

Analyzing the Performance of IC Engine using LabView

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Abstract—

With a growing demand for transportation IC engines have gained lot of importance in automobile industry. It is therefore necessary to produce efficient and economical engines. While developing an IC engine it is required to take in consideration all the parameters affecting the engines design and performance. There are enormous parameters so it becomes difficult to account them while designing an engine. So it becomes necessary to conduct tests on the engine and determine the measures to be taken to improve the engines performance. Engine performance is an indication of the degree of success of the engine performs its assigned task, i.e. the conversion of the chemical energy contained in the fuel into the useful mechanical work. Performance of an IC Engine depends on it some of the performance parameters like inlet temperature, exhaust gas temperature, air fuel ratio etc. These parameters are measured by different methods and conditions.

Keywords—Engine Performance; LabVIEW; Sensors.

I. NEED FOR VIRTUAL INSTRUMENTATION

With a growing demand for transportation IC engines have gained lot of importance in automobile industry. It is therefore necessary to produce efficient and economical engines. While developing an IC engine it is required to take in consideration all the parameters affecting the engines design and performance. There are enormous parameters so it becomes difficult to account them while designing an engine. So it becomes necessary to conduct tests on the engine and determine the measures to be taken to improve the engines performance.

Engine performance is an indication of the degree of success of the engine performs its assigned task, i.e. the conversion of the chemical energy contained in the fuel into the useful mechanical work. Performance of an IC Engine depends on it some of the performance parameters like inlet temperature, exhaust gas temperature, air fuel ratio etc. These parameters are measured by different methods and conditions.

There are many methods for the measurement of same parameter. For example temperature can be measured by Thermometer in conventional methods, but now a day it can be measured by thermocouple with some digital displays. Usage of thermometer has many drawbacks. But the thermocouple have varying range and accurate. Thus selection of suitable measuring instrument and generalized instrument for the measurement of many parameters is known as measuring system.

The conventional measuring system needs extra attachment to the working system for measurement. But the modern systems like virtual instrumentations need just fixing of sensors and graphical programming which make us to measure the parameters in real time.

Virtual instrumentation is the use of customizable software and modular measurement hardware to create user-defined measurement systems, called virtual instruments. The primary difference between hardware instrumentation and virtual instrumentation is that software is used to replace a large amount of hardware. The software enables complex and expensive hardware to be replaced by already purchased computer hardware. Generally in Virtual instrumentation a Measurement system can be considered to be made up of three basic elements: sensors, signal conditioner and display. (Vasanthi and Jeganathan 2007, Vasanthi

et.al., 2008, Raajasubramanian et.al., 2011, Jeganathan et.al., 2012, 2014, , Sridhar et.al., 2012, Gunaselvi et.al., 2014, Premalatha et.al., 2015, Seshadri et.al., 2015, Shakila et.al., 2015, Ashok et.al., 2016, Satheesh Kumar et.al., 2016).

II. INTRODUCTION TO LABVIEW

LabVIEW is a graphical programming environment used by millions of engineers and scientists to develop sophisticated measurement, test, and control systems using intuitive graphical icons and wires that resemble a flowchart. It offers unrivaled integration with thousands of hardware devices and provides hundreds of built-in libraries for advanced analysis and data visualization – all for creating virtual instrumentation. From taking simple temperature measurements to controlling the world's largest particle accelerator, engineers and scientists use the LabVIEW graphical system design platform to meet a wide range of application challenges.

Programs created using LabVIEW are called virtual instruments (VIs). This is because the appearance and operations of these programs imitate physical instruments, such as oscilloscopes and multimeters. These programs are saved with a .vi extension. LabVIEW contains a comprehensive set of VIs and functions for acquiring, analyzing, displaying, and storing data. It also contains tools to help us troubleshoot our code. (Manikandan et.al., 2016, Sethuraman et.al., 2016, Senthil Thambi et.al., 2016, Ashok et.al., 2018, Senthilkumar et.al., 2018,).

