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Experimental Analysis to find the optimum Specific Fuel Consumption for Driver's Intimation

Elavarasan G., Kannan M., Karthikeyan D.

Abstract: The crude oil based fuel price is constantly increasing in India, So it is compulsory to utilize the fuel properly by the user. As most of the driver tends to press the gas pedal unnecessarily, the fuel used at that particular condition is excess than the requirement. This experiment focuses on improving the fuel economy by warning the driver to drive their vehicles in optimum Specific Fuel Consumption (SFC) range using electronic SFC Speed Range Indicator. In variable speed Internal Combustion Engines there will be an optimum SFC range for a particular load and Engine Speed. Our system will monitor the Engine speed and load continuously and also compare the values with best SFC speed range graph and depends on these values the three Light Emitting Diode (LED) on Specific Fuel Consumption Speed Range Indicator(SFCSRI) will glow accordingly to mention the driver about the optimum, low or high speed. This helps the driver to drive their vehicles on optimum SFC range.

Index Terms: Driver alert for SFC, Fuel economy, Optimum SFC, SFC Range, vehicle indicator,

I. INTRODUCTION

Amirta sen, et al, have clearly reported that there will be an increase in the oil demand in future, As the automobile population will keep on increasing[1]. The current situation of crude oil demand and the reserves to production ratio of India and other world countries were clearly reported in our previous work[2]. The gasoline consumption on the fuel economy was analyzed by H Spencer Banzhaf et al. in their research work[3]. The researches in the field of improving the fuel economy of the vehicle will increase the overall vehicle cost because of the implement of the advanced technology in the vehicles[4]. With increase in the fuel economy of the vehicle we can save upto a million liters of the fuel consumption in a period of timeline in the whole country[5]. A study also states that the fuel economy of the vehicle increases if we increase the distance travelled by the vehicle per day[6] & [7]. Automobile manufacturers are reducing the engine horse power and torque in order to increase the fuel economy of the vehicle[8]. Fuel economy in the gasoline powered engines is improved by modification in the fuel injection system like dual-port fuel injection [9]. There so many indication in the vehicle for the driver to drive the vehicle in desired conditions, Some drivers respond to the vehicle feedback and that results in the increase of fuel economy of about 4.4%[10]. Our SFCSRI system is also a kind of driver alerting system in which the system will intimate the driver with the help of LED lights about the optimum SFC range based upon the indications, the driver will increase or decrease the acceleration. SFC is the amount of fuel consumed for producing a unit brake power in the engine[11]. The SFC will vary according to the load conditions of the engine[12]. Generally, SFC will decrease if we increase the load up to particular level and it will start to increase after that level, this SFC decides the fuel economy of the engine[13]. From the Fig. 1, At 100% load the specific fuel consumption is minimum at 3200 rpm. But at both higher and lower speeds the SFC rises but only at a smaller rate. At 50% load the specific fuel consumption is minimum at 3100 rpm. At lower speed it raises abruptly and reaches value of 0.8 at 1000 rpm. At 25% load the specific fuel consumption is minimum at 2800 rpm which shows the value of 0.7. At lower speed a maximum of 1.2 is reached which is not a good fuel consumption.

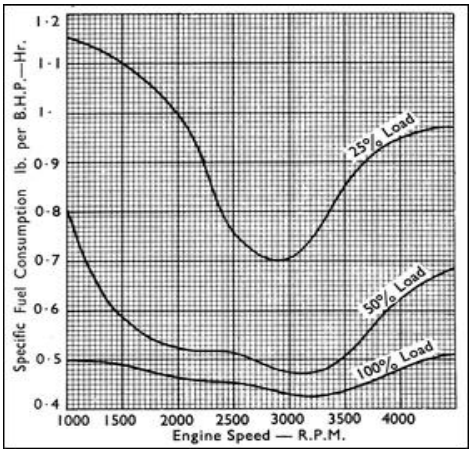

Figure.1 Engine speed Vs SFC

Increasing Fuel Economy on Automobiles is the main driving force behind the requirement of SFCSRI. Most of the drivers are not aware of the SFC range in engine speed for a particular load. They will just increase the speed of the engine by pressing the accelerator pedal to overcome the load.

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***** Correspondence Author

Elavarasan G *, Mechanical Engineering, Annamalai University , Chidambaram,India.

Kannan.M , Automobile Engineering, NCR Campus, SRM IST, Ghaziabad, India.

