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# The Study and Analysis of Problems in Fuel Injector of a Diesel Engine

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**ABSTRACT:** The design geometry of a fuel injector of diesel engine and the flow characteristics of diesel are the parameters which affect the atomization of the fuel, its combustion and the formation of pollutants during the exhaust stroke of the diesel engine (emission of pollutants). A realistic model arrangement is shown to demonstrate the fuel flow in the injector. Different constraints are occurred during the proper flow of the fuel in its journey from the inlet to the nozzle outlet of an injector. Various ways of solving the problems in an injector is shown in order to obtain a proper (nearly ideal) flow of fuel inside the injector. An electronic machine is used to operate the fuel injector. The fuel injection pump is driven by the electric motor, the pressure control valve regulates the pressure at 100 bar and the calibration fluid is injected through the nozzle into the measuring cylinder. There are two test tubes provided in the machine setup, one is for the measuring of mains supply of diesel from the fuel tank and the other is for the measurement of fuel return from the injector. For analysis, the fuel injector is made to operate normally and the fuel collected in both test tubes are compared respectively for the analysis. A detailed report can be printed fro values. If any problem is occurred during the normal flow of fuel in the injector, then the injector can be manually disassembled and its parts can be replaced for the proper function of the fuel injector.[1]

**KEYWORDS:** Fuel injector, Emission, Calibration, Throttle-Body Injection.

## I. INTRODUCTION

Fuel Injection is the introduction of fuel in an internal combustion engine, most commonly automotive engines, by means of an injector. The mass production of Diesel engines for passenger cars were introduced in the late 1930s, they came with a fuel injection system. The fuel injection system in the petrol engines for passenger cars came in the early 1950s; they became much popular that, they replaced the injectors with carburetors by 1990s. The Carburetor and fuel injector differ by- In fuel injector, the fuel is atomized through a small nozzle under high pressure, while the carburetor relies on suction created by intake air accelerated through a venturi tube to draw the fuel into the air stream.

The type of fuel injection used in newer cars are, Single point fuel injection or throttle- body injection, port or multipoint fuel injection, sequential fuel injection and direct fuel injection. Single point or throttle body injection is the earliest and the simplest type of fuel injection. It replaced the carburetor with fuel injector nozzle in the throttle body, which is the throat of the engine's air intake manifold. It is less expensive and easier to service. The port or Multi point fuel injection devotes a separate injector nozzle to each cylinder, right outside its intake; hence it is sometimes called as port injection. The Sequential fuel injection is although a type of multi port injection triggers each injector nozzle independently. Timed like spark plugs, they spray fuel immediately before or as their intake valve opens. Direct injection is the injecting of fuel into the combustion chambers, past the valves. Direct injection is another tool that can be used in low emissions lean-burn engines (engines with burning of fuel with an excess of air). Hence, fuel injectors are used nowadays for the fuel supply systems for internal combustion engines. In this study, we are using a 6-hole fuel injector at different pressures in order to study and analyse the characteristics of fuel injected into the cylinder of internal combustion engine, to study the different constraints occurring the fuel injector and the solutions offered by the fuel injector servicing shops to solve the problems of a fuel injector.

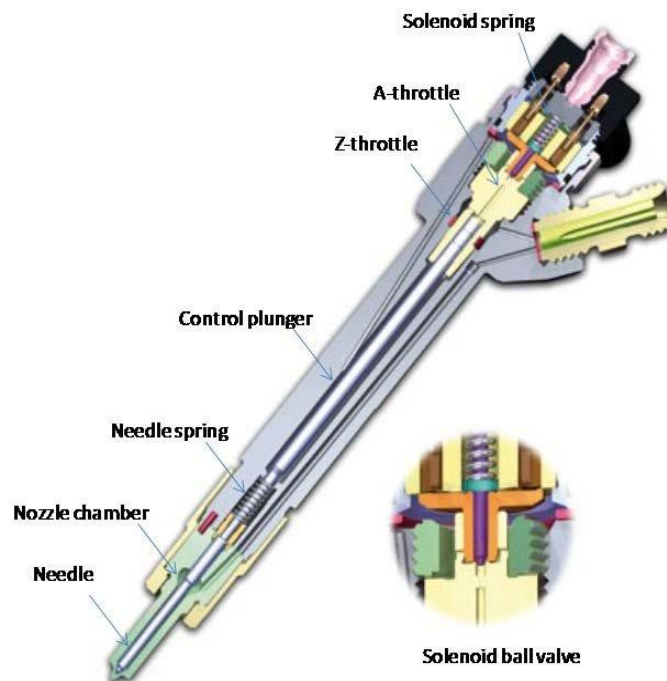
## II. RELATED WORK

Since few decades, the cars come with Fuel injectors, especially for Diesel engines. During the function of a fuel injector in the IC Engines, many problem occur to the IC Engine because of a failure in the fuel injector, they are

