www.ierjournal.org International Engineering Research Journal (IERJ) Special Issue 2 Page 1471-1475 2015, ISSN 2395-1621

ISSN 2395-1621

Refurbishment of an IC Engine Test Setup and Interfacing with LabVIEW

[#1]S.G.Raut, [#2]V.N.Kapatkar, [#3]S.A.Kulkarni

[1]sumitraut277@gmail.com
[2]vnkapatkar.scoe@sinhgad.edu
[3]sakulkarni.scoe@sinhgad.edu

[#13]Department of Mechanical Engineering, Savitribai Phule Pune University
Sinhgad College of Engineering
[#2]Sinhgad College of Engineering Pune, Maharashtra, India

ABSTRACT

The available engine test setup lacked modern measurement approach, thus it has been equipped with instrumentation for accurate and precise measurements through a personal computer. The objective is to refurbish the available test setup and display the engine performance information in virtual test environment. The inputs to the data acquisition system includes analog signals from the thermocouples to measure temperature, piezo transducer for pressure, strain gauge for load measurements and pulse train signal from an angle encoder for measuring crank angle and rpm. The LabVIEW software National Instruments (NI) Inc. is used for analysis of performance parameters of the IC engine. The IC engine operating data such as temperature, load, in-cylinder pressure are to be transferred using NI USB CDAQ-9174 module interface while the crank position/rpm data using a micro-controller from the sensors to the CPU. The output of the system is display of performance characteristics in real time. The refurbishment of the IC engine test setup is used to demonstrate the performance and testing of an IC engine and labVIEW and for data acquisition and processing. The test setup has been upgraded with the use of latest hardware and software through refurbishment.

Keywords- **DAQ, LabVIEW, Serial Communication, TED Sensors, Virtual Instruments**

ARTICLE INFO

Article History

Received :28th Septmber 2015

Received in revised form :

1st October 2015

Accepted : 5thOctober , 2015

Published online :

6th October 2015

I. INTRODUCTION

The available IC engine test setup is a 4 cylinder, 4 stroke petrol engine having brake power of 65 bhp at 4000 rpm coupled with an eddy current dynamometer through a carden shaft. The engine test setup had issues in starter motor and, also the dedicated software of test setup had a compatibility issue with new generation computers. The lack of software support and engine starter issue rendered the setup idle, thus required refurbishment and repairs. NI C-DAQ 9174 multifunction data acquisition module and a microcontroller are used for data acquisition by using NI labVIEW software by the help of its serial communication protocol. LabVIEW is used as it is industry-standard programming environment, mainly used to acquire data quickly and easily by graphical execution of block diagram. It is also used to analyse and present experimental data in a user friendly manner. The study of control system for IC engine test rig with the help of labVIEW and its interfacing is main attraction of the study. LabVIEW has advantage of ease of handling and graphical environment. The graphical programming makes labVIEW a highly functional environment which is widely used in research areas. The program execution is based on data flow and has ability to connect several DAQ cards. Therefore, it is widely used for data acquisition, data analysis, and data control.

II. LITERATURE REVIEW

The need to develop engines with improved energy efficiency, pollution control and human safety has been emerged [1][2]. For this purpose accuracy of functional tests of engines is important. The common practice described in the study is to control several performance parameters and record these simultaneously. To achieve robust system requirements and comfortable data acquisition it is necessary to develop a labVIEW code for acquiring and measuring engine parameters like various temperatures, load capacity, fuel efficiency etc. There is a requirement of advance test equipment as it leads to fast and accurate performance analysis. The performance parameters like torque, fuel mass flow rate, temperature values at exhaust etc can be measured with the help of appropriate load cells, piezo transducers and thermocouples respectively [2][3][4]. Several accounts of data acquisition using labVIEW with different communication protocols for example GPIB, Serial, and Ethernet are available in literature. The observations include measurement of various physical parameters with the help sensors feedback and labVIEW for data acquisition. Ling Wang *et al* [1] suggested to combine the technique of virtual instruments and characteristics of Solar Absorption Refrigerator (SAR) using labVIEW with a DAQ system with a view to realize the real time data of temperatures, water flow rates and pressure. Here, the temperature measurement uses only thermocouples. Tufan Koc *et al* [2] designed a control system of an IC engine test unit which virtually analyzes real time data using labVIEW UI wherein thermistors are also incorporated to reduce cost for measurements where temperature range is low as 100°C. The performance parameters are measured and transferred to PC via USB-625 DAQ card. A two-cylinder, water cooled SI engine with compression ratio 10.7 and power of 15kW is used for experiments. Tianbing Ma *et al* [3] have proposed a design of a sensor states monitoring system based on labVIEW and wireless nodes. RF 905 wireless module, single chip micro computer, serial bus and labVIEW are used in the system. Bharadwaja and Nagraju [4] attempted to prototype a temperature characteristics measurement system to sense temperature around the engine is made using AT89C55 hardware and data acquisition. Zhang Minglea *et al* [5] implemented DAQ system for water purification system through monitoring and control of temperature of hollow fibers spinning machine whereas Nair and Venkatesh [6] implies to construct an antilock braking system (abs) tester based on labVIEW by monitoring wheel speed sensors. Huizong Feng *et al* [7] described a testing system for gas-fueled engines based on labVIEW in which tests on ignition control, deceleration air feed cutoff relay control and intake manifold stepper motor control is carried out. André V. Bueno *et al* [8] explained methods for measurement of in-cylinder pressure and crank position.

