## CHAPTER 3

**Experimental Work**

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CHAPTER 3

EXPERIMENTAL WORK

3.1 INTRODUCTION

For the present investigation, an experimental set up is installed in the laboratory with the necessary instrumentation to measure the performance, combustion and emissions characteristics from a direct injection compression ignition engine at different operating conditions. A schematic of the experimental set up is shown in the Fig 3.1. This set up involves an engine with dynamometer and provisions for measurement of engine speed, fuel and air flow rates, cylinder pressure history and exhaust emissions such as smoke and oxides of nitrogen. The details of each of these components of the test set up are furnished below.

In this chapter, the experimental set up and its instrumentation are discussed in detail.

3.2 TEST ENGINE

Single cylinder water cooled four stroke, direct injection compression ignition diesel engine is chosen for the present investigation. The detailed engine specifications are provided in Appendix-A. The recommended injection timing by the manufacturer is 28° bTDC (static) and the nozzle opening pressure of 200 bar.

3.3 ENGINE INSTRUMENTATION

The details of the engine instrumentation associated with the present test set up are discussed below.
3.3.1 Dynamometer

An eddy current dynamometer is coupled to the engine. The dynamometer can be controlled externally by a computer to control the speed and load.

3.3.2 Speed Measurement

The speed is measured using an electro-magnetic pick up in conjunction with a digital indicator of AQUTAH make. A magnetic pickup is fitted close to the flywheel with pins fixed on the periphery. The signals generated are fed to the display unit, which is calibrated to indicate the speed directly in number of revolutions per minute (rpm).

3.3.3 Fuel Flow Measurement

Fuel flow rate is measured on the volume basis using a burette and stopwatch. The fuel from the tank is sent to the engine through a graduated burette using a two way valve. When the valve is set, at position 1, the fuel is sent to the engine directly and in position 2, the fuel contained in the burette is sent to the engine. For the measurement of the fuel flow rate of the engine, the valve is set at position 2 and the time for a definite quantity of the fuel flow is noted. This gives the fuel flow rate for the engine.

3.3.4 Air Flow Rate Measurement

The inlet manifold of the engine is connected to the surge tank to avoid pressure fluctuation at the inlet. A calibrated turbine type flow meter is attached to the tank, which is directed to the atmosphere. This is done with due care that there is no air leakage. During the engine operation, the air to the engine from the atmosphere is through the flow meter. The time required for the intake of a definite quantity of air gives the airflow rate of the engine.
3.3.5 Temperature Measurement

Temperature of the exhaust and the mean cylinder wall temperature are measured using chromel-alumel (k-Type) thermocouples. The thermocouple wire is 2 mm in diameter and the bead diameter is 5 mm. A digital indicator with automatic room temperature compensation facility is used. For the cylinder wall, temperature measurement the thermocouple is located on the outer surface of the cylinder wall. The temperature indicator is calibrated periodically.

3.3.6 Pressure Pickup

The cylinder pressure is measured by the piezo-electric pressure transducer of Kistler make 701A. The unit is fitted to the cylinder head by means of a suitable adaptor. The pickup communicates to the combustion chamber by means of a 1 mm diameter hole drilled on the cylinder head, and is constantly cooled by a stream of fresh water. The signals sensed by the pickup are sent to a charge amplifier of KISTLER make. The pressure pulses after amplification are fed to the signal analyzer and this is used for analyzing the various combustion parameters such as occurrence of peak pressure, start of the combustion and ignition delay.

3.3.7 Coolant Water Measurement

Coolant water flow is measured by collecting the water in a pail for two minutes and weighing it in a spring balance. The flow of water is measured in kg/min. The inlet and outlet temperature of the cooling water is measured using a temperature gauge. From the above the amount of heat lost to the cooling water is calculated. To prevent overheating a constant water flow is maintained through the engine.
3.3.8 TDC Pick-up

An inductive pickup is used to get a TDC signal from a disc mounted on the engine camshaft extension. Metallic protrusion is made on the disc corresponding to the TDC mark. By triggering inductive pickup, the data recording can be started. The inductive pickup is attenuated appropriately to a level compatible with the recording instrument.

3.3.9 Smoke Measurement

Smoke level is measured using a standard BOSCH smoke meter system. The measuring instrument consists of a sampling pump that sucks a definite quantity of 330 cm$^3$ of the exhaust sample through a white filter paper. The smoke particle gets deposited on the filter paper due to which it becomes colored. Before every measurement, it is ensured that the exhaust sample from the previous measurement is completely removed from the sampling tube and the pump. This sample is then taken to the test bench for being tested with the BOSCH smoke meter. This consists of the light source and an annular photo detector surrounding it. The instrument sends out a light beam of a calibrated intensity. The reflected light intensity is determined using a photoelectric cell. The instrument is calibrated to read zero with a white paper and 10 with a completely black paper. Before every measurement, the smoke meter is calibrated for zero reading using a plain white filter paper. The reflectivity of the filter paper gives the smoke value of the collected sample.

3.3.10 Exhaust Gas Analyzer

A gas analyzer (Delta 1600S), for evaluation of the pollutants in the exhaust gas is attached to the engine. The analyzer is used to measure the three important pollutants i.e. Carbon Monoxide (CO), Nitric Oxide (NO$_x$) and unburnt Hydro Carbons (HC).
3.4 EGR Experimental Setup

The experimental setup used for EGR system is shown in Fig. 3.1. Some part of the exhaust gases coming out from the engine is made to flow back to the engine through a separate pipeline known as EGR loop. This loop connects exhaust pipe with intake pipe via a water calorimeter and an air box. Calorimeter, shown in figure, is used to reduce the temperature of hot exhaust gases with water as cooling medium. An air box, with a damper on one side, is provided to measure the flow rate of exhaust gases re-circulated to the engine by using an orifice. Flow rate is calculated from the pressure head between upstream and downstream of the orifice with the help of a U-tube manometer. EGR loop with this flow measurement setup is shown in figure. The entire EGR experimental setup is schematically shown in Plate 3.1. The pressure difference between the air intake (suction pressure) and the stagnation pressure in the exhaust gas stream is the driving potential for the flow of exhaust gases in the EGR loop.

Fig. 3.1 Schematic of the experimental setup
3.4.1 EXPERIMENTS WITH THE ENGINE

The present investigation is intended to improve the performance and emission characteristics of the diesel engine. For this purpose, the following few techniques are considered.

I. Use of the Karanja Bio-Diesel blends

1. Karanja Bio-Diesel blend ‘K15’ (15% Karanja oil+ 85% diesel by volume).

2. Karanja Bio-Diesel blend ‘K20’ (20% Karanja oil+ 80% diesel by volume).

II. In-cylinder turbulence inducement through grooves on the piston crown.

1. Cutting of six elliptical grooves on brass piston crown.
2. Cutting of nine elliptical grooves on brass piston crown.
3. Cutting of twelve elliptical grooves on brass piston crown.

III. Exhaust gas recirculation.

1. 10% of Exhaust gas recirculation (EGR10)
2. 15% of Exhaust gas recirculation (EGR15)
3. 20% of Exhaust gas recirculation (EGR20)

These techniques are used to enhance the swirl inside the combustion chamber for better combustion. The modified piston crowns to enhance the turbulence in the cylinder are shown below (Plate 3.2 – 3.4).

PLATE 3.2 Piston crown with six grooves.
PLATE 3.3 Piston crown with nine grooves.

PLATE 3.4 Piston crown with twelve grooves.