

Investigative Report on First Pass Yield Improvement in PFR 1 k Pumps

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ABSTRACT: The PFR pumps such as **F002F20 036 & F002F20 049** are used in portable Diesel powered water pumps & in light commercial vehicles. The project was carried out at BOSCH, with an intension to improve the first pass yield of the above mentioned pumps. The following pumps were rejected in the calibration stage due to various reasons such as the Injector issue & few issues with the element. After experimental procedure & close observation of overall manufacturing process few necessary changes were inducted / recommended and the efficiency increased by 8% and 7% respectively.

KEYWORDS: Fuel pumps, Construction, Pump Components & Functions, Shaft Clearance Test.

I. INTRODUCTION

Since Diesel is one of the most efficient & energy dense fuel available today, the effectiveness or the efficiency of diesel engines are more, and also considering the amount of torque produced the diesel engines are more efficient comparatively to SI engines.

The fuel injector unit/pump is the most crucial part of any engine. The atomization of fuel mainly depends upon the pressure at which the fuel is injected. The cluster or small particles of fuel is then combusted, hence for efficient and effective combustion, fuel atomization is of grave concern.

The fuel pump PFR is driven by a means of external cam by which the rotary motion of the cam is converted into reciprocating motion of the plunger within barrel, thus pressurising the fuel and pushing it through its helix angle, hence controlling the required amount of fuel to be delivered.

Classification of BOSCH diesel fuel injection pumps:-

1. Mono Block
2. Q Type
3. K Type

1.1 Feature:-

i. Delivery pressure ranges from 300 – 700 Bar:

The diesel is forced to enter the engine at a high pressure which ranges from 300 to 700 bar. Fuel injected at this pressure results in fine atomization resulting in complete combustion of fuel.

ii. The robust design to cater a wide range of single cylinder pump:

PFR pumps are designed such that the changes can be made easily, hence if there any changes in the future, the changes can be implemented easily as required. By making or implementing small changes in stroke length, cam profile and change of clearance in element.

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1.2 Problem Affecting First Pass Yield of Fuel Pumps

i. What is fast pass yield improvement?

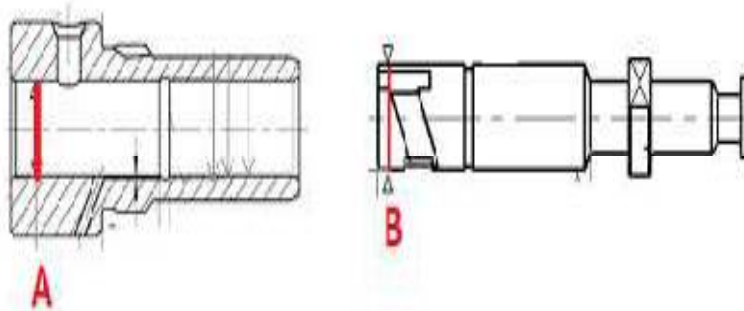
FIRST PASS YIELD (FPY) also known as THROUGHPUT YIELD is defined as the number of units coming out of a process divided by the number of units going into that process over a specified period of time.

ii. Issue causing inefficiency of yield

The pumps F002F20 036 & F002F20 049 were getting rejected at the calibration stage due to less starting delivery and more setting delivery in both the pumps.

The starting delivery at 100rpm was less than the required delivery in F002F20 049 pump, the reasons were at lower rpm, the fuel supplied to the pump will be in limited quantity and if the injector nozzle is blocked by foreign particles it affects the input being supplied to the pump which would directly affect the output delivery from the pump.

The second reason for less delivery was the pressure loss which occurred due to more volumetric clearance (+150 cc) provided between plunger and barrel assembly.



A-B = Mechanical Clearance

a. Sketch Exhibiting the Tolerance Limits

The pump F002F20 036 had an issue of high delivery rate the reason was excess pressure was getting built up due to the small inlet hole diameter of the barrel, and all so was very less delivery are no delivery at 750rpm because the cone angle provided for the ball seating arrangement was less than that of the required specification [30degree], thus the ball was struck while torque is being applied, hence blocking the path of fuel flow.

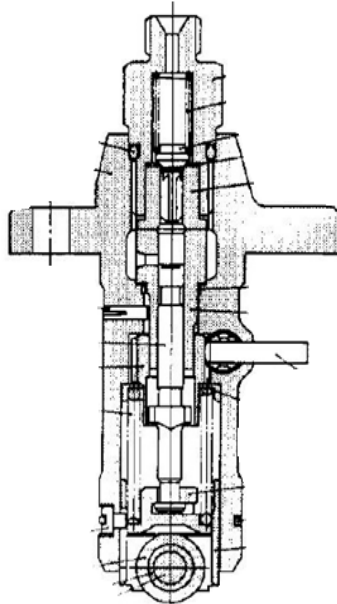
II. CONSTRUCTION OF FUEL INJECTION PUMP & ITS PARTS

The pump F002F20 049 has a dedicated delivery valve and pump F002F20 036 has a ball bearing which moves against the spring to actuate the delivery.

