Asian Review of Mechanical Engineering
ISSN: 2249-6289 (P) Vol.10 No.1, 2021, pp.1-7

DOI: https://doi.org/10.51983/arme-2021.10.1.2795

# Design Optimization of Frame of Mechanical Press Machine

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***Abstract*** **- Power presses are used for the simple, accurate, and economical production of large quantities of articles quickly, accurately, and economically from the cold working of mild steel and other ductile materials. The components produced range over an extremely wide field and are used throughout the industry. Sometimes the pressings may be complicated and more than one pressing operation may be required. The press purpose is to shift one or more sources and movements to a tool or to die to shape or blanch a piece of work. Press design calls for the application of special knowledge about the production process. The press is designed either to perform a specific process or for primarily universal use. The manufacturing process for the metal formation is almost chip less. To perform these tasks Press tools are used. Job component deformation to the desired size is achieved by applying pressure. Presses are regarded as the best and most efficient way of shaping sheet metal into finished products. Pneumatic presses are widely used for operations such as punching, grinding, molding, clinching, blanking, deep drawing, and metal shaping.**
***Keywords:*** **Frame of Mechanical Press Machine, Press Design Press Tools**

## I. INTRODUCTION

We recognize there are three types of electric, hydraulic and pneumatic power presses. These may have mechanical or electro-mechanical control systems. Through these three main types of power presses share many common features, the mechanical power press is the most widely used and researched. Mechanical power press works on the principle of reciprocating motion and the flywheel, and crankshaft, clutch are the main components for power transmission. A motor gives flywheel rotational motion and a clutch is used to couple the flywheel rotation to the crankshaft. The crankshaft transforms the flywheel's rotational motion into the press rams down and upward motions. A piece of work is fed, either automatically or manually, into the lower die and the system process is started. The ram (with an upper die) on the down stroke travels towards the area of operation. A re-formed piece is produced when the upper and lower dies press together onto the stock material. Once the down stroke is complete, the work piece created is removed and a new work piece is fed into the machine and process again [1].

A mechanical power press is a machine used to provide force to a die used to shape, blank, or shape metal or non-metallic material. Thus, a press is a component of a manufacturing system that combines to produce a part the press, die, material, and feeding method. The production system designer must also provide sufficient point-of-service guards for safeguarding the staff in the press room. Every part of this production system is important and will be discussed later in this article.

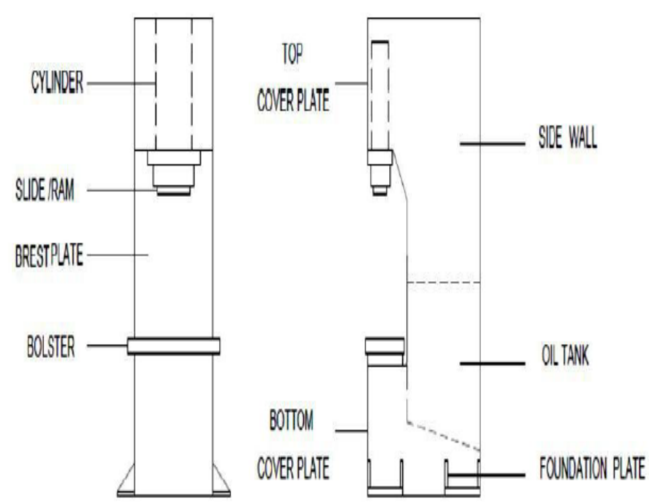


Fig. 1 Block Diagram of Hydraulic Press

A mechanical power press is a machine used to provide force to a die used to shape, blank, or shape metal or non-metallic material. Thus, a press is a component of a manufacturing system that combines to produce a part the press, die, material, and feeding method. The production system designer must also provide sufficient point-of-service guards for safeguarding the staff in the press room. Every part of this production system is important and will be discussed later in this article.

## II. THEORY

The various hydraulic and pneumatic presses are designed from all the various articles. We are working on the mechanical press inside my group. Here we focus primarily on reducing low-charged components such as frame and other low-charged components.

*Scope*

The current industry scenario is the high-weight mechanical pressing machine that causes various problems such as machine base, machine repair, and exhaustion for workers. Because of such large machines, the machine costs are also higher. This improves resource consumption and isn't good for new start-ups. Therefore there is room to reduce the machine's weight without altering its efficiency and retaining the necessary strength as it is. Current machine study is needed for this. The new system is also built with various necessary parameters changing. CATIA software is used for 3 D modelling of the system, and ANSYS software is used for analysis [2].

