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# OBD-II and Power- Train Procedure: Study for Fuel Injection System in I.C. Engine

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***Abstract*:- On Board Diagnostics (OBD-II) systems were designed to maintain low emissions of in use vehicles, including light and medium duty vehicles. In 1989, The California code of Regulations (CCR) known as OBD-II was adopted by the California Air Resource Board (CARB).**

**Fuel injector located in the intake manifold near the intake valve is the current practice. Each fuel injection is a solenoid activated plunger which normally inhabiting fuel delivery and when activated, the valve open and a predeterminated quantity of fuel is sprayed into the air flowing into the cylinder and mixed with this air. The valve opening is timed relative to the intake stroke by the PCM controller.**

***Key words: FIP, Malfunction Indicator Light (MIL), Plunger, Turbocharger,***

## 2. INTRODUCTION:

The efficiency of combustion in I.C. Engines depends upon the degree of atomization of the fuel and the thoroughness of mixing with air. The end of the compression ratio, the fuel injected into the combustion chamber by means of high injection velocity.

Air injection systems means, " The systems of injecting fuel into the combustion chamber of a diesel incorporates a fuel injection pump which meters out correct quantity of fuel at high pressure and at precise timings to the injectors. For example, in a four cylinder four stroke I.C. Engine, the quantity of fuel to be injected per cylinder per cycle if it consumes 0.4 kg/bhp and develop 500 bhp at 300 rpm. Specific gravity of fuel being 0.9.

<u>Solution:</u>

Fuel consumption/hr = 500 × 4 = 200 kg.
And number of cycle per hour:

$= \frac{300}{2} \times 60 = 9000$ cycles,

∴ Weight of fuel per cylinder per cycle =

$\frac{100}{9000} \times \frac{1}{4} = 0.00277$ kg.

Now, specific gravity of fuel = 0.9

∴ Density of fuel = $0.9 \times \frac{1}{2000}$ kg/cc

∴ Quantity of fuel injected per cylinder per cycle:

$= .00277 \times \frac{2000}{0.9} = 6.1$ cc.

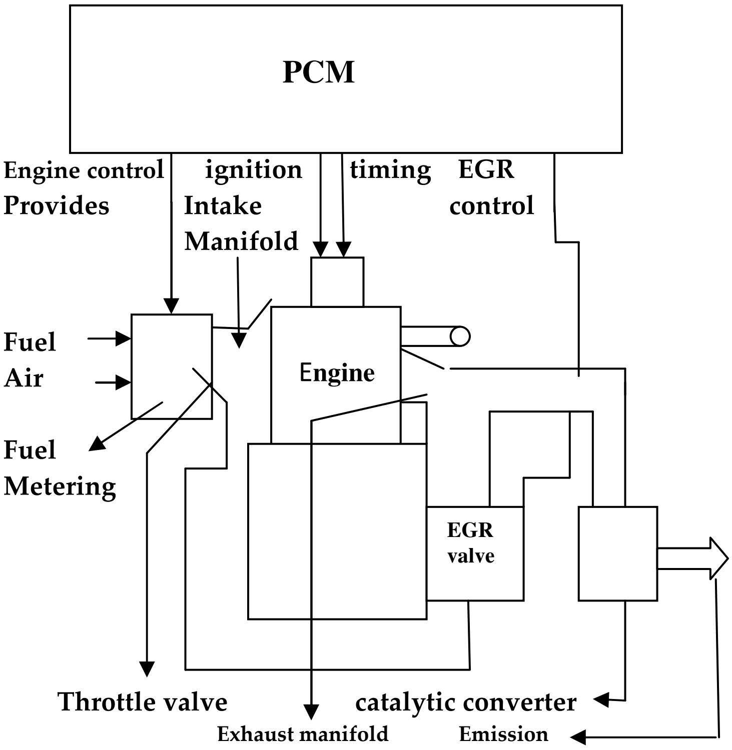


Fig: 2(a) Major Controller out-put to Engine.

(Source: SAE 2000 India Mobility Conference, New Delhi)

## 3. LITERATURE REVIEW:

A supercharge driven by the engine exhaust gas is called turbo-charger. However, it is a supercharging device which uses thermal energy of exhaust gases to run a turbine in turn device a compressor to force air under pressure into the induction manifold of engine.

Gasoline motors are turbocharged, but depending on performance. Because turbocharger on a motor is to increase the amount of air fuel cylinder, as a result explosion and more being produced. For the introducing of turbocharger in gasoline engine, which is not required due to bigger explosion under normal atmospheric pressure and respectable to the amount of explosion burn and help to more useful energy horsepower and in this regard for diesel engine, burns long and slow and disesl engine needs more air to get same kind.

