© May 2025 | IJIRT | Volume 11 Issue 12 | ISSN: 2349-6002

# Design and Development of Bush Pressing Machine

Suresh Pawara[1], Krishna Kohar[2]
*Dhiraj Deshmukh, MET BHUJBA L KNOWLAGE CITY/MECHANICL DEPARTMENT*

***Abstract- The design and development of a bush pressing machine was undertaken to address the need for a compact, cost-effective, and precise solution for press-fitting operations. Existing hydraulic press systems, while powerful, are often oversized and expensive for small-scale applications, creating a demand for lighter, specialized equipment. In this project, the required pressing force was calculated to be 400 N based on the interference fit between the bush and the component. A two-column pneumatic press frame was designed using SolidWorks 2023, modifying an initial four-column concept to improve compactness and ease of fabrication. Finite Element Analysis (FEA) simulations were conducted on the machine frame and on the shrink-fit operation of the bush. The frame structure was tested under load to validate its performance, and the shrink fit stress during pressing was also analysed. The frame simulation results showed a maximum von Mises stress of 270 MPa, a displacement of 0.03754 mm, and a factor of safety (FOS) of 13, ensuring structural safety under operational loads. In the shrink-fit simulation, the maximum von Mises stress was 979.9 MPa, relative to a material yield strength of 351.6 MPa, resulting in a stress-to-yield factor of 2.79. The developed bush pressing machine successfully meets the project objectives, demonstrating sufficient strength, precision, and safety margins for bush pressing applications, while offering a more compact and affordable alternative to conventional presses***

***Key results-Bush Pressing Machine, Shrink Fit Simulation, Finite Element Analysis (FEA), Factor of Safety***

## I. INTRODUCTION

In this project, a bush pressing machine is designed and developed for use in a breaker assembly line, where precise insertion of bushes into components is required as part of the sub-assembly process. The machine utilizes a pneumatic actuator, eliminating the need for hydraulic systems, which are often more complex, costly, and harder to maintain. Pneumatic systems are particularly well-suited for lower force applications like this, where the pressing force requirement is calculated to be 400 N.

To ensure structural stability and precision during pressing, a custom fixture was incorporated to hold the plate securely, minimizing misalignment and reducing operational error. The overall frame structure of the machine was designed in SolidWorks, and its performance was verified using Finite Element Analysis (FEA). The frame simulation showed a maximum von Mises stress of 270 MPa, maximum displacement of 0.03754 mm, and a Factor of Safety (FOS) of 13, indicating a highly stable and overengineered design. Additionally, a shrink-fit simulation for the bush pressing operation revealed a maximum von Mises stress of 979.9 MPa compared to a yield strength of 351.6 MPa, giving a stress-to-yield ratio of 2.79, which is acceptable for localized contact stress during interference fitting.

The design and simulation strategies are supported by existing research in the field. Patil and Patil (2019) emphasized the significance of fixture design in bush pressing machines to improve accuracy and operator safety. Similarly, Gopinath and Sugumaran (2021) highlighted the importance of FEA in validating the structural integrity and performance of press machines during component insertion operations.

## II. METHODOLOGY

### *1. Concept Development and Selection*

To initiate the design process of the bush pressing machine, multiple conceptual frameworks were explored. The goal was to determine a structural layout that would ensure strength, simplicity in fabrication, cost-effectiveness, and operational reliability. Three distinct design configurations were developed and evaluated:

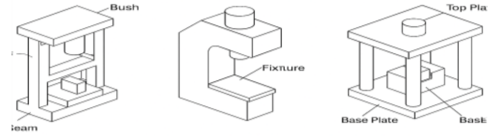



Figure 1: Shows Three Concept Drawing

- Concept 1: This design incorporated a heavy-duty structure constructed using I-beams. While it offered high strength and rigidity, it was considered over-engineered for the force requirements of a typical bush pressing operation. Additionally, the bulkiness of the design would increase both cost and fabrication time.
- Concept 2: A C-frame configuration, commonly seen in single-column presses. Though it provided better access for the operator and compactness, the asymmetric structure had a tendency to deflect under off-centre loads, potentially compromising accuracy.
- Concept 3 (Final Selection): A four-column guided press structure with a top plate, bottom plate, and vertical support pillars. This configuration was finalized due to the following advantages:
  - Symmetrical force distribution, reducing chances of bending or misalignment
  - Ease of fabrication using Mild Steel (MS)
  - Better guidance and alignment of moving components
  - Suitable for compact setups while maintaining structural integrity

This concept provided the best balance between performance, manufacturability, and cost, and was selected for detailed modelling and prototype development.

