IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
PP 15-20

Automation of Mechanical Unit Injector Tester Machine

Ashlesha Rajendra Dongre[1], Nikita Gopinath Koli[2], Shalini Manohar Jha [3] ,
Ashwini Ashok Shendarkar [4],Manoj N. Kshirsagar[5]
[1]*B.E.student, Mech.engg.Dept.Terna Engineering College,Navi Mumbai, Maharashtra*
[2]*B.E.student, Mech.engg.Dept.Terna Engineering College,Navi Mumbai, Maharashtra*
[3]*B.E.student, Mech.engg.Dept.Terna Engineering College,Navi Mumbai, Maharashtra*
[4]*B.E.student, Mech.engg.Dept.Terna Engineering College,Navi Mumbai, Maharashtra*
[5]*Asst.Professor, Mech.engg.Dept.Terna Engineering College,Navi Mumbai, Maharashtra*

Abstract: *Automation is today's fact, where things are being controlled automatically, usually the basic task of turning ON/OFF certain devices, either remotely or in close proximity. In this paper an attempt is being made to proposed automation of a machine, namely Mechanical Unit Injector (MUI) tester, specially used for the testing of mechanical injector. The automation of a MUI tester can be done by using pneumatic system and pressure sensors. There are mainly two operations-calculate leak of time of Fuel Injection Pump (FIP) and check the fuel pattern. With the help of this operation, testing of an injector is done. By doing automation of this machine, time consumption for operations reduces and errors in operation minimizes.***
Keywords: - *MUI, FIP, Injector, pressure sensor, pneumatic system.*

I. Introduction

Mechanical unit injector tester machine is a manually operated machine which is used to ensure proper functioning of injector by testing it. The operation of this machine is manually control and for better convenience this machine is converted into automatic.

Manually operated injector testing machine consist of two sides, supply side and delivery side. These sides consist of following components and they are pumping system which is used to pump the fuel into the injector, fuel tank which is used to store the fuel, pressure gauge used to set the pressure limit, timer to check the leak of time of FIP, fuel pipe used to supply the fuel from fuel tank to the injector, popping lever is used to give a force on an injector, injectors which is to be tested in this testing machine, bowl for receiving the fuel sprayed from the nozzle and blower to suck the injected fuel as shown in “Fig.1(a)” [4]

Fig.1(a) MUI testing machine

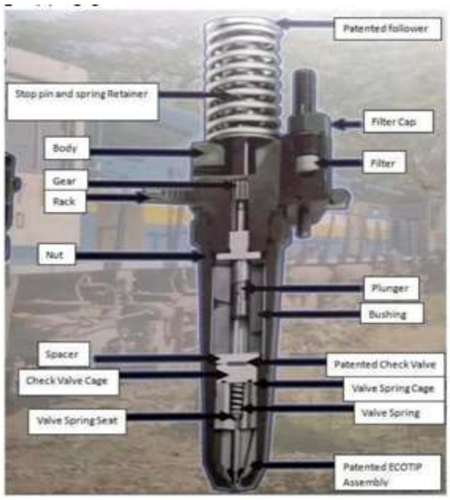


Fig.1(b) mechanical unit injector [4]

The mechanical unit injector, as shown in “Fig.1(b)” is use to provide right amount of fuel at right moment and in suitable condition for combustion process. The injection of the fuel is achieved by the location of cam on a camshaft.This camshaft rotates at an engine speed for two-stroke engine and at half speed for four-stroke engine.The unit injector combine the injection pump, the fuel valves and the nozzle in a single housing. This unit provide a complete and independent injection system for each cylinder. The unit are mounted on the cylinder head with their spray nozzles protruding into the combustion chamber.[4]

Fuel is supplied to the injector through the filter cap. After passing through a fine-grained filter element in the inlet passage, the fuel fills the annular shape of supply chamber that is created between the bushing and the spill deflector. The downward movement of plunger force the fuel to pass through the needle valve and out through the spray holes from the tip of the injector.[4]

II. Manual Procedure For Mui Tester Machine [4]

Regular testing of the fuel injection system ensures that the diesel pump works effectively. The testing is done in two operations:

1. Testing for inspection of fuel pattern.
2. Testing for inspection of leak off time.

A. Manual procedure for inspection of fuel pattern

- The injector to be tested is fitted in the injector holder.
- Initially the hex nut which is used to control the fuel supply is loosed and then the popping lever is pressed downward on the top of an injector.
- The downward movement of the popping lever results in the fuel to be sprayed through an injector when the nozzle pressure reaches to 234 bar.
- This leads to spray of fuel in a certain pattern as shown in “Fig.2”
- If this fuel pattern is standard, designed by the manufacturer then an injector is a good one. Otherwise the injector will be rejected.

