INTERFERENCE FITMENT OF A BUSH ON A PINION FOR RELIABLE PERFORMANCE OF THE COMPONENT

[1]Prof. Bhagirathi Bai V, [2]Elton Joy D'Souza, [3]Prakruthi K, [4]Shrigouri Girish Jumnalkar

[1234]Acharya Institute of Technology, Bengaluru, India Mechatronics Engineering.

Abstract- The main aim of our project is to provide a solution for a quality fitment of two components (component assembly) for reliable performance. This is done by considering various parameters such as material used, press load, press distance, total production count which includes the accepted and rejected components and finally the cycle time required for the entire process. The machine is designed and developed with all integrated features providing spontaneous results in a well-defined manner which would further help the operator to carry out the required action in response to the output produced. This would lead to increased productivity, quality fitment and operator safety.

I. INTRODUCTION

A bush is a mechanical fixing between two, possibly moving parts, or a strengthened fixing point where one mechanical assembly or sub assembly is attached to another. A bush is mainly found in cars and various other automobiles. In a car or other vehicle's suspension, bushes are used to connect the various moving arms and pivot points to the chassis and other parts of the suspension, it is also found in the starter motor assembly and many other applications which require a strengthened fixing.

A pinion is a round gear, usually to the smaller of two meshed gears. Generally, when meshing a pair of gears, the smaller gear is called a pinion gear. A pinion gear is used in a starter motor where the pinion is designed to fit into the grooves of the ring gear. When the ignition switch is turned on the electromagnet inside the body of a starter motor engages & pushes out a rod to which the pinion is attached. The pinion meets the flywheel and the starter motor turns. The pinion is also referred to as the cylindrical gear that meshes with a rack in a rack-and-pinion mechanism which transforms rotational motion to linear motion.

II. LITERATURE SURVEY

"Stress analysis of a frame of a bush pressing machine for pumps IJIRSET vol 4, issue 2, February 2015 by Amith Kalekar, S. B. Tuljapure, Walchand Institute of Technology"

A bush pressing machine is designed for pressing bronze bushes into a pump frame or casing. Finite element method (FEM) based software ANSYS is used for modeling & analysis work. As the machine is symmetrical about a vertical plane, only half model is prepared using the modeling facilities available in ANSYS. Meshing is done using tetrahedral (Solid-45) elements. A force of 17.78 KN is applied on the job mounting plate & cylinder mounting plate in the form of pressure. Deflections and stresses are observed after the analysis. Both deflection & stresses are the allowable within limit. The stress values obtained by FEM are in well agreement with the analytical values.

"Programmable Logic Controllers", W. Bolton, Elsevier India, Edition 6, 2016. From this book, we learnt about the basics of ladder programming and the use of functional blocks in programming. We also learnt representation of several logical symbols in the ladder logic and also several conditions to manipulate the functional block. We also learnt to represent timers and counters in ladder logic and use it in the program to obtain desired result.

"CX- Programmer Introduction guide", published by Omron Corporation. -From this book, we learnt how to setup the software on our systems. We also learnt about function of each attribute present in the software and as well as how to write, compile, execute, simulate as well as upload the program to the PLC.

"Building the PLC panel", By Edvard -This article discusses the design issues in implementation that must be considered by the designer. The physical dimensions of the devices to be considered, and adequate space needed to run wires between components. The essential requirements of a control panel are mentioned in this article.

"Hydraulics and Pneumatics- A technician's and engineer's guide", Andrew Parr, Elsevier Science, Edition 3, 2011-This textbook contains the basics of the operation of hydraulic and pneumatic systems. It talks about the fundamental principles and various components of a hydraulic and pneumatic system like hydraulic pumps, air compressors, control valves, actuators and several other accessories.

"Pneumatic Systems Principles and Maintenance", Textbook, S R Mujumdar, Tata McGraw Hill Publishing Company Limited, 16th Reprint -This textbook contains the basics of pneumatic system as well as information about the various components of a pneumatic system. It also talks about the basics of Hydro-pneumatics and its application. Various basic pneumatic circuits are given to learn and various methods to create a pneumatic circuit for various application is also given.