## III. CONSTRUCTION AND WORKING

*A. Working Principle and Construction*

We have recognized there are three types of electric, hydraulic and pneumatic power presses. Their control systems are theoretically mechanical or electro-mechanical. Through these three major types of power presses share some common characteristics; the most widely used and studied is the mechanical power press. There are two main beds and a moving ram in the power press. Mechanical power press works on the principle of reciprocating motion and the flywheel, and crankshaft, clutch are the main components for power transmission. A motor gives flywheel rotational motion and clutch is used to couple the flywheel rotation to the crankshaft. The crankshaft transforms the flywheel's rotational motion into the press ram's downward and upward motions. A piece of work is fed, either automatically or manually, into the lower die and the system process is started. The ram (with an upper die) on the down stroke travels towards the area of operation. A re-formed piece is created when the upper and lower dies press together on the stock material. Once the down stroke is complete, the work piece created is removed and a new work piece is fed into the machine and repeat [3].

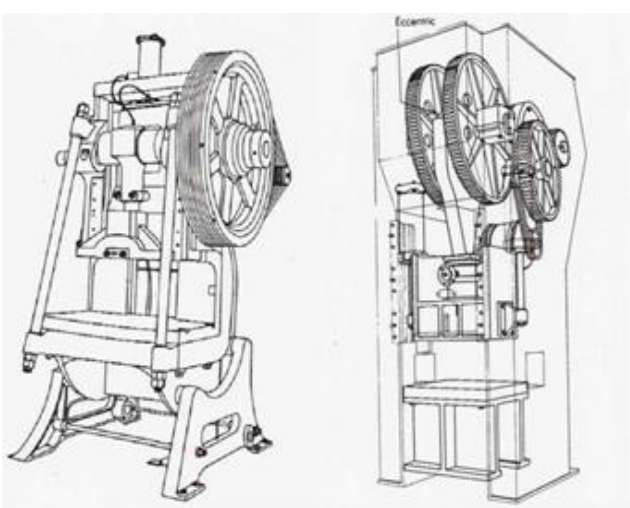

Fig. 2 Press Frame

## IV. DESIGN OF EXISTING PRESS MACHINE

Check design and specifications of existing press machine in the industry.

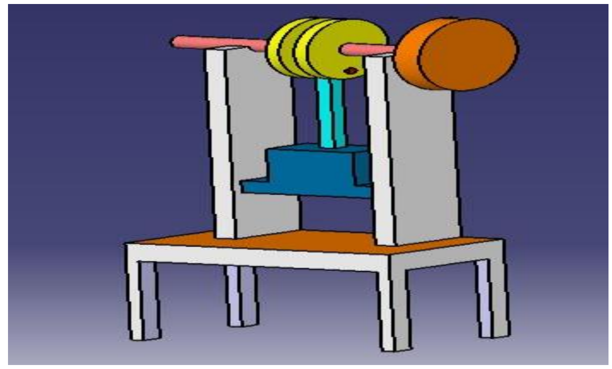

Fig. 3 3D Model of Existing Design

TABLE I SPECIFICATIONS OF PRESS MACHINE

| Sl. No. | Parameters | Dimensions |
|---|---|---|
| 1 | Height from bottom | 3000 mm |
| 2 | Bed size | 1040×730 mm |
| 3 | Width of C Frame | 700 mm |
| 4 | Height of C Frame from bed | 2100 mm |
| 5 | Thickness of C Frame | 65 mm |
| 6 | Diameter of Punch | 530 mm |
| 7 | Thickness of punch | 60 mm |

## V. THEORETICAL STRESSES ON DIFFERENT MACHINE COMPONENT

Theoretical design of frame assumption: The material of the frame perfectly homogeneous and isotropic i.e. it is same material throughout and of equal elastic properties in all direction. The material used is mild steel. And the properties are described below.

