e-Library Science Research Journal
ISSN 2319-8435

Impact Factor : 2.2030(UIF)
Volume -3 | Issue - 10 | Aug - 2015

REVIEW OVER AUTOMATION FOR ENGINE TESTING SYSTEM

Sagar Hate
BE (E&TC), Project Engineer for ETL,

Co - Author Details :
Shahu Chikhale
ME (CN), NMIET, Pune University,

ABSTRACT

To control various systems we require an operating system or equipments such as machinery, processing units, networks, reduced human intervention to get automated test bench. The biggest result of automation is to save labor, energy, materials, and time to improve quality, accuracy and precision. Test automation can automate some repetitive but necessary tasks in systematic manner. In this paper we discuss about the generalized automated engine test cell which gives facility to develop, characterize, test engines. An ideal test cell includes overall system test parameters, such as SCU, MMI CPU, Digital controller CPU, ESSC, Throttle controller, Dyno Controller.

KEYWORDS :*Test cell, ESSC, SCU (Signal Conditioning Unit), Throttle controller, Dyno Controller, MMI CPU, Digital controller CPU etc.*

INTRODUCTION :

With a growing demand of vehicles, IC engines have gained lot of importance in automobile industries. It is therefore necessary to produce efficient and economical engines. While developing engine it is required to take all the parameters affecting the engines design and performance into consideration. So it becomes necessary to conduct different tests on the engine and determine the ways to improve the engines performance. After running the engine in particular environment (very hot or very cold) and different road conditions for specific time duration, what will be the effect on Rings, Pistons, Crankshaft, Gear box and other part of the engine is observed in R&D of engine/engine parts. These atmospheric conditions are created inside test cells using different Conditioning Units like CCU, FCU, OCU, Super charger etc. And in production plant of engine/engine parts sampling of product is done to test quality in a batch.

There are different test standards set by government organizations of different countries, which must be passed before launching the vehicle. Also sampling of engine is also done to monitor the quality of production. ARAI (Automotive Research Association of India) is one of those organizations of India which gives license to Indian and foreign vehicles to launch in India. A special

watch is kept on Emission of vehicle [1]. Since exhausts gas consists of different poisonous gases like nitrogen oxide (NOx), total hydrocarbon (THC), non methane hydrocarbons (NMHC), carbon monoxide (CO) and particulate matter (PM) are regulated for most vehicles. EURO1 (India 2000), EURO2 (BS2), EURO3 (BS3), EURO4 (BS4) the emission standards set by Europe and analogous standards are in India are mentioned in the bracket.

II.PROPOSED SYSTEM

In order to cope up with all above conditions and test system, we are proposing the basic engine testing system as shown in the following diagram

Diagram-

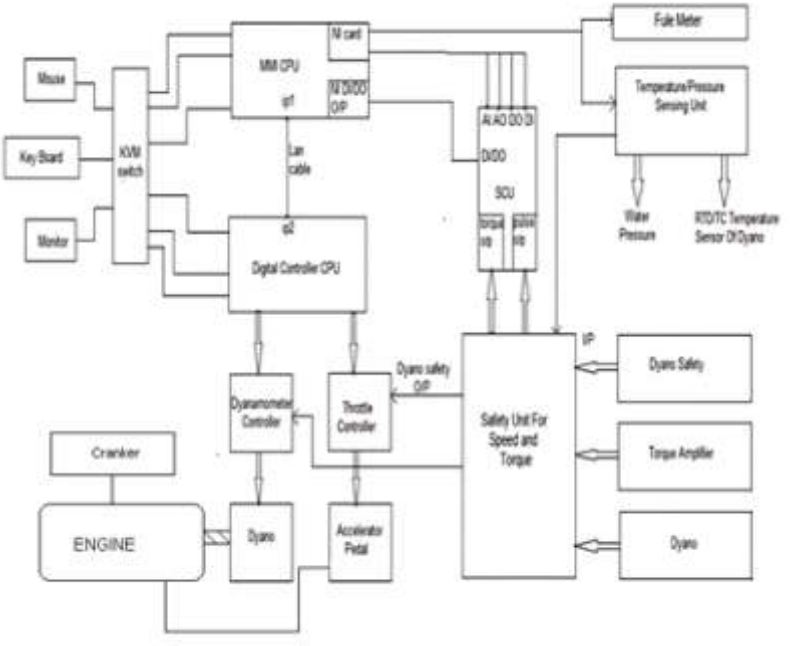

Fig.1 Engine Testing System [4]