III. OBJECTIVE

The fitment of two finished products using a mechanical press may cause material fractures or cracks due to this the material is discarded and the whole process must be started again. Also due to the usage of traditional methods the safety of the worker is at risk.

Our objective is to ensure

1. Increasing accuracy of the fitment using press fit system with graphical display.
2. Ensure the quality of fitting.
3. Safety of the operator.

IV. PROPOSED BLOCK DIAGRAM

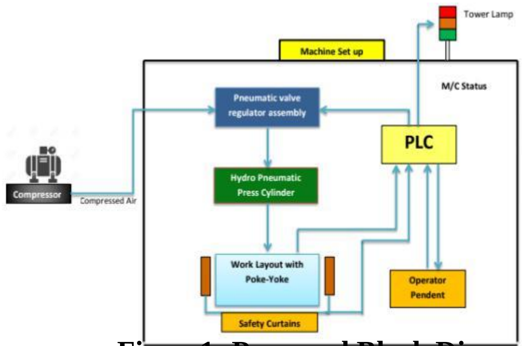

Figure1: Proposed Block Diagram

The objectivity of this project is productivity, quality and safety. We are going to use a hydro-pneumatic press with PLC controls, load feedback of the interference experienced by the bush. This interference load is compared with the set limits to ensure quality check and acceptance in the production line itself.

A. *MACHINE DESIGN*

Machine Design is done in order to convert resources or energy into useful mechanical forms. The design is done in order to develop a fully automated bush pressing machine. The major components of the bush pressing machine are highlighted below:

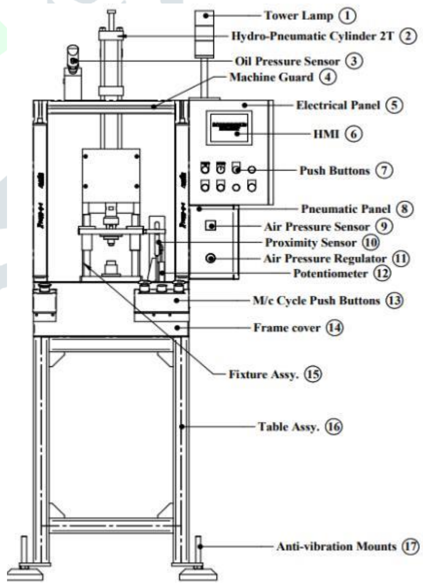

Figure 2: Machine layout

V. METHODOLOGY

1. Pre study of the requirements of the project.
2. Analysis of requirement.
3. Defining the objective of the project.
4. Scheduling of project.
5. Proposal design (Estimation and costing).
6. Design and development of project.
7. Analysis of the design and development (Corrections if any).
8. Preparation of part drawings, assembly drawings and bill of materials.
9. Manufacturing of parts.
10. Quality assurance.
11. Assembly.
12. Electrical and electronics integration.
13. Supply power to the machine.
14. Trials and updation.

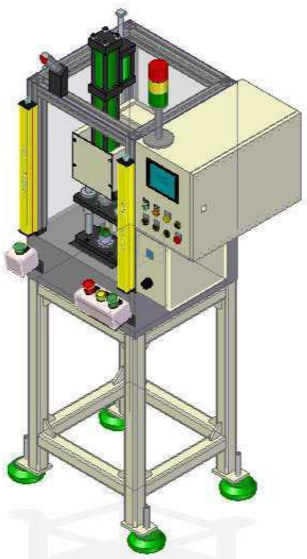

Figure 3: Machine layout obtained after designing

VI. WORKING PRINCIPLE OF THE MACHINE

Working principle of this machine is that a hydro-pneumatic cylinder converts the energy from compressed air into a steady linear movement in alternating direction and within a limited stroke.

The machine consists of a customized fixture assembly which performs the operation of inserting the bush as shown in **figure 4**.