Knocking of Engine due to dirty fuel injection, leaking fuel injection, misfiring engine, uneven power in the engine, diminished fuel economy, emission of pollutants, mechanism failure in injector, sensor failure, emptying of fuel from the tank, long start of IC Engine and inconsistent Engine idling due to dirty fuel injector. Many specialists of fuel injectors, fuel injector service shops suggest that the above stated problems occur due to malfunction and mechanism failure of different parts of the fuel injector and can be solved by examining the control valve and nozzle of an injector. Many specialists replace the control valve and nozzle, if the problem is more serious.[3]

**3. Different parts of fuel injector with dimension and their working :**

For demonstration we took a BOSCH Common rail Injector. The fuel injector is comprised of many parts. We are discussing some of major parts of the Fuel injectors that are involved in proper functioning of the Injector. The Fuel injector is placed 25.49mm inside the Engine cylinder when measured from the spraying needle.



**Figure 3.1:** Different Parts of a Fuel Injector[2]

**3.1 Body:** The body of a fuel injector contains all the parts arranged systematically in it. It is made up of non-conducting material, so as to avoid the interference of body material with the function of solenoid. The total length of the Fuel injector is measured to be 210mm. The main body has three diameters, 28.88mm (major dia), 19.45mm in the middle and 7.10mm at the lower end i.e., nozzle

**3.2 Solenoid actuator:** The Solenoid actuator consists of magnet and solenoid casing. Magnet is placed inside the Solenoid actuator and its function is to create magnetic field and it moves the spring attached to it upwards. The total length of the Solenoid actuator is 32.38mm.

**3.3 Spring inside the Solenoid actuator:** The spring inside the Solenoid actuator is usually made up of steel material. Its length is measured to be 10.16mm; it has a diameter of 5.67mm. It is attached with Solenoid and its function is to compress when the solenoid is actuated upwards and then expand when the solenoid is released downwards.

**3.4 Control Plunger:**

The control plunger is a steel rod which is a plunger that moves only in vertical direction. The Control plunger is measured to be 106mm in length and has a diameter of 4.3mm.

### 3.5 Needle Spring:

The control plunger is placed inside the spring at its bottom. It is measured to be 10.83mm in length and 4.7mm in diameter. Its function is to store the energy whenever the plunger is actuated upwards and energy of spring is released as it expands to move the plunger downwards.

### 3.6 Needle:

The Needle is placed below the control plunger. It is like a step bar placed vertically. Its total length is 41.6mm. its major diameter is 4mm and its minor diameter is 3.2mm. It is the main functioning part of the fuel injector which fluctuates vertically inside the nozzle chamber to allow the fuel to pass into the nose.

### 3.7 Nose:

The Nose is situated at the end( last) of the fuel injector and it plays a vital role in the injection of fuel into the engine cylinder. The Bosch Fuel injector that we are using for demonstration has a length of 2mm and an average diameter of 2.30mm. It has 6 small and finite holes of diameter 0.19mm each.

