



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

**Volume 9, Issue 9, September 2020**

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

**Impact Factor: 7.512**

9940 572 462

6381 907 438

[ijirset@gmail.com](mailto:ijirset@gmail.com)

[www.ijirset.com](http://www.ijirset.com)

# Design & Development of Special Purpose Disc Brake Oil Filling & Testing Machine to Increase Productivity and Reduce Defects

Saif Tamboli<sup>1</sup>, Tanmay Penta<sup>2</sup>

U.G. Student, Department of Mechanical Engineering, RMDSSOE, Pune, Maharashtra, India<sup>1</sup>

U.G. Student, Department of Mechanical Engineering, RMDSSOE, Pune, Maharashtra, India<sup>2</sup>

**ABSTRACT:** Brake is important part of automobile and comes under active safety measures. Majority of vehicle accidents occur due to braking failure. Hence, it is very essential to manufacture and test the brakes effectively to avoid accidents and save life. The disc brakes works upon the principle of Pascal’s Law, hence brake oil is the important parameter for effective braking. The performance of disc brakes mainly depends upon brake oil properties, level, concentration and Pressure. On the other hand various disc brake manufacturing companies face various problems during Manufacturing of brakes, especially during filling of oil in brakes. This paper focuses upon analysing those problems and defining a conceptual solution to overcome those problems. Followed by design and development of Special Purpose Machine(SPM), that will automate the process of oil filling and testing of Two wheeler disc brakes, to increase the productivity and reduce the defects caused during the manufacturing of brakes. The design of various components of machine is carried out taking into consideration manufacturing feasibilities. The designed machine proves to be very efficient for automating the process of filling of oil in to oil vessel and for automatic testing of brakes. Thereby resulting into effective manufacturing & testing of brakes in very less time without any error. Implementation of this machine ensures maximum efficiency during manufacturing of disc brakes, thereby helping to achieve the aim of producing ‘Zero Defect’ brakes with increased productivity.

**KEYWORDS:** Disc Brakes, Manufacturing, Testing, SPM, Productivity, Zero Defect

## I. INTRODUCTION

Brakes are used for bringing the body (any moving object or vehicle) which is in motion to its rest or for reducing the speed of the vehicle, by application of effective force required for resisting the motion of body.

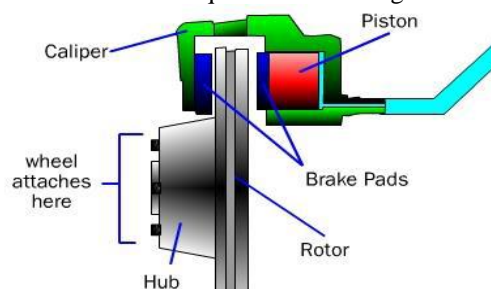


Fig 1. Diagrammatic view of general working of disc brake

A disc brake system consists of a brake disc, a brake caliper and brake pads. When the brakes are applied, pressurized hydraulic fluid squeezes the brake pad friction material against the surface of the rotating brake disc. The result of this contact produces friction which enables the vehicle to slow down or stop. The piston acts as an actuator. It receives hydraulic pressure from the oil line. The piston carries a brake pad on its outer end. The rotor is mounted on the wheel. The brake pads apply force on the rotor causing retardation due to friction. The brake pads are made up of material having high coefficient of friction. They convert the frictional energy into heat energy. The caliper houses the brake pad. The Fluid line carries high pressure oil when the brake is applied. The fluid line should not have any leakage as it can cause accidents.

Disc brake manufacturing companies are facing many problems during filling of oil in closed vessel of brakes. The closed vessel or chamber into which the brake oil is filled is as shown in Fig. 2



Fig. 2. Closed Chamber/Vessel

Leakages in closed chamber-The small leaks in closed oil chamber which are not visible to naked eyes cannot be identified in earlier stages. The leakage in the oil chamber is observed, once the oil is filled in it. This leads to wastage of oil and time.

1. Filling of oil at required pressure- Filling of brake oil manually does not meet the required standard pressures set by the company.
2. Filling of oil up-to required level-There is a certain volume set by company up-to which the oil should be filled in closed chamber, but during manual filling process, oil is filled sometimes more or less than required level leading to wastage of oil.
3. Movement of Brakes- Due to vibration the brake moves, causing difficulty in filling of oil.
4. Testing of Brakes- Manual testing of brakes, does not exactly gives the precise results for force required to apply the brakes. Sometimes the brakes, which take too much force for braking, are also accepted, and this is very dangerous from safety point of view. Moreover, the time required for testing brakes manually is too high, and hence affects the productivity of brakes.