As shown in the above diagram. The whole testing system is divided into two parts-

1. CPU Section-
a) MMI CPU
b) Digital Controller CPU
c) SCU (Signal Conditioning Unit)

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2. Controllers Section-
a) ESSC (Engine Start Stop Controller)
b) Accelerator Controller
c) Dyno Controller
d) Safety unit for over speed and torque

1. CPU SECTION

The CPU section mainly transmit commands or receives signal, process signals to show the values of different important parameters in user understandable format. CPU Section also stores this

data and presents this data as a reference for future research and development. In order to reduce the delay between command given (e.g. demand of speed) and time taken to reach the command (demand of speed at engine side) we are using 2 industrial CPU. These 2 CPU communicate with each other via LAN cable. So two IP are provided for 2 CPU.

a) MMI CPU:

MMI CPU[5] is man to machine interface CPU .This CPU consist of industrial high frequency processor, National instruments cards for AI, AO, DI, DO, counter I/p etc along with windows OS (Windows XP, Windows 7, Windows 8). Windows OS are slow response OS. LAN cable is attached between MMI and Digital controller CPU.IP Address for this CPU is 192.168.20.130 .This CPU has a special purpose software which reads all the values (analog and digital) Coming from different sensors to Digital controller CPU and also to itself directly. Also, demand is set for different devices by manual or programmable input. The actual demand for some devices are monitored and controlled by Digital controller CPU.

MMI consists of a single integrated interface, which controls a variety of devices and functions. The system consists of the MMI terminal and the MMI display screen.

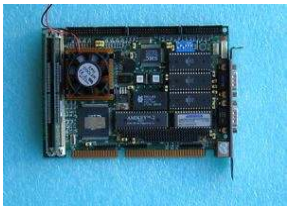

Fig.2 NI6016 Analog I/O Card [6] Fig.3 Industrial Motherboard [7]

Fig.4 NI 6503 Digital I/O Card [6]

b) DIGITAL CONTROLLER CPU:

Digital controller [5] central processing unit is the main controller of our system. All the input-output terminals are provided to and from Digital controller CPU via Digital controller CPU termination board .Digital controller CPU is connected to MMI PC via LAN connection. IP for this CPU is 192.168.20.120.

Digital controller CPU has cent as (Linux based) Digital controller CPU is PID controller. Cent OS is fast response operating system which responses into millisecond for change in the speed and torque for the dyno. All demands for dyno and throttle are given by Digital controller CPU and feedback from them is also acknowledged.

The principle behind demand and feedback [8] [9] is like the curve shown in following diagram-

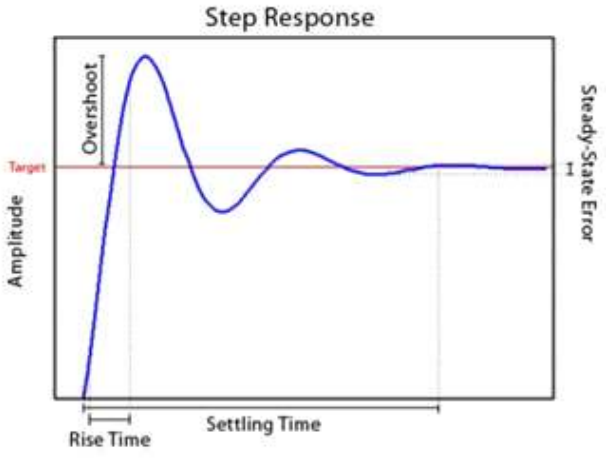

Fig.5 Step Response For Speed Demand [8]

Suppose you gave the demand of speed as 3000RPM.Then speed will gradually rise. This increase in value is very fast response curve. Therefore rise time is very small. Then it will not take directly value as 3000 but the value will go something above it called as overshoot. Then gradually the difference between SV (Set value) and PV(Processed value/actual value reached) is reduced. And finally after settling time the PV matches SV.