Fig.(2) fuel pattern

B. Manual procedure for holding and leak off time.

- Manually hold the test stand fuel line block on the injector. Pump until the fuel is discharged from the filter cap on the opposite side, to remove air. Tighten block securely to injector using a hex nut applied to the injector stud.
- Apply 2000 psi (138 bar) pressure to the injector. No leakage is permitted at the nut to body seal, filter cap gasket, body plugs, or between spray tip and injector nut.
- Reconditioned injectors should be qualified on the pressure holding test by timing the interval for a drop in pressure from 2000 psi to 1500 psi (138 to 103 Bar).
- If this interval is less than 30 seconds, repeat the test, but close the pressure shutoff valve on the test stand immediately after establishing the 2000 psi (138 Bar) pressure. This is to ensure that the leak-down time is not being affected by possible leakage in the test stand itself.
- If the time interval for the pressure drop from 2000 psi to 1500 psi (138 to 103 bar) is still less than 30 seconds, the injector should be rejected.

III. Automation

Automation of MUI machine will be done by using pneumatic piston cylinder and pressure sensor.

- Pneumatic system [1]

Fluid power system using air as a medium for developing, transmitting, controlling and utilizing power is commonly referred to as Pneumatics. In this Pneumatic cylinder, Rotary actuators and Air motors are used to provide the automation. A basic pneumatic system consists of two main sections:

- The Air Production
- Distribution system

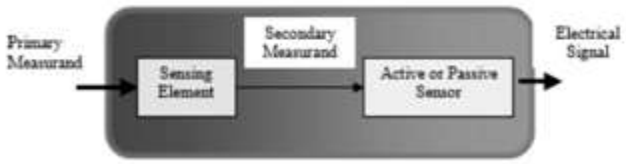
1. Compressor- Air taken it, at atmospheric pressure is compressed and delivered at a higher pressure to the pneumatic system. It thus transforms mechanical energy into pneumatic energy.
2. Pressure Switch - Controls the electric motor by sensing the pressure in the tank. It is set to a maximum ressure at which it stops the motor and a minimum pressure at which it restarts it.
3. Pressure Gauge - Indicates the tank pressure.
4. Safety Valve - Blows compressed air off if the pressure in the tank should rise above the allowed pressure.
5. Filter Regulator Lubricator - This component is used to eliminate vapour particles, dust, solid particles, corrosive gasses, oil vapours etc from the air. It also use to regulate the supply of air.
6. Double-acting cylinders (DAC) - DAC is a Mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion. DAC use the force of air to move in both extend and retract strokes.

- Pressure sensors.

Sensors are the devices that measure information from a surrounding environment and provide an electrical output signal in response to the parameter it measured.[2] There are various types of sensors:

1. Thermal sensor
2. Electromagnetic sensor
3. Mechanical sensor
4. Pressure sensor and others.[3]

Pressure sensors are the devices that read changes in pressure and relay data to recorders or switches.[2]



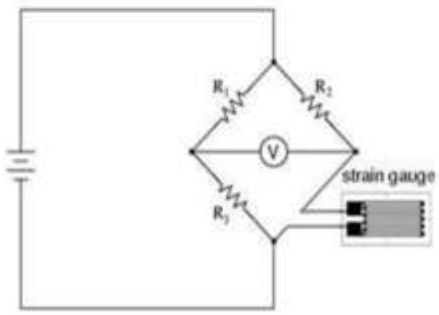


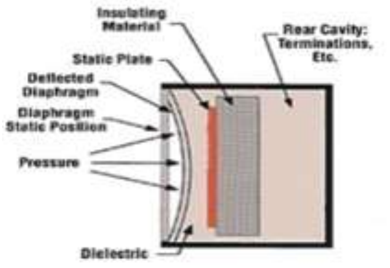
Fig.3(a) Principle of Pressure Sensor[6] **Fig. 3 (b)** Quarter-bridge Strain Gauge Pressure Sensor[8]

The sensing element as shown in figure 3(a) is the device which ensures initial translation of the pressure (primary measurand) into another non-electric physical quantity, the secondary measurand. The latter is translated by another sensor into an electric signal.[6]

Types of Pressure Sensors[8]

1. Strain Gauge Type:

These sensors are similar to a wheat stone bridge in their working. In wheat stone bridge, the ratio of resistances of two adjacent arms connected to one end of the battery should be equal to that of other two arms connected to another end of battery. When the two ratios are equal, no output is generated from the wheat stone bridge. In the case of a strain gauge, one arm of the wheat stone bridge is connected to a diaphragm. The diaphragm compresses and expands due to the pressure applied. This variation in the diaphragm causes the output in the bridge to vary. A voltage would be generated proportional to every deviation from the normal balanced condition, so every single compression or expansion movement of the diaphragm will produce an output indicating a change in pressure conditions. Since resistance change is the main cause for potential difference, these sensors are also termed as piezo-resistive type of pressure sensors.