Specification of press:
Press capacity= 100 tones
Density= 7850 kg/m3
Syt = 590 Mpa
Considering uniformly distributed load & FOS as 2
Allowable Stress ($\sigma$all) = Syt / Fs
= 590/2
= 295 Mpa.
Young's modulus= 2.1 x 105Mpa
Poisons Ratio= 0.3
Formulas and calculation
The frame subjected to direct tensile stress and bending stresses at section x-x1.
$\sigma$ total = $\sigma$ tensile + $\sigma$ bending Mpa .................... (1)
$\sigma$ - total = P/A + Mb / Z Mpa..................... (2)
Where,
$\sigma$ = Permissible stress in Mpa
P= Applied load in N = 100 × 1000 × 9.81 = 981 KN

A= Area of frame section in mm2
Mb= Bending moment in N.mm
I= Moment of inertia in mm4
Z= Section modulus
Area: 2 × (400 × 80) = 64000 mm2
Direct stress = P/A ……………. (3)
= (100 × 1000 × 9.81) / 64000
= 15.33 Mpa
Bending stress = M/Z …………….. (4)
M = Force * perpendicular distance ……. (5)
= 981000 * 2100
= 2060100000 N-mm
Section modulus (Z) = B*H2/6 …………….. (6)
= 80 × 21002 / 6
= 58800000 mm3
Bending stress = Mb/Z
= 2060100000 / 58800000
= 35.03 Mpa.
Total stress = 35.03 + 15.33 = 50.36 Mpa

## VI. STRESS ANALYSIS OF MODEL

The figure shows the stress on the system

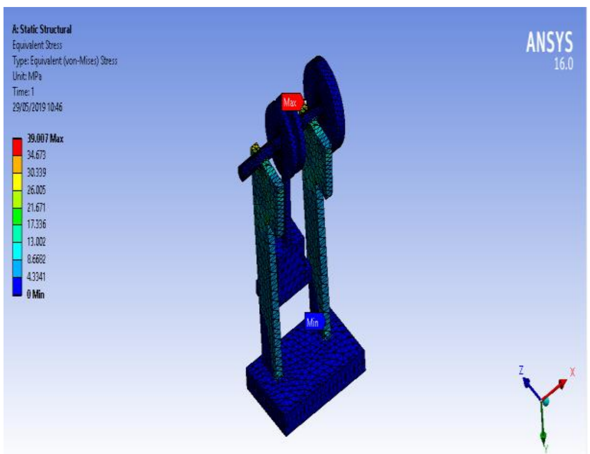


Fig. 4 Stress Analysis of Model

After application of 981 KN force on the system, the maximum stress is 39.007 Mpa and minimum stress is 0 Mpa. The bluish colour shows that there is more work to do

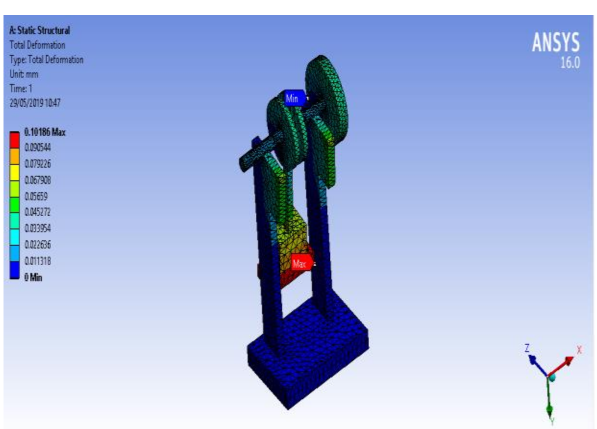


Fig. 5 Deflection of Model

The above figure shows the maximum deflection of 0.10186 mm and minimum 0 mm, after application of the required force [4].

## VII. DESIGN OF OPTIMUM SYSTEM

The design of this system for optimization will be started after the study of the existing system. System optimization will be according to one of the following cases:

1. Changing system dimensions and keeping the material exactly as it is.
2. Keeping the same dimensions and modifying component material,
3. Change of both material and component dimensions.8.1 CASE1: Changing system dimensions and keeping the material exactly as it is

Allowable Stress (σall) = Syt / Fs
= 590/2
= 295 Mpa.