The main objective of this paper is to overcome all the problems faced by disc brake manufacturer by automating the process of oil filling and testing of brakes. To produce zero defect brakes and to increase the efficiency during manufacturing of brakes. To reduce the cost by preventing wastage of oil. To reduce the overall cycle time, thereby increasing the productivity rate.

## II. RELATED WORK

S. Anbazhagan [1] studied and carried out analysis on the brake oil filling machine. Study stated that, the use of sensor fitted torque wrenches would ensure torque and perfection of work thus this technique would help in ensuring 100% perfection to overcome the problem of under tightening or not torque checked with ease in parts of brake lines. The preventive maintenance would sort out problems related with the brake oil filling machine. Some proper oil storage techniques followed by leading oil production companies would vastly help the company to bring down problems related with the air entering the storage drums. Proper oil storage would completely stop air interruption in the system.

Mohan Mali [2] stated that performance and quality of power steering, radiator, brakes, steering, clutch, engine, gears and air conditioner is mainly determined by the exact filling with fluids. The fluid pressure, concentration and physical properties are very important from the working point of view. In order to ensure correct working of such fluid filling machines, it is necessary to eliminate this problems causing huge assembly line downtime. The paper described few suggestions to eliminate the problems occurring in the brake oil and coolant filling machine used for filling the fluids in the cars.

Shivshankar S. Trivedi [3] stated that the majority of accidents in vehicles happen due to chassis failure and braking failure. The brakes are the most important active safety of a car and one of its key pieces.

ShaileshS.Pachbhai [4] evaluated that minimizing workpiece deformation due to clamping and cutting forces is essential to maintain the machining accuracy. The various methodology used for clamping operation used indifferent application by various authors are reviewed in this paper. Fixture is required in various industries according to their

application. This can be achieved by selecting the optimal location of fixturing elements such as locators and clamps. The fixture set up for component is done manually. For that more cycle time required for loading and unloading the material. So, there is need to develop system which can help in improving productivity and time. Fixtures reduce operation time and increases productivity and high quality of operation is possible.

Kausik Chakraborty et al. [5] experimentally studied that stepper motors are mainly used in open loop position control systems. But open loop control of stepper motor can cause loss of steps or slip of steps. To overcome these problems, closed loop position control is developed. In Order to show if any wrong position (i.e. due to loss of steps or slip of steps) of stepper motor have been achieved. So in the present paper, a system is described by microcontroller program which can control the position of stepper motor properly. The microcontroller is interfacing with ADC 0804 IC .This ADC interface is provided to set the position of the stepper motor angle. Drive the stepper motor for each step and read the output of slot for movement of each step. Count the step value and display in LCD.

FarhadAghili et al. [6] studied that to increase the signal-to-noise (S/N) ratio and sensitivity of a load cell, it is desirable to design a structure that generates large strain close to maximum allowable strain of the sensor material for a given rating load force. However, accommodating the margin of safety with respect to overloading, compromises the sensitivity. This paper presents the design, analysis, and prototype testing of a load cell which can provide large overload protection capacity without compromising the sensitivity of the sensor. This is achieved by a special design of sensor structure that becomes virtually rigid after its flexures reach their maximum deflection, thereby the sensor can be protected against a large over load. The sensor dimensions, which maximizes the sensor's sensitivity, for given values of rating load and overload are obtained through mechanical strength analysis. A load cell prototype is fabricated and then tested to measure its linearity and overload characteristics. The experimental results show an accuracy of 0.2% of full scale and overload protection of the sensor flexures.

W.K. Lai et al [7] studied that pneumatic actuators offer several advantages over electromechanical and hydraulic actuators for positioning applications. Nonetheless, pneumatic actuators are subject to high friction forces, dead band and dead time, which make fast and accurate position control difficult to achieve. This research paper presents the process of controller identification, design, modelling and control for pneumatic actuator system.

