Study of Emission Measurement Techniques in Internal Combustion Engine

J. Kadhir selvana[1], D. Veerappanb[2], R. Sivashankarc[3], V. Munusamid[4]
[1,2,3,4] *Department of Mechanical Engineering, Narasu's Sarathy Institute of Technology, Salem*

Abstract- **The Rapid growth of the automobile in recent years is one major source of the air pollutants. In order to control the emission of internal combustion many research work were under the progress. The emission measurement techniques were expensive and complicated in nowadays. Due this reason computerised measurement techniques were adopted in order to provide accuracy in the emission measurement. The software package like Engine software LV and Lab view 2010 software were employed in the measurement of emission of the gas. These software works with the help of sensors and they are connected to the signal conditioning system, and a data acquisition system is used as interface for a computer in order to measure and monitor in real time the emissions of O2, NO, CO, SO2, and CO2 gases. This paper shows the working of the individual measuring equipment and the results of the software, which make it flexible and easy to users.**

Index Terms- **Emission, fuel, software.**

INTRODUCTION

Air pollution is caused by the vehicles due to the burning of fossil fuels that provide the pollutant gases such as NO, CO, SO2, and CO2 . Diesel has been one of the most used fuels in internal combustion engines for more than one century. It is due to its high availability, competitive prices, and high energy density. Diesel is used, for example, in urban transport, cargo transport, light-duty vehicles, agricultural machinery, ships, and electricity generation. Emissions generated by diesel combustion directly affect the health and population life quality. Likewise, these are largely responsible for the climate change problem the biodiesel utilization is an alternative to reduce the pollutant emissions from vehicles with internal combustion engines that run on diesel. Biodiesel is a renewable and environmental-friendly fuel that is derived from lipids. These react with a short chain alcohol in the presence of a catalyst, no matter whether it is acid, basic, or enzymatic, producing a monoalkyl esters mixture of fatty acids. The physicochemical characteristics of biodiesel are similar to diesel. Therefore it may be replaced partially or completely, since the currently applied technology does not require major changes for its use.

Biodiesel has become more important worldwide, and it has shown rapidly industrial growth as an alternative fuel instead of diesel .Therefore, it is necessary to measure the respective emissions to determine the emissions decrease regarding the fossil fuels. Governments introducing new regulations that establish more strict emission limit to reduce the greenhouse gases emissions. As a result, it is essential to have efficient systems that measure the emissions from internal combustion engines, as well as regulate them.

The measurement systems for emissions measurement of internal combustion usually use specialized analysers that work under standardized methods. These provide related information about the composition and quantity of the combustion gases. It is a useful tool to understand and regulate combustion. The implementation of these systems is based on taking a gas sample that is produced in, for example, boilers, engines, and industrial ovens. The sample passes through the electrochemical cells analyzer, obtaining the concentration of each of its components and defining its own quality. In this way, if it is carried out with the relevant current regulations is established, at the same time ensuring the equipment is in proper conditions with its resulting fuel saving. There are several types of systems in the market for emissions measurement of internal combustion; these may also be fixed or portable depending on their implementation. Currently, the systems based on the computerized technology by using Engine soft VL software with the data acquisition instrument have been used as an alternative to the conventional systems for emissions measurement.

MEASUREMENT SYSTEMS

The Various measurement systems were used to capture the experimental data. The measurement has been carried out in several areas like load measurement system, fuel injection pressure measurement system, cylinder pressure measurement system, emission measurement system with help of computerised data acquisition system. This paper mainly focus on the method of the emission measurement

EMISSION MEASUREMENT SYSTEM

The emission measurement system is used to measure the constituents of exhaust gas and its opacity (smoke number). This system consists of an exhaust gas analyzer and a smoke meter. The exhaust gas analyzer measures the exhaust gas constituents of Carbon dioxide (CO2), Carbon monoxide (CO), Oxides of nitrogen (NOx), Un burnt Hydrocarbons (HC), Oxygen (O2) and Oxides of sulphur (SOx). The smoke meter is used to measure the intensity of exhaust smoke and it is measured in terms of Hartrigde Smoke Unit (%) and light absorption coefficient (K expressed in m-1).The range, data resolution and accuracy of the exhaust measurement systems are given in table 1