Young’s modulus= 2.1 x 105Mpa
Poisons Ratio= 0.3
Formulas and measurement
The frame at section x-x1 subject to direct tensile stress and bending stresses
σ total = σ tensile + σ bending Mpa.................... (1)
σ total = P/A + Mb / Z Mpa.................... (2)

Where,
σ = Permissible stress in Mpa
P= Applied load in N = 100 × 1000 × 9.81 = 981 KN
A= Area of frame section in mm2
Mb= Bending moment in N.mm
I= Moment of inertia in mm4
Z= Section modulus
Area: 2100 * 80 * 2 + (400 × 80) = 288000 mm2
Area: 2 × (400 × 80) = 64000 mm2

Direct stress = P/A ……………. (3)
= (100 × 1000 × 9.81) / 64000
= 15.33 Mpa

Bending stress = M/Z …………….. (4)

M = Force * perpendicular distance ……. (5)
= 981000 * 2100
= 2060100000 N-mm

Section modulus (Z) = B*H2/6 …………….. (6)
= 80 × 21002 / 6
= 58800000 mm3

Bending stress = Mb/Z
= 2060100000 / 58800000
= 35.03 Mpa

Total stress = 35.03 + 15.33
= 50.36 Mpa

## VIII. STATIC STRESS ANALYSIS ON ANSYS SOFTWARE

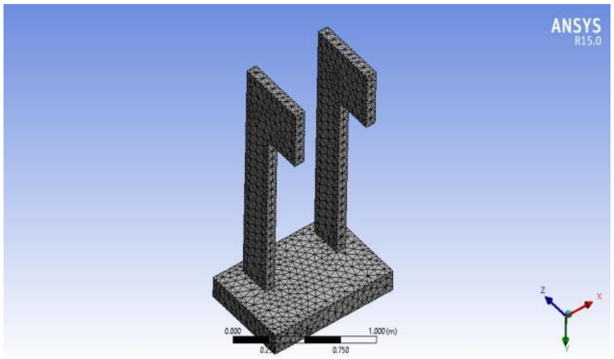

Fig. 6 Meshing of Changed C Frame Dimension

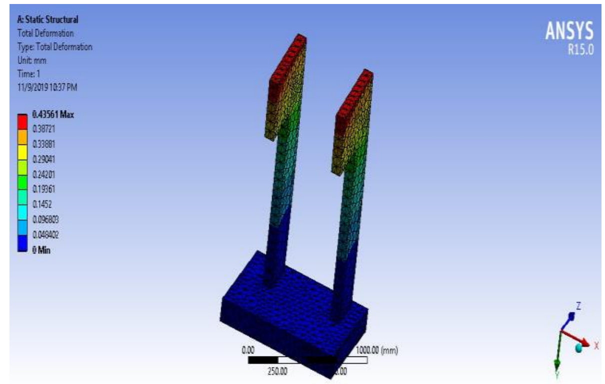

Fig. 7 Analysis of Changed Dimension C Frame

As above 34 such iterations were carried out, the following are tabulated.