III. LIST OF SENSORS USED FOR MEASUREMENT

A. Measurement of Torque – Dynamometer

A dynamometer can also be used to determine the torque and power required to operate a driven machine such as a pump. In that case, motoring or driving dynamometer is used. A dynamometer that is designed to be driven is called an absorption or passive dynamometer. A dynamometer that can either drive or absorb is called a universal or active dynamometer.

In addition to being used to determine the torque or power characteristics of a machine under test (MUT), dynamometers are employed in a number of other roles. In standard emissions testing cycles such as those defined by the United States Environmental Protection Agency (US EPA), dynamometers are used to provide simulated road loading of either the engine (using an engine dynamometer) or full powertrain (using a chassis dynamometer). In fact, beyond simple power and torque measurements, dynamometers can be used as part of a test bed for a variety of engine development activities, such as the calibration of engine management controllers, detailed investigations into combustion behavior, and tribology.

B. Speed of the Engine – Proximity Sensor

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor always requires a metal target.

The maximum distance that this sensor can detect is defined "nominal range". Some sensors have adjustments of the nominal range or means to report a graduated detection distance. Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between sensor and the sensed object.

Proximity sensors are also used in machine vibration monitoring to measure the variation in distance between a shaft and its support bearing. This is common in large steam turbines, compressors, and motors that use sleeve-type bearings.

C. Mass of Air Flow – Mass Air Flow Sensor

A mass air flow sensor is used to find out the mass flow rate of air entering a fuel-injected internal combustion engine. The air mass information is necessary for the engine control unit (ECU) to balance and deliver the correct fuel mass to the engine. Air changes its density as it expands and contracts with temperature and pressure. In automotive applications, air density varies with the ambient temperature, altitude and the use of forced induction, which means that mass flow sensors are more appropriate than volumetric flow sensors for determining the quantity of intake air in each piston stroke.

D. Inlet and Exhaust Temperature – Temperature Sensor

Temperature sensors are devices used to measure the temperature of a medium. There are 2 kinds on temperature sensors: 1) contact sensors and 2) noncontact sensors. However, the 3 main types are thermometers, resistance temperature detectors, and thermocouples. All three of these sensors measure a physical property (i.e. volume of a liquid, current through a wire), which changes as a function of temperature. In addition to the 3 main types of temperature sensors, there are numerous other temperature sensors available for use.

E. Pressure Sensor

A pressure sensor measures pressure, typically of gases or liquids. Pressure is an expression of the force required to stop a fluid from expanding, and is usually stated in terms of force per unit area. A pressure sensor usually acts as a transducer; it generates a signal as a function of the pressure imposed. For the purposes of this article, such a signal is electrical.

Pressure sensors are used for control and monitoring in thousands of everyday applications. Pressure sensors can also be used to indirectly measure other variables such as fluid/gas flow, speed, water level, and altitude. Pressure sensors can alternatively be called pressure transducers, pressure transmitters, pressure senders, pressure indicators and piezometers, manometers, among other names. Pressure sensors can vary drastically in technology, design, performance, application suitability and cost. A conservative estimate would be that there may be over 50 technologies and at least 300 companies making pressure sensors worldwide.

F. Exhaust Gas Oxygen Content – Oxygen Sensor

An oxygen sensor (or lambda sensor) is an electronic device that measures the proportion of oxygen (O₂) in the gas or liquid being analyzed. It was developed by the Robert Bosch GmbH company during the late 1960s under the supervision of Dr. Günter Bauman. The original sensing element is made with a thimble-shaped zirconia ceramic coated on both the exhaust and reference sides with a thin layer of platinum and comes in both heated and unheated forms. The planar-style sensor entered the market in 1998 (also pioneered by Bosch) and significantly reduced the mass of the ceramic sensing element as well as incorporating the heater within the ceramic structure. This resulted in a sensor that started sooner and responded faster.

