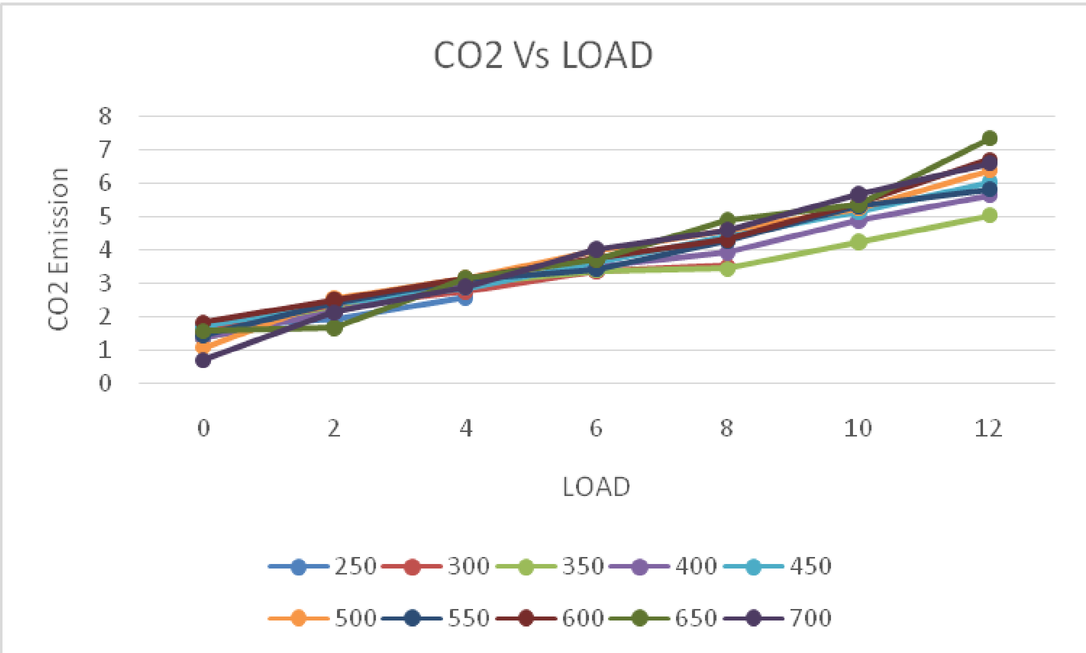

Figure 5.4

For Co2 Emission

At 700 bar pressure and 0kg load CO2 is low but the load increases CO2 gets increased. For 350 bar as load increases CO2 emission decreases as compare to others.

"Graph 5"

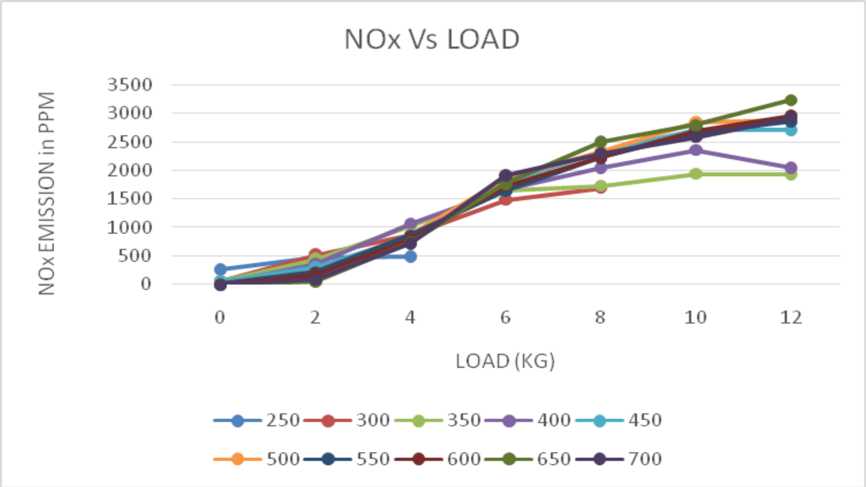

Figure 5.5

For NOx Emission

NOx increases as the load increase but for 250-350 bar at load 12kg it is found lowest as compared to 650-750 bar which is maximum.

As injection pressure increases the CO% decreases in exhaust because of high turbulence in combustion chamber & better atomization. Shown in figure 5.6

"Graph 6"

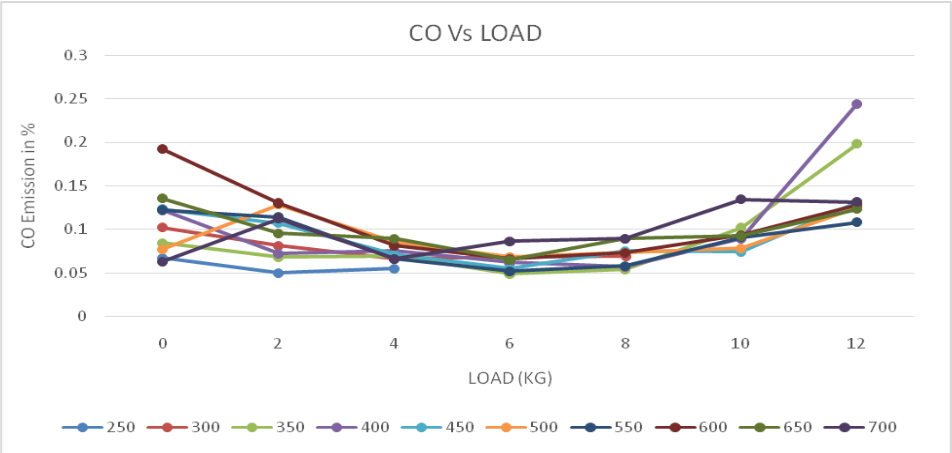

Figure 5.6

This reading was taken on Single Cylinder CRDI Engine.

VI.CONCLUSIONS

1. The Highest Brake thermal efficiency was found at 400 bar & it decreases for higher pressure.
2. At 700 bar pressure we get the less SFC as compared to other pressure.
3. At the fuel injection pressure at 300,400 bar, the percentage of CO_2 in the exhaust gas was found be the Lowest.CO_2 is maximum for 350-450-500-650-700 bar pressure range.
4. The percentage of CO in the exhaust gas is reduces as injection pressure increases.
5. As injection pressure increases NOx emission increases.

VII.FUTURE SCOPE

Performance of the developed CRDI engine is analyzed with basic testing methodology. Further addition of ECU controlled parts such as turbocharger, cooled EGR, variable timing valve setup can be done and optimize the parameters for enhancing the performance of the engine. Also, this current CRDI engine can be incorporated as a variable compression ratio engine with a programmable CRDI engine which can help the researchers to carry out the test.

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