TABLE II RESULTS OF ITERATIONS

| Sl. No. | Height | Width | Thickness | Direct Stress | Bending Stress | Total Stress | Weight | Difference with original |
|---|---|---|---|---|---|---|---|---|
| 1 | 2100 | 400 | 80 | 15.33 | 38.04 | 50.36 | 528.19 | 0.00 |
| 2 | 2100 | 350 | 80 | 17.52 | 35.04 | 52.55 | 462.17 | 66.02 |
| 3 | 2100 | 300 | 80 | 20.44 | 35.04 | 55.47 | 396.14 | 132.05 |
| 4 | 2100 | 250 | 80 | 24.53 | 35.04 | 59.56 | 330.12 | 198.07 |
| 5 | 2100 | 500 | 70 | 14.01 | 40.04 | 54.06 | 577.71 | -49.52 |
| 6 | 2100 | 400 | 70 | 17.52 | 40.04 | 57.56 | 462.17 | 66.02 |
| 7 | 2100 | 350 | 70 | 20.02 | 40.04 | 60.06 | 404.40 | 123.79 |
| 8 | 2100 | 300 | 70 | 23.36 | 40.04 | 63.40 | 346.63 | 181.56 |
| 9 | 2100 | 250 | 70 | 28.03 | 40.04 | 68.07 | 288.86 | 239.34 |
| 10 | 2100 | 500 | 60 | 16.35 | 46.71 | 63.06 | 495.18 | 33.01 |
| 11 | 2100 | 400 | 60 | 20.44 | 46.71 | 67.15 | 396.14 | 132.05 |
| 12 | 2100 | 350 | 60 | 23.36 | 46.71 | 70.07 | 346.63 | 181.56 |
| 13 | 2100 | 300 | 60 | 27.25 | 46.71 | 73.96 | 297.11 | 231.08 |
| 14 | 2100 | 250 | 60 | 32.70 | 46.71 | 79.41 | 247.59 | 280.60 |
| 15 | 2100 | 500 | 50 | 19.62 | 56.06 | 75.68 | 412.65 | 115.54 |
| 16 | 2100 | 400 | 50 | 24.53 | 56.06 | 80.58 | 330.12 | 198.07 |
| 17 | 2100 | 350 | 50 | 28.03 | 56.06 | 84.09 | 288.86 | 239.34 |
| 18 | 2100 | 300 | 50 | 32.70 | 56.06 | 88.76 | 247.59 | 280.60 |
| 19 | 2100 | 250 | 50 | 39.24 | 56.06 | 95.30 | 206.33 | 321.87 |
| 20 | 2100 | 500 | 40 | 24.53 | 70.07 | 94.60 | 330.12 | 198.07 |
| 21 | 2100 | 400 | 40 | 30.66 | 70.07 | 100.73 | 264.10 | 264.09 |
| 22 | 2100 | 350 | 40 | 35.04 | 70.07 | 105.11 | 231.08 | 297.11 |
| 23 | 2100 | 300 | 40 | 40.88 | 70.07 | 110.95 | 198.07 | 330.12 |
| 24 | 2100 | 250 | 40 | 49.05 | 70.07 | 119.12 | 165.06 | 363.13 |
| 25 | 2100 | 500 | 30 | 32.70 | 93.43 | 126.13 | 247.59 | 280.60 |
| 26 | 2100 | 400 | 30 | 40.88 | 93.43 | 134.30 | 198.07 | 330.12 |
| 27 | 2100 | 350 | 30 | 46.71 | 93.43 | 140.14 | 173.31 | 354.88 |
| 28 | 2100 | 300 | 30 | 54.50 | 93.43 | 147.93 | 148.55 | 379.64 |
| 29 | 2100 | 250 | 30 | 65.40 | 93.43 | 158.83 | 123.80 | 404.40 |
| 30 | 2100 | 500 | 20 | 49.05 | 140.14 | 189.19 | 165.06 | 363.13 |
| 31 | 2100 | 400 | 20 | 61.31 | 140.14 | 201.46 | 132.05 | 396.14 |
| 32 | 2100 | 350 | 20 | 70.07 | 140.14 | 210.21 | 115.54 | 412.65 |
| 33 | 2100 | 300 | 20 | 81.75 | 140.14 | 221.89 | 99.04 | 429.15 |
| 34 | 2100 | 250 | 20 | 98.10 | 140.14 | 238.24 | 82.53 | 445.66 |

The figure below indicates a maximum deflection of 0.300 mm and a minimum of 0 mm, after the necessary force has been applied [5].

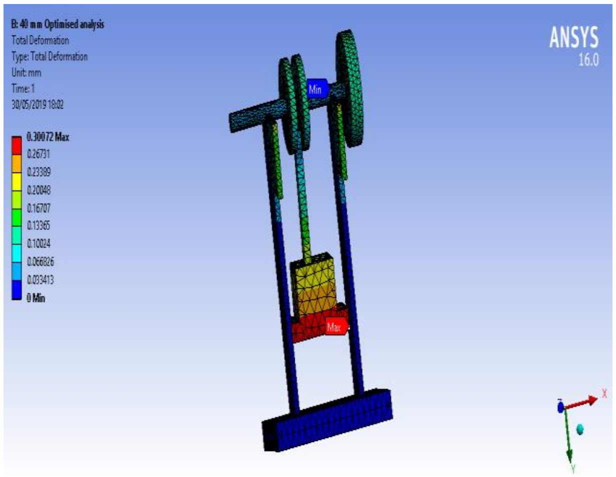


Fig. 8 Deflection of Model

This deflection model will gives results with following data.

