

DESIGNING & MODIFICATION FOR FLEXIBILITY OF INJECTOR ASSEMBLY LINE

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ABSTRACT

The main aim of this paper is to summarize the basic procedure about the injector assembly line and methods to combine two different injector lines such that on a single line two different types of injector can be assembled easily. There are various manufacturers of injectors so to assemble that different types injector separate lines are required which increases the cost of manufacturing as well as requirement of space. There are various generations of CRI injectors as 1-14 (First Generation) and 2-16 (Second Generation). The assembly line of injector include five lines out of which line 2,3,4,5 are used for the assembly of 2-16 types of injector and only line 1 is used for the assembly of 1-14 types of injectors. Presently, individual line capacity is 85,125 injectors per month considering cycle time as 17 sec per injector. Mahindra and Mahindra is a main customer for 1-14 type injectors. Recently, there is an increase in demand from Mahindra and Mahindra. Earlier their demand was of one lakh injectors per month which now have been increased to one and a half lakh. Due to which, there is a requirement in increase in production of injectors. Hence, to increase the production of 1-14 injectors, number of assembly line should be increases or any one of the line should be upgrade or flexible which can assemble both generations of injectors. So these paper focuses on flexibilizing the assembly line 5 in such way that it will accommodate both generation of injectors on single assembly line thus fulfilling customer requirement.

Keywords:- CRI Injector, Injector Assembly Line, Production, Customer Requirement, Flexible Line, Quality

I. INTRODUCTION

1.1 CRI Injector:-

Common rail diesel fuel injection is a direct fuel injection system for petrol and diesel engines. On diesel engines, it features a high-pressure (over 1000 bar or 100 MPa or 15000 psi) fuel rail feeding individual solenoid valves, as opposed to a low-pressure fuel pump feeding unit injectors. Third-generation common rail diesels now feature piezoelectric injectors for increased precision, with fuel pressure up to 3000 bar or 44000 psi. In petrol engines, it is used in Gasoline direct injection (GDI) engines technology.

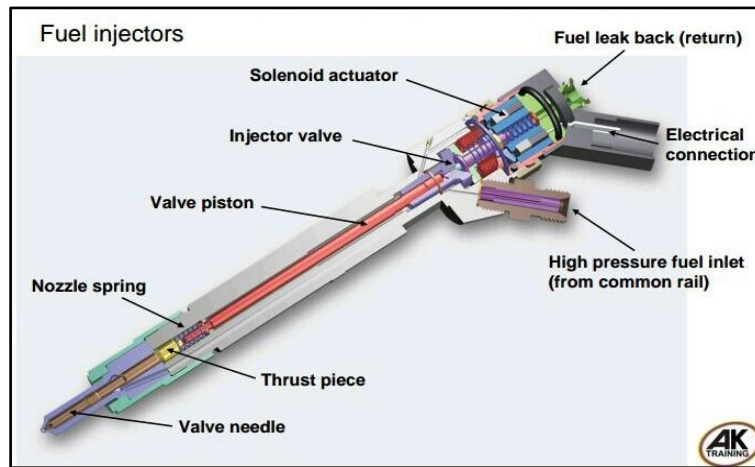


Figure: Common Rail Fuel Injector ⁽¹⁾

In common rail systems, a high-pressure pump stores a reservoir of fuel at high pressure- up to and above 2000 bars. The term “common rail” refers to the fact that all of the fuel injectors are supplied by a common fuel rail which is nothing more than a pressure accumulator where the fuel is stored at high pressure. The accumulator supplies multiple fuel injectors with high-pressure fuels. This simplifies the purpose of the high-pressure pump in that it only needs to maintain a commanded pressure at a target.

The common rail system is suitable for all types of road cars with diesel engines, ranging from city cars (such as Fiat Panda) to executive cars (such as the Audi A8). The main suppliers of modern common rail systems are Robert Bosch GmbH, Delphi, Denso and Siemens VDO (now owned by Continental AG).

1.2 Injector Generations:-

First generation of injector is 1-14 injectors. It is also known as LCCR (low cost common rail injector). Line 1 assembles 1-14 type of injector. This line of assembly of injector is known as RBKR (Robert Bosch Korea Rail), as the line is imported from Korea. This type of generation of injector operates at a high pressure of about 1400 bar. This generation of injector is a platform project at Nashik plant. It is said to be their platform project because the line is developed at Nashik plant only. The demanding customer of this type of injector is Mahindra and Mahindra.

Second generation of injector is 2-16 injectors. It is also known as IPN (International product network), combination with all Bosch plants throughout the world. Among the five lines, line 2,3,4,5 assembles 2-16 type of injector. This line of assembly of injector is known as RBTR (Robert Bosch Turkey Rail), as the line is imported from Turkey. This type of generation of injector operates at a high pressure of about 1600 bar. The demanding customer of this type of injector is Suzuki.