### III. METHODOLOGY

After identifying all the problems related to manufacturing of disc brakes, a concept is proposed, which would eliminate all the above mentioned problems more effectively. This concept consists of implementation of hydraulic and pneumatic circuits for flow of oil from start to end. Sequencing pneumatic circuit is selected for this particular type of application. Gravitational force is being utilized for flow of oil to take place with required pressure. Based on this concept the general parts and components required are being selected and designed.

In the proposed system, the brake oil filling machine comprises of an evacuation system to evacuate the internal volume of the closed chamber into which oil is to be filled, a leak measurement system for measurement of any leakage in the component and oil filling system to fill brake oil and a control system to manage the whole process [1]. A filler adaptor/connector is fitted to the component and the cycle is started. First operation is evacuation process, the component is subjected to leak test. If a leak is detected then an alarm output is generated and further operation is stopped, otherwise the evacuation system is isolated by closing a solenoid valve and oil filling system fills the component. After a set quantity of oil fill this process stops. Then the adaptor is removed from the component and fitted to a vacuum reservoir to suck out line leftover oil to prevent oil loss and also to protect the leak measurement system.

The evacuation and leak measurement system comprises of a motor driven vacuum pump, a reservoir and Maxeff make type DP3 leak detector. The oil filling system comprises of a gear pump, a relief valve, a hydraulic piston cylinder, four numbers solenoid valves, one oil filter and two numbers proximity sensors. It also includes two numbers additional solenoid valves and a reservoir for recovery of line oil and for protection of leak detector. The controller is a Micro PLC programmed to manage the entire operation.

The brake oil filling machine is conceptualized to work in the following manner.

1. Vacuum Creation- For this test vacuum pump is used which will create the vacuum in the closed chamber. The vacuum pressure maintained is about 1.1 to 1.6torr. Due to use of a vacuum test the air in the closed vessel is removed and interruption of air is prevented.

2. Leak Test- If there is any leakage in the closed vessel, there will be change in the vacuum pressure reading. This will be sent as a signal to warning alarm devices which will warn the operator that there is a leak in the vessel so that he can take the preventive measures.

3. Filling -After performing vacuum test and leak test, filling starts. For filling, we require oil storing tank and filling pump. Oil from the tank flows to the gun (adaptor) which is attached to the closed chamber and impinges the oil into the vessel at a pressure of 5-6 bar.

4. Levelling Test- This is the process in which the machine checks the oil level and if oil is filled above the set level then it sucks the oil and the excess oil is supplied to oil tank and if less oil is filled then oil from the tank is sent to vessel.

The above tests (1 to 4) are performed on basis of hydraulic circuit as shown in Fig. 3.

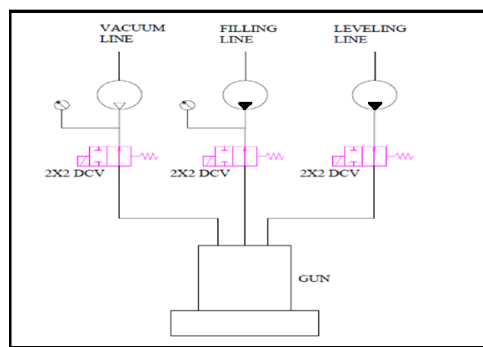


Fig. 3. General design of hydraulic circuit

Fig. 3. Shows that the hydraulic circuit consists of connection of three lines or processes. First is the vacuum line, which is connected to the vacuum pump and Gun (adaptor) through a 2x2 DCV. Second line is connected between oil tank and gun, followed by motor and 2x2 DCV. Through this, the oil from the oil tank flows to the gun through which it gets filled up into oil chamber. Third line joins the oil tank and gun for restoring the excess oil back to the oil tank or to fill the extra oil required to match the desired oil level.

5. Force Analysis Test- This test is done to calculate the force required for effective braking. The arrangement to perform this test is as shown in Fig. 6.