Karthikeyan.D, Mechanical Engineering, Annamalai University, Chidambaram,India.

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But the speed increased may not match with the optimum SFC speed range on that particular load. The above case is existing more in buses where the driver cannot be able to run the engine depending on the load. Because the number of passengers boarding and leaving the vehicle are varying regularly

This makes the load on the vehicle to vary all the time. So, the driver cannot be able to drive in the optimum SFC range. The SFCSRI system helps the driver to know about his driving range on SFC and alert him to drive the vehicle in correct speed so that the fuel consumption on the vehicle is getting reduced. The main objective of this experiment is to enhance the engine fuel economy by alerting the driver to drive the vehicle in optimum SFC range and to increase the engine performance by running the engine at perfect fuel consumption and speed.

II. PROPOSED METHODOLODY

The major components used for the experiment are GX 25 CC Engine, Starter Motor, Alternator, Arduino MC, Throttle Position Sensor, IC LM393 (comparator IC), 5V supply Battery, 10kΩ Resistor and LED lights. These components were purchased and fitted together in a working condition and finally result was obtained.

A. *Specification of GX 25cc Engine*

Honda 25cc,a mini 4-Stroke Overhead Camshaft (OHC) engine powered by gasoline was selected for the research purpose as it is having the less weight and oil consumption. Also the staring ability of this engine is also very impressive. Because of these reasons this engine was chosen for the experimental setup.

Table.1 Engine Specification (Table shows the specification of the engine used for the experiment)

Engine Type	Air-cooled 4-stroke OHC
Bore x Stroke	35 mm x 26 mm
Displacement	25 cm3
Net Power Output	1.0 HP (.72 kW) @ 7,000 rpm
Net Torque	0.74 lb-ft (1.0 Nm) @ 5,000 rpm
Power Take Off (PTO)Shaft Rotation	Counterclockwise (from PTO shaft side)
Compression Ratio	8.0:1
Carburetor	Diaphragm-type (overflow return)
Ignition System	Transistorized magneto
Starting System	Recoil

B. *SFC of GX 25cc Engine*

Fig.2 is the SFC graph of the Honda GX 25cc engine and it shows the graph between the engine torque and speed and SFC of the engine used for the experiment. The values given in the graph were company provided data and these values were taken for the consideration in the programming part of this experiment. It is clear from the figure that there is a specific fuel consumption is there for particular speed and torque requirement. From the torque requirements of the engine we can able to calculate the vehicle load conditions. So there is a way to connect the engine load condition and torque requirement of the vehicle. So from the above figure it is clear that there is a particular SFC is there for a particular speed and load of the engine. This data will be helpful for our system to find the correct SFC range of the engine for the various operating conditions.

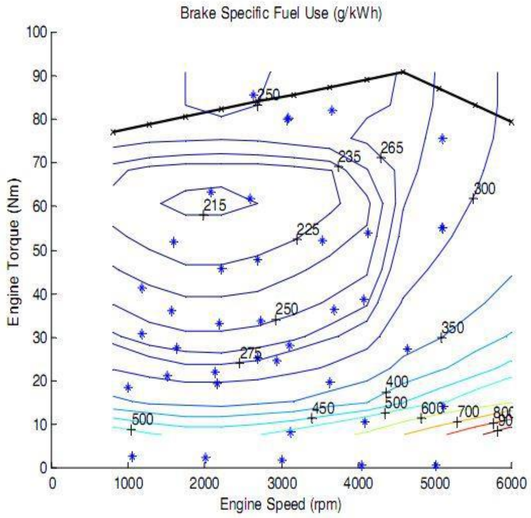

Figure.2 GX 25cc Torque vs speed vs SFC

III. WORKING PRINCIPLE

Mini Eddy-current dynamometer set-up was finished and fabricated. Starter motor was fixed to the engine by removing Recoil starter system. Arduino MC was selected and purchased. Comparator circuit was designed and checked the data with Cathode Ray Oscilloscope (CRO). Preliminary circuit was finalized. Circuit diagram was finalized. Purchased Hall Effect Sensor and Potentiometer. Sensor was attached to the Engine – Alternator set-up. Potentiometer was fixed to the throttle. Display unit for the driver was finalized. Both the mechanical and electronic system were successfully connected. Now the total system was made to run and checked for any corrections.

