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Research Paper

EFFECT OF INJECTION PRESSURE ON THE PERFORMANCE AND EMISSION CHARACTERISTICS OF DI DIESEL ENGINE RUNNING ON NELLI OIL AND DIESEL FUEL BLEND

M L S Deva Kumar[1], M Venkata Ramudu[1]* and K Vijaya Kumar Reddy[2]

*Corresponding Author: M Venkata Ramudu, ✉ mugathalaramudumech@gmail.com

Due to the increasing demand for fossil fuels and environmental threat, a number of renewable sources of energy have been studied worldwide. An attempt is made to assess the suitability of vegetable oil for diesel engine operation, without any modifications in its existing construction. One of the important factors which influence the performance and emission of diesel engine is fuel injection pressure. In the present investigation vegetable oil, Nelli oil has been investigated in a constant speed, DI diesel engine with varied fuel injection pressures (180, 200 and 220 bar). The main objective of this study is to investigate the effect of injection pressures on performance and emissions characteristics of the engine. The injection pressure was changed by adjusting the fuel injector spring tension. The performance and emission characteristics were presented graphically and concluded that increase in injector opening pressure increases the brake thermal efficiency and reduces unburned hydrocarbon and smoke emissions significantly.

Keywords: Diesel engine, Vegetable oil, Nelli seed oil, Fuel

INTRODUCTION

Diesel engine has gained the name and fame in serving the society in many ways. Its main attractions are ruggedness in construction, simplicity in operation and ease of maintenance. But due to the shortage of fossil fuel, we may not be able to avail its services for long time. Hence efforts are being made all over the world, to bring out non-conventional fuels for use in diesel engines. The performance and emission characteristics of diesel engines depends on various factors like

[1] Department of Mechanical Engineering, JNTUA College of Engineering (Autonomous), AnantapuramU 515002, Andhra Pradesh, India.

[2] Department of Mechanical Engineering, JNTUH College of Engineering (Autonomous), Hyderabad 500082, Andhra Pradesh, India.

fuel quantity injected, fuel injection timing, fuel injection pressure, shape of combustion chamber, position and size of injection nozzle hole, fuel spray pattern, air swirl, etc. The fuel injection system in a direct injection diesel engine is to achieve a high degree of atomization for better penetration of fuel in order to utilize the full air charge and to promote the evaporation in a very short time and to achieve higher combustion efficiency. The fuel injection pressure in a standard diesel engine is in the range of 200 to 1700 atm depending on the engine size and type of combustion system employed (John Heywood, 1988). The fuel penetrationdistance become longer and the mixture formation of the fuel and air was improved when the combustion duration became shorter as the injection pressure became higher (Seang-wock Lee *et al.*, 2002). Whenfuel injection pressure is low, fuel particle diameters will enlarge and ignition delay period during thecombustion will increase. This situation leads to inefficient combustion in the engine and causes the increase in NOx, CO emissions. When the injection pressure is increased fuel particle diameters willbecome small. The mixing of fuel and air becomes better during ignition delay period which causes lowsmoke level and CO emission. But, if the injection pressure is too high ignition delay become shorter. So, combustion efficiency falls down. Therefore, smoke is formed at exhaust of engine (Rosli Abu Bakar *et al.*, 2008; and Venkanna *et al.*, 2009). In this work, the effects of fuel injection pressure are experimentally studied on performance and emission characteristics of single cylinder direct injection diesel engine using nelli oil as a fuel. The Table 1 compares some of the important properties of different vegetable oils, which are used as fuels in diesel engines.

Table 1: Engine Specifications

Engine	New Kissan Diesel Engine
Type	Vertical
Rated power	5.0 HP
Specific fuel consumption	250 grams/kw hr
Stroke	110 mm
Bore	85 mm
Type	Water Cooled
Speed	1500 rpm

NELLI OIL

Common names for Nelli oil

English: Aonla, Emnelicmyrobahala, Indiangoosederry.

Sanskrit: Adiphala, Akara, Dhatri, Shriphala, Vayastha, Umrita.

Hindi: Aamla,mlaki, Amliki, Aungra, Daula.

Tamil: Amalagam, Andakoram, Indul, KatuNelli, Nellikai, Tani, Tanttri.

Malayalam: Amalakam, Boamalaca, Laka, Melaka.

Telugu: Amalakamu,Pullayusirika, Usirikaya, Usiriki, Usri.