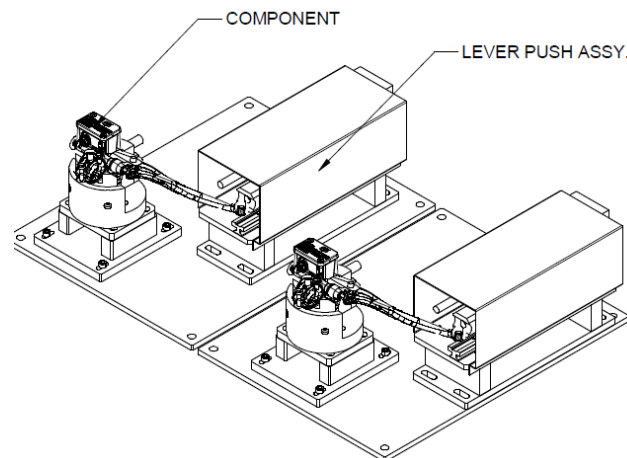


Fig. 4. Force Analysis test

In this test stepper motor is used which pushes the rod on the brake lever and the load cell measures the force required. If the required force is more than the specified force, the brake is rejected and sent for rework.

To perform these tests mechanically, the motion or movement of machine part occurs as per the pneumatic circuit shown in Fig. 5.

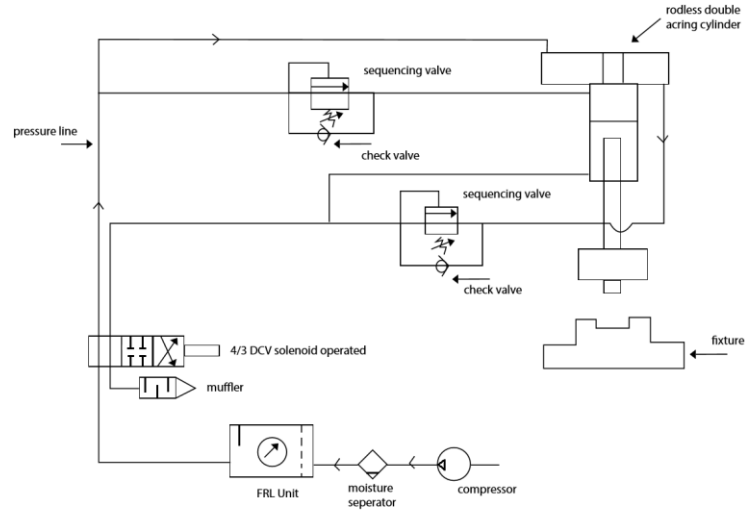


Fig. 5. Pneumatic circuit for movement of machine parts

Fig. 5. Shows that, the compressor compresses the air and passes it to moisture separator where moisture content in air is separated and only dry air is passed to FRL unit. FRL unit filters, regulates and lubricates the air. The air then passes through 4/3 DCV solenoid operated valve and passes to the horizontal cylinder. Flow of air at same time in vertical cylinder is prevented by sequencing valve. The air flows in horizontal cylinder and causes the piston to move in forward direction. After moving upto desired distance the sequencing valve opens and it causes flow of air to take place in vertical cylinder. This causes piston to move downwards thereby moving oil filling gun close to the oil chamber and oil filling process starts. Once the oil filling is done, the whole process repeats in reverse direction and it brings back the piston, both horizontally and vertically, to its initial position.

#### IV. DESIGN & SELECTION OF SPM COMPONENTS

The designed machine comprises of various sub assemblies and components, for their multi functional uses.

**Base Frame:** The base frame is the important part, as all the assemblies has to be mounted upon it. A base frame of rectangular cross section welded together as shown in Fig. 6 is designed, capable to withstand the loads of various components mounted on it. The whole machine is mounted on base frame made up of Stainless Steel to prevent the frame from corrosion. The concept of automation and the functionality of machine influenced the design of base frame.

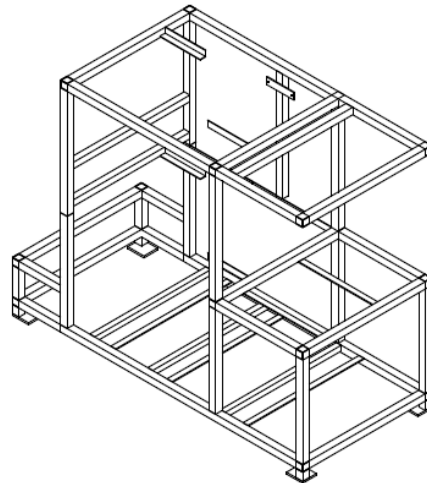


Fig.6. Base Frame Design

**Fixture:** Fixture is designed to hold, locate and support Brake during Oil filling and testing operations. Fixtures provides mean to reference and align the oil filling gun to the oil chamber. The fixture consists of following three main parts. The fixture is designed for holding of brakes firmly to sustain the pressure and force exerted on it. Hence the base plate of fixture is designed to sustain the load and force applied on it as below.