A. *Experimental setup*

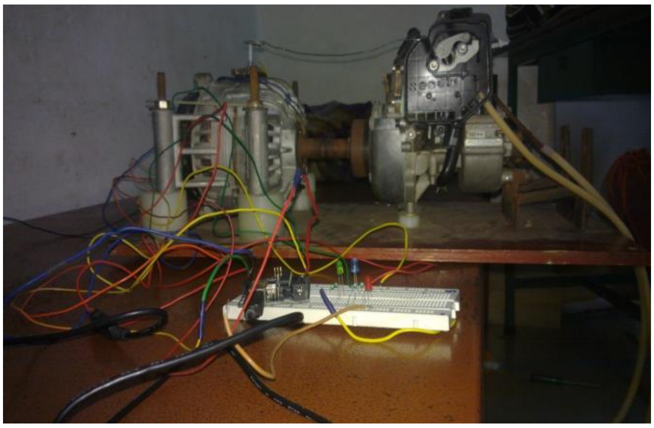

Figure.3 Photographic view of experimental setup

The engine is coupled with the alternator. Throttle position sensor is fixed on the engine throttle valve and hall effect sensor is fixed on the alternator shaft. Both the sensors are connected to the arduino board. The advantage of the arduino board is that the device does not require any hardware programmer as it have the 0.5KB boot loader to burn the program into the circuit.

The arduino board consists of LED lights, resistors, 5 pin relay and connecting wires. The power supply to arduino is given from the supply battery.

The fuel is supplied to the engine and pumped out from the engine through the tubes. The engine and alternator set up is fixed on a board. The Alternator has been used to give load to the engine by connecting various batteries at different charging conditions.

B. *Difficulties faced while Installation*

GX 25 has recoil starter mechanism on one side of the crank shaft as the initial start for the engine and on the other side alternator was fixed by a shaft which is directly coupled to the engine to run both at the same speed without any losses. From this the Rpm of the engine has been directly measured from the rpm terminal of alternator. The recoil starter has been removed to modify that into Electric starter mechanism. The problems on fixing of starter motor to the 25 cc engine is there we cannot able to find the starter motor to match the idling speed and initial torque for this engine. We went on lots of problems on fixing the gear to the engine for using Bendix type starter motor. The other problem we faced on measuring the rpm of the engine using the rpm terminal of alternator. The RPM terminal signal was checked using CRO before and after connecting with IC LM393. But the wave produced on both readings showed a different frequency value which means a different rpm values are carrying out of the RPM terminal. And also the readings are coming out differently on rpm terminal when we checked with Tachometer to find the exact speed of engine. This shows that our circuit is wrong and we went on reading journals about to rectify this problem but we couldn't able to find the exact circuit to find out the rpm through alternator. For the starter motor, we have chosen a dc motor of 1500 rpm and 10 Kg-m torque which is directly coupled with the engine on the side of recoil set up which rectifies the problem on starting the engine with motor. And for the other problem of measuring the rpm of engine we used Hall Effect sensor to find out the speed. The hall sensor was used to measure the speed of a rotating shaft that was connected in between the engine and alternator by placing a magnet on it. Whenever the magnet comes in contact with the hall sensor for each revolution some voltage will be generated due to magnetic field. By measuring the time difference between the voltage generation and also with the diameter of the shaft we can measure the rpm of the rotating shaft.

C. *Throttle Position Sensor*

Figure.4 Throttle position sensor in the setup

Throttle position sensor is used to sense the degree of angle the throttle has turned. Based upon the work of Mckay.D et al, and Garrick.R.D in the area of throttle control system this was designed [14]&[15]. Throttle is connected with the potentiometer. As potentiometer is rotated voltage goes into the microcontroller will also vary. From that variation, throttle position of the engine can be measured. We took that the throttle position (minimum variation as 5deg as it is difficult to maintain the position in constant) as the reference point. If a constant fuel flows at this throttle position then engine speed will decrease with the increase in the load which can be used to find the load.