### 4. Tools used for disassembling an injector:



Figure 4(a): The tools used for Disassembling an Injector

5. Function:

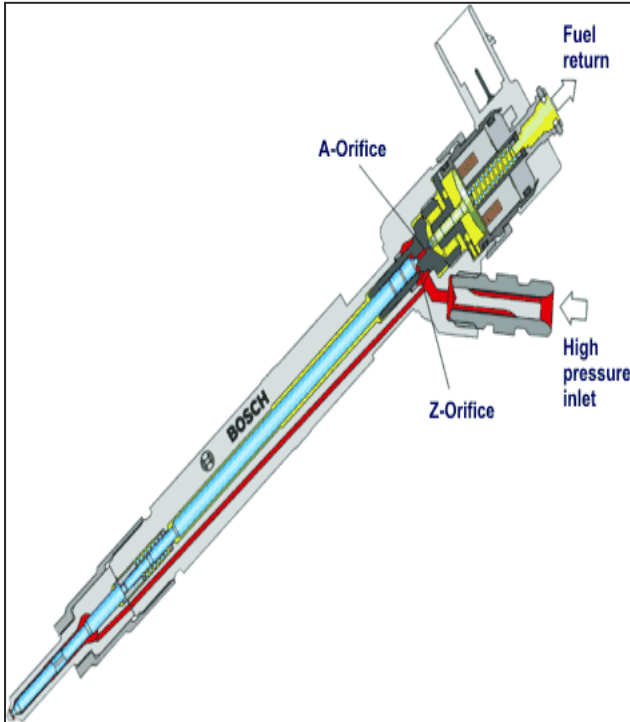


Figure 5(a): Diagram demonstrating the Flow in an



Figure 5(b): Control Plunger and Nozzle of an Injector Injector[5]

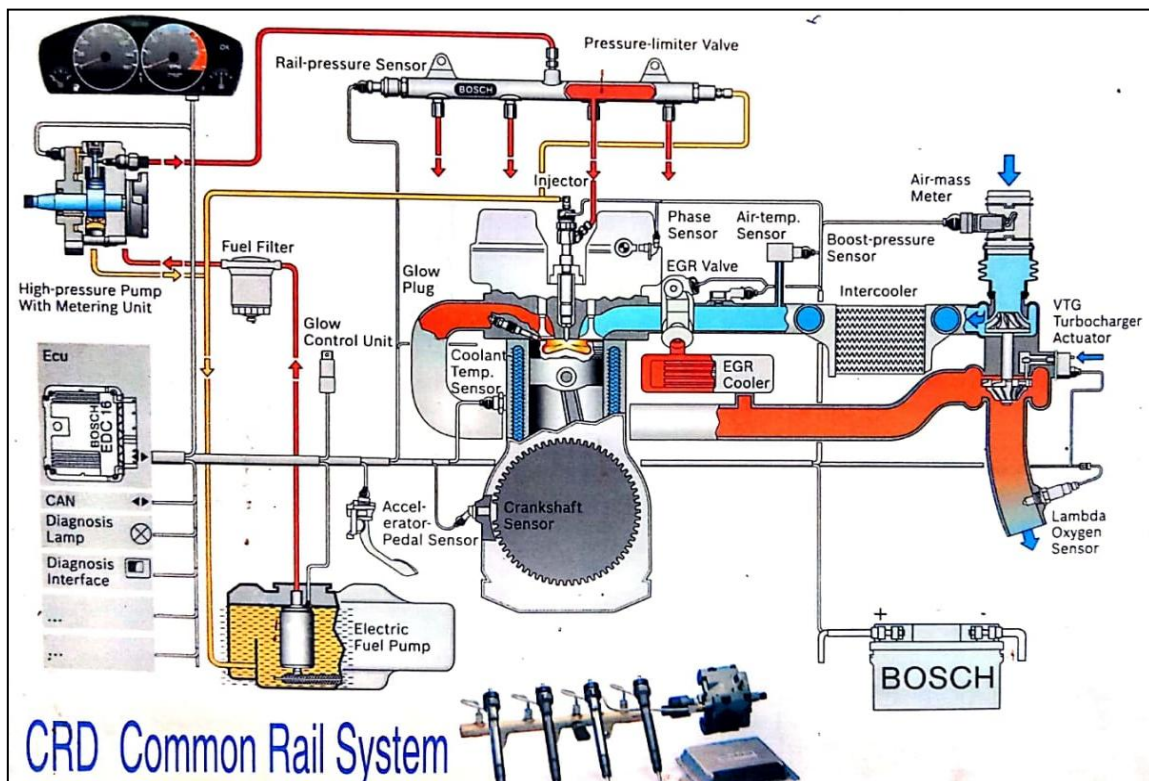


Figure 5(c): Common Rail System[6]

The injector is permanently supplied with fuel from the rail via the high-pressure connection. The injection process is initiated by the control unit via the electrical connection. The return flow quantities arising during the injection process flow back to the tank via the fuel-return line[4].

The valve needle of the injector has a lift of 0.12mm.