III. METHODOLOGY

The setup consists of four cylinder, four-stroke, Petrol engine with 9:1 C.R. and 65 bhp. The Eddy dynamometer is provided for engine loading. The setup panel consists of an air box, fuel tank, manometer, fuel measuring unit. The air-box is fabricated with orifice meter having 35 mm diameter. Rotameters are provided for cooling water and calorimeter flow measurement. Thermocouples K-type are properly mounted for measuring temperature at engine jacket cooling water inlet, outlet and exhaust gas outlet temperature from calorimeter. The positive and negative terminal is fed to pin 4 and 5 of a c-9219 channel to take measurement in thermocouple mode. A PCB piezo sensor is mounted in a single cylinder and is provided with low noise cable and bnc male connector which fits directly into the c-9234 female.

A. Hardware Implementation and Data Acquisition

Data acquisition system incorporated is capable of measuring dynamo-meter load, fuel consumption, in-cylinder pressure, rpm and temperatures. For this, inputs to the DAQ are taken from strain gauge, level sensor, piezo sensor, thermocouple and incremental angle encoder respectively. NI USB cDAQ-9174 module is used with c-9219 and c-9234 DAQ cards. System configuration is composed of two parts viz. hardware and software. LabVIEW (short for Laboratory Virtual Instrumentation Engineering Workbench) is a platform and development environment for a visual programming language from National Instruments. LabVIEW is commonly used for data acquisition, instrument control, and industrial automation. Benefit of using labVIEW is the extensive support for accessing instrumentation hardware. The provided driver interfaces save program development time. The graphical approach also allows non programmers to program simply by dragging and dropping virtual representations of lab equipment with which they are already familiar with, thus it is easier to implement due to the inherently parallel nature of G-code.

The NI 9219 used is a four-channel universal C Series module for testing in any NI CompactDAQ chassis. It can measure several signals from sensors such as strain gages, RTDs, thermocouples, load cells, and other powered sensors. The channels can be individually selectable from the G-code used. The NI 9234 is a 4-channel C Series dynamic signal acquisition module for high accuracy frequency measurements from piezoelectric sensors with NI CompactDAQ. Its individual input channel can digitize signals at rates up to 51.2 kHz with built-in anti-aliasing filters and can adjust to required sampling rate on its own. Installation of the test setup needs 230V 50Hz, single phase electric supply with neutral voltage less than 5Vac and a 5A three pin socket with switch. A microcontroller with encoder hardware is used for rpm of the engine. The VISA palette is used to establish communication between labVIEW and micro-controller via serial com port.