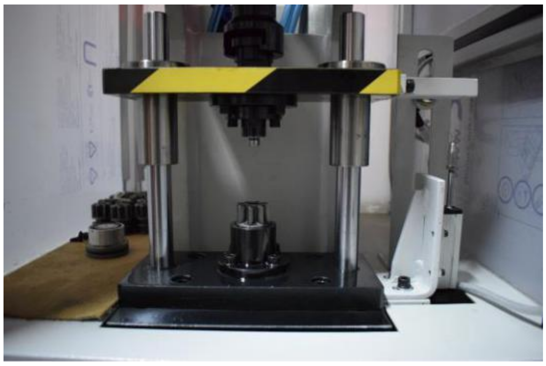

Figure 4: Fixture assembly

The Pressing operation takes place in two strokes. First, the approach stroke (pneumatic pressure) where the shaft of the cylinder moves down due to which the bush approaches the surface of the pinion. In the second stroke which is also known as the power stroke the bush is pressed into the pinion. The sequence of operation is as shown in the flow chart (figure 9):

The main power supply is given to the machine by switching on Main switch. The Control ON push button is pressed which will switch ON the entire machine. If this button is not pressed, the machine won't work even if we have supplied it with power.
We have two modes of operation, Manual mode and Auto mode. Both these have their own sequence of operation that will be performed.

When Manual mode is selected, first we have to press the Approach stroke push button which causes the respective solenoid to get activated. This results in the piston 1 moving downward with minimum force and maximum distance travelled. When the Power Stroke push button is pressed, the respective solenoid gets activated this causes the piston 2 to move downward with maximum force and minimum distance. The above process will result in the bush getting pressed into the pinion. When we press Return push button, the top plate of the fixture assembly comes to the home position.

When Auto mode is selected, we have to press the two Cycle Start push buttons simultaneously to start the operation. This causes the approach stroke solenoid to get activated and after some time delay, the power stroke solenoid gets activated. The operation performed is same as mentioned in the above step.
During machine operation there are a few safeties as well as machine protection safety interlocks. Based on

3

the fault caused there will be different reset conditions in order for the machine to work.

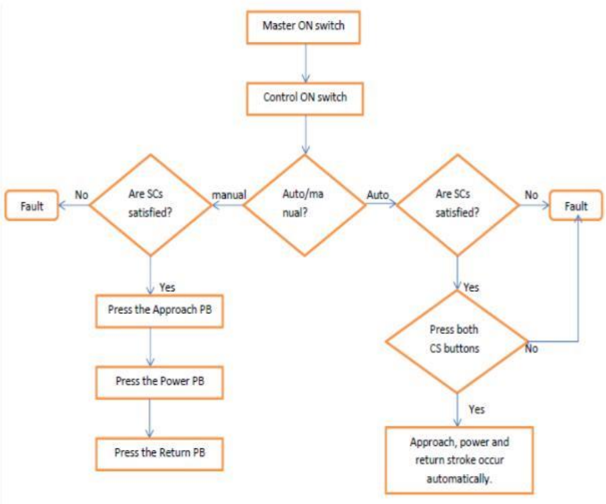

Figure 5: Flowchart of Operation

The machine is also provided with a tower lamp. The tower lamp is used to determine the status of the machine. There are three colors in the tower lamp namely red, amber and green. The red tower lamp as shown in **figure 6** is used to indicate that the machine is in fault mode. The fault mode can be triggered in many ways such as the low air pressure fault, low oil fault, low or high load fault and safety fault. The amber lamp as shown in **figure 7** is used to indicate that the machine is in manual mode and the green lamp as shown in **figure 8** is used to indicate that the machine is in auto mode.

Figure 6,7,8: Working modes of Machin

VII. Implementation And Results

A. *ANALYSIS OF C-FRAME*

One of the most vital parts of the machine is the C-Frame. The C-Frame is used to house the hydro-pneumatic cylinder and many other components including the fixture assembly. It is important to subject the C-Frame to the stress analysis in order to verify the load bearing capacity of the frame. The major parameters of the analysis include part properties, material used and its properties, load and constraint information. By using the above information we can identify if the C-Frame is fit for use or if there have to be changes made. The below charts shows the data used for the analysis of the C-Frame.