**A. Fixture base Plate:** The plate is made up of mild steel coated with nickel and chrome. The fixture plate is subjected to vertical load due to the clamping cylinder

$$\text{Vertical Load} = 150 \text{ kg} = 150 \times 9.81 = 1471.5 \text{ N}$$

Hence, the dimensions of fixture plate are selected as below, to withstand the given load without fracture.

$$\text{Width of plate (b)} = 55 \text{ mm} = 0.055 \text{ m}$$

$$\text{Length of plate} = 60 \text{ mm} = 0.060 \text{ m}$$

$$\text{Thickness of plate (d)} = 10 \text{ mm} = 0.01 \text{ m}$$

The fixture plate is as shown in Fig.7. The holes are drilled in the fixture plate, for mounting of fixture body

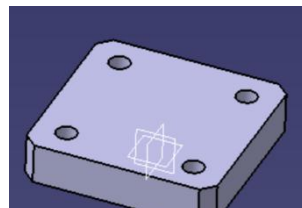


Fig.7. Fixture Plate

**B. Fixture holding assembly:** The Fixture Holding assembly is as shown in Fig.8.

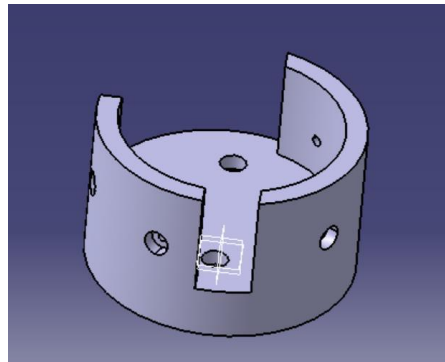


Fig. 8. Fixture Holding assembly

The fixture holding assembly is used for mounting and holding the fixture. It is made up of aluminium, as aluminium is light in weight and is corrosion resistant. To prevent the wear of brake parts, the fixture parts are made up of nylon.

**Oil filling Gun:** The oil filling gun is designed as shown in Fig. 9.



Fig. 9. Oil filling Gun

From the Fig. 9. It can be observed that, the oil filling gun consists of three ports connected to oil filling line, vacuum line, & levelling line. The 3D cad model for Gun holding assembly is as shown in Fig. 10.

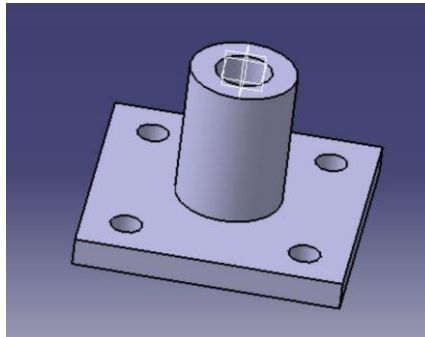


Fig. 10.Gun Holding assembly

**Oil tank:**

Type of Tank: Capsule tank-Fabricated.

Material – Stainless Steel.

Volume(V)= 3\*flow(In LPM), Volume(V)=3×28 = 84litre, Size of Tank-84litre.

Height of tank l =600mm, diameter of tank d=400mm. The oil tank is as shown in Fig. 11.



Fig. 11.Oil Tank

**Pump:** Air Operated Diaphragm Pump is selected because it is a positive displacement pump that uses a combination of the reciprocating action of a rubber, thermoplastic or teflon diaphragm and suitable valves on either side to pump a fluid.



Fig. 12. Pump

Volume of oil required in brake =250ml

Time for Filling oil = 10 sec = 0.1667 min

Discharge = Volume/Time Limit = $250 \times 10^{-3} / 0.1667$ ,  $Q = 1.5 \text{ lpm}$

Pump Selected – Air Operated Diaphragm Pump 26.5 lpm (Max Discharge), Pressure 100psi (max), Make - GracoHusky-307 D31311

**Clamping Cylinder:**

Assuming clamping force to be 150kg. Oil pressure is 7 bar

Pressure = Force/Area, Force = 150 kg =1500N,  $7 \times 10^5 = 1471.5 \pi^4 \times D^2$ , D = 0.053 m = 53 mm.