2. 3D Modelling of Frame

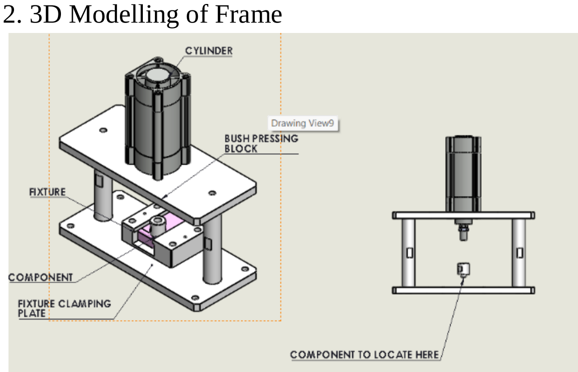



Figure 2: 3D cad model of Final Concept Design.

The final structure selected for the bush pressing frame was based on Concept 3. While the original Concept 3 proposed a four-column guided press structure to ensure better force distribution and alignment, a design modification was introduced during the finalization stage: instead of four columns, only two vertical support columns were utilized. This change simplified the frame, reduced material costs, and maintained the necessary rigidity and guidance for the pressing operation without compromising performance. The selected structure (Concept 3) was modeled in SolidWorks 2023, combining static and functional elements to accurately replicate real-world bush pressing operations. The design ensures proper alignment between the pneumatic actuator, fixture, and the component being pressed. The frame consists of a thick mild steel (MS) top plate that supports the pneumatic cylinder and provides a rigid surface for vertical motion. The bottom plate serves as the main base platform, where the fixture block is securely mounted to hold the component during pressing. Instead of four guide pillars as initially proposed, the final design uses two cylindrical MS guide columns. These two columns effectively maintain linear motion and restrict lateral displacement, ensuring precise vertical alignment throughout the pressing operation. The fixture block is carefully designed to locate and securely hold the bush and the plate in the required orientation. A basic pneumatic control system is integrated, using manual valves and switches to control the actuator’s operation, providing a simple and safe pressing cycle. Minor design refinements were made to optimize the spacing between elements, improve stability, and ensure that the overall structure remained compact, cost-effective, and capable of handling the required pressing loads without compromising on safety or performance.

3.Calculations:

i. Calculation for Pressing Force for Bush Pressing Machine

The pressing force required for inserting the bush into the plate was calculated based on interference fit principles, considering the material deformation required during assembly. The force can be estimated using the following formula for press-fit joints:

$$F=\pi \cdot d \cdot L \cdot p$$

Where:

F= Pressing force (N)
d= Diameter of the bush (mm) = 18.05 mm
L = Length of the bush (mm) = 12 mm
p= Contact pressure (MPa), derived from interference and material properties.

To calculate contact pressure p, we use:

$$p = \frac{\delta \cdot E}{d}$$

Where:

δ = Interference = 18.05−18.00=0.05 mm

E = Modulus of elasticity for steel = 210,000 MPa

d = Mean diameter = 18.025 mm

$$p = \frac{0.05 \times 210000}{18.025} \approx 582.7\,\text{MPa}$$

Now calculate the pressing force:

$$F = \pi \cdot 18.05 \cdot 12 \cdot 582.7 \approx 396,305\,\text{N-mm} = 396.3\,\text{N}$$

So, the required pressing force is approximately 400 N, matching the earlier empirical estimation. This validates the assumption and supports proper actuator selection.

ii. Sizing Calculation for Pneumatic Actuator

Using the confirmed pressing force, the pneumatic actuator is sized using the standard formula:

F=P·A

Where:

F=400 N

P=0.5 MPa (typical compressed air pressure)

$$A = \frac{F}{P} = \frac{400}{0.5} = 800\,\text{mm}^2$$

Now solving for diameter:

$$D = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4 \cdot 800}{\pi}} \approx 31.9\,\text{mm}$$

Therefore, a 32 mm bore pneumatic actuator is suitable. A stroke length of 50 mm is selected based on component height and assembly clearance requirements.

iii. Actuation Mechanism

The pressing operation is powered by a pneumatic actuator, selected for its:

- Rapid and repeatable motion
- Clean and oil-free operation (compared to hydraulic systems)
- Ability to generate sufficient pressing force for interference-fit applications

The actuator is mounted on the top plate and operates vertically downward. On activation, compressed air drives the actuator, which in turn presses the bush into the hole in the plate. The return stroke is activated after the pressing cycle is complete.

iv. Operational Workflow

The machine operates based on the following steps:

1. Fixture Setup: The plate with a predefined hole is positioned within the fixture, and the bush is placed above the hole.
2. Cycle Initiation: The operator presses the green start button, activating the pneumatic actuator.
3. Pressing Operation: The actuator applies a downward force, inserting the bush into the plate using an interference fit.
4. Retraction and Removal: Once pressing is complete, the actuator retracts, allowing the operator to remove the assembled component.

The guide pillars ensure the pressing motion remains vertically aligned throughout, minimizing the risk of tilting or bush misplacement

Equation or Math Type Equation). —Float over text‖ should not be selected.

## III. RESULTS AND DISCUSSION

The final design concept of the bush pressing machine was developed and modelled using SolidWorks 2023. A complete 3D model was created, and a detailed bill of materials (BOM) was prepared to define the components and materials used in the construction. The design focused on achieving structural simplicity, operational accuracy, and manufacturability within budget constraints.

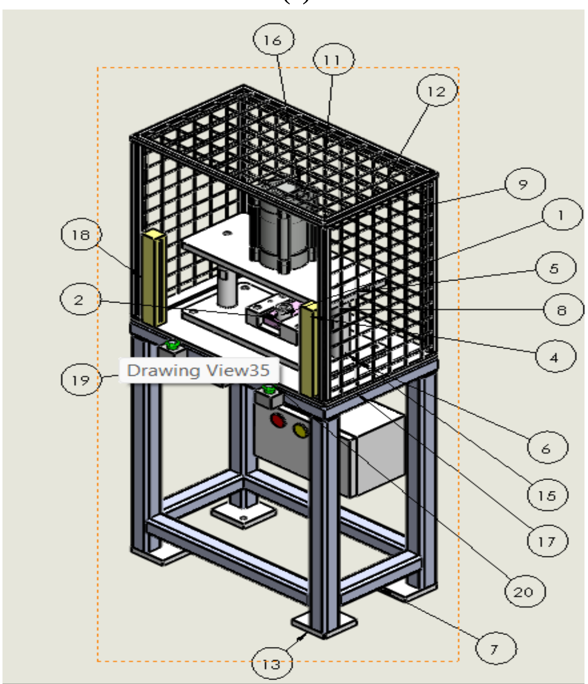
The frame structure was evaluated for its ability to accommodate the pneumatic pressing operation with reliable alignment and minimal deflection. The fixture and actuator placement were finalized through iterative modelling to ensure a stable and compact setup. The final model provided a practical foundation for prototype development and assembly, meeting the functional requirements of the bush pressing process used in breaker assembly lines.

## IV. 3D CAD MODELLING

To create the 3D parts of the bush pressing machine, SolidWorks 2023 was used. The bill of materials (BOM) and the complete 3D model of the assembly are presented in Figure 3.