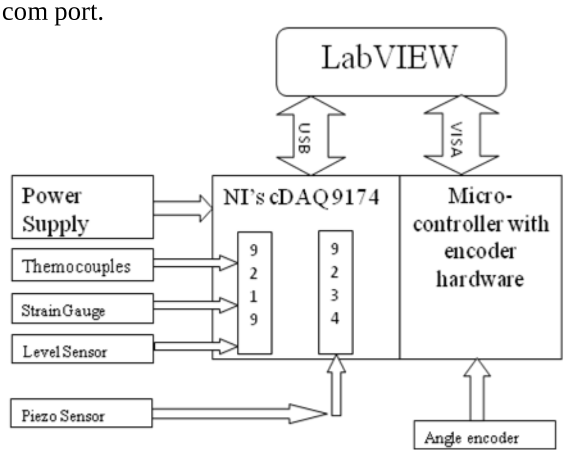

Fig. 1 System Implementation

B. Software Implementation

The software part consists of a G-code that can continuously measure the performance parameters simultaneously. The front panel of the labVIEW code serves as user-interface for controlling the process of measurement, storage and display of the data acquired. The front panel for reading the sensors is mentioned. Front panel consists of the indication and control tools like waveform charts, rpm gauge and push buttons/numeric controls to initiate, configure or stop the acquisition process. Using labVIEW's application development privilege, a dedicated application is created to acquire the mentioned data of the test setup. The part of G-code for rpm indication is given. This particularly makes use of serial com port as a input channel which is achieved by using labVIEW's serial drivers namely, VISA.

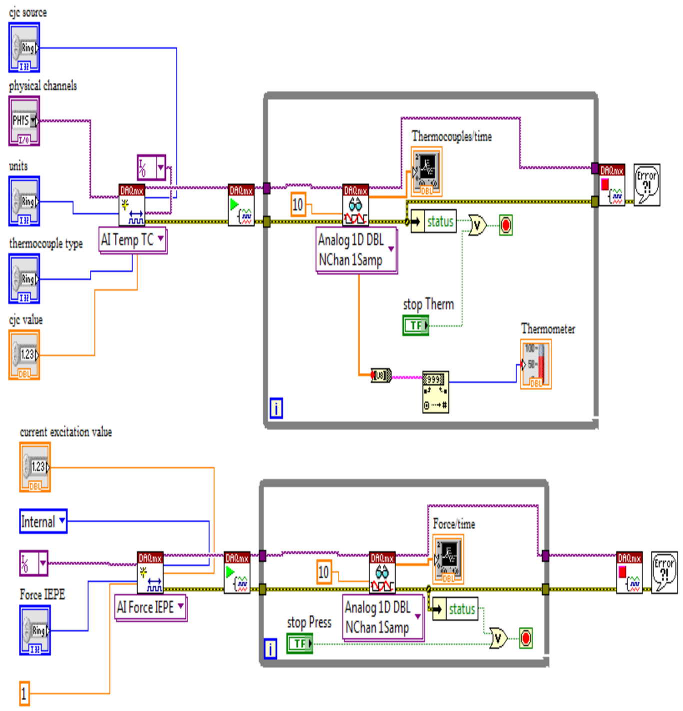

Fig. 2 G-code to receive data from physical channels of NI 9219 and NI 9234.

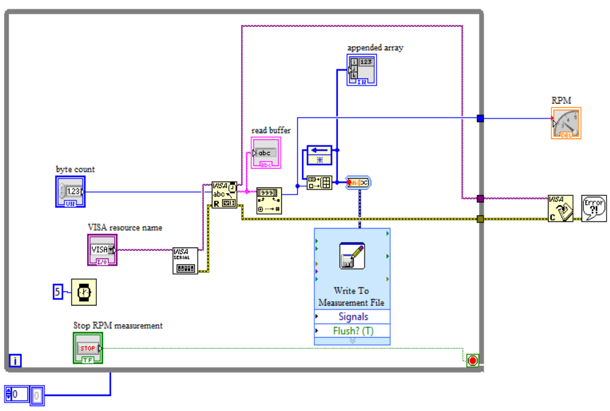

Fig. 3 G-code to receive data from serial com port and to display it in labVIEW.

The data acquisition through NI 9174 requires proper connection to the sensors to avoid noise and ambiguities. The sampling rate must be good enough to avoid aliasing or interference and depends on the sensor's response time. The DAQmx or DAQ assistant Express VI of labVIEW is used to acquire data through physical channels of the DAQ cards.

A micro-controller is used to count the number of encoder pulses in order to measure the rpm of the engine. The encoder is provided with 360 pulses per revolution. It has three channels A, B and M. Channels A and B are 90 degree out of phase while channel M gives impulse for completion of one revolution also called the 'marker'. Thus rpm is given by obtaining reciprocal of time (min) between two pulses of M channel. The position and direction of revolution can also be found out by making use of all three channels. The normal working encoder outputs following signals in clock wise and anti-clock wise direction. Using the following table as a look up, the direction of revolution is determined.