Figure 1: Seeds of Nelli

Table 2: Properties of Nell Oil

Properties	Diesel	Nell Oil
Kinematic viscosity at 40 °C (cSt)	0.715	43.53
Density at 15 °C (kg/m^3)	850	910
Flash point (°C)	45	280
Calorific value (kJ/kg)	43000	39100
Sp. gravity	0.85	0.91

LITERATURE SURVEY

The details of the diesel engine design vary significantly over the engine performance and size range. In particular, different combustion chamber geometries and fuel injection characteristics are required to deal effectively with major diesel engine design problem achieving sufficiently rapid fuel-air mixing rates to complete the fuel burning process in the time available. According to Heywood (1988) and Ganesan (1999), a wide variety of inlet port geometries, cylinder head and piston shapes, and fuel-injection patterns are used to accomplish this over the diesel size range. The engine ratings usually indicate the highest power at which manufacturer expect their products to give satisfactory of power, economy, reliability and durability under service conditions. Maximum torque and the speed at which it is achieved, is usually given also by Heywood (1988). The importance of the diesel engine performance parameters are geometrical properties, the term of efficiency and other related engine performance parameters. The engine efficiencies are indicated thermal efficiency, brake thermal efficiency, mechanical efficiency, volumetric efficiency and relative efficiency (Ganesan, 1999). The other related engine performance parameters are mean effective pressure, mean piston speed, specific power output, specific fuel consumption, intake valve mach index, fuel-air or air-fuel ratio and calorific value of the fuel.

EXPERIMENTAL SETUP AND PROCEDURE

Introduction

The details of the experimental set up are presented in this chapter the alternations made to the instrumentation are also described. The experimental setup is fabricated to fulfill the objective of the present work. The various components of the experimental set up including modification are presented in this chapter.

Experimental Set Up

The experimental set up consists of engine, an alternator, top load system, fuel tank along with immersion heater, exhaust gas measuring digital device and manometer.

Engine

The engine which is supplied by M/s.New Kissan Company the engine is single cylinder vertical type four strokes, water-cooled, compression ignition engine. The engine is self governed type whose specifications are given in Appendix 1 is used in the present work.

Reasons for Selecting the Engine

The above engine is one of the extensively used engines in industrial sector in India. This engine can with stand the peak pressures encountered because of its original high compression ratio. Further, the necessary modifications on the cylinder head and piston crown can be easily carried out in this type of engine. Hence this engine is selected for the present project work.

Dynamometer

The engine is coupled to a generated type electrical dynamometer which is provided for loading.

Fuel Injector: A cross sectional view of a typical BOSCH fuel injector.

The injector assembly consists of:

- A needed valve
- A compression spring
- A nozzle

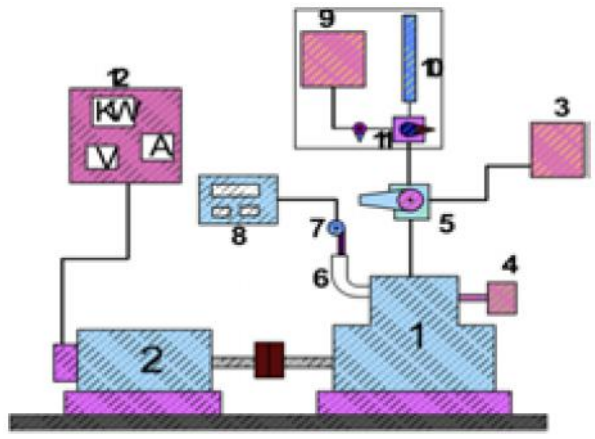
U-Tube Manometer

The one of end of the U-tube manometer is connected to the orifice of the air tank and the other end is exposed to the atmosphere, the manometer liquid used is water.

Digital Thermometer

It consists of a temperature sensing element connected to the electronic digital display which is operated by battery.

Figure 2: Experimental Setup



Various Parts of Experimental Setup

- Newkissan Engine
- Alternator
- Diesel Tank
- Air Filter
- Three Way Valve
- Exhaust Pipe

Figure 3: Schematic Diagram of Engine

- Probe
- Exhaust Gas Analyser
- Alternative Fuel Tank
- Burette
- Three Way Valve
- Control Panel

VARIATION OF THE INJECTION PRESSURE

The fuel injection system in a direct injection diesel engine is to achieve a high degree of atomization in order to enable sufficient evaporation in a very short time and to achieve sufficient spray penetration in order to utilize the full air charge. The fuel injection system must be able to meter the desired amount of fuel, depending on engine speed and load and to inject that fuel at the correct time and with the desired rate. Further on, depending on the

particular combustion chamber, the appropriate spray shape and structure must be produced. A supply pump draws the fuel from the fuel tank and carries it through a filter to the high-pressure injector. During this phase

Figure 4: Fuel Injector

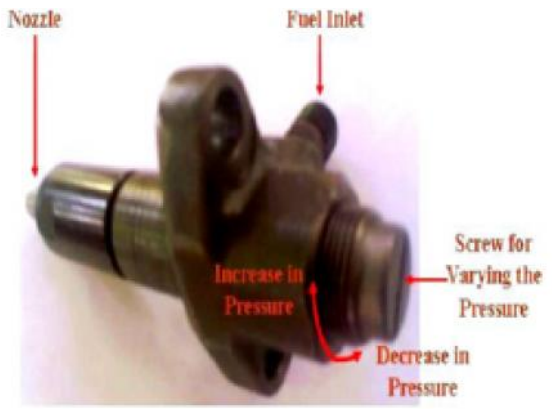


Figure 5: Pressure Tester Gauge

of the project, injection pressure is varied. The injection pressure of this high speed diesel engine is approximately 180 bar. The injection pressure of the injector can be varied by tightening or loosening the screw of the injector as shown in the Figure 4. The injector pressure can be determined by a fuel injector pressure tester as shown in the Figure 5 given below.