### III. METHODOLOGY

#### 6. Experimental Analysis:



**Figure 6(a):** Fuel Sample collected from Main supply and Return supply of Injector



**Figure 6(b):** Injector with a 6 hole nozzle Spraying the Fuel

- \* The fuel collected in the left tube is Fuel supplied from the injector to the Engine
- \* The fuel collected in the right tube is the Fuel returned back through the Common rail

### IV. EXPERIMENTAL RESULTS

#### 6.1. Experimental Tabulation:

To carry out the experimental analysis, we have used an injector with Injector No: 0445110310 manufactured by Bosch and it is adopted in Mahindra Scorpio vehicle. The injector we have used in analysis is a brand new product and company standard values are obtained as shown in the table 6.1 given below

Test	Pulse	Bar	Time(sec)	Frequency	Injection	Return
					Main(in ml)	Back(in ml)
Leak test	0	1000	60	0		3
VL	800	1000	60	F 4	58	16
EM	650	800	60	F4	35	11
LL	460	300	60	F4	3.25	5.75
VE	300	800	60	F1	3	3.5

**Table 6.1:** Company Specific Values for a normal Injector manufactured by the company.[7]



The Injection quantity tolerance of a rapid injector should be within 10% of that of a new injector of same part number.

- \* VE denotes Fuel flow during the Starting of the Engine
- \* LL denotes Fuel flow during the idling of the Engine
- \* EM denotes Fuel flow during the Load carrying of the Engine
- \* VL denotes Fuel flow when the Engine is running with Top gear

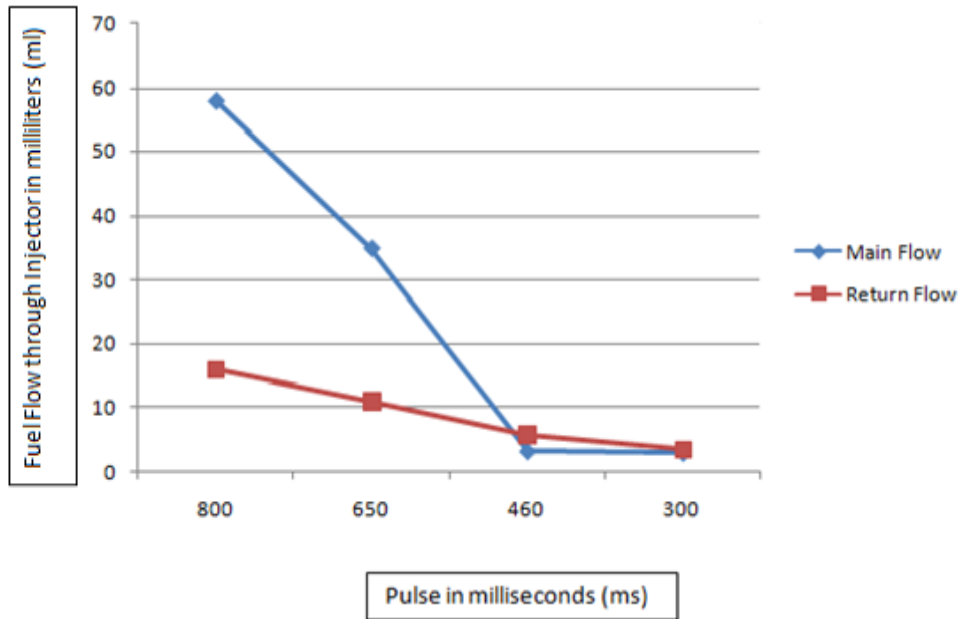


Figure 6.1: Ideal values of a fuel injector

**6.2. Experiment on an injector with a starting trouble:**

The injector we have used in the analysis is adopted in Mahindra Scorpio vehicle and is reported with starting trouble. Experiment is carried out and the values are obtained as shown in the table 6.2 given below.