TABLE I
DECODING PRINCIPLE FOR ENCODER DIRECTION

A-ck	B-ck	A-ack	B-ack
1	0	1	0
1	1	0	0
0	1	0	1
0	0	1	1

IV. RESULTS AND DISCUSSIONS

The pressure sensor available is piezoelectric type and is connected to channel '0' NI 9234 DAQ module through standard BNC cable in IEPE configuration. This directly outputs the force in desired units acted upon the cross sectional area of the sensor's pressure tip. The obtained results are stored in MS-Excel file format so that it is fast and easily available to process and analyse. More than 100 samples are taken at constant rpm and can be plotted as below.

TABLE II
CLUSTER OF SENSOR DATA STORED AT 3500 RPM

Time(sec)	Force(N)
0.008477	240.445
0.009082	283.234
0.009687	309.175
0.010293	288.541
0.010898	258.538
0.011504	215.391
0.012109	168.607
0.012715	133.196
0.01332	100.511
0.013926	77.392
0.014531	52.1697
0.015137	40.3406
0.015742	22.6869
0.016348	15.637
0.016953	2.8038

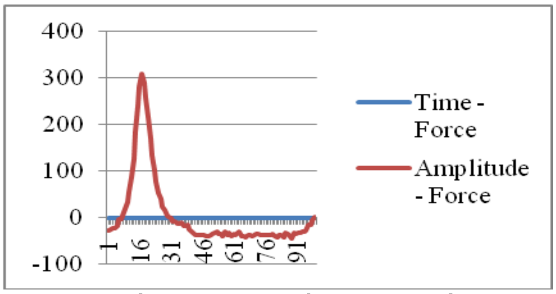

Fig. 3 Force on the sensor vs time when engine speed at 3500rpm

The font panel developed for dedicated application is tabular. It consists of four pages/tabs for four different sensors, their controls and indication purpose. The thermometer and rpm gauge are used as indicators for temperature and rpm respectively. Waveforms charts are provided to compare signals with respect to time. Several controls to select the physical channels, serial resource name and desired units etc are also provided. The acquisition is continuous and the G-code is formulated within a while loop which stops whole execution when the 'stop' button is pushed. Individual stop condition helps to avoid waste of computers resources when the particular sensor's data is not required.

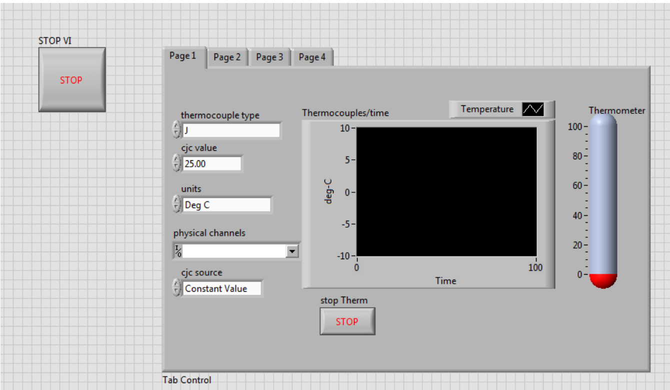

Fig. 4 Front panel for thermocouple

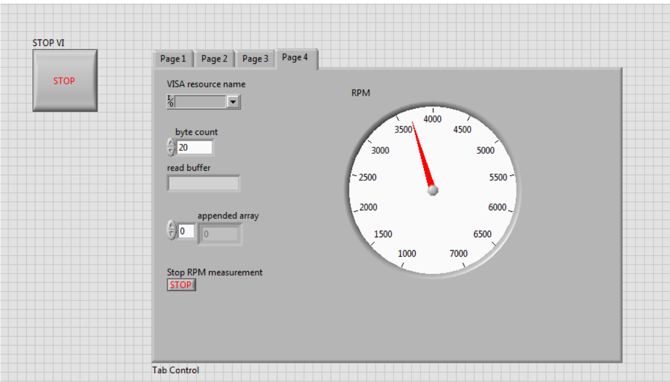

Fig. 4 Front panel for encoder

V. CONCLUSIONS

Brake power is obtained from torque and angular speed of the engine output shaft. BMEP depends upon break power and rpm value. Brake thermal efficiency is calculated by using brake power, fuel consumption and calorific value of the fuel. The differential pressure across the orifice in the air-box is measured by manometer to calculate the mass of air flow, this in turn is used to calculate the volumetric efficiency.