II.COMPARISONS BETWEEN GENERATIONS OF INJECTORS

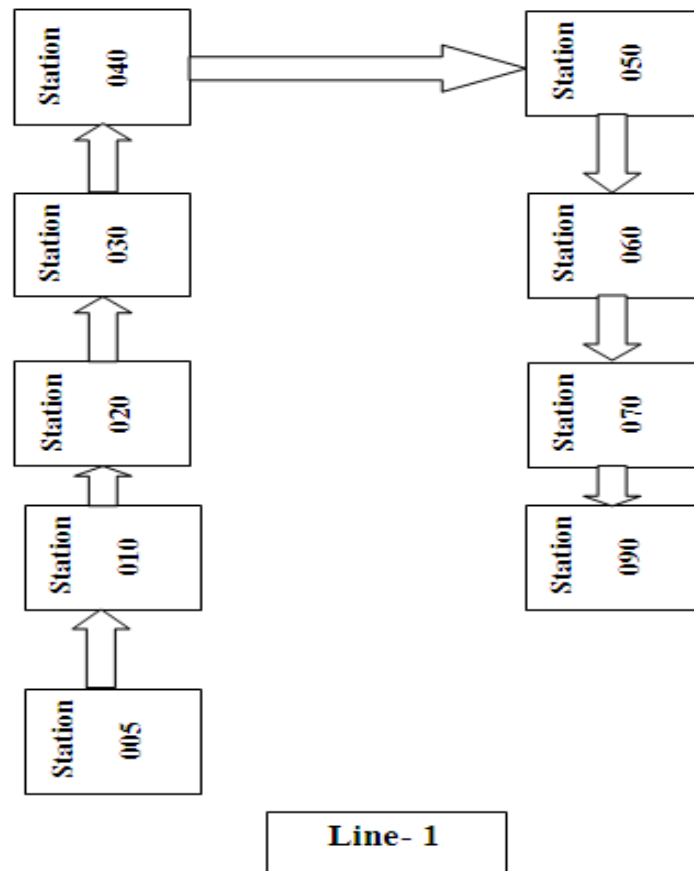
No.	Components in injector	1-14	2-16
1.	Body	P	P
2.	Magnet	P	P
3.	O-Ring	P	P
4.	Armature Plate	P	P
5.	Air Gap Shim (A H Shim)	-	P
6.	Valve Nut/ VSS	P	P
7.	Armature Bolt	-	P
8.	Armature Spring	-	P
9.	Armature Guide	-	P
10.	Armature Shim	P	P
11.	Sealing Ring	P	P
12.	Support/Backup Ring	P	P
13.	Nozzle Body	P	P
14.	Dowell Pin	P	P
15.	Nozzle Body	P	P
	I] Nozzle	P	P
	II] Needle	P	P
16.	Edge Filter	P	P
17.	High Pressure Fitting	P	P
18.	Gasket Sealing	P	P
19.	Ball Guide	-	P
20.	Valve Guide	P	P
21.	Valve Group / Set	P	P
	I] Valve Body	P	P
	II] Valve Piston	P	P
22.	Lock Sleeve	-	P
23.	Clamping Saddle	-	P

Where, P= Component Present in Injector

(-)=Component NOT Present in Injector



III.ASSEMBLY LINE 1



Description of line 1:

For assembly of injector, Bosch assembly line has 5 lines; line 1 is totally concern with the assembly of 1-14 type of injector. This is most affordable type of injector called LCCR (Low Cost Common Rail) with less number of parts as compared to 2-16. Therefore number of stations required to assemble 1-14 is less as compared to 2-16. Out of twelve stations 1-14 contributes to nine stations. Those stations are enlisted and explained below.

- Station (005)

CRI 2.2: Pre-assembly bench.



Figure: Inlet Connector⁽²⁾

At this station there is an assembly of inlet connector to body. The connection between inlet and a high pressure fuel line is made with injector inlet connector. This allows passage through a drilled hole in cylinder head. This station also assembles sealing washer or gasket.

- Station (010)

CRI 2.2 Valve set assembly



Figure: Valve set ⁽³⁾

After assembly of inlet connector and sealing washer to body, the injector is followed to this station where support ring is inserted to support valve body, to check the accurate insertion of support ring poke-yoke in form of cameras, followed by sealing ring. This station provides proper lubrication to the assemblies assembled yet. After assembling, support ring and seal, a valve set assembly including assembly of valve piece and piston is assembled in injector body. Thus the injector is further send to next station.