The Model Selected is Model Number DNC Square Rod Festo DNC63-200-PAQ, having diameter = 63mm and Length of stroke =200 mm as shown in Fig. 13.





Fig. 13. Clamping Cylinder

**Stepper Motor:** A stepper motor for applying load to brake lever is selected based upon the below calculations.



Fig. 14. Stepper Motor

Length of Brake lever = 10 mm = 0.01 m. Considering comfortable braking force which has to be applied on brake = 5 kg = 50 N

Torque = Force \* Distance, Torque = 50 \* 0.01 = 0.5 Nm

Stepper motor is selected having torque more than 0.5Nm and step angle 1.8°

**Machine Assembly:** All the designed parts and sub assemblies are assemble together as shown in Fig. 15. And further manufactured and assembled as shown in Fig. 16.

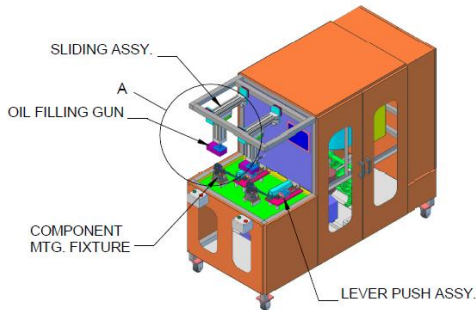


Fig.15. Cad Model of SPM Fig. 16. Assembly of SPM

### V.TEST, RESULTS & DISCUSSIONS

This chapter describes various test results conducted on the machine like volume, productivity, time and force

Table 1. Time and Force

Sr. No.	Vacuum Time(s)	Filling Time (s)	Levelling Time(s)	Total Cycle Time (s)	Force(N)
1	8.5	13.8	9.1	31.4	51
2	8.6	13.2	10.5	32.3	52
3	8.5	13.4	11.6	33.5	51
4	9	13.5	11.4	33.9	48
5	9.5	14.2	12.8	36.8	53
6	8.8	14.1	11.55	34.45	50

Average Cycle time – 33.733 s, Average Force – 50.83 N



**1. Productivity:**

For shift of 8 hrs (480min):

- Time allowances for operator:

Personal allowance = 80 mins (Lunch & tea break), Fatigue allowance = 20 mins

Total allowance= Personal allowance + Fatigue Allowance =80 + 20 =100 mins

Therefore Actual Working Hours = 480 – 100= 380 mins

- Time required to complete cycle of oil filling manually =10 mins
- Time required to complete cycle of oil filling automatically=2 mins

A. Productivity before the use of oil filling machine

Total components manufactured: Available working time/time required: 380/10 = 38 components.

Availability of worker for oil filling operation= 5, therefore in a shift of 8 hours total number of components manufactured = 5×38= **190 units**

**B. Productivity after using oil filling machine**

Maintenance and repair allowance = 30 mins, therefore total available time= 380 – 30 = 350 mins

Total components manufactured: Available working time/time required: 350/2= 175 units

As the Designed Brake oil filling machine is capable of filling oil into two brakes simultaneously at one time.

Total components manufactured = 175×2= 350

% Increase in productivity= $\frac{\text{Productivity after} - \text{productivity before}}{\text{Productivity before}}$   
 = (350–190)/190= **84.21 %**

**2. Leak Test:**The main aim of leak test is to check or detect leak in the component.

Procedure:

- 1 load the component on the fixture
- 2 Switch on the machine
- 3 Carryout leaks test and note the pressure gauge readings and compare with standard readings.

**Case I: For a defective component**

When defective component with crack was placed on the fixture, pressure gauge showed standard reading of 2 bar which was less than standard reading of 5 bar. This signal of deflection in pressure gauge was sent to alarm device which warned the operator about the leak.

**Case II : Non Defective component**

When non defective component was placed on the fixture, the pressure gauge showed reading 5 bar (Approximately).Which is its set value. Therefore, there was no deflection in the pressure gauge reading and no signal was sent to alarm device which made the operator easy to understand that the component is not defective and can carry out the further processes of filling and levelling.