The setup enables carry out experiments to study engine performance. Thus enables to study brake power, BMEP, brake thermal efficiency, volumetric efficiency, specific fuel consumption, air/fuel ratio and heat balance of an IC engine. The cylinder pressure vs crank angle (P-theta) plot can be used to obtain cylinder pressure vs swept volume plot (P-V) using the crank slider mechanism which characterize the relation between crank angle and swept volume. The P-V plot is necessary to compute the indicated power and related efficiency and yet to be implemented in the software in near future.

ACKNOWLEDGMENT

'Accomplishment needs the efforts of many', thus thanks to Head of Department Mechanical, SCOE, Pune Dr H. V. Vankudre for his permission to use the necessary facilities for developing the system.

REFERENCES

[1] Lin Wang,Yingying Tan, Xiaolong Cui Hongli Cui,"The Application of LabVIEW in Data Acquisition System of Solar Absorption Refrigerator",Energy Procedia, vol.16, pp.1496 – 1502,2012.

[2] Tufan Koc, Durmus Karayel, Baris Boru, Vezir Ayhan, Idris Cesur, Adnan Parla,"Design and Implementation of the Control System of an Internal Combustion Engine Test Unit",Advances in Mechanical Engineering Vol 10, pp.1155-1164,2014.

[3] Tianbing Ma, Fei Du, Chuanzhi Fang,"Sensors State Monitoring based on LabVIEW and Wireless Nodes",Advance in Control Engineering, vol.15, pp.2639-2643,2011.

[4] G.V.Bharadawaja Sarma, C.H.Nagraju,"Automotive Engine Temperature Control Employing Apt Temperature Measurement And Control Measures", International Journal of Engineering Research and Applications, vol.2, pp.1425-1429,2012.

[5] Zhang Minglea, Yun Jintiana, Jin Guoguanga, Liu Gang,"System on Temperature Control of Hollow Fiber Spinning Machine Based on LabVIEW",International Workshop on Information and Electronics Engineering, vol.29, pp.558-562,2012.

[6] Shyam.R.Nair, Venkatesh Thalaimalayan,"Design of a LabVIEW Based Real Time Simulator for ABS Tester", International Journal of Scientific and Research Publications, vol.2, issue 5, 2012.

[7] Huizong Feng, Fenglin Liu,Yang Xu,"Functional Testing System Based on LabVIEW for Gas-fueled Automobile Engine ECU",International Confrence on Advanced Computer Control (ICACC 2011).

[8] A.V. Bueno, J.A. Velásquez, L.F. Milanez,"Internal Combustion Engine Indicating Measurements", Applied Measurement Systems, chapter 2, pp 23-46, 2008.

[9] M.Abd-Elhady, T.Zornek , S.Balestrino, "Influence of gas velocity on particulate fouling of exhaust gas recirculation coolers", *International Journal of Heat and Mass Transfer, Elsevier,* Vol. 54, pp. 838-846, June 2010.

[10] A. Warey, A.S. Bika, S. Balestrino, Patrick Szymkowicz, "Influence of water vapor condensation on exhaust gas

recirculation cooler fouling", *International Journal of Heat and Mass Transfer, Elsevier*, Vol. 65, pp. 807-816, June 2013.

[11] H. Wei, T. Zhu, G. Shu, "Gasoline engine exhaust gas recirculation – A review", *Applied Energy, Elsevier,* Vol. 99, pp. 534–544, March 2012.

[12] Yang Shuai, Liu ling, "EGR Control and Simulation about EGR Rates Influence on Diesel Engine Operation Performance", *IEEE* paper 978-1-4244-8039-5, 2011.

[13] J. Rajaraman, K. Saraswathi,"A Labview Based Monitoring and Controlling of Various Process Variables",International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol.3, issue 10, 2014.

[14] S.Rajesh Kumar, S.Rameshkumar,"Industrial Temperature Monitoring and Control System Through Ethernet Lan",International Journal Of Engineering And Computer Science, vol.2, issue 6, 2013.

[15] R.Karhe, C.Patil,"Real Time Data Acquisition and Home Parameters Monitoring using LabVIEW", *IJARCET* vol.2, issue 3, 2013.

[16] B.J.Bunker, M.A.Franchek, B.E.Thomason,"Robust Multivariable Control of an Engine-Dynamometer System",*IEEE TRANSACTIONS ON CONTROL SYSTEMS TECHNOLOGY*, vOL. 5, issue 2, pp. 189-199 1997.