Test	Pulse	Bar	Time(sec)	Frequency	Injection	Return
					Main(in ml)	Back(in ml)
Leak test	0	1000	60	0		3
VL	800	1000	60	F 4	60	35
EM	650	800	60	F4	37	20
LL	460	300	60	F4	3.25	5.75
VE	300	800	60	F1	3.2	4.5

Table 6.2: Experimental values for an injector of an engine detected with Starting trouble

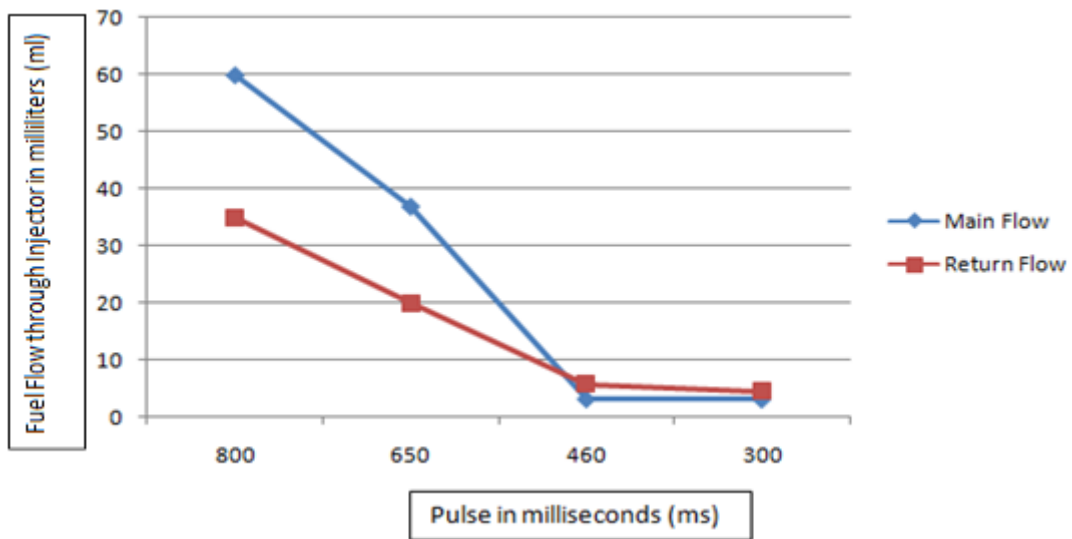


Figure 6.2: Experiment on an injector with a starting trouble

**Result and Discussion:** As we can notice from the obtained values that, fuel injector with Starting Problem has main fuel injection increased by 2ml and 2 ml respectively during the Top gear and Load carrying of the engine. But, there is an increase of 19 ml and 9 ml, during the Top gear, Load carrying of the Engine. The Fuel Injector will act properly over its lifetime, either mechanism of operation or some parameters of the fuel may obstruct the proper functioning of the injector.

**6.3. Experiment on an Injector for Excess smoke from the engine:**

The injector we have used in the analysis is adopted in Mahindra Scorpio vehicle and is reported with Excess smoke from the engine. Experiment is carried out and the values are obtained as shown in the table 6.3 given below.

Test	Pulse	Bar	Time(sec)	Frequency	Injection	Return
					Main(in ml)	Back(in ml)
Leak test	0	1000	60	0		3
VL	800	1000	60	F4	68	25
EM	650	800	60	F4	40	18
LL	460	300	60	F4	3.25	5.75
VE	300	800	60	F1	3	3.5

Table 6.3: Experimental values for an injector of an engine detected with Excess smoke