**3.Volume Test:** The main aim of volume test is to ensure filling oil up to the required level in the closed vessel.

Procedure: Ten components were filled by the oil filling machine and were later disassembled and the volume of oil was measured

Component	Volume of oil (ml)
1	246
2	249
3	256
4	250
5	252
6	247
7	248
8	251
9	247
10	254

Average Volume =2520/10 = 252 ml

The above value is close to the standard value of 250 ml.

As variation of ±10 ml is permissible the achieved value is acceptable. Which states that the levelling test is successfully done by the machine



**4. Comparative Analysis:** The comparative analysis before use of the SPM and after use of the SPM is as shown in Table 2.

Table 2. Comparative analysis

Parameter	Manual Filling	Automatic Filling
Quality of Filling	In manual filling, over filling or under filling of oil takes place which leads to spillage of oil and dirty and slippery work place	In automatic filling, there is no over or under filling
Pre- process Test	In Manual filling no arrangement was made for leak test, therefore chances of wastage of oil due to leak was more.	No chance of wastage of oil as the machine performed leak test before filling .
Levelling	No arrangement for levelling of oil	Levelling of oil was performed accurately .
Time	Manual filling required more than 10 mins	Automatic filling requires 1min to 2mins .
Labour	Skilled labour is required for carrying out the operation	No skilled labour is required as the process is automated .

**5. Summary:** From testing we can conclude that all the problems that were occurring during oil filling of brakes are overcome by automatic disc brake oil filling machine which in turn increased the efficiency of brakes. Following observations are noted after installation of machine

- Only one operator is required for complete fill and top off procedure hence this machine reduced the human work and time.
- Due to proper levelling system and leakage free operation there was no loss of fluid with clean and drip-free operation.
- Positive displacement pump (Diaphragm Type) used for filling hence; desired pressure can was achieved in less time.
- Continuous flow of oil is achieved during filling, due to absence air bubble.
- All the brakes are tested effectively with which ensured the safety for braking operation.
- Self-contained and compact in size. Excellent access for maintenance with all components tagged for ease of identification.
- From testing it is observed that the productivity is increased by 84% after use of this machine.

## VI. CONCLUSION

The paper describes the systematic approach to automate the process of oil filling into the disc brakes. A concept was developed with the help of hydraulic and pneumatic circuit that automated multiple processes effectively. The parts of the machine were selected and designed taking into consideration the functionality of machine, dimensional constraint, and cost. The machine served as a best solution thereby eliminating all the problems occurring during filling of oil and testing of brakes. As a result of which the productivity in manufacturing of brakes increased by 84% with improved quality of brakes thereby ensuring safety.

## REFERENCES

- [1] Anbazhagan, S., “Analyses on the Brake Oil Filling Machine”, Middle-East Journal of Scientific Research, ISSN 1990-9233, pp.1425-1430, 2004.
- [2] Mohan Mali, “Fault Analysis of Brake Oil and Coolant Filling Machine” Imperial Journal of Interdisciplinary Research (IJIR) Vol-2, Issue-8, ISSN: 2454-1362, pp.175-225, 2016.
- [3] Shivshankar S. Trivedi , “Analysis of failure of Brakes due to leakages of cylinder through CFD” ,IOSR Journal of Mechanical and Civil Engineering , ISSN: 2320-334X , pp. 01-1, 2013.
- [4] ShaileshS.Pachbhai, LaukikP.Raut ,”A Review on Design of Fixtures” International Journal of Engineering Research and General Science Volume 2, Issue 2, ISSN 2091-2730, 2014.



- [5] KausikChakraborty, Nisarga Chand, BappadityaRoy “Design and Development Stepper Motor Position Control System Using Atmel 85c51 Microcontroller” International Journal of Emerging Research in Management &Technology, ISSN: 2278-9359,Volume-2, Issue-12, 2013.
- [6] FarhadAghili ;”Design of a load cell with large overload capacity” Canadian Space Agency (CSA), Saint-Hubert, Quebec, Canada, J3Y 8Y9.
- [7] W.K. Lai, M.F. Rahmat and N. Abdul Wahab “Modeling and controller design of pneumatic actuator system with control valve“, International journal on smart sensing and intelligent systems, vol. 5, 2012.



**INNO SPACE**  
SJIF Scientific Journal Impact Factor

**Impact Factor:  
7.512**

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  [ijirset@gmail.com](mailto:ijirset@gmail.com)



[www.ijirset.com](http://www.ijirset.com)

Scan to save the contact details