RESULTS AND DISCUSSION

The Performance and emission characteristics Nelli-oil diesel blend are compared with pure diesel operation. The basic performance parameters such as, brake specific fuel consumption, brake thermal efficiency. Two test fuels were used during experiments including 100% diesel fuel and a blend of 50% Nelli oil by volume in the diesel. The tests were carried out for both the proportion of Nelli oil and diesel. The performance tests are conducted on DI diesel engine at 1500 rpm with variable fuel injection pressure from 180 bar, 200 bar and 220 bar (in steps of 20, 40, 60, 80 and 100%) of maximum load.

Brake Specific Fuel Consumption

Figure 6: Load vs. BSFC

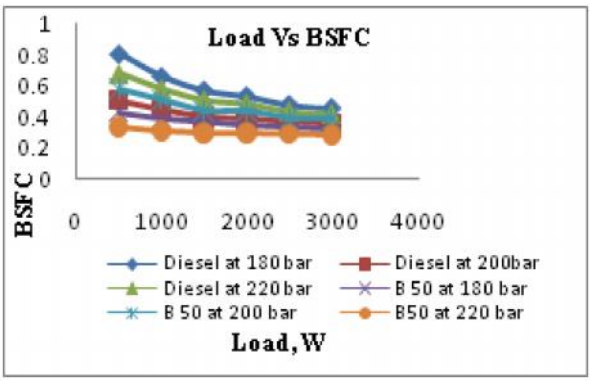


Figure 7: Load vs. Brake Thermal Efficiency

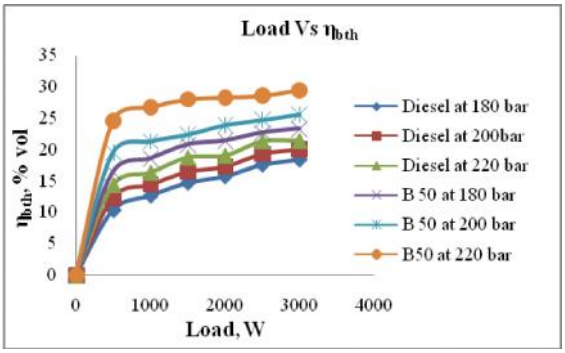


Figure 8: Load vs Mechanical Efficiency

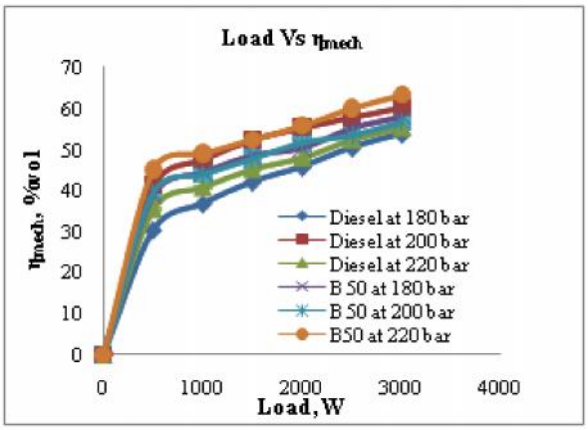


Figure 9: Load vs Hydro Carbons

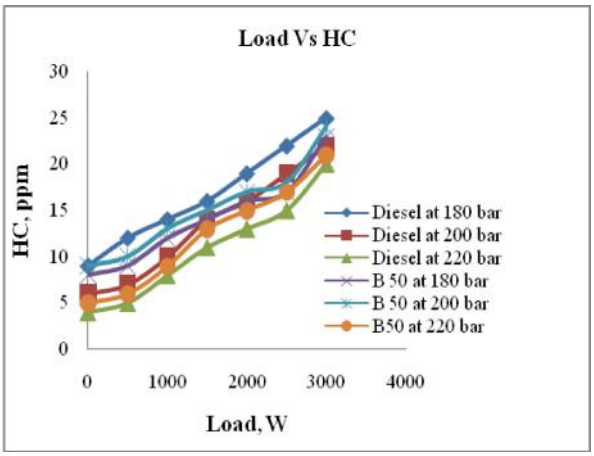


Figure 10: Load vs CO

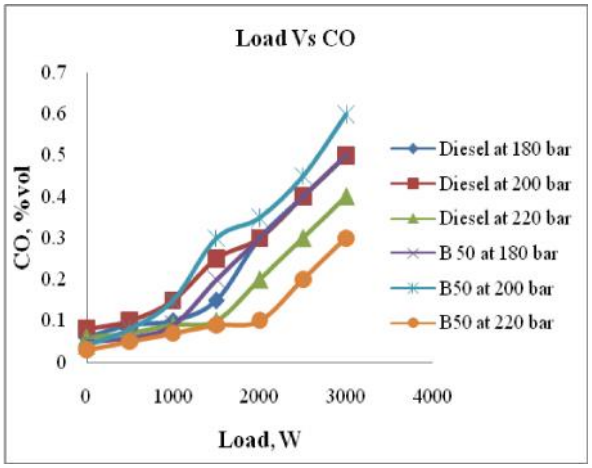
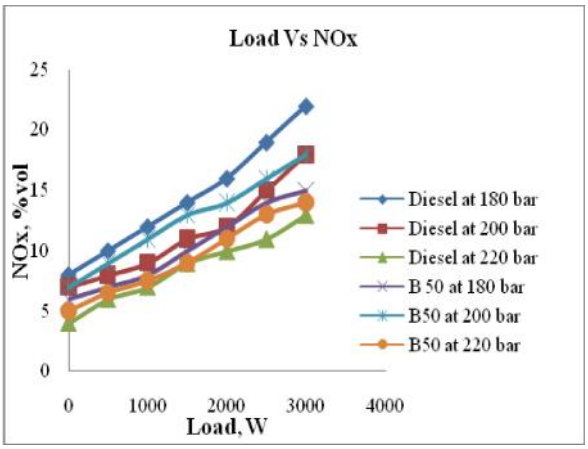


Figure 11: Load vs NOx



From Figure 6 it is observed that, as the injection pressure increases break specific fuel consumption decreases. The figure also reveals that BSFC decreases with increase in injection pressure at 180, 200 and 220 bar Nelli oil- Diesel blend. The injector was set for different opening pressures namely 180 bar, 200 bar and 220 bar and the engine was tested. This may be due to good atomization at higher injection pressure which helps in faster rate of heat release. The variations in brake specific fuel consumption of Nelli-oil diesel blend are compared diesel fuel at all loads, and is found that Nelli oil diesel blend B50 at 180, 200 and 220 bar shows decrease in BSFC compared to 180, 200 and 220 bar pure Diesel.

The variation of brake thermal efficiency with respect to load for Nelli oil-Diesel blends at various pressures is shown in Figure 7. For all the readings of diesel fuels and blends at various injection pressures the brake thermal efficiency increases with respect to various loads. The brake thermal efficiency values at full load are 20.094% , 29.430% and 18.407% for B50 at 180, 200 and 220 bar. The brake