Part Name	C Frame
Mass	78.503 kg
Volume	10022052.124 mm^3
Weight	0.769 kN

Table 1: Part Properties

Material Used	Mild Steel
Mass Density	7833.000 kg/m^3
Young's Modulus	199947.953 MegaPa
Poisson's Ratio	0.290
Thermal Expansion Coefficient	0.0000 /C
Thermal Conductivity	0.032 kW/m-C
Yield Strength	262.001 MegaPa
Ultimate Strength	358.527 MegaPa

Table 2: Material Properties

Load Set Name	Load 1
Load Type	Force
Number of Load Elements	1
Load value	20.000 kN

4

Load Set Name	Load 2
Load Type	Force
Number of Load Elements	1
Load value	20.000 kN

`Number of Constrained Faces	1

Table 3,4&5: Load Constraint Information

By using the following data we can obtain the results for the stress, displacement and the Factor of Safety (FOS).

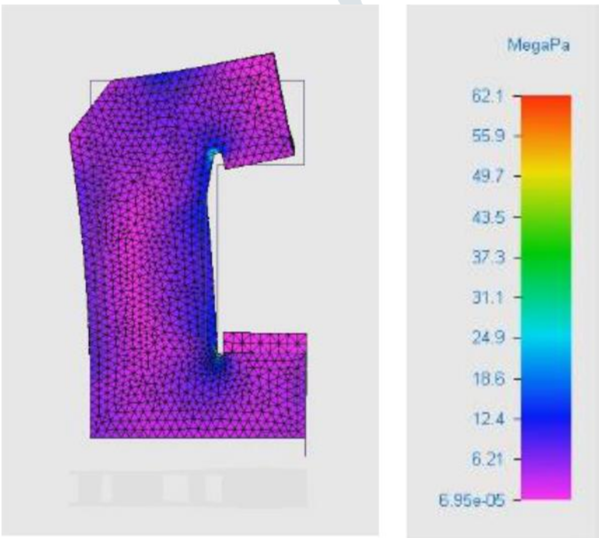

Figure 9: Stress analysis of C-Frame

Type	Extent	Value	X	Y	Z
Von Mises Stress	Minimum	6.951e-05 MegaPa	-37.50 mm	-92.50 mm	0.00 mm
	Maximum	6.214e+01 MegaPa	-215.59 mm	-20.00 mm	145.59 mm

Table 6: Stress Results

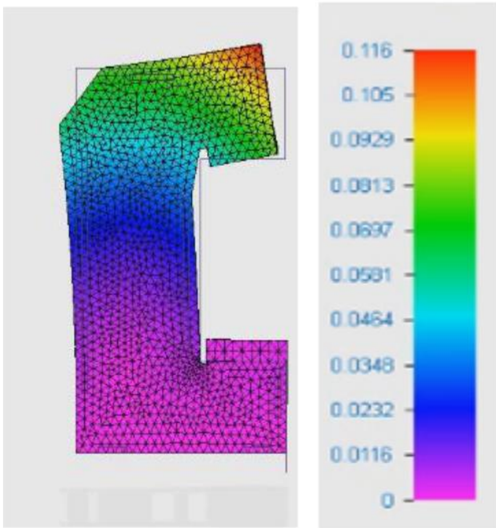

Figure 10: Displacement analysis of C-Frame

Type	Extent	Value	X	Y	Z
Resultant Displacement	Minimum	0.00e+00 mm	-287.50 mm	-20.00 mm	0.00 mm
	Maximum	1.16e-01 mm	-362.41 mm	-185.00 mm	629.41 mm

Table 7: Displacement Results

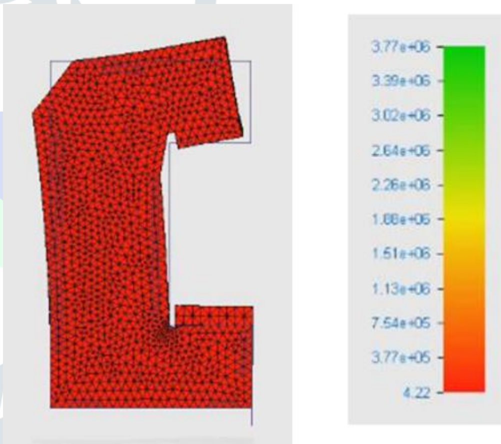

Figure 11: Factor of Safety of C-Frame

Factor of Safety	4.216

Table 8: Factor of Safety Result

B. *PNEUMATIC CIRCUIT DESIGN*

Pneumatics is application of compressed air (pressurized air) to power machine or control or regulate machines. A pneumatic circuit is an interconnected set of components that convert compressed gas (usually air) into mechanical work. The major constituents of the pneumatic circuit include a FRL unit, cylinder, oil reservoir, flow control valves, direction control valves, quick exhaust valves and most importantly a compressor for the supply of compressed air.