The most common application is to measure the exhaust gas concentration of oxygen for internal combustion engines in automobiles and other vehicles. Divers also use a similar device to measure the partial pressure of oxygen in their breathing gas. Scientists use oxygen sensors to measure respiration or production of oxygen and use a different approach. Oxygen sensors are used in oxygen analyzers which find a lot of use in medical applications such as anesthesia monitors, respirators and oxygen concentrators.

G. Knock Sensor

Regarding their principle of functionality, knock sensors are basically vibration sensors and are suitable for detecting structure-borne acoustic oscillations. These occur as “knock” for instance in a vehicle's engine when uncontrolled ignition takes place, and are converted into electrical signals by the sensor and inputted to the Electronic devices like ECU or DAQ. As a rule 4 cylinder in-line engines are equipped with one

knock sensor; 5 and 6 cylinder engines, with two; and 8 and 12 cylinder engines have two or more. They are switched in accordance with the ignition sequence. Thanks to their robust design, these vibration sensors can withstand even the most severe operating conditions.

IV. FIXING OF SENSORS

Fixing or mounting of sensors in the engine is an important and difficult thing. Holes and machining should be done in the engine parts in such a manner that should not disturb the performance and working of the engine.

A. Proximity Sensor



Fig. 1. Proximity sensor & fixing

Proximity sensor we have is screw type, 12mm outer diameter (M12x1.0) and sensing distance of 2mm. A hole with thread of M12x1.0 is drilled in the flywheel cap of the engine.

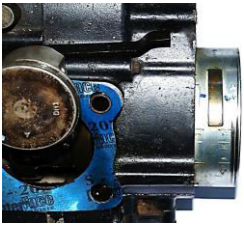


Fig. 2. Cut Section of Flywheel

A metal strip is attached to the surface of the flywheel of the engine for detection of pulse.

B. Hot Wire Air Sensor



Fig. 3. Hot wire sensor

Hot wire air sensor is used to measure mass of air flow into the engine. So it is fixed before the carburetor by make a small hole in air filter tube.

C. Temperature sensor



Fig. 4. Hot wire sensor

To measure the intake air temperature, the thermocouple is fixed before the Carburetor and after the Air Filter. A small hole is made in the tube between carburetor and air filter. Thermocouple is inserted and attached to the tube by any adhesive material.

To measure the Exhaust Gas Temperature, the thermocouple is fixed within three inches from the Exhaust Manifold. A hole is made in silencer and nut is welded to it. Thermocouple is screwed in the nut which is welded.

D. Manifold Absolute Pressure sensor



Fig. 5. MAP sensor

It is used to measure the pressure of the Inlet air in the intake manifold. So it is fixed between the carburetor and the air filter.

E. Oxygen Sensor



Fig. 6. Oxygen sensor

It is fixed in the silencer of the engine within three inches from the exhaust manifold. A hole is made to fix it in the silencer.

F. Knock sensor



Fig. 7. Knock sensor & placement position

Knock sensor is to mount in such a manner that it should touch the cylinder of the engine so some of the fins that surround the cylinder have to be removed. And a provision is to be made to tighten the sensor with cylinder.

V. PROGRAMMING WITH LABVIEW SOFTWARE

A. Program for Knock Sensor In Labview

For programming in labview software the front panel and the block diagram had to be designed.