Actually as per described in above paragraph, when we practically give demand as 3000 RPM, accelerator immediately responds, causing the Overshoot. Now in order to control the speed Dyno applies the load on the engine causing the speed down than the Target value (i.e.3000).Then feedback of PV is taken. Again throttle and dyno coordinates within themselves to achieve the target value.

c) SIGNAL CONDITIONING UNIT:

SCU [4],[2] is main block in workstation. It receives and gives out analog and digital signals. Signal Conditioning Unit takes a composite input signal, splits the signal into its broadband AC and low-pass DC signals, amplifies these signals, then applies the amplified signals to AC and DC outputs.

The AC output voltage can be determined using a lock-in amplifier and a digital voltmeter and can be used to measure the DC output voltage. The ratio of the AC to DC voltage is a necessary computation for the measurement of linear and circular dichroism. The signal conditioning unit accepts input signals from the analog sensors and gives a conditioned output of 0-5V DC corresponding to the entire range of each parameter. This unit also accepts the digital sensor inputs and gives outputs in 10 bit binary with a positive logic level of +5V.

2. CONTROLLERS SECTION

a) ENGINE START AND STOP CONTROL UNIT (ESSC)

This is one of important unit of the testing bed. As the name concern ESSC[4],[2] (i.e. Engine start and stop control unit), thus the overall controlling of cranking or stopping of engine is done through it. The in cell unit implies as the testing room and ESSC as controller section. Both the in cell unit and ESSC are provided with one to one connection.

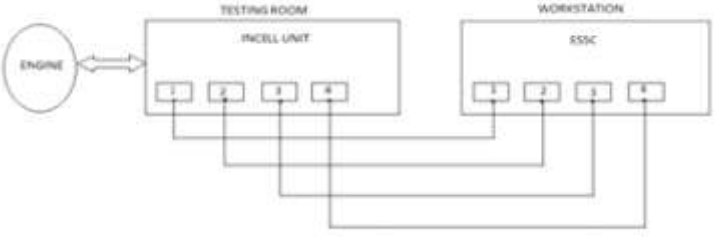

Fig. 6 One To One Connection Of ESSC And INCELL UNIT. [4]

As shown in the above diagram. This unit can perform four main tasks as START, IGNITION, HEATING, and STOP.[4][5] These connections are shown in following diagrams. The numbers in boxes 1,2,3,4 indicates the relay numbers for START, IGNITION, HEATING and STOP respectively. As it is having one to one connection thus all the above task will be proceed if and only if both the system are active, else not.

b) THROTTLE CONTROLLER:

Throttle control (TC)[4] is an automobile technology which "connects" the accelerator pedal to the throttle[3]. Throttle controller can also be called as accelerator controller. Throttle controller is connected to the throttle motor which is supplied with 3 phase or 2 phase supply for its rotation. The Throttle cable is connected to throttle motor and another end is connected to accelerator paddle which control the flow of air. The demand is sent to throttle through Digital controller CPU. Throttle feedback is taken from throttle on Digital controller CPU. Electronic throttle control (ETC) also used. The ECM[5] is a type of electronic control unit (ECU), which is an embedded system that employs software to determine the required throttle position by calculations from data measured by other sensors, including the accelerator pedal position sensors, engine speed sensor, vehicle speed sensor, and cruise control switches.

Fig.7 Accelerator Controller [9]

c) DYNAMOMETER CONTROLER:

In order to test the engine it is necessary to use a dynamometer [3]. Generally, it is not possible to measure the speed and load of engine directly. Thus dynamometer is attached to the engine via shaft. It can be as shown in fig.1.This is usually an electronic unit which has the capability of controlling the load on the dynamometer and can measure or sense the load and speed and is implies the load and

speed of engine. [4] Dynamometer controllers generally operate in two modes: Speed Controlled operation or Load Controlled operation.

