# DESIGN OPTIMIZATION OF MULTIFLEX HIGH PRESSURE MOLDING MACHINE FOR CASTING MOLDS

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***Abstract :*** This paper focuses on design optimization of MULTIFLEX high pressure-molding machine. Multiflex high pressure molding machine is a standalone mold-making machine. Static structural analysis is performed on the mainframe body of the machine. The initial design consists of a structure, which is supported by four tie-rods and had a higher factor of safety. The modified structure design is supported only by two tie-rod. The finite element analysis is carried out considering the material as Mild steel AISI-1020 (normalized), and then the material is changed to AISI-1040 (normalized) for the analysis.

***Index Terms* - design optimization, multiflex, high-pressure molding, casting, design analysis.**

## 1. INTRODUCTION

The traditional molding is a very time consuming as well as clumsy process, the major difference between the traditional and machine based mold is the equal or even compressibility of the mold. This, leads to the rapid growth in the requirement of fast and accurate mold making techniques, which are evenly pressed and has a nice dimension accuracy along with the high production rate. Hence, to fulfil the requirement new technologies are developed viz. squeeze head molding machine [1], high-pressure molding machine, etc. Multiflex high pressure molding machine [1] is similar to the squeeze head mold-making machine.[2][3][4]

The metal products are long lasting and very durable along with robust properties. Hence, the demand for mold making machine does not decreases over time and such machinery is a onetime investment for the company. As these machines provide better control over the mold making process and is highly functional as compared to the traditional processes. The major attraction of this machine is the production rate and the accuracy of the mold generated. One machine among it is Multiflex high pressure molding machine shown in the figure 1. The machine consist of 6 sub-assemblies 1. Batch hopper assembly, 2. Main body frame, 3. Bloster stripper assembly, 4. Mold table assembly, 5. Turn table assembly and Multi-piston assembly.


Figure 1: Multiflex high pressure molding machine [8]

The mainframe assembly is the structure that holds the whole machine together, the turn-table is mounted on the main frame of the body and which holds the mold table assembly on which the mold boxes are placed. The bloster stripper assembly holds the mold boxes at their individual places. The squeeze head assembly is mounted on the mainframe structure, which squeezes the mold-boxes at an equal rate of around 10kg/cm$^2$. The batch hopper assembly is an free assembly which pours an fixed amount of the sand into the mold box.

Compression is the major step for producing the molds.[1] The higher the sand is compressed the better chances of getting a perfect finished mold. Compression must be between a perfect range. If the mold is too loose, the chances of sand falling apart from the cavity are high or the ability to withstand the desired shape is less. Were as compressing the sand too high can lead to damage in the mold and pattern. The low compression of sand affects the quality of the product produced using the mold, which is loosely packed. The sand mold cools rapidly leading to uneven flow of molding material. Due to sudden cooling, the smaller cross section region solidifies faster hence the molding material cannot flow pass it and there is the possibility of cold shut defect in the produced part. If the sand is compressed too high the breathability of the mold decreases i.e. the gases produced by the mold on pouring are trapped and could not get out, leading to gas porosity defect in the produce part. Even the surface finish of the product is affected by the compression of sand.[4][5][6]

## Specification of the Multiflex:

Multiflex machine have the following specification as shown in table 1.[8]

*Table 1: specification chart of the Multiflex machine.* [8]

| Sr. no | Properties | Fm-3 |
|---|---|---|
| 1 | Rang of cope and drag box size (mm) | 1000x800-1300x1100 |
| 2 | Cope and drag box height range (mm) | 200-450 |
| 3 | Molding rate (mold/hr.) | 40-80 |
| 4 | Specific squeeze pressure (kg/cm$^2$) | 10 |
| 5 | Overall dimension (LDH) (m) | 3.7x2.7x4 |
| 6 | Electrically connected load (kw) | 30amp 50kw |

## Problem identification:

It was observed that the Multiflex machine has a higher factor of safe around 6. In addition, the loads acting on the machine is in an appropriate range and would not affect the structural stability of the machine if a few components are eliminated. The initial design is a machine with the four (4) tie-rod turns out to be having a higher factor of safety.