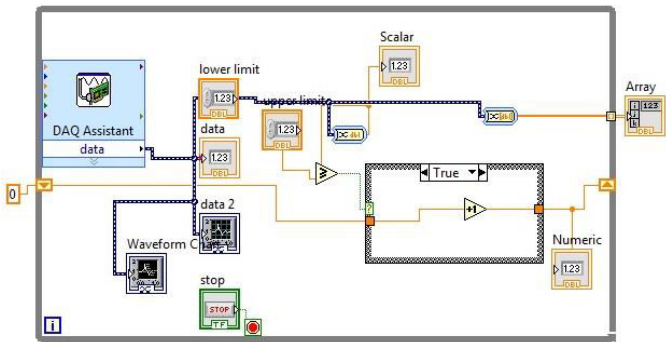


Fig. 8. Block diagram for knock sensor

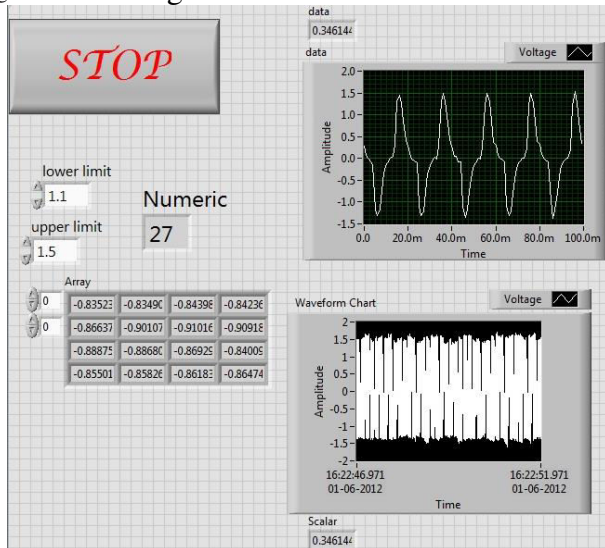


Fig. 9. Front Panel for Knock Sensor

Steps for acquiring signal from the sensor include the following steps: Right click in the block diagram panel and go to express→input→data acquisition. Click and drag the icon to the block diagram panel.

Double click the data acquisition icon and click the acquire signal function and select the voltage function. Select the port to which the sensor lines are connected and click ok. Now the vi is built.

To run the program continuously the whole block diagram has to be brought under the while loop. To set the timing right click the stop icon and go to create control and give the timing.

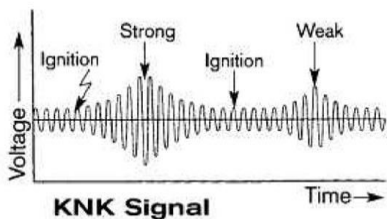


Fig. 10. Knock Signal

The graph obtained in the software is compared with the calibrated graph to obtain whether there is knocking in the engine. When there is abnormal vibration in the engine the signal in the graph reaches peak level.

B. Program for oxygen sensor with labview software

Programs created using LabVIEW are called virtual instruments (VIs). This is because the appearance and operations of these programs imitate physical instruments, such as oscilloscopes and multimeters. These programs are saved with a .vi extension. LabVIEW contains a comprehensive set of VIs and functions for acquiring, analyzing, displaying, and storing data. It also contains tools to help we troubleshoot our code.

For programming in labview software we have to design the front panel and the block diagram.

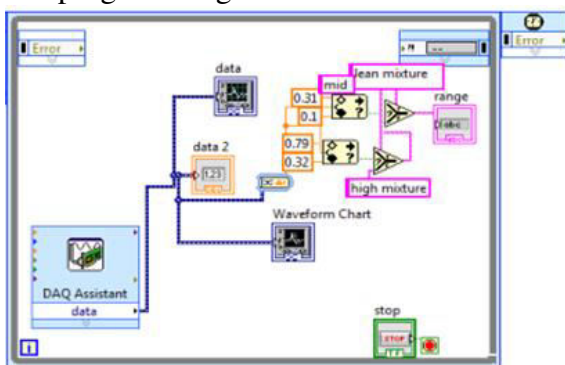


Fig. 11. Block diagram for Oxygen Sensor

Steps for acquiring signal from oxygen sensor. The input to the oxygen sensor is given using RPS as 12V. Right click in the block diagram panel and go to express→input→data acquisition. Click and drag the icon to the block diagram panel. Double click the data acquisition icon and click the acquire signal function and select the voltage function. Select the port to which the sensor lines are connected and click ok. Now the vi is built.