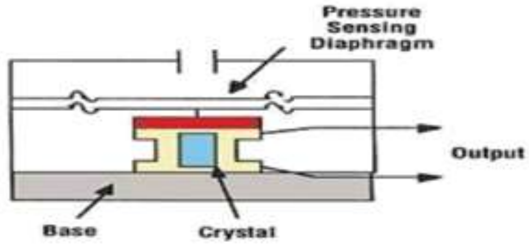


Fig.3 (c) Internal Structure of Capacitive Pressure Sensor [8]   Fig.**3(d)** Details of Piezoelectric Pressure Sensor[8]

2. **Capacitive Pressure Sensor**:

A capacitor has two metal plates and a dielectric sandwiched between them. In capacitive pressure sensor, one of these metal plates is permitted to move in and out so that the capacitance between them changes due to varying distance between the plates. The movable plate is connected to a diaphragm which senses the pressure and then expands or compresses accordingly. The movement of the diaphragm would affect the attached metal plate’s position and capacitance would vary. These sensors, though much ineffective at high temperatures, are widely used at ambient temperature range due to their linear output.

3. Piezoelectric Pressure Sensor:

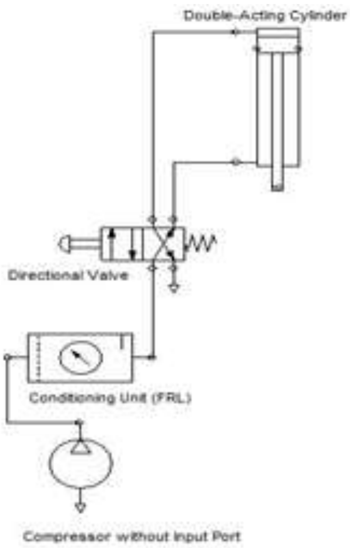
Piezoelectric crystals develop a potential difference (i.e. voltage is induced across the surfaces) whenever they are subjected to any mechanical pressure. These sensors have the crystal mounted on a dielectric base so that there is no current leakage. Attached to the crystal is a horizontal shaft to which a diaphragm is connected. Whenever the diaphragm senses pressure, it pushes the shaft down which pressurizes the crystal and voltage is produced.

IV. Automation Procedure

Automation procedure consists of inspection of fuel pattern and holding and leak off time.

A. The proposed automation procedure for inspection of fuel pattern is mentioned below.

- The downward press handling system will be automated by replacing the popping lever with the piston cylinder as shown in fig.4 (a).
- Selection of the piston cylinder depends upon the load acting on the injector. The criteria implemented for finding load acting on an injector is given in analytical calculation.
- Pneumatic supply will be provided to that cylinder.
- Now this pneumatic press will automate the downward press for the testing of the Fuel injector.



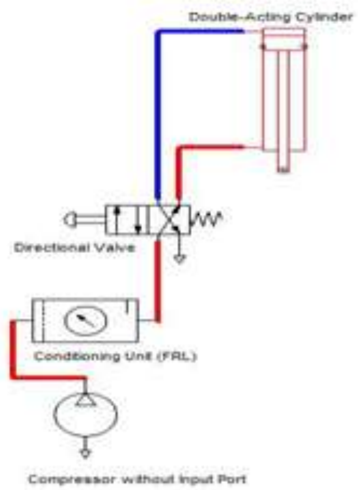


Fig.4 (a) Pneumatic system circuit diagram[7]   **Fig.4 (b)** Simulation of above pneumatic system[7]

Circuit shown in figure 4 (a) has been simulated using simulation software Automation Studio. Resultant output is represented in figure 4(b).

B. Automation procedure for holding and leak off time

- Set the pressure at the 2000 psi (138 bar).
- The pressure sensor present on the pressure gauge will sense the pressure. And accordingly control the ON/OFF of timer.
- If the pressure sensor senses the pressure of the 2000 psi (138 bar), immediately it will ON the timer.
- When the pressure reaches the 1500 psi(103 bar), the pressure sensor should immediately switch OFF the timer.
- This will help to find the time interval for the pressure drop from 2000 psi (138 bar) to 1500 psi (103 bar).
- If the time interval is more than 30 seconds injector is accepted and when it is less than the 30 seconds the injector is rejected.
- The above mentioned steps for automation for holding and leak off time are as shown in fig 4 (c).