TABLE III UNIT SYSTEM

| Unit System | Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius |
|---|---|
| Angle | Degrees |
| Rotational Velocity | rad/s |
| Temperature | Celsius |

TABLE IV MODEL (B4) > GEOMETRY

| Bounding Box | |
|---|---|
| Length X | 1139. mm |
| Length Y | 2050.5 mm |
| Length Z | 799.8 mm |
| **Statistics** | |
| Bodies | 1 |
| Active Bodies | 1 |
| Nodes | 29253 |
| Elements | 15617 |
| Mesh Metric | None |

TABLE V MODEL (B4) > MESH

| Object Name | Mesh |
|---|---|
| State | Solved |
| **Display** | |
| Display Style | Body Color |
| **Defaults** | |
| Physics Preference | Mechanical |
| Relevance | 0 |
| **Sizing** | |
| Use Advanced Size Function | Off |
| Relevance Center | Fine |
| Element Size | Default |
| Initial Size Seed | Active Assembly |
| Smoothing | High |
| Transition | Fast |
| Span Angle Center | Fine |
| Minimum Edge Length | 2.0 mm |
| **Patch Conforming Options** | |
| Triangle Surface Mesher | Program Controlled |
| **Patch Independent Options** | |
| Topology Checking | No |
| **Statistics** | |
| Nodes | 29253 |
| Elements | 15617 |
| Mesh Metric | None |

TABLE VI MODEL (B4) > ANALYSIS

| Object Name | Static Structural (B5) |
|---|---|
| State | Solved |
| **Definition** | |
| Physics Type | Structural |
| Analysis Type | Static Structural |
| Solver Target | Mechanical APDL |
| **Options** | |
| Environment Temperature | 22. °C |
| Generate Input Only | No |

TABLE VII MODEL (B4) > STATIC STRUCTURAL (B5) > LOADS

| Object Name | Fixed Support | Force |
|---|---|---|
| State | Fully Defined | |
| **Scope** | | |
| Scoping Method | Geometry Selection | |
| Geometry | 7 Faces | 8 Faces |
| **Definition** | | |
| Type | Fixed Support | Force |
| Suppressed | No | |
| Define By | | Components |
| Coordinate System | | Global Coordinate System |
| X Component | | 0. N (ramped) |
| Y Component | | 9.81e+005 N (ramped) |
| Z Component | | 0. N (ramped) |

TABLE VIII MODEL (B4) > STATIC STRUCTURAL (B5) > SOLUTION (B6) > RESULTS

| Object Name | Equivalent Stress | Total Deformation |
|---|---|---|
| State | Solved | |
| **Scope** | | |
| Scoping Method | Geometry Selection | |
| Geometry | All Bodies | |
| **Definition** | | |
| Type | Equivalent (von-Mises) Stress | Total Deformation |
| By | Time | |
| Display Time | Last | |
| Calculate Time History | Yes | |
| Identifier | | |
| Suppressed | No | |
| **Results** | | |
| Minimum | 0. MPa | 0. mm |
| Maximum | 112.58 MPa | 0.30072 mm |

## IX. RESULTS AND DISCUSSION

Comparison of Theoretical Stress and Ansys Results
The following table shows these results.

TABLE IX COMPARISON RESULT

| Dimensions | Design calculations Results | Ansys Results |
|---|---|---|
| Length = 2100 mm Width = 250 mm and Thickness = 40 mm | Stress | Stress |
| | 119 MPa | 112.58 |

The table above shows results of optimized Press deformation. It also indicates some variance in tests that are inferior to 10 per cent and marginal.

In this step, the existing system is optimized. The optimization description is shown in the table above. The current C Frame weight is 530 Kg and the optimized machine weight is 165 Kg. And we reached a weight reduction of 363 kg [6][7].

TABLE X COMPARISON OF WEIGHT OF EXISTING AND OPTIMIZED SYSTEM

| Weight of Existing C-Frame | Weight of optimized C - Frame | Total Weight Reduction |
|---|---|---|
| 530kg | 165kg | 363kg |

## X. CONCLUSION AND PERSPECTIVES

1. The existing system is heavier in weight than the supporting frame. An optimized system is lighter in weight and is a workaround for existing system drawbacks.
2. Optimization on device load-bearing components such as C Frame was achieved.
3. Calculations of architecture, model of study, and experimental results of the existing system and optimized system are compared based on stress.

C Frame surface treatment may be done to increase C Frame strength. Pressure base and bed should be built, optimization can be accomplished by modifying its geometry or physical characteristics.

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