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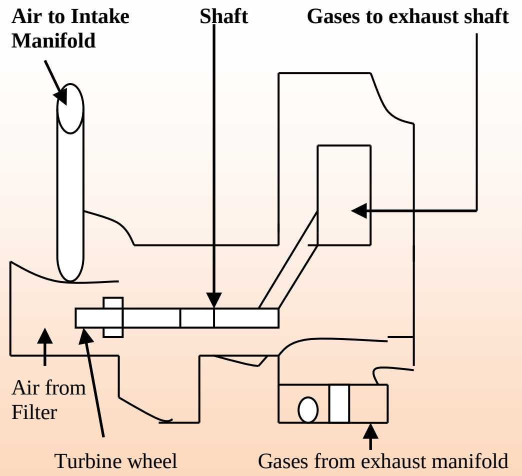


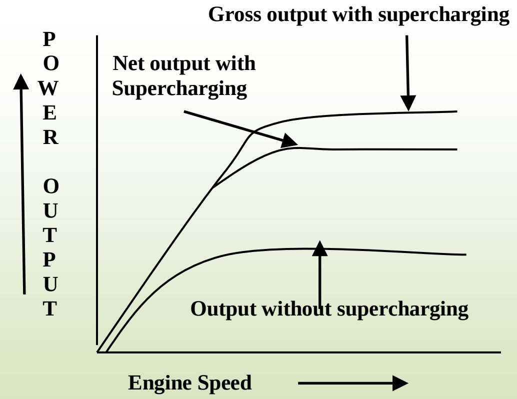

Fig: 3(a) Turbocharger (Sectional View)
Source: SAE 2000 India International Conference, New Delhi

We know that the purpose of a nozzle is to atomize and direct the spray of the fuel droplets into the combustion space in such a manner that proper penetration and distribution are obtained. Let the diameter of the injector orifice to spray a fuel quantity "Q" per cycle cylinder is $d_r$. The injection pressure is $p_1$ combustion chamber pressure is $p_2$, density of fuel is $p_r$ and period of injection is t-second.

Pressure difference causing the fuel flow through the orifice = ( $P_1$-$p_2$) kg/cm $^2$ .

Pressure head causing the fuel flow

= ht = $\frac{p1-p2}{pf}$ cm of fuel.




Graph: (Supercharged engine output)
Source: Automotive Design problem by K M Agrawal, India.

However, for the OBD-II diagnostics, the Fuel Injector consists of a spray nozzle and a solenoid operated plunger. Whenever the plunger is lifted from the nozzle, fuel flows at a fixed rate through the nozzle into the air stream going to the intake manifold. The plunger acts as a fuel injection on-off valve. The plunger position is controlled by a solenoid is activated, causing fuel to flow which is under pressure. The solenoid , plunger and nozzle act as an electrically switched valve, which is closed or open , depending on whether the control current is off or on respectively. The fuel flow rate is regulated by fuel pressure and nozzle geometry. The amount of fuel is proportional to the time the valve is open. The control current that operates the fuel injector is pulsed on and off, and the air fuel ratio is proportional to the duty cycle of the pulse train from PCM controller.

## 4. METHODOLOGY:

*Fundamental of Power train Control Strategies & OBD II Diagnostic:*

*Fuel system Monitoring:* For Fuel control strategies multipoint pulsed fuel injector system is assumed. The power train control strategy is to provide the correct Air/Fuel ratio under all operating conditions, except during cold-start. The systems involved in this metering, fuel pump, ignition timing, fuel injectors, injector pulse width and lambda control. The PCM determines the required injector pulse width to maintain Air/Fuel ratio within the lambda control window (0.93 to 1.07). The PCM adds correction factors to injector pulse width to increase fuel injection during cold start and wide open throttle , in closed loop operation . During declaration, PCM closes fuel injection. Ignition timing affects emissions and excessive spark advances will cause engine knock. Consequently fuel system monitoring is done by using predeterminated data map with optional fuel required for each load (MAP Value) and engine RPM point. The amount of fuel is determined by the duty cycle of the injector pulse width.

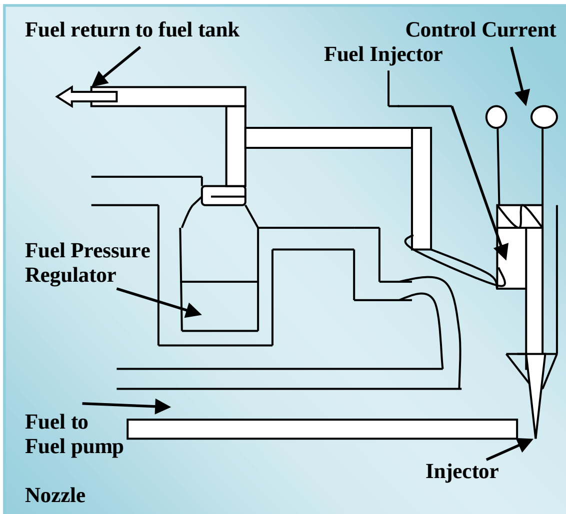



Fig: 4(a) Throttle Body Fuel Injector (TBFI) Fuel Metering
Source: www.sae.org

The lambda closed loop control system provides feedback to the PCM on the necessary correction to the present data points. The corrected information is stored in the PCM's memory so that the next time that operation point is reached, less correction of the Air Fuel mixture ratio will be required. If the PCM correction passes a predetermined