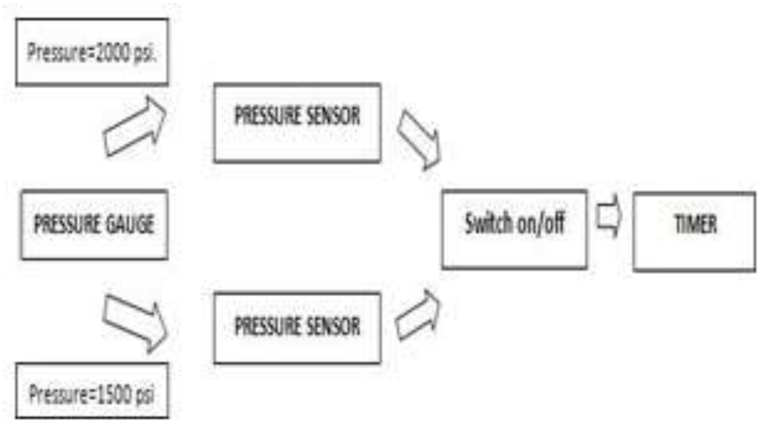


Fig.4 (c). Block diagram for automation procedure of holding & leak off time

V. Analytical Calculation

Calculating load for piston cylinder arrangement

Standard conversions:

1 bar = 14.5038 psi

1 kgf = 9.80665 N Spring Specifications: -

Height	: 9.025 cm
Wire Diameter (d)	: 0.445 cm
Outer Diameter	: 3.87 cm
Inner Diameter	: 2.98 cm
Mean Diameter (D)	: 3.425 cm
No of Coil (n)	10
Max. Deflection (δ)	: 2 cm
Material	: Alloy Steel
Modulus of rigidity	: 836.16x103 kgf/cm2

Load acting on the Spring (P) = $\frac{\delta Gd4}{8D^3n}$ [5]

$= \frac{2x836.16x103x0.4454}{8x3.4253x10}$

= 20.40 kg

Force Acting (F) = 200.124 N

Standard nozzle operating Pressure:- (193-234) Bar[4]

These calculation shows that the minimum 200 N load is required to inject the fuel from injector.

VI. Components Required For Automation

SR NO	COMPONENT NAME	SPECIFICATION	QUANTITY
FOR PNEUMATIC SYSTEM			
1	Compact Cylinder	Bore 50 mm x stroke 25 mm	1
2	5/2 Lock down valve	-	1
3	Straight connector	1/8" BSP x 6mm OD	3
4	Straight connector	¼" BSP x 6mm OD	3
5	PU Tubing	6mm OD x LD 4 mm	20 meters
FOR PRESSURE SENSORS			
1	Pressure Sensor	-	2
2	Switch	-	1
3	Timer	-	1

VII. Conclusion

Proper functioning of injector should be ensured for better performance of engine. Fuel injector plays a vital role since it allows the fuel to enter the engine in spray form which ensures homogeneous mixture of fuel and air for complete combustion of discharge. In this proposed work, inspection of fuel injector will be automated in order to reduce the human efforts and minimizes errors. This paper has given detailed plan about implementation of mechanical unit injector testing machine.

Acknowledgement

We would like to express our deep gratitude and thanks to Mr.Ashutosh Parmar, SSE, Kalyan Diesel LOCO shed, Indian Railway, for giving us an opportunity to work under his guidance for our review of research papers and his consistent motivation & direction in this regard. We extend our sincere thanks to Mr. Suraj Patil, JEE, kalyan Diesel LOCO shed ,Indian Railway, for his continuous support and encouragements throughout the course work. Our thanks are due to Mr.Vinod Shirke,Head of FIP Section, Kalyan Diesel LOCO shed. Also we want to thank Dr. Chandrashekhar Choudhari , HOD,Mechanical Department,Terna Engineering College,Nerul, Navi Mumbai.

Reference

[1]. Karan Dutt, ANALYTICAL DESCRIPTION OF PNEUMATIC SYSTEM, International Journal of Scientific & Engineering Research, Volume 4, Issue 9, September-2013, 1443-1445.

[2]. Vinay Shettar, Sneha B. Kotin, Kirankumar B. B. And B. G. Sheeparamatti, SIMULATION OF DIFFERENT MEMS PRESSURE SENSORS, International J. of Multidispl. Research & Advcs. in Engg.(IJMRAE), ISSN 0975-7074, Vol. 6, No. II (April 2014),74.

[3]. Ahmed M. Almassri, W. Z. Wan Hasan, S. A. Ahmad, A. J. Ishak, A. M. Ghazali, D. N. Talib, and Chikamune Wada, Pressure Sensor: State of the Art, Design, and Application for Robotic Hand, Hindawi Publishing Corporation Journal of Sensors Article ID 846487, 14 January 2015, 4.

[4]. MUIS overhauling manual of Indian railway.PSG design data book (Kalaikathir Achchagam, 1968).

[5]. André migeon and Anne-Elisabeth Lenel, pressure sensor, 11.

[6]. Automation Studio Software.https://www.engineersgarage.com/articles/pressure-sensors-types-working