CHAPTER 4

EXPERIMENTAL SETUP

4.1 EXPERIMENTAL SETUP

A single cylinder, four stroke, water-cooled, direct injection, Kirloskar make diesel engine capable enough to develop 4.4 kW at rated speed 1500 rpm was used for conducting experiment. The inlet and outlet side of the engine has the necessary measuring facility. The suction side of the engine has an electronic fuel injector for admitting neat ethanol. It has a pressure pickup in the combustion chamber to get the pressure signals and crank angle encoder to sense the crank position. Both are connected to a computer through a data acquisition system for logging combustion data. Lab-view based software used in the computer helps to calculate performance and combustion parameters. The setup has a five gas analyzer and smoke meter for measuring pollutants concentration and smoke value in the exhaust. The specifications of the engine used for the experiment investigation are given in Table 4.1. The schematic and pictorial view of the experimental setup is shown in Figure 4.1 and 4.2 respectively.

Figure 4.1 Schematic of the experimental setup
Figure 4.2 Pictorial views of the experimental setup
Table 4.1 Engine specifications

<table>
<thead>
<tr>
<th>Make</th>
<th>Kirloskar</th>
</tr>
</thead>
<tbody>
<tr>
<td>General details</td>
<td>Four stroke, compression ignition, constant speed, water cooled, direct injection</td>
</tr>
<tr>
<td>Number of cylinders</td>
<td>One</td>
</tr>
<tr>
<td>Bore</td>
<td>87.5 mm</td>
</tr>
<tr>
<td>Stroke</td>
<td>110 mm</td>
</tr>
<tr>
<td>Cubic capacity</td>
<td>661 cc</td>
</tr>
<tr>
<td>Compression ratio</td>
<td>17.5:1</td>
</tr>
<tr>
<td>Rated speed</td>
<td>1500 rpm</td>
</tr>
<tr>
<td>Rated output</td>
<td>4.4kW</td>
</tr>
<tr>
<td>Fuel injection timing</td>
<td>23º bTDC</td>
</tr>
<tr>
<td>Diesel injector opening pressure</td>
<td>180 bar</td>
</tr>
</tbody>
</table>

4.2 AIR PREHEATER

Air preheater is used to preheat the incoming air and it is fixed in the suction side of the engine next to the anti-pulsating drum. In the present work a 1.0 kVA electric heater is deployed for heating the incoming air. It has a power regulator to vary the electric supply and their by varies the temperature of incoming air. The temperature of air before and after the air heater has been measured using thermocouple and electronic temperature readout.

4.3 AIR AND FUEL FLOW MEASUREMENT

Air flow rate is an important parameter it is used to determine the exhaust flow rate and emission constituents. In the present work the air flow rate has been measured using orifice meter. The orifice meter used in the
present work has mounted in the anti-pulsating drum which maintains a steady flow of air to facilitate air measurement. The manometer fixed in the down side of the orifice meter helps to determine the suction depression of the engine.

The fuel flow rate of the direct injection experiments have been measured by the conventional methodology. In this measurement the fuel flow rate has been measured using burette and stop watch. In electronic fuel injection system, the fuel flow rate has been measured using the calibration curve and ECM (engine control module) parameters. More specifically, the fuel flow rate has been measured using number of pulses and pulse width of the electronic signal used by the injector. The calibration curve of the ethanol injector used in the present investigation is shown in Figure 4.3.

![Figure 4.3 Calibration curve for ethanol injector](image)

4.4 ELECTRONIC FUEL INJECTION SYSTEM

The electronic fuel injection system consisted of fuel tank, fuel pump, fuel pressure regulator and an electronic injector. The fuel (ethanol) to be injected by the injector has been stored in a tank and from where the fuel
has been delivered to the common rail using a low pressure fuel injection pump. The common rail used in the present system connects all injectors and supply fuel with a constant pressure. The pressure in the common rail has been maintained by a differential pressure regulator. It maintains a constant line pressure of 270 kPa between the pump and regulator.

This system uses a specially designed Engine Control Module (ECM) for injector operation. The power required and input pulse for ECM operation has been provided by the 12 volt automotive battery and pulse from the inductive pickup respectively.

4.5 TEMPERATURE MEASUREMENT

The ambient air temperature, hot air temperature and exhaust gas temperature have been measured using K-type thermocouples and digital temperature readout. The thermocouples have been located at approximately 15 cm from the inlet and exhaust manifold of the engine to avoid measurement errors.

4.6 DATA ACQUISITION SYSTEM

Present work uses national instruments (NI) data acquisition system (6036E - 16 inputs/2 outputs) to acquire high speed data from the pressure pickup and crank angle encoder with a sampling rate of 200 kS/s and 16 bit of differential voltage input. The acquired signals have been processed through ‘Labview’ software. This software has been used to determine the performance and combustion parameters of the experiments. More specifically it is used to determine the cylinder pressure, rate of heat release, rate of pressure rise and mean gas temperature.
4.7 EXHAUST EMISSION MEASUREMENTS

Engine emissions have been measured by a five gas analyser AVL DiGas 444 exhaust gas analyzer. It has helped to measure the concentration of emission constituents present in the exhaust gas, such as CO, CO$_2$, HC, and NO$_x$. It uses non-dispersive infrared (NDIR) sensor for measuring CO, CO$_2$ and HC and electro chemical sensors for measuring NO$_x$ and excess oxygen. The HC and NO$_x$ have been measured in terms of ppm and CO and CO$_2$ in terms of percentage.

4.8 CYLINDER PRESSURE MEASUREMENT

The cylinder pressure has been measured using a Kistler quartz piezo-electric pressure transducer, type- 601A, having a range of 0-250 bar with a sensitivity of 14.80 pC/bar. The transducer has housed in a suitable adapter and flush mounted in the combustion chamber. The output of the transducer has fed to the Kistler charge meter, type 5015A, to provide a voltage signal proportional to the pressure. A 16-bit data acquisition system (DAQ) connected to a computer has helped to acquire pressure signals at an interval of 1° crank angle.

4.9 EXPERIMENTAL UNCERTAINTY

All the experimental results are generally supported with uncertainty analysis. The uncertainty of the final result is governed by the uncertainties of various instruments used during the experimentation. The errors and uncertainties in the experiments arise due to instrument selection, condition, calibration, environment, observation, reading and test planning.

In the present experimental investigation, various instruments have been used for measuring various parameters. Each one has a certain
uncertainty level, which affects the certainty of the final result. Hence, a detailed uncertainty analysis (error analysis) was carried out to fix the uncertainty level of obtained results. The uncertainty analysis was carried by the method described by Holman (2001).

The overall uncertainty of the experimental investigation, arrived by the uncertainty analysis (shown in Appendix 6) is ±1.3%. This indicates that the results of the experiments are subjected to ±1.3% uncertainty.