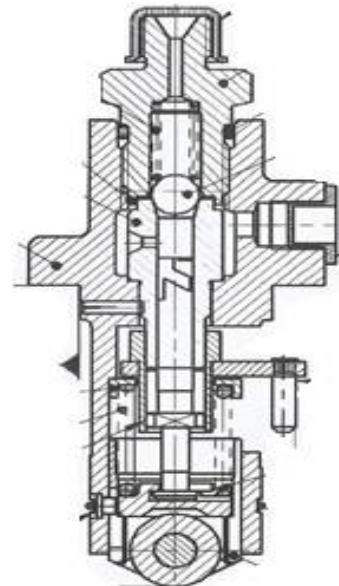
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b. Fig representing F002F20 049pump



c. Fig representing F002F20 036pump

The above pumps consists of the following parts

- Pump Housing
- Name Plate
- Delivery Valve
- Delivery Valve Holder
- Plunger
- Barrel
- Eccentric pin
- Roller tappet
- Fuel Inlet
- Lock Ring
- Compression Spring
- Control Rod
- Regulating Sleeve
- Top Spring Plate
- Bottom Spring Plate

2.1 Functions of Components

- **Pump Housing:** Supports other components of the pump.
- **Element:** Pressurizes the fuel oil to the required pressure and also regulates the quantity of the fuel. It acts as the piston-cylinder arrangement for reciprocating pumps.
- **Compression Spring:** Used to provide necessary pressure of injection.
- **Fuel Inlet:** Used to inject the fuel oil inside the cylinder of the engine.
- **Delivery Valve:** Allows the flow of oil from element to nozzle in one direction only and its opening & closing is controlled by its own spring.
- **Delivery Valve Holder:** Used to connect the high pressure fuel line to the pump and to hold the pump elements & delivery valve in the pump housing.
- **Control Rod:** Used to control the flow of fuel inside the cylinder.

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2.2 Experimental Procedure

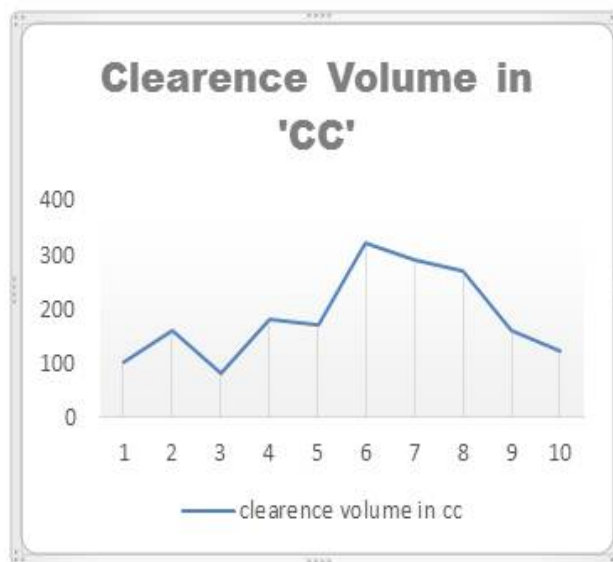
Both good pump samples and bad pump samples were tested with critical components/parameters include

- Delivery valve clearance test
- Plunger and its critical dimensions
- Barrel and its inlet hole diameter, depth of slot provided to housing eccentric pin
- Clearance between plunger and barrel assembly
- Cone angle measurement(F002F20 036)
- Repeatability of test bench
- Injector delivery consistency
- Assembly process observation

2.3 Experimental Outcomes

- The volumetric clearance between plunger and barrel assembly was more than required(greater than 150)
- Injector had lower delivery at lower rpm because of blockage, hence affecting output
- Inlet hole diameter of barrel was less and in few samples being tested burrs were present
- Cone angle lesser then required specification less than 30degree in case of F002F20 036 pump

Shaft Clearance Measurement	
Sl. No.	Clearance Volume in CC
1	100
2	160
3	80
4	180
5	170
6	320
7	290
8	270
9	160
10	120



d. Table Representing Volumetric Clearance

e. Graph Representing Volumetric Clearance

2.4 Shaft Clearance Test

The volumetric clearance between barrel and plunger were tested in ROTTA SHAFT CLEARANCE TEST. The device works on pneumatics where air at a pressure of 1 bar is passed through its inlet and the outcome is measured in terms of cc/mm^3 .

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III. CONCLUSIONS

- Based on investigation, it was observed that Element is the root cause for pump rejection in calibration stage.
- Further investigation / measurements of the Element critical parameters show deviation.
- Through further analysis of test result, it was suspected that rejections are due to Rota-Shaft Clearance and Fuel Injector in Calibration stage.
- It is advised to reduce tolerance band of volumetric clearance between (20 cc to 120cc) instead of (20cc to 150cc) \pm 20cc
- For the F36 Pump the barrel inlet diameter is found to be of lesser than specification (2mm+.01mm) and also burrs were found which contributes for pressure variation.
- The cone angles in few barrels were out of specification, which may cause the ball to get struck in cone seating of barrel resulting in very less delivery.

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