D. WORKING OF THE LAYOUT

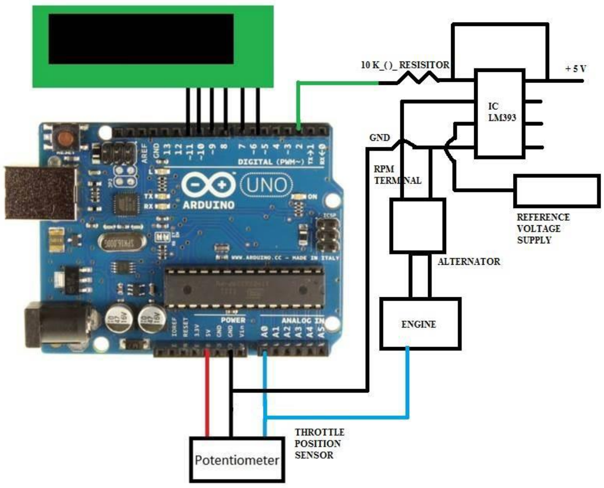

Fig.5 Block Diagram of Experimental layout

When the engine starts, the Arduino MC senses the signal from comparator to find the engine speed. From the RPM terminal of alternator the sinusoidal wave will be generated according to the speed of the alternator runs by the engine. Here the alternator and engine coupled directly by the shaft hence the speed of the both are equal. This sinusoidal wave has been converted to square wave using IC LM393 (comparator IC) and then fed into the MC. The MC measures the ON & OFF time of the square wave and then finds out the frequency to measure the exact RPM of the engine. Once the engine RPM has been found out the MC will looks for the throttle position by measuring the voltage drop in potentiometer which is fixed on the throttle lever. From this voltage variation the MC senses the angle of the throttle movement. After measuring this value the MC will then looks for the load acting on the engine by sensing any drop in engine speed for a particular throttle position with the values of engine speed and throttle position at no load conditions. From this calculation the MC can able to find out the load acting on the engine for a particular brake power of the engine. After finding out the load the MC will again look for the speed because the engine speed has to be raised to overcome the load acting on it. With this engine speed and load the MC will compare the speed and load for the best SFC range and then alerts the driver by giving signal to the corresponding LED's according to the speed range. Fig.3 shows the experimental layout.

IV. RESULT & DISCUSSIONS

Fig.6. shows the initial obtained square waveform in the dual trace oscilloscope using a Hall Effect sensor. The square waves are necessary for the feed into the micro controller.

Figure.6. Square waveform of speed obtained in a dual trace oscilloscope

The fig.7 shows the photographic view of the three types of indicator that was given to the driver. The blue color indicates the engine is running below than the SFC range, the red color indicates that the engine is running above the SFC range and the green color indicates the vehicle is running within the SFC range.

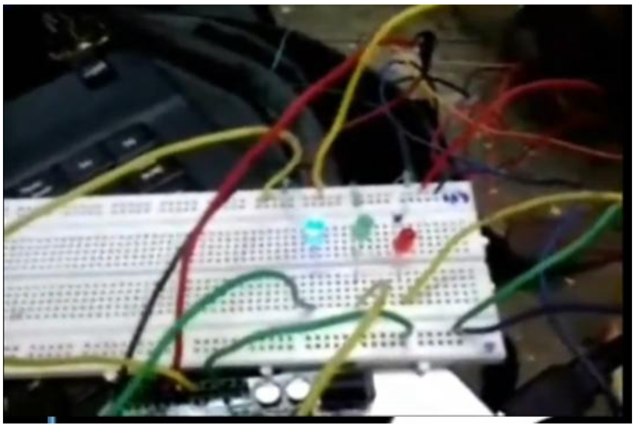

Figure.7. Photographic view of the indicator

Figure.8,9 & 10 show the obtained result in the computer, when the engine is running in the various conditions for the understanding purpose the color is varied. The color variation is according to the operating conditions of the engine. Here the optimum SFC range of rpm is having the minimum of 2000rpm to the maximum of 2200rpm according to the load conditions of the vehicle. If the vehicle is operating below the rpm range then the engine is running under low sfc range, So it will indicate the blue color then the driver will understand that he have to increase the rpm. Likewise the red color indicates that the engine is running in higher rpm than the required rpm at that load condition, So the driver will understood that he have to reduce the rpm. This green color indicates that the vehicle is running in the desired sfc according to the operating condition, So the indication is to understood that the engine is running in the desired sfc range. By this indication we can increase the fuel economy for the various operating conditions of the engine. Thus this system gives an alert to the driver about the fuel consumption during the running condition of the engine according to the load acting upon the engine.