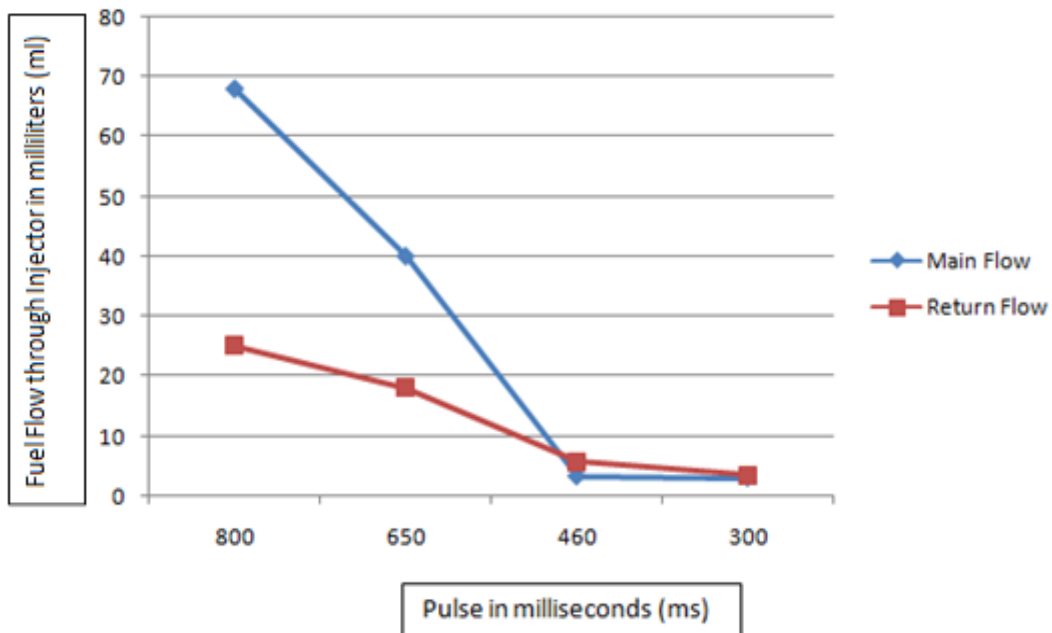


Figure 6.3: Experimental values for an injector of an engine detected with Excess smoke

**Result and Discussion:** As we can notice from the obtained values that, fuel injector with Starting Problem has main fuel injection increased by 10ml and 5 ml respectively during the Top gear and Load carrying of the engine. But, there is an increase in Return fuel of 9ml, 7ml, and 1ml during the Top gear, Load carrying and starting of the Engine. There may be some mechanism failures of the injector or the improper maintenance of the engine at regular intervals may cause the excess smoke from the engine.

**6.4. Overall Analysis of main flow through injector in different conditions:**

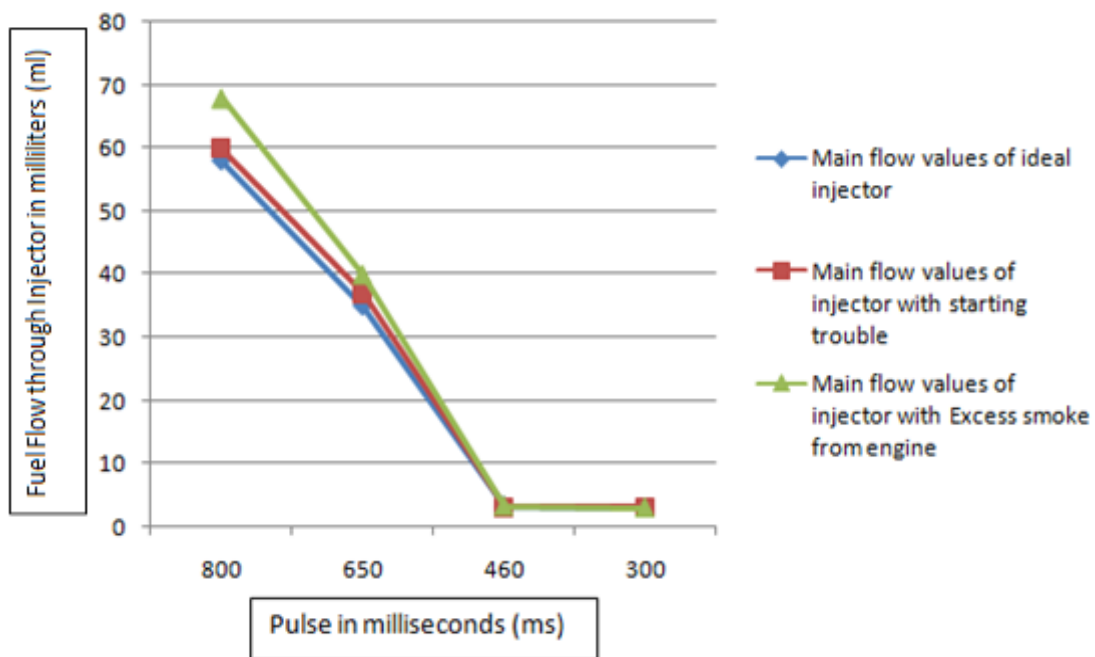


Figure 6.4: Overall Analysis of main flow through injector in different Conditions