Gas	Range	Data Resolution	Accuracy
CO	0-15.00%, 0-4000ppm	0.01%, 1ppm	±0.06%, ±5%
CO_2	0-20.00%	0.01%	±0.5%
HC	0-30000 ppm	0.01%	±12 ppm
O_2	0-25.00%	1 ppm	±0.1%
NO_x	0-5000 ppm	1 ppm	±3 ppm
SO_x	0-5000 ppm	1 ppm	±5%
Smoke	0-100% HSU	0.1%	±0.1%

Table 1 Range, Resolution and Accuracy of Exhaust Measurement Systems

EXHAUST GAS ANALYZER

An instrument used to analyze the chemical composition of the exhaust gas released by a reciprocating engine is called exhaust gas analyzer. The analyser (Model PEA205) is of make INDUS Scientific Pvt Ltd, Bengaluru. The instrument measures the concentrations of Carbon monoxide (CO in % & ppm), Carbon Dioxide (CO2) and Oxygen (O2) in percentage, Hydrocarbons (HC), Nitric Oxide (NOx) and Oxides of Sulphur (SOx) in ppm in the engine exhaust gas. The technical specifications of the exhaust gas analyser are given in the Table 2.

Gases Measured	Carbon Monoxide, Hydrocarbon, Carbon dioxide, Oxygen, NO_X and SO_X
Principle	Non-Dispersive Infrared Sensors for CO,CO_2,HC and Electrochemical sensors for O_2,NO_x and SO_x
Data Resolution, Accuracy, Range	Given in Table 1
Startup Time	<2minutes from power ON. Full accuracy in 3 minutes
Auto Zero	Every 24 minutes with automatic fresh air intake
Gas Flow Rate	500–1000 ml per minute
Sample Handling System	S.S.Probe, PU Tubing with easily detachable connectors, water separator cumfilter, disposable particulate fine filter.
Operating conditions	Temperature:5 to 45 °C Pressure:813 to1060 Mpa Humidity:0-90%

Table 2 Technical Specifications of Exhaust Gas Analyzer

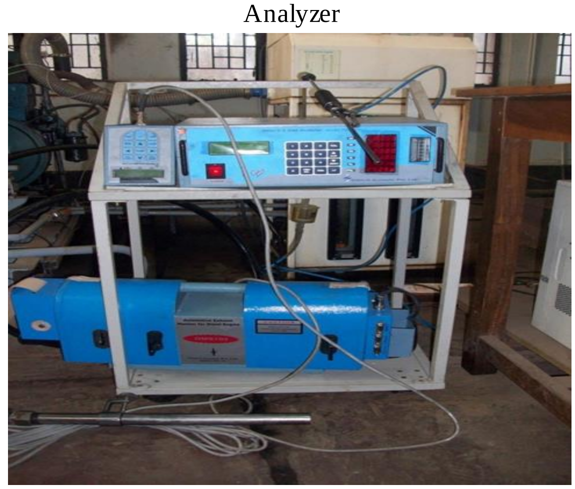

Figure 1 Assembly of Emission Measurement Systems

The analyzer uses the principle of Non-Dispersive Infra Red (NDIR) for measurement as shown in Figure1. In this technique, an infrared light is passed through the exhaust gas. Most molecules of gas can absorb the infrared light, causing it to bend, stretch or twist. The amount of infrared light absorbed by the gas molecules is proportional to their concentration in the exhaust gas. This method of detection does not cause ionization of gas molecules because the energy of the photons is not high enough. The source of infrared light is an incandescent bulb. The type of molecule absorbing the light depends on the wavelength of light absorbed by the molecule. CO, HC & CO_2 are sensed measured by NDIR principle while O_2, NOx, SOx use Electro Chemical (EC) sensors, for their measurement.