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threshold , it indicates a faulty fuel system, that some components in the fuel supply system outside of its operating range. Some possibilities are defective fuel pressure regulator, contaminated fuel injectors, defective manifold absolute pressure (MAP) sensor, and intake air system leakage or exhaust system leakage. All electronics components are checked for circuit continuity, rated current, rated voltage and rational parameter values within limits of operation. These include fuel pump, ignition circuit, injection solenoids, engine RPM sensor, and MAP sensor. If the fuel correction exceeds the limit, either in absolute value or in update rate, the fuel system is deemed faulty and a fault code is stored and MIL is illuminated. Since fuel system has a major impact on emissions, its diagnostic are crucial to control emission and consequently to OBD II. The legal OBD II requirements are: the diagnostic system shall amount monitor the fuel delivery system for its ability to provide compliance with emission standard.

*From example from different angle:*

Problem: A centrifugal supercharger has to delivery air at 1.03 kg/cm$^2$ when working at a supercharger per kg of air if the exponent of compressor is 1.7.

Solution:
The temperature at 10 kilometers above sea level,
= 15 – 10 × 5 = - 35° C = 233° K.
P = Pressure at a high of 10 km = 0.2815 kg/cm$^2$

Assuming the weight of air to be 1 kg and applying the gas law , we have $P_1V_1 = wRT_1$

$$\therefore V1 = \frac{wRT1}{P1} = \frac{1\times 29.2\times 238}{0.2815\times(10)4}$$
= 2.39 m$^3$
= Volume of 1 kg of air before compression at 10 km height.
Again, $P_1V_1^{\ 1.7} = P_2V_2^{\ 1.7}$
Where $P_2$ and $V_2$ refer to the condition after compression,

$$\therefore\ V_2 = V_1\left(\frac{P1}{P2}\right)^{1/1.7} = 1.14 \text{ m}^3$$
Work done per kg of air = $\frac{n}{n-1}$ ( $P_2V_2 - P_1V_1$
$= \frac{1.7}{0.7}(1.03 \times 1.14 - 0.2815 \times 2.39) \times 10^4$
= 11.610 kg.m /minute
∴ H.P. = 2.58

## 5. RESULT AND DISCUSSION:

Power train Control Module (PCM) perform microprocessor based self diagnostics to ensure correct operation of the PCM and safe storage of OBD II diagnostic data in memory. Perform on Board diagnostics in real time and alert the driver by illuminating MIL in case of a fault perform power train control functions to reduce emissions and meet OBD II regulations during open – loop operation as start up time.

For the secondary air system, the PCM shall monitor the secondary air delivery system and proper functioning of the air switching valves. The algorithm consists in monitoring the lambda sensor for correlated deviations when the secondary air flow is changed from exhaust manifold or to catalyst chamber or to outside air cleaner.

For the fuel system, PCM shall monitor the fuel delivery system. The algorithm is to monitor the deviations of the stoichiometric ratio which last for a longer time and store them within the adaptive mixture controller consisting of short term fuel trim, and long term block learn. If these values exceeds defined limits, components of the fuel system are deemed defective. This will result in illuminating the MIL and storing the DTC in memory.

## 6. TYPE OF DATA:

6.1. Complaint Reported :
Engine hard starting every initial stage (Source: Mico Dealer in India for Heavy Commercial Vehicle)
6.2. Engine No: 697 DI 21 B VQ 103406
6.3. Chassis No: 357SP 21 F VQ 7 33476
6.4. K.M., 19600 kms.
6.5. Fuel Injection Pump No: 76625658
6.6. Spill timing Checked: comes 20 before T.D.C. ( 1 drop in 15 sec from swan neck)
6.7. Injectors checked and found:
( Source: Mico Dealer in India)

| | **Description** | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|---|
| **1.** | **Opening pressure** | **180** | **182** | **180** | **180** | | |
| **2.** | **Dribbling : yes/No** | **NO** | **NO** | **NO** | **NO** | | |
| **3.** | **Spray : ok/Blocked** | **G** | **G** | **G** | **G** | | |
| **4.** | **Leak test – ( checked at 10 kg/cm$^2$ less than opening press : ok/leaks** | **OK** | **OK** | **OK** | **OK** | | |
| **5.** | **Any other Observation:** | | | | | | |