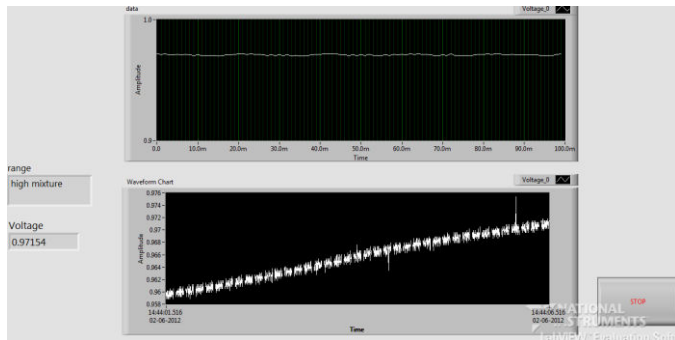


Fig. 12. Front Panel For Oxygen Sensor

To run the program continuously the whole block diagram has to be brought under the while loop. To set the timing right click the stop icon and go to create control and give the timing.

TABLE I. CALIBRATION OF OXYGEN SENSOR

<i>Exhaust oxygen</i>	<i>Content Oxygen Sensor Output</i>	<i>Air/Fuel Ratio</i>
Low High	Above 0.45 Volts	Rich
High Low	Below 0.45 Volts	Lean

C. Programme for exhaust gas temperature

Steps for acquiring signal from the sensor. Right click in the block diagram panel and go to express→input→data acquisition. Click and drag the icon to the block diagram panel. Double click the data acquisition icon and click the acquire signal function and select the temperature function and then select the thermocouple as k-type. Select the port to which the sensor lines are connected and click ok. Now the vi is built.

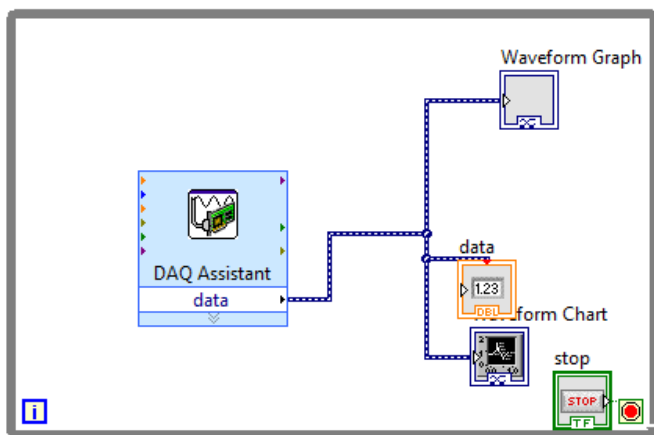


Fig. 13. Block Diagram for Exhaust Temperature

To run the program continuously the whole block diagram has to be brought under the while loop. To set the timing right click the stop icon and go to create control and give the timing.

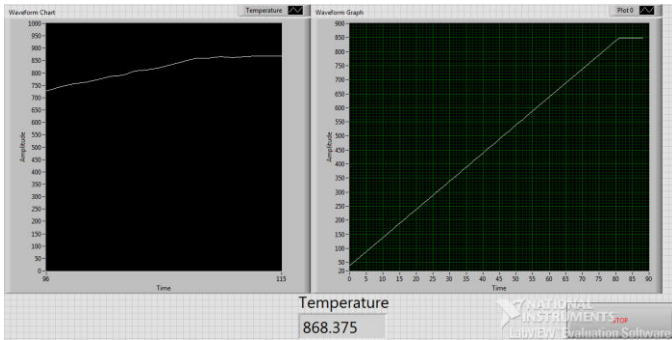


Fig. 14. Front Panel for Exhaust Temperature

D. Programming For Inlet Temperature of Air

Steps for acquiring signal from the sensor. Right click in the block diagram panel and go to express→input→data acquisition. Click and drag the icon to the block diagram panel. Double click the data acquisition icon and click the acquire signal function and select the temperature function and then select the thermocouple as k-type. Select the port to which the sensor lines are connected and click ok. Now the vi is built.