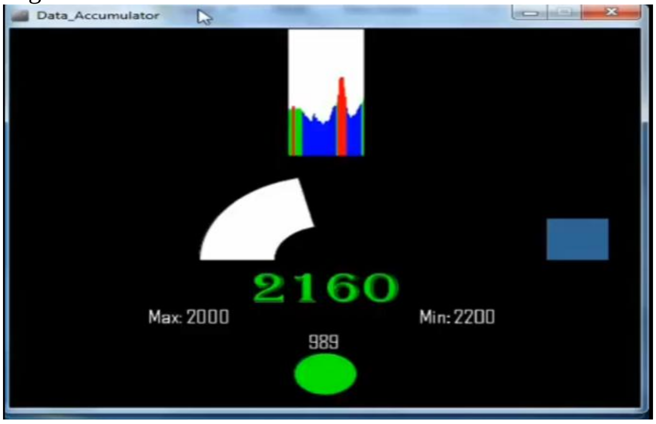

Figure.8. Engine operating in desired SFC range

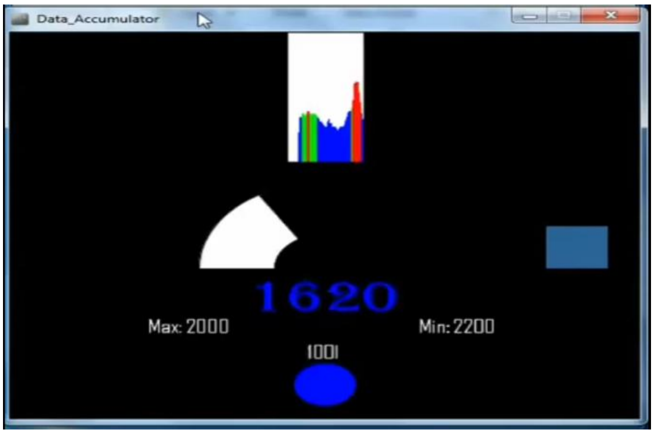

Figure.9. Engine operating under low SFC range

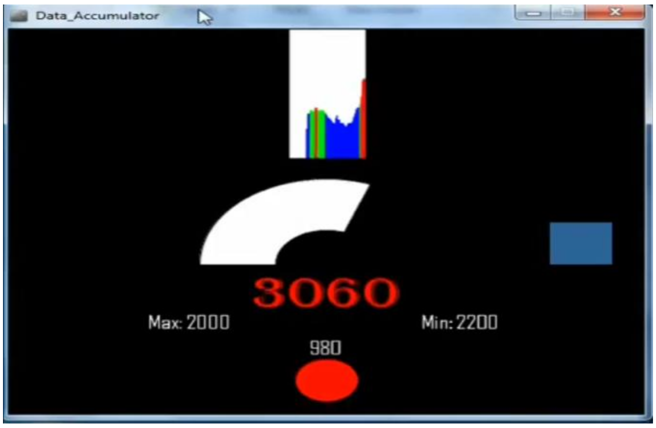

Figure.10. Engine operating in high SFC range

V. CONCLUSION

The SFCSRI system finds out the speed range for the best SFC range while the vehicle in running conditions. Thus the system alerts the driver by indicating three lights on the sfc range. This helps in driving the vehicle in better fuel economy and helps the future in fuel usage and also the correct measure of fuel consumption reduces the unburned HC emissions.
The following are the benefits of the SFCSRI system

- ➢ Alert the driver about the best speed range.
- ➢ Increases Fuel economy by reducing the wastage of fuel.
- ➢ Reduces unburned HC emissions.
- ➢ Improvising the engine performance.

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AUTHORS PROFILE

Elavarasan G received his BE(Automobile) from MIT campus, Anna University, Chennai and MTech(Energy) in SITE,Subharti University, Meerut.The author have published around 2 International journals with ISSN number. He is currently pursuing his Phd (Mechanical) in Annamalai University, Chidambaram. His area of interest is emission control in internal combustion Engines.

Kannan.M received his BE(Automobile) from MIT campus, Anna University, Chennai and MTech(Energy) in SITE,Subharti University, Meerut. The author have published around 2 International journals with ISSN number. He is currently working as an Assistant Professor at SRMIST, Ghaziabad. His area of interest is Alternative source of energy for the Automobile sector.

Karthikeyan D completed his doctor of philosophy in the department of Mechanical engineering at Annamalai University, Chidambaram, India and currently working as an Assistant Professor in the department of Mechanical Engineering, Annamalai University, Chidambaram. The author have published around 4 International journals with ISSN number and 1 journal with scopus indexing. His area of interest is Engine emission control using selective catalytic reduction technique in the exhaust system. Currently the author is working as an investigator in a project sponsored by NLC India Ltd., in the area of emission reduction in IC Engines.