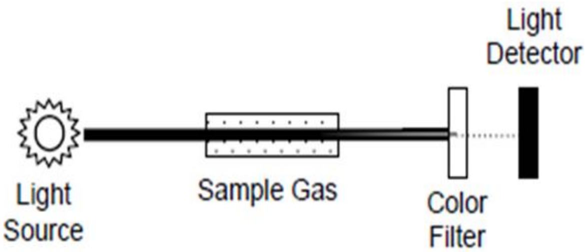

Figure 2 Principle of Non-Dispersive Infra Red Technique

When the probe is inserted into the exhaust pipe of the engine the exhaust gas is passed through a metal mesh screen. The screen filters the soot and dust particles after which it is allowed to pass through a fine fibre element which filters the entire gas for any foreign particles. After this, the clean and cool sample gas enters the direct sensor measurement through a filter arrangement and the readings are displayed on the screen and are recorded. The emission measurements are carried out on dry basis.

Figure3 Measurement of Exhaust Gas Constituents

SMOKE METER

Photographic image of the Smoke Meter (Automotive Exhaust Monitor) given in figure 4 is of make INDUS Scientific Pvt Ltd, Bengaluru. The smoke meter is used for measuring the opacity of the exhaust gas from the engine. The instrument measures the smoke opacity in terms of Hartridge smoke unit (HSU) which is measured in % and in terms of light absorption coefficient K (1/m). The exhaust monitor consists of a smoke chamber which contains the smoke column through which the smoke from exhaust pipe of the engine is passed and smoke density is measured. The gas to be measured is fed into the smoke chamber. The gas enters the smoke column at its center. The smoke column is a tube, which has a light source and a detector placed at one end. The opacity of smoke is directly proportional to the attenuation of light between a light source and a detector. The technical details of Smoke Meter are given in Table 3

Figure 4 Smoke Meter

Principle of Operation	Attenuation of light beam
Geometry	Folded Hartridge Geometry
Measurement	Smoke density in Hartridge smoke units (HSU)&K(m-1)
Range	0to100% in HSU,0.01m-1inK
Resolution	Given in Table 1
Time Constant	Physical 0.4 second, Electrical 1m second
Temperature Sensor	RTD(PT-100)or Thermocouple
Light Source	LED, Green Spectrum(567nm)
Detector	Photocell
Probe	A steel probe with synthetic crubber connecting hose
Warm-up Time	20minutes
Operating Temperature	5to50˚C
Measuring Temperature	80˚C

Table 3 Technical Specification of Smoke meter

The working of smoke meter based on the principle of folded geometry is illustrated in Figure.5 The light source is a green LED, marked as ‘S’. The light beam from ‘S’ falls on a partially coated mirror ‘PM’, gets reflected to the right and passes through the smoke column in the pipe ‘P’. The beam hits a mirror ‘M’ located at the end of the smoke column and gets reflected in the opposite direction. The beam passes through the lens ‘L’ for the second time to get focused on the detector ‘D’ after transiting the partially coated mirror. The net result of this beam folding is that the beam travels through the smoke column twice, thus making the traversed length twice the length of the smoke column. A heater is placed around the smoke pipe in order to raise the temperature of the smoke. This will prevent condensation of smoke inside the smoke column. A centrifugal fan is mounted at the either end of smoke column to drive out the smoke after measurement. The smoke opacity is measured by inserting the probe of the smoke meter in the exhaust pipe of the engine.