thermal efficiency values at full load are of 21.51%, 23.383% and 25.684% for diesel at 180, 200 and 220 bar are decrease to the brake thermal efficiencies of diesel at various loads.

Mechanical efficiency indicates how good an engine is inverting the indicated power to useful power Figure 8 shows that the Mechanical Efficiency increased for all injection pressures of 180, 200, 220 bar nelli oil-diesel fuel blends Compared to diesel fuel.

CONCLUSION

The engine was made to run on diesel fuel mode, and nelli oil-diesel mode. The experiments were conducted at 3 different fuel injection pressures of 180 bar, 200 bar and 220 bar. The performance and emission of the engine at full load were investigated. The following results were obtained.

The engine was able to run on 180 bar, 200 bar and 220 bar fuel injection pressures on diesel fuel mode and nelli oil-diesel mode.

- Brake specific fuel consumption for the nelli oil-diesel blend when compared with diesel is than the BSFC with 0.358 kg/kWhr at 180 bar, 0.325 kg/kWhr at 200 bar and 0.284 kg/kWhr at 220 bar.
- The brake thermal efficiency of the engine for nelli oil-diesel blend of operations is high compared to diesel mode at 180, 200 and 220 bar.
- The exhaust gas temperature of nelli oil-diesel blend mode is less compared to diesel mode at fuel injection pressures of 180, 200 and 220 bar.
- HC emissions of nelli oil-diesel blend mode is lower compared to that of diesel fuel mode at all fuel injection pressures.
- CO emissions of nelli oil-diesel blend mode is lower compared to that of diesel fuel mode at all fuel injection pressures.
- NOX emissions of nelli oil-diesel blend mode is lower compared to that of diesel fuel mode at all fuel injection pressures.

From the above analysis the main conclusion is nelli oil blend are suitable substitute for diesel at high injection pressure, at produce lesser emission and better performance then diesel.

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