6.8. For black smoke : high fuel consumption, low pulling power, following are to be checked at the nearest Mico Dealer and recorded:
6.8.1. External damages if any: No
6.8.2. Max stop screw : Intact/tempered/broken
6.8.3. Tamper of probolts: Intact/tempered.
6.8.4. Other Seals: Intact/tampered

6.9. Fuel delivery : IN AS IS CONDITION:
(Source: Mico Dealer in India)

| | **Max Fuel Delivery At 500 strokes** | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|---|
| **1.** | **1600 rpm** | **21.5** | **21.5** | **21.5** | **19.0** | | |
| **2.** | **1000 rpm** | **21.5** | **20.00** | **21.5** | **18.0** | | |
| **3.** | **600 rpm** | | | | | | |

**Cutting in rpm: 1650**

| Max Fuel delivery at 500 strokes | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| 1. | 1600 rpm | 25.0 | 25.0 | 25.0 | 25.0 | | |
| 2. | 1000 rpm | 29.5 | 29.0 | 27.0 | 26.5 | | |
| 3. | 600 rpm | | | | | | |

**Cutting in rpm : 1690**

## 7. CONCLUSION:

OBD – II, tests all sensors, actuators (valves) , switches and wiring for proper connectivity and checks the inputs and output of each are within allowed range of value. Each sensor circuit consists of mainly three parts, i.e. sensor, signal processor and a display device.

Oxygen sensor and Heater, monitoring for the performance of oxygen sensor, while it's operating temperature maintained within a specific range above 260° C. For this reason a heater is used to keep the oxygen sensor temperature at the desire value However, fuel injection system plays an important part in supplying the required air fuel mixture to a spark ignition engine for improving mixture preparation contributes to an enhanced power and fuel economy. The engine port injection mode performance at here different throttles openings over a wide range of engine speed. At 50% and20% open throttle position as compared to wide open throttle position there is s fall in engine performance and increase in CO and HC emissions.

## 8. BIOGRAPHIES

Dr. Porag Kalita has completed his PhD in Automobile Engineering. Presently, he and is the Head of Department of Automobile Engineering of M. R. S. Higher Secondary School, Titabor, Assam, India under the Government of India.

He is editorial board member of various UGC approved journals. He is fellow member of IASED,IFERP, Fellow United Writers Association, Chennai and SAE International and is recipient of gold medal and BOLT Award from AIR India Ltd, Mumbai, 2004 and Editor of the Award/2017, from www.mtres.org.

Mr Alakesk Kalita, student of B.Tech in Engineering Physics (Dual) , 4$^{6th}$Semester, IIST, Government of Space, Govt of India, Kerala and published papers in www.ijcert.org , www.ijer.in , www.ijesrt.com , Swetha Engineering College, etc.

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[17] Definition/Acronyms/Abbreviation

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DEFINITION:

Air Injector: This system of injecting fuel, into the combustion chamber of a diesel engine using a blast of compressed air.

Pintle: A small extension of the needle valve tip projecting through the discharge nozzle. When the needle lifts, the oil passes through the opening between the circumstance of the orifice and that of the pintle.

Smog: A term coined from the words, "Smoke" and "fog", first applied to the froglike layer that hangs in the air under certain atmosphere conditions. Now, generally used to describe any a condition of dirty air and or fumes or smoke.

Throttle valve: The butterfly valve of a petrol engine.

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Thrust: axial force acting on a shaft.

Volumetric Efficiency: Ratio of the volume discharged from a pump to the piston displacement of the pump. In diesel engines a term often used instead of the correct term 'charge efficiency'

ACRONYMS

Idle Air Control valve (IACV): The valve is an electronically controlled throttle by pass valve which allows air to flow around throttle plate

Contd..P/10

(which is closed due to low engine rpm and vehicle being stationery) and produces the same effect as if the throttle slightly opened.

Solenoid: A type of electro-magnet often used to operate the starter motor switch.

Mixture: One kg of gasoline requires 15 kg of air called Normal mixture. Air is more than 10 % in the mixture called Lean Mixture. And One part of gasoline is mixed with 12 or 15 part of air i.e. Rich Mixture, ratio is 1:12 . Operation by Lean mixture may loss of power and poor economy ; and due to higher rate of combustion ,rich mixture as a result, increased fuel consumption and loss of power.

Abbreviation :

CARB = California Air Resource Board.
CCR = California Code of Regulations.
DTC = Diagnostic Trouble Code,
FTP = Federal test Procedure.
I.C. ENGINE = Internal Combustion Engine.
MIL = Malfunction Indicator Light.
MAP = Manifold Absolute Pressure

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