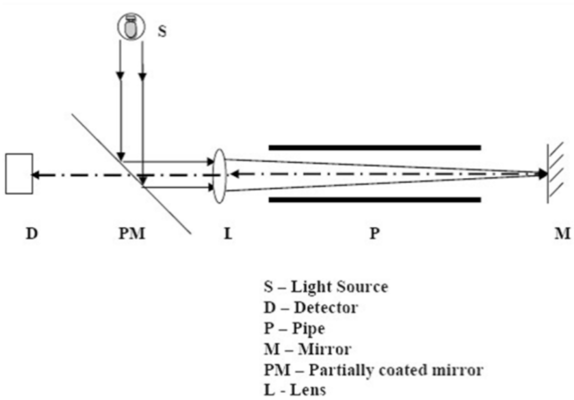

Figure 5 Principle of Folded Geometry

COMMERCIAL SOFTWARE – ENGINE SOFT LV

Lab view based Engine Performance Analysis software package ―Engine soft LV‖ is used for the on line performance evaluation. Sensor gives a signal in which interface with Engine soft LV. Engine Soft LV can serve most of the engine testing application needs including monitoring, reporting, data entry, data logging. The software evaluates power, efficiencies, fuel consumption and heat release. It is configurable as per engine set up. Various graphs are obtained at different operating conditions. While on line testing of the engine is in RUN mode necessary signals are scanned, stored and presented in the form of graphs. Stored data file is accessed to view the data graphical and tabular formats. The results and graphs can be printed. The data in excel format can be used for further analysis.

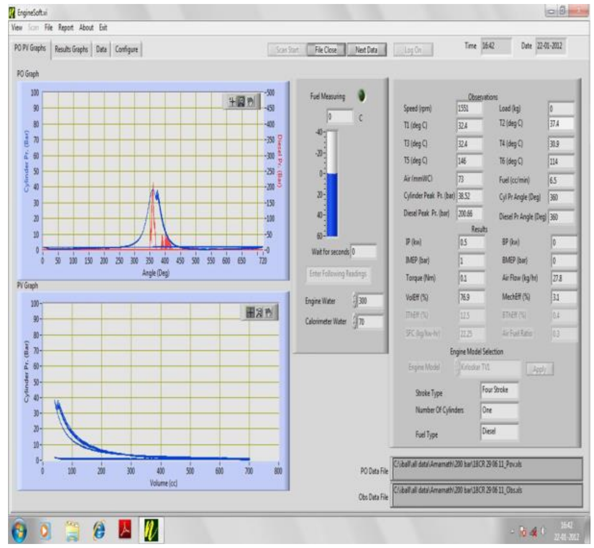

Figure 6 Interface of Engines soft LV

APPLICATIONS

The main operation of the measurement system for gas emissions of internal combustion is to measure the gases concentration of O_2, NO, CO, SO_2, and CO_2, for which it uses electrochemical and infrared sensors. Sensors measure the emissions that are generated from a diesel engine that runs with diesel-biodiesel blends. The measurement is performed once the combustion gases are conducted through a pipeline. The flow is firstly conducted to an oil separator and finally to a heat exchanger. Then, the gases are conducted to an exhaust manifold, where the different outputs are connected to the sensors to meter readings in real time, register and storage data provided by the signal conditioners devices and processed through the virtual instrument in the PC. There is the versatility to meter readings every 15 and 20 seconds, as well as 1 and 5 minutes, to create a database.

CONCLUSION

In this work a virtual instrument based on the Engine Soft LV plat form was developed to measure and monitors the emissions such as O_2, NO, CO, SO_2, and CO_2 from internal combustion engines that run on gasoline, diesel, or diesel-biodiesel blends. It is an open architecture instrument and user-friendly. It is possible to modify its graphical interface and include new operations, for example, sensors that measure other emissions depending on the type of concentration and pollutant volumes, according to the user needs. The Software is a useful tool for the emissions measurement that could be used by the industry sector and motor vehicles, as well as its use in the research and academics. It is recommended to add more sensors to the VIEM to measure a wider range of gases as well as some sensor or analyzer to measure in the order of parts per million.

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