The other issue, which was identified, was related to a sub assembly called bloster stripper. The bloster stripper liners were to be replaced every six month due to wear, which is caused due to the friction generated between them. It is used to guide and hold the mold box at their fixed position. Usually the sand particles are smaller than the gap between the liner plates but few large particles present in the green sand stuck between the liners of the bloster and stripper causing a high amount of damage to surface, which further leads to imbalance of the mold box on the bloster stripper assembly.

## Objective:

To determine the deformation on the Mainframe structure of MULTIFLEX high-pressure molding machine static structural analysis is performed on the mainframe assembly where the material is normalized AISI 1020 for the conventional and modified designs. The convention design is a 4 tie-rod design and the modified design is a designed with 2 tie-rods. Along with the tie-rod, the material of MULTIFLEX high pressure molding machine is changed from normalized AISI-1020 to normalized AISI-1040. The finite element analysis is carried out in Ansys software.

## Model and load description:

The mainframe structure of MULTIFLEX high pressure molding machine consist of

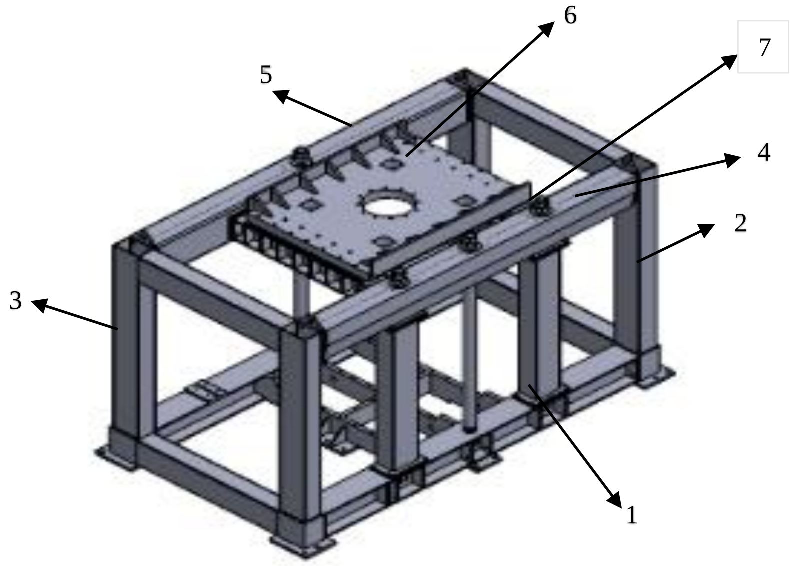


Figure 2: Mainframe assembly

1. Bottom frame
2. Left hand side frame
3. Right hand side frame
4. Top end front frame
5. Top end rear frame
6. Top cylinder plate.
7. Tie-rods

The bottom frame (#1) is the fixed geometry for the analysis represented in blue colour and the top cylinder plate (#6) is provided with the load of 3157.5 N represented in red colour (figure3 & figure 4). This load was calculated by considering 10kg/cm$^2$ of compression applied on the sand and adding self-weight of the overhead assembly.