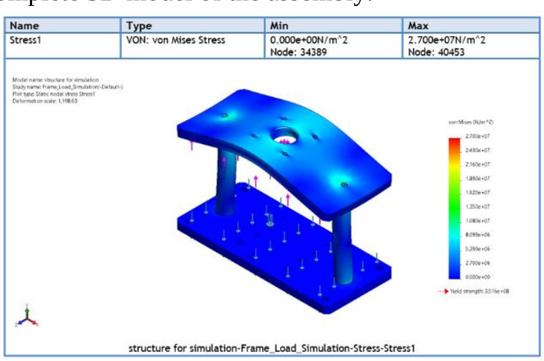
| ITEM NO. | PART NUMBER | Material | QTY. |
|---|---|---|---|
| 3 | 100-PRESSING PIN BP-1 | EN24 | 1 |
| 4 | 100-PLATE MOUNTING FIXTURE BP-1 | EN8 | 1 |
| 5 | 100-BASE PLATE-BP-01 | M.S | 1 |
| 6 | 100-BOTTOM PLATE-BP-01 | M.S | 1 |
| 7 | 100-EXISTING TABLE BP-1 | MS | 1 |
| 8 | 100-BASE PLATE-01 BP-1 | MS | 1 |
| 9 | 100-WIRE MESH PART BP-1 | MS | 2 |
| 10 | 100-WIRE MESH FABRICATED STRUCTURE | MS | 1 |
| 11 | 100-WIRE MESH PART BP-2 | MS | 1 |
| 12 | 100-WIRE MESH PART TOP BP-3 | MS | 1 |
| 13 | 100-GROUNTING PLATE BP-1 | MS | 4 |
| 14 | 100-MOUNTING PLATE BP-1 | MS | 2 |
| 15 | 100-GUIDE ROD BP-1 | STD | 2 |
| 16 | 1384808 DSBC-100-100-PPVA-N3---(0) | STD | 1 |
| 17 | 100-MAIN CONTROL PANEL-BP-1 | STD | 1 |
| 18 | 100-LIGHT CURTON BP-3 | STD | 2 |
| 19 | 100-EMERGENCY PUSH BUTTON PL R1 | STD | 1 |
| 20 | 100-TWO HAND PUSH BUTTON PL R1 | STD | 2 |

(a)

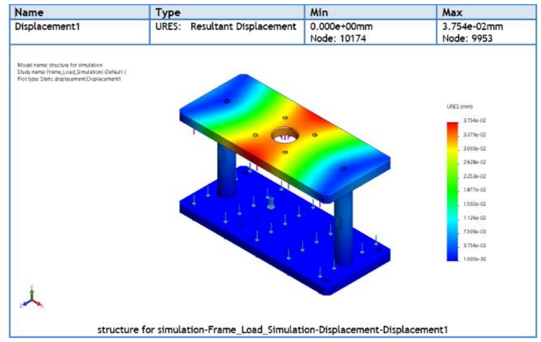



(b)

Figure 3. (a)&(b) Shows the Bill of Materials and the complete 3D model of the assembly.

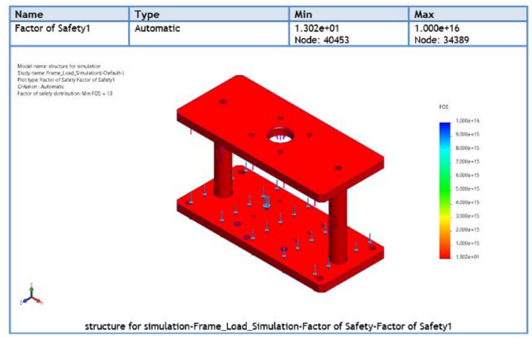



(a)




(b)

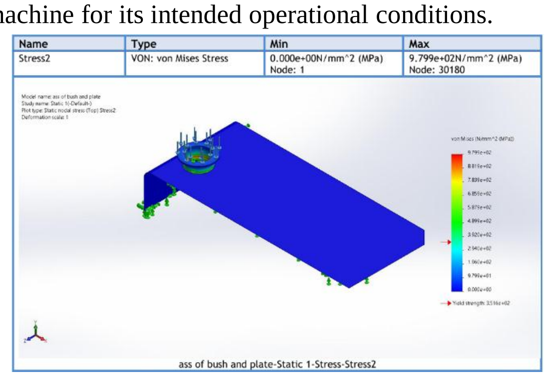
D



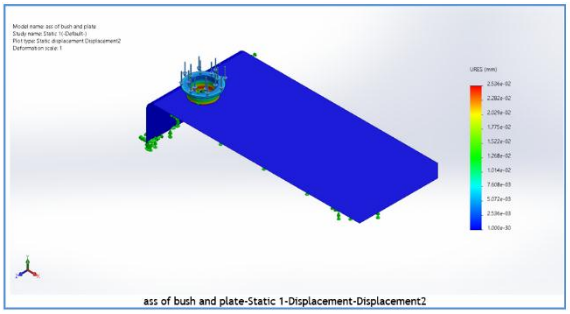

(c)