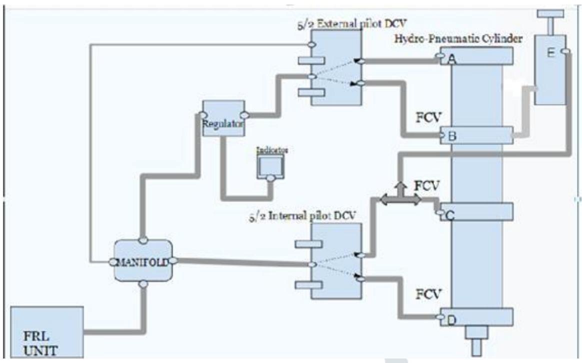

Figure 12: Pneumatic Circuit

In the above circuit, compressed air is sent through the FRL unit to the manifold. The manifold acts like an air distribution system hence distributing air to the different components in the circuit. The circuit consists of a digital air pressure indicator which indicates the air pressure within the system. The direction control valves are used for the supply and exhaust of air within the system. The major element in the circuit is the hydro-pneumatic cylinder. The hydro-pneumatic cylinder is responsible for the pressing operation involved during the insertion of the bush into the pinion.

C. *ELECRICAL PANEL DESIGN*

An electrical panel is defined as a component of an electricity supply system that divides an electrical power feed into the subsidiary circuits. It is mainly used to control the mechanical equipment. The panel consists of the PLC, MCB, safety relays, SMPS, push buttons, terminals, grounding and an enclosure. The panel is designed according to the components used based on the dimensions of each individual components. The components are studied thoroughly and then a design and circuitry is created using the auto CADD software. Once the design is ready, the panel and wiring is done accordingly.

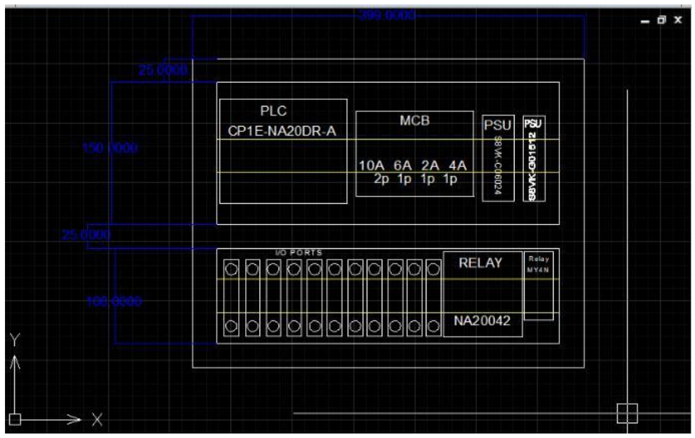

Figure 13: Auto CADD design of Electrical Panel

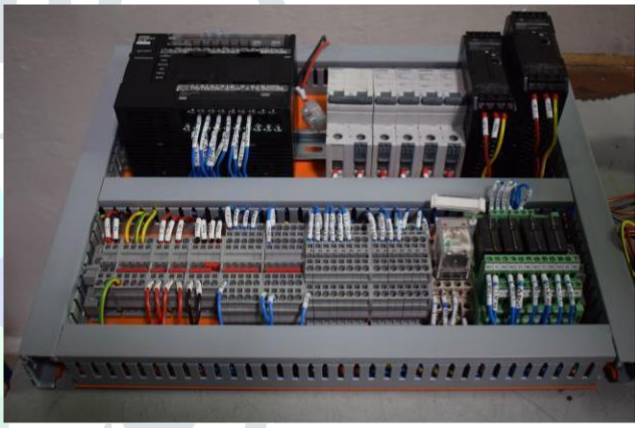

Figure 14: Electrical Panel

D. *INTERFERENCE FIT*

An interference fit, also known as a press fit or friction fit is a fastening between two parts which is achieved by friction after the parts are pushed together, rather than by any other means of fastening.