- Station (020)

CRI 2.2 Armature lift

At this station, initially the valve nut is inserted in assembly. Then the assembly of armature plate and armature ball is placed over the valve nut.

- Station (030)

CRI 2.2 Armature plate Assembly

At this station, the ball is inserted over the armature plate manually. Before placing ball, tip of plate is lubricated by oil for placing ball easily.

- Station (040)

CRI 2.2 Residual air gap

At this station, high technological machine are used to measure air gap between body and magnet. The gap is displayed on the monitor, according to which the operator places the RLS shim which is used for filling the gap between body and magnet. Finally, O-ring is placed on magnet assembly.

- Station (050)

CRI 2.2 Valve Spring Force

This station has similar technological machine like previous station but here there is a check for body and magnet measurements. Based on digital reading, VFK shim is inserted. The assembly further undergoes for

magnet oiling unit for lubrication. Further a unit measures the spring force and a spring is placed. At this station, a sound poka-yoke is introduced to detect pressure of O-ring; this ensures a accurate quality control without any mistakes.

- Station (060)

Alignment + Screwing of magnet groove



Figure: Magnet Unit

At this station, checking is performing through a sound poka-yoke of alignment of all the angels of earlier placed parts of the injector such as angle of inlet connector with the magnet unit. Then the magnet unit is screwed over the body of injector.

- Station (070)

CRI 2.2 Armature lift + pneumatic tightness checking

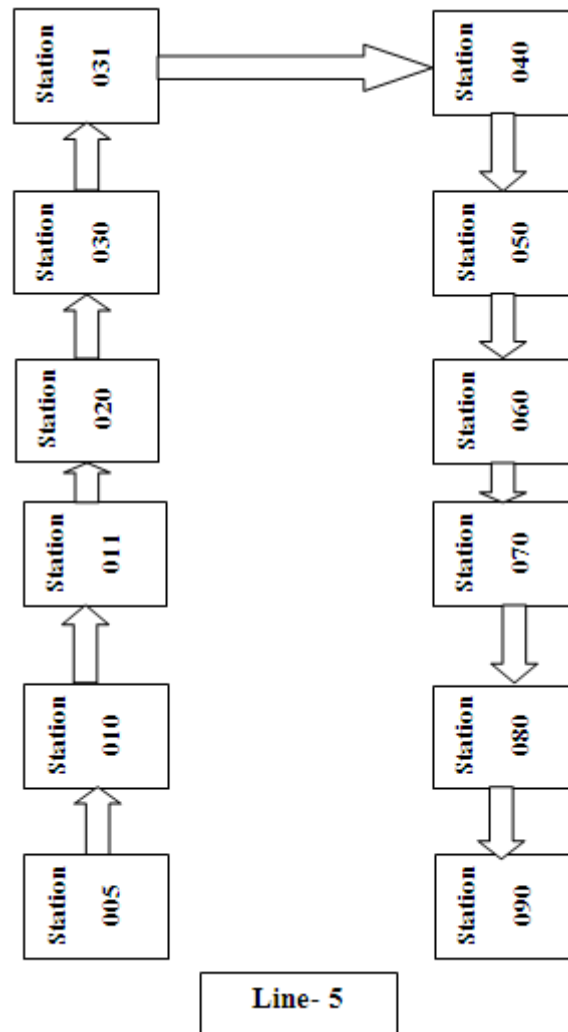
This is station is like a quality check station. At this station, following things are checked pneumatically viz. position of O-ring, air gap if any in the body and leakages if any. Another sound poka-yoke is inserted in this station which does not let any defective injector to go further. If everything is within desire quality the injector is send further to final state of assembly station.

- Station (090)

CRI 2.2 Assembly of nozzle

This is a last station where assembly of 1-14 gets completed. At this station, there are three units. At first unit dowel pin is assembled by machine. Then at second unit, guide bush is assembled manually. And at last unit, nozzle is cleaned initially pneumatically, and then it is fitted followed by NR nut tightening. This completes the assembly of 1-14. After this assembly the injector is further forwarded to testing line to ensure its quality check.

IV.ASSEMBLE LINE 5:-



Description of line 5

This line is concern with assembly of 2-16 type of injector. As compared to 1-14 the number of stations is more due to presence of more number of components. 2-16 contributes for twelve stations. Those stations are enlisted as below.

- Station (010)

CRI 2.2: Inlet Connector Pre-assembly.

This is first station which receives body of injector and further working for assembly of injector starts from this station. At this station there is an assembly of inlet connector to body. The connection between inlet and a high pressure fuel line is made with injector inlet connector. This allows passage through a drilled hole in cylinder head. This station also assembles sealing washer or gasket. These are sealing metallic ring assembled with specific angle and torque.