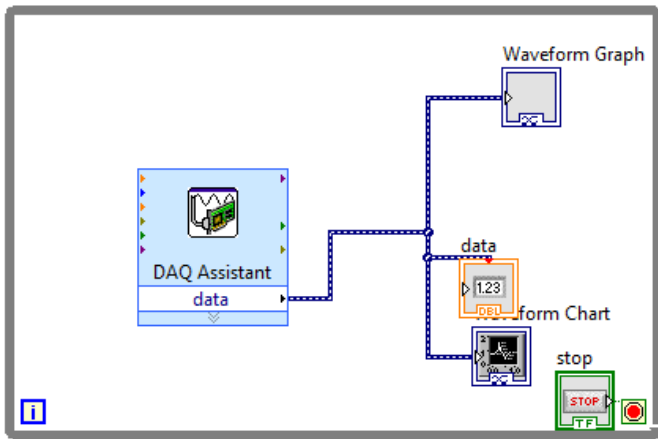


Fig. 15. Block diagram for Inlet Temperature

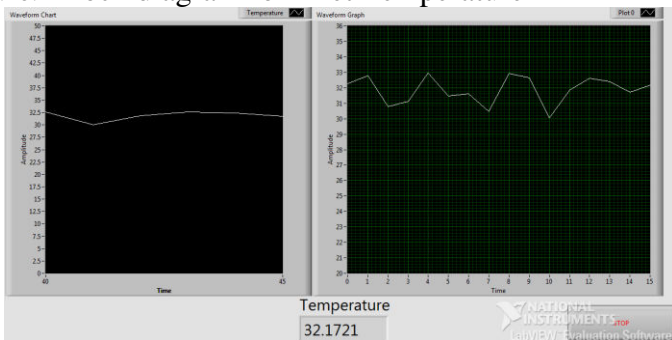


Fig. 16. Front Panel for Inlet Temperature

To run the program continuously the whole block diagram has to be brought under the while loop. To set the timing right click the stop icon and go to create control and give the timing.

E. Programming for Inlet Pressure of Air

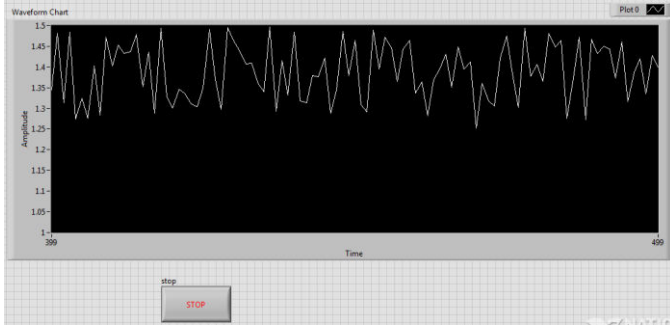


Fig. 17. Front Panel For Pressure Sensor

TABLE II. CALIBRATION OF PRESSURE SENSOR

Volta ge Drop Vo	0.3- 0.5	0.7- 0.9	1.1- 1.3	1.5- 1.7	1.9- 2.1	3.2- 3.5	3.6- 3.8
Appli ed Vacu um kPa	13. 3	26. 7	40. 0	53. 5	66. 7	87. 2	102 .7

$$V_o = 0.03P + 0.6, (2)$$

when $P = 120 \text{ kPa}$,

$$V_o = (0.03 \times 120) + 0.6,$$

$$V_m = 4.2 \text{ volts},$$

where V_o – Output voltage from MAP sensor, Volts,

P – Atmospheric pressure, kPa,

V_m – Maximum output voltage, Volts

VI. CONCLUSION

This paper presents the use of various sensors like oxygen sensor, temperature sensor, proximity sensor, knock sensor, throttle sensor and MAP sensor connected in an open loop system. The input powers to these sensors are given by using DAC and output from these sensors are collected by using same DAC. The output from DAC is analyzed using LABVIEW software. This work has been implemented on a four stroke two wheeler IC engine to monitor the performance characteristics on a real-time scale.

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