6.5. Overall Analysis of return flow through injector in different conditions:

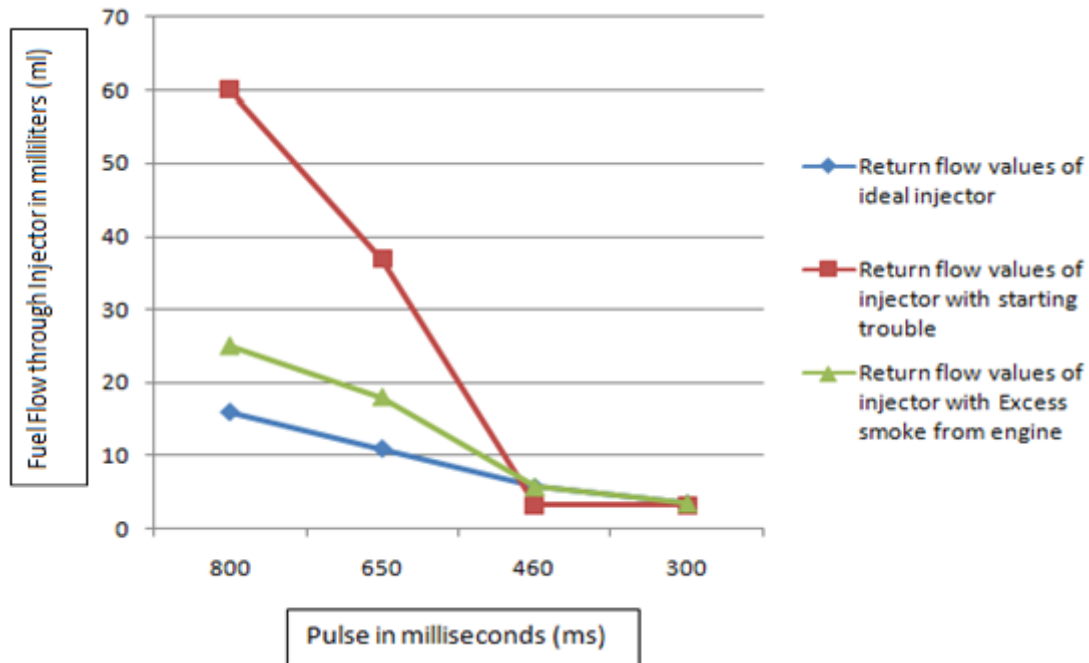


Figure 6.5: Overall Analysis of return flow through injector in different Conditions

V. CONCLUSION

When the Fuel Injector is tested for different rpm, the values obtained are tabulated in the above Tabular column.

- |                                    |                               |
|------------------------------------|-------------------------------|
| Causes:                            | Effect:                       |
| • Inadequate filtration            | - Starting problems           |
| • Poor quality fuel supply         | - Poor performance            |
| • Inadequate maintenance intervals | - Idling problems (vibration) |

The constraints that occur in any typical injector and their solutions respectively are, Knocking- Shim adjustment is required; Emission- valve adjustment is required; Mechanism failure- calibration is required; White Smoke and miss firing- Injector over oiling is required, diesel line needs to be checked, Air filter and diesel filter needs to be checked for blockage; Injector not working – ECU (Electronic Control Unit) needs to be checked for servicing; Jerking and Excess smoke from the engine- Injector needs to over oiling.

Generally, these solutions are used by the Specialists of Fuel Injection Pumps to solve, whenever any problems are detected in their servicing shops regarding the various types of Fuel Injectors.

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- [3] “History of Fuel Injectors” – Fuel Injection- [https://en.wikipedia.org/wiki/Fuel\\_injection](https://en.wikipedia.org/wiki/Fuel_injection)
- [4] Image; credits-Working diagram; credits – [https://www.dieselnet.com/tech/images/diesel/fi/cr/components/bosch\\_inj.png](https://www.dieselnet.com/tech/images/diesel/fi/cr/components/bosch_inj.png)
- [5] Image diagram for showing parts; credits- [https://www.researchgate.net/profile/Nuray\\_Kayakol/publication/280877122/figure/fig1/AS:391453797830658@1470341266604/Cross-section-of-Bosch-common-rail-injector.png](https://www.researchgate.net/profile/Nuray_Kayakol/publication/280877122/figure/fig1/AS:391453797830658@1470341266604/Cross-section-of-Bosch-common-rail-injector.png)
- [6] Overall Working diagram; Credits- BOSCH Mobility Solutions
- [7] The tabulation chart and the values used in the Experimental Tabulation are the one provided by the Bosch Mobility Solutions to their nodal and private Fuel servicing agencies.



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