- Station (020)

CRI 2.2 Assembly of Valve set.

After assembly of inlet connector and sealing washer to body, the injector is followed to this station where support ring is inserted to support valve body, to check the accurate insertion of support ring poke-yoke in form of cameras, followed by sealing ring. This station provides proper lubrication to the assemblies assembled yet. After assembling, support ring and seal, a valve set assembly including assembly of valve piece and piston is assembled in injector body. Thus the injector is further send to next station.

- Station (030)

CRI 2.2 Ball and Ball holder assembly

At this station valve ball and valve guide are assembled by machine. The armature guide is placed by operator and manually and after pressing it is bolted by machine. Then this assembly is forwarded for assembling shim.

For placing of air shim the gap between injector body and magnet is calculated by machine and based on digital reading shim of required dimension is placed. This station is only used in 2-16 as assembly of armature guide is not present in 1-14.

- Station (040)

Armature lift

At this station, the valve nut is inserted in assembly followed by armature plate and ball. Although the armature plate is inserted by machine.

- Station (045)

Valve nut screwing

At this station, the ball is inserted over the armature plate manually. Before placing ball, tip of plate is lubricated by oil for placing ball easily.

- Station (050)

Over lift

In this C-shim is placed. The size of C-shim is calculated by measuring the gap between body and magnet and based on digital reading. C-shim of require dimension is assembled. After that this assembly is further move for insertion of locking washer and locking sleeve. C-shim is only used in 2-16. So this station is missing in 1-14 assembly lines.

- Station (060)

CRI 2.2 Residual air gap

When partly assemble injector come to this station. At this station there are high technological machine are used to measure air gap between body and magnet. The gap is displayed to operation according to the range of reading RLS shim is inserted by operator. Finally, O-ring is placed on magnet assembly.

- Station (065)

CRI 2.2 Valve Spring Force

This station has similar technological machine like previous station but here there is a check for body and magnet measurements based on digital reading VFK shim is inserted. The assembly is further undergoing magnet oiling unit for lubrication. Further to spring force measuring unit to maintain required spring force. At this station, poka-yoke is reduced to detect pressure of O-ring; this ensures an accurate quality control without any mistakes.

- Station (070)

Alignment + Screwing of magnet groove

At this station there is an alignment along with screwing of magnet group.

- Station (080)

CRI 2.2 Armature lift + pneumatic tightness checking

This is first like a quality check station which checks assembly pneumatically to detect O-ring position, gaps in body, if any presence of leak. If everything is within desired quality the injector is sent further to final state of assembly station.

- Station (085)

Needle lifts nozzle spring force

After checking pneumatically DFK shim is assembled at these stations. DFK shim serves the purpose of supporting armature guide. Further guide bush is assembled over the DFK shim. At the same station nozzle spring is calculated by machine to maintain adequate spring force.

- Station (090)

CRI 2.2 Assembly of nozzle

This is a last station where assembly of 1-14 completes. At this station, dowel pin is assembled by machine, guide bush is assembled manually. Followed by nozzle cleaning pneumatically, nozzle fitting and NR nut tightening. This completes the assembly of 1-14.

After this assembly the injector is further forwarded to testing line to ensure its quality check.

VI. CONCLUSIONS

Based on our research work on line 1 and line 5 we came to a conclusion that the components of line 1 of 1-14 injector has less components (16) than the components of 2-16 injector (23). So, in order to flexibilize the line we found some of the common stations between line 1 and line 5. Thus to flexibilize the line 5 combining all stations of line 1 in line 5 and developed a single new line which will be flexible to assemble both generation of injector along with addition of some new stations and new tooling for new station.

Due to flexibilizing line we will achieve following advantages:

1. Cost reduction of new line.
2. Space reduction.
3. Reduce tooling cost.

4. Cycle time reduction.
5. Fulfill customer demand.

REFERENCES

- [1.] <https://www.slideshare.net/amgadradihiadi/common-rail-diesel-fuel-systems>
- [2.] 2.https://www.google.co.in/search?dcr=0&biw=1067&bih=761&tbm=isch&sa=1&ei=RcdVWsGKNcPcvASLx4KwCw&=inlet+connector+for+injector&oq=inlet+connector+for+injector&gs_l=psyab.3...6580.14480.0.14735.13.13.0.0.0.282.2018.0j10j2.12.0....0...1c.1.64.psyab..1.1.173...0i30k1j0i5i30k1j0i8i30k1.0.qQKLkScgNc#imgsrc=7UB2ne8fWp0vXM
- [3.] <https://www.aliexpress.com/item/diesel-fuel-injector-valve-set-F00R-J02-056-common-rail-control-valve-f00rj02056-for-bosch-injector/32767279573.html>