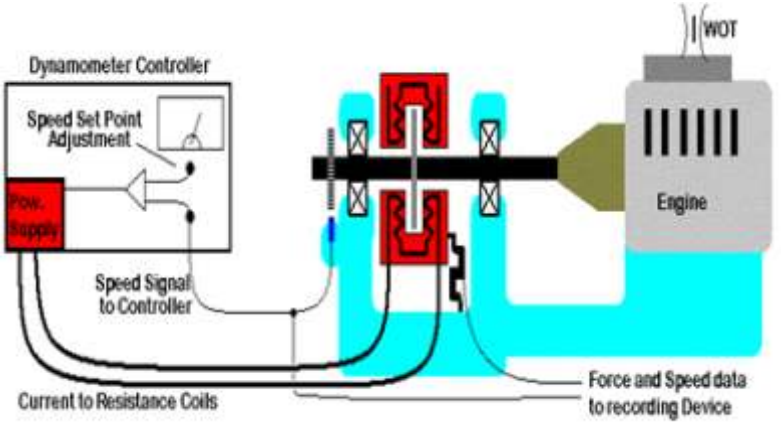

Fig.8 Schematic of a Speed Controlled Test of Engine[6]

In Speed Controlled mode a set speed is given to the controller. If the measured speed of the shaft is less than that of the set speed, the load is decreased. If the measured speed of the shaft is greater than that of the set speed, then the load is increased. Assuming the engine has sufficient torque to attain the set speed; this will maintain a constant speed.

In Load Controlled mode a set load is given to the controller. If the measured load on the dynamometer is greater than that of the set load, the load is decreased. If the measured load on the dynamometer is less than that of the set load, then the load is increased. Assuming the engine has sufficient torque to attain the set load; this will maintain a constant load while the speed varies. In addition to above two parameters i.e. speed and load it is also important to measure the dynamometer temperature and the pressure of water used for cooling the dynamometer. Thus, diode is used for sensing the dynamometer temperature and current output pressure sensor is used for measuring water pressure.

D) SAFETY UNIT FOR OVER SPEED AND TORQUE

This controlling unit is only for safety purpose [2],[4] of the engine. Suppose Rated Speed of engine is 5000 RPM but we want to control the speed only upto 4000 RPM for safety purpose then using this controlling electronic circuit we can generate an alarm as Over speed. Similar situation is about torque.

TESTING CONDITIONS ON ENGINE [5],[4]

The tests on I.C. engines can be divided into two types:

1. Variable – speed test.
2. Constant – speed test.

Variable – speed tests can be divided into full – load tests, where maximum power and minimum SFC at each different speed are the objectives, and part – load tests to determine variation in the SFC [7]

Constant –speed test is run with variable throttle from no load to full load in suitable steps of load to give smooth curves. Starting at zero loads, the throttle is opened to give the desired speed. Then

a load is put on the engine and the throttle is opened wider to maintain the same constant speed as before, and the second run is ready to start. The last run of the test is made at wide-open throttle. In a CI-engine test the last run would show smoke in the exhaust gas.

III.CONCLUSION

The proposed system can be used to test the engine on different test standard set by Indian and other countries like EURO series, Japanese series, BS series etc. Some tests like emission analysis, Oil oxidation test (used for oil R&D), Fuel consumsion measurement (SFC, BSFC) are also possible using the same test system. Only we have to add different conditioning units and smart sampler for emission measurement.

For engine production section, we just need to add pallet trolley in the system. Pallet trolley is movable arrangement to sample engine one by one, crank it for specific time and release the engine for new sample. Vehicle testing next step of engine testing in which some mechanical (dyno) is different than this system and road conditions are maintained in test cell. All other things are similar to the proposed system.

APPENDIX

AC: Alternating Current
CPU: Central processing unit
Dyno: Dynamometer
DC: Direct Current
ESSC: Engine start and stop control unit
ETC: Electronic throttle control
FCU: FUEL CONDITIONING UNIT
I.C. engines: Internal combustion engines
LAN: Local area network
MMI: Multimedia interface
PV: Processed value
SFC: Specific fuel consumsion
SV: Set value
SCU: Signal Conditioning Unit
OS: Operating System
CCU: Coolant Conditioning Unit
OCU: Oil Conditioning Unit

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