Here, the parts are a steel bushing and a steel hub. The bush is mounted on a top tool whereas the pinion is located or held in the component holder. Upon starting the machine cycle the bush approaches and sits on the surface of the pinion, once the solenoid gets activated and the power stroke takes place the bush is pushed into the pinion and the fitment takes place.

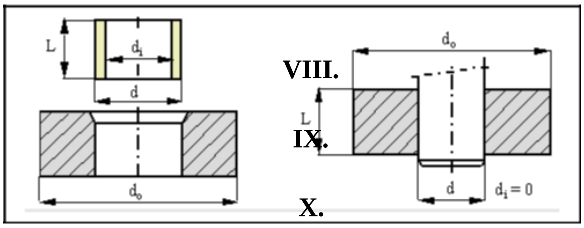

Figure15: Illustration of an Interference Fit

For an interference fit to take place, we need to know what kind of material is being used, internal diameter and external diameter of the bush, internal diameter of the pinion, length of the bush, diametric interference, Young's modulus, coefficient of friction and the Poison's ratio.

d_i	10.03mm	L	6mm	E_i	210 GPA	v_i	0.3
d	13.56mm	δ^1	0.3mm	E_o	210 GPA	v_o	0.3
d_o	28.3mm	μ^2	0.1	-	-	-	-

Table 9: Parameters required for Interference Fit

d_i	Internal diameter of the bush
d	External diameter of the bush
d_o	External diameter of the pinion
L	Length of the bush
δ^1	Diametric Interference
μ^2	Coefficient of Friction
E_i. E_o	Young's modulus of Steel
v_i, v_o	Poison's Ratio of Steel

Table 10: Abbreviations of the Parameters used

Interference pressure	P	926.94Mpa
Friction force	F	23.69kN
Transmission torque	T	160.64Nm

Table 11: Result of the Interference Fitment

VIII. Application

The application of the project is bush pressing.

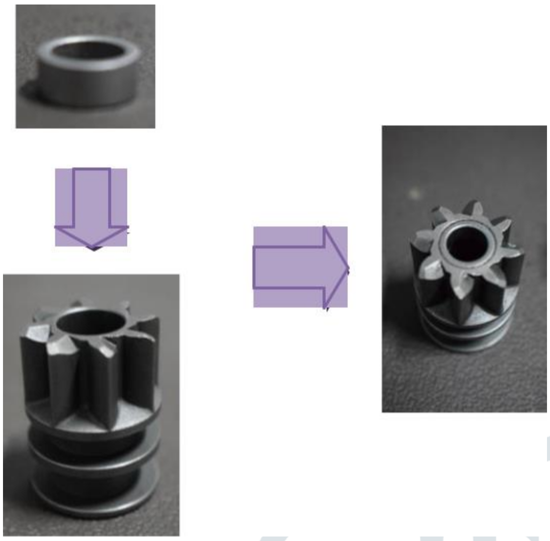

Figure 16: Bush Pressing

4. CX- Programmer Introduction guide", published by Omron Corporation.
5. Hydraulics and Pneumatics- A technician's and engineer's guide, Andrew Parr, Elsevier Science, Edition 3, 2011.
6. Pneumatic Systems Principles and Maintenance, Textbook, S R Mujumdar, Tata McGraw Hill Publishing Company Limited, 16th Reprint

IX. Conclusion

To conclude, the main focus of building this machine was to ensure quality fitment, automation of the existing system, and safety of the operator operating on the machine at a specific time. It is user friendly and customizable. It has multiple applications, but this project is made for one specific application. By changing the fixture assembly as shown in figure 8 one can modify it to various other small scale pressing operations.

X. References

1. Stress analysis of a frame of a bush pressing machine for pumps IJIRSET vol 4, issue 2, February 2015 by Amith Kalekar, S. B. Tuljapure, Walchand Institute of Technology.
2. Programmable Logic Controller, W. Bolton, Elsevier India, Edition 6, 2016.