Figure 4: The maximum value of Von Mises Stress(a), maximum Displacement (b), Minimum FOS for Frame at 4000N(c).

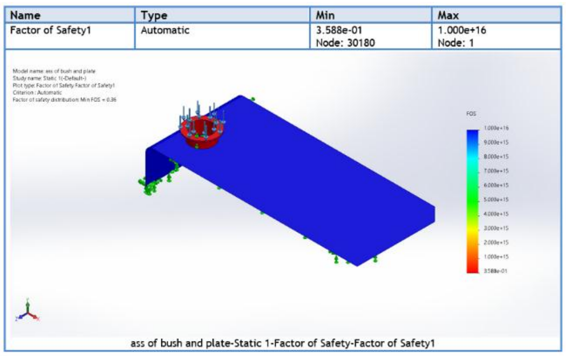
According to the simulation results as shown in figure, the maximum von Mises stress developed in the frame structure is 27 MPa, which is significantly below the yield strength of the material used (351.6 MPa), indicating safe structural performance. The maximum resultant displacement observed is 0.0375 mm, which is minimal and confirms that the frame maintains structural integrity under the applied load. Additionally, the factor of safety for the frame is found to be 13.02, demonstrating that the design has a substantial margin of safety against failure. These results validate the frame design of the bush pressing machine for its intended operational conditions.




(a)




(b)




(c)

Figure 5:(a) Maximum von Mises Stress, (b) Maximum Displacement, and (c) Minimum Factor of Safety (FOS) for Shrink Fit Analysis on the Component.

The structural performance of the bush and plate assembly under shrink fit conditions was evaluated using a static simulation. The analysis focused on three key aspects: stress distribution, displacement, and the factor of safety (FOS). The simulation results revealed that the maximum Von Mises stress reached approximately 979.9 MPa, concentrated at the interface between the bush and the plate. This value exceeds the material's yield strength of 351.6 MPa, indicating localized plastic deformation in that region.

The maximum displacement observed in the assembly was about 0.025 mm, which suggests that the overall deformation is minimal and confined primarily to the shrink fit area. This behaviour is characteristic of shrink fit assemblies, where tight interference causes deliberate plastic deformation to ensure a secure mechanical fit.

The factor of safety distribution showed a minimum value of 0.36 near the high-stress region. Although this is below the commonly acceptable threshold of 1, the localized low FOS is acceptable due to the intentional plastic deformation in the shrink fit zone. The rest of the component maintains a high factor of safety, indicating structural integrity in those areas. Hence, the design is considered safe for operation, with the critical shrink fit region functioning as intended within the engineering design limits.

i. Fabrication Process of the Bush Pressing Machine

Following the completion and finalization of the bush pressing machine's concept design and analysis, the manufacturing process commences utilizing the recommended design. The primary procedures involved in the fabrication and assembly are cutting, welding, and potentially drilling.

ii. Cutting Process and Welding Process

The initial stage of part fabrication involves cutting the Mild Steel (MS) raw materials, such as structural sections (like beams, channels, or rectangular tubes) and plates, to the precise dimensions specified in the 2D drawings. These cutting operations are performed using appropriate machinery, such as band saws, laser cutters, or plasma cutters, ensuring accuracy for the subsequent assembly.