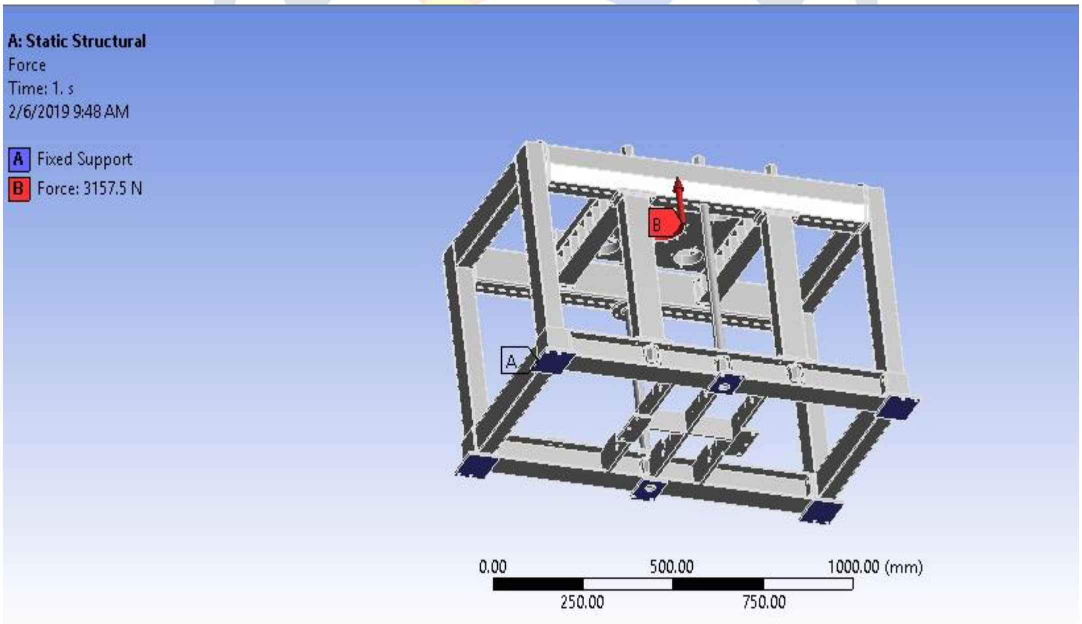


Figure 3: Boundary conditions for 4- tie-rod assembly.

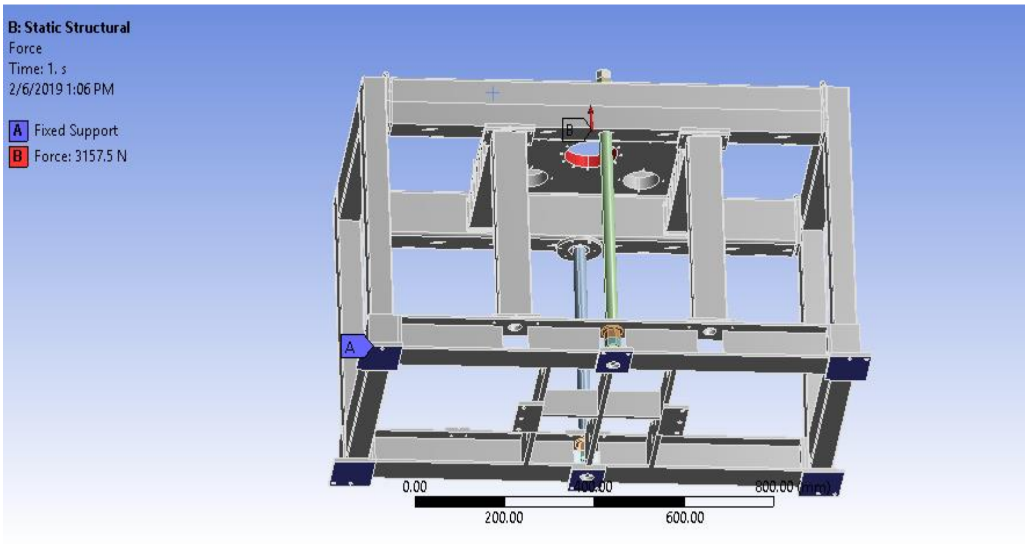


Figure 4: Boundary conditions for 2 tie-rod assembly

## Assumptions:

1. There was no load affecting the mainframe body of the Multiflex machine except self-weight.
2. The squeeze head applies 10kN/cm$^2$ of load on the mold box.
3. The size of the mold box is 1200m X 1300 mm.
4. The force applied and experienced is uniformly distributed.
5. The model is scale by 1:4 and it does not affect the properties of the model.
6. The structure is stable and is not affected during the squeezing process.

## Results and discussion:

On analysing deformation plots (figure 5 and figure 6), we can conclude that two tie- rod model could sustain the same amount of load as in four tie-rod assembly as shown in table 2. However, there is a significant difference in the maximum principal stress yet the stress is under limit of AISI-1020.