Once all the structural members and plates are cut to the required sizes, the frame of the bush pressing machine is assembled and joined together using a robust welding technique, typically MIG (Metal Inert Gas) welding. This process ensures strong and rigid connections between the MS components, forming the base frame, upright supports, and the structure that will house the pressing mechanism and safety guards. Depending on the design, certain components might also require drilling for bolt holes to facilitate assembly or the mounting of other parts.

iii. Surface Preparation and Powder Coating Process (Concise)

The Mild Steel frame undergoes thorough cleaning to remove dirt and grease. A chemical pre-treatment (like phosphating) is applied to enhance powder coat adhesion and corrosion resistance. Then, powder coating is electrostatically applied and the machine is baked in an oven to create a durable, protective, and coloured finish.

## V. FINAL PRODUCT ASSEMBLY

The final assembly of the bush pressing machine involves integrating all fabricated and finished components, including the welded Mild Steel frame, the pneumatic actuator, ram, guide columns, work table, fixture, and safety cage. The pneumatic actuator is mounted to the upper frame, connected to the ram guided by the columns for controlled vertical movement. The work table supports the fixture, which aligns the workpiece for bush pressing. Finally, the safety cage and control box are attached, and all connections are tested to ensure safe and efficient operation using pneumatic power to exert the pressing force.

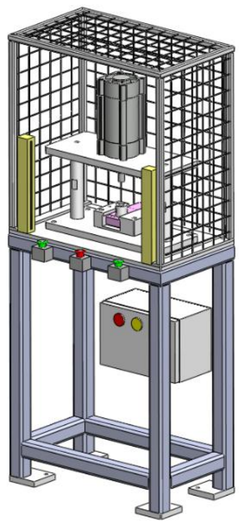


Figure 6: Shows the final assembly of the bush pressing machine.

## VI. CONCLUSION

The design and development of the Bush Pressing Machine were successfully completed to meet the operational needs of bush assembly, particularly in breaker assembly lines. A pressing force of approximately 400 N was calculated based on interference fit parameters, which was critical for selecting an appropriate pneumatic actuator.

Simulation and structural analysis were carried out to validate the design. For the frame, the maximum von Mises stress was found to be 270 MPa, with a displacement of 0.03754 mm and a factor of safety (FOS) of 13, indicating strong structural integrity under loading. For the shrink-fit analysis, the maximum von Mises stress reached 979.9 MPa, exceeding the yield strength of 351.6 MPa, resulting in an intentional localized plastic deformation. However, since this is confined to the press-fit region, the rest of the component maintains a high FOS, and the overall design is considered safe.

## VII. AUTHOR CONTRIBUTION

Krishna Kohar: 3D modelling, simulation analysis, design development, fabrication planning, and documentation.

Suresh Pawara: Conceptual design input and pressing force calculation methodology.

## VIII. CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the outcome of this project.

## IX. ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support of MET Bhujbal Knowledge City. Special thanks to Mr. Suresh Pawara for his valuable guidance in the conceptual design and force calculations. The authors also sincerely thank Mr. Dhiraj Deshmukh for his expert mentorship and continued guidance throughout the *Design and Development of Bush Pressing Machine* project. Appreciation is extended to all faculty members and technical staff for their assistance and encouragement.

## X. REFERENCES

[1] Patil, A. B., & Patil, S. S. (2019). *Design and Development of Bush Pressing Fixture for Hydraulic Press*. International Research Journal of Engineering and Technology (IRJET), 6(5), 1304–1309.

[2] Gopinath, R., & Sugumaran, V. (2021). *Design and Analysis of Mechanical Press for Bush Insertion*. Journal of Manufacturing Processes, 58, 331–338B

[3] Design Optimization of Hydraulic Press Plate using Finite Element Analysis. Akshay Vaishnav 1 .et. al. Int. Journal of Engineering Research and Applications, Vol. 6, Issue 5, (Part - 4) May (2016), pp.58-66.

[4] Design of an automated line for pressing cylindrical bushings with screws, Jozef Jenisa *, Slavomír Hrčeka ,

[5] Structure Frame Analysis & Design Optimization of Metal Forming Heavy Duty Hydraulic Press,

IJIRS, Engineering and Technology, Vol. 4, Issue 8, August 2015.

[6] Design and Fabricate of Lifting Equipment for Workshop, M. Nur Irfan1*, Alias Mohd1*, Zahari Deraman1, International Journal of Synergy in Engineering and Technology Vol.5 No.1 (2024) 9-23.