Table 2: deformation of initial and modified design

| Deformation in axis | Four tie-rod design | Two tie-rod design |
|---|---|---|
| X axis | 0.057mm | 0.068mm |
| Y axis | 0.16mm | 0.179mm |
| Z axis | 0.036mm | 0.043mm |
| Max. principal stress | 49.276Mpa | 84.652Mpa |

**Deformation in four tie-rod assembly:**

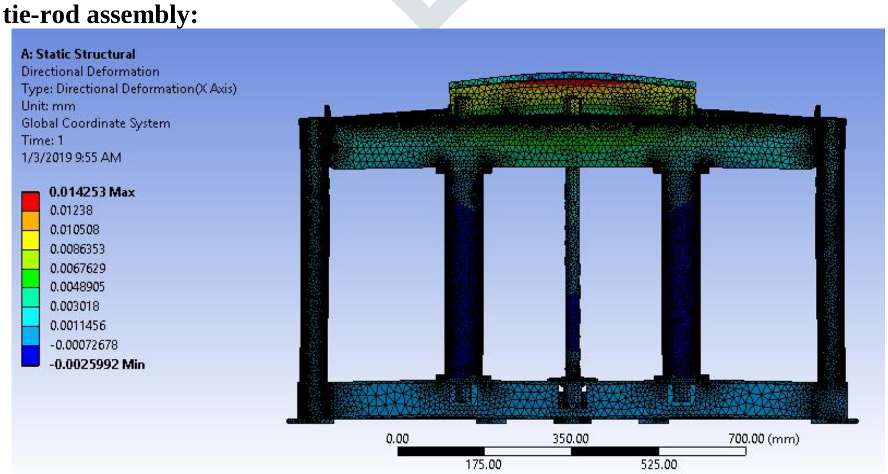


Figure 5: Deformation in four tie-rod assembly

**Deformation in two tie-rod assembly:**

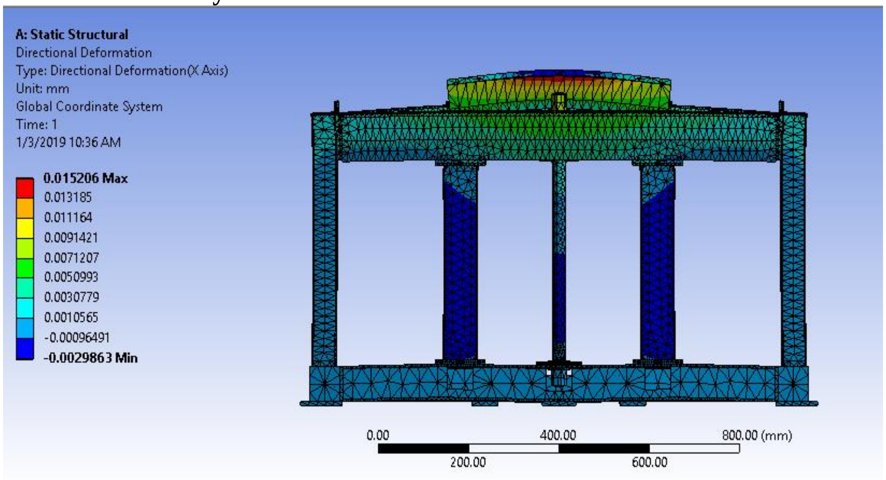


Figure 6: Deformation in two tie-rod assembly

By comparing the results of AISI 1020 and AISI 1040 material for the of the mainframe structure (table 3), it can be concluded that the structure shows similar properties and AISI1040 can also be used for the manufacturing of the machine.

Table 3: deformation of initial material and modified material

| Deformation in axis | AISI-1020 | AISI 1040 |
|---|---|---|
| **X axis** | **0.057mm** | **0.0596mm** |
| **Y axis** | **0.16mm** | **0.1708mm** |
| **Z axis** | **0.036mm** | **0.03832mm** |
| **Max. principal stress** | **49.276Mpa** | **48.072Mpa** |

The bloster stripper assembly, which has an issue of wearing due to stucking of sand between the liner plates, the issue was solved using compressed air. The compressed air is introduced between the liner plates using an copper tube assembly as shown figure 7. [9] Copper tube assembly will remove the sand particles between the liners using compressed air. This will enhance the life of the liner plates.


Figure 8: copper tube assembly for compressed air.

## Conclusion:

On analyzing the traditional design of Multiflex high pressure molding machine with four tie-rod and comparing it to the newly proposed design with two tie rod, it can be concluded that;

1. It was observed that the weight of Main structure was reduced by 1.7%.
2. The labour cost was reduction by 3.9%.

the modified bloster stripper assembly design along with the new attachment is significantly increasing the life of the liner plates in bloster stripper assembly.

## Future scope:

- The inner liner of the bloster stripper can be coated with the wear resistance materials.

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