# Optimization of Turret Components of Tablet Press Machine

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***Abstract* - A tablet press is a mechanical device that compresses powder into tablets of uniform size and weight. To form a tablet, the granulated material must be metered into a cavity formed by two punches and a die, and then the punches must be pressed together with great force to fuse the material together. A method of structure optimization for tablet press is proposed in order to reduce mass while assuring adequate stiffness. Pre compressor assembly, main compressor assembly, turret, plates are determined as optimal objects by mass analysis. Key geometric parameters of plates which have relatively larger impacts on mass and stiffness are extracted as design variables. In order to research relationship between stiffness, mass and design variables, command batch file is built by CREO and analysis is done in ANSYS and topology optimization is done in HYPERMESH.**

***Index Terms* - Optimization, Tablet press machine**

## I. INTRODUCTION

A tablet press is a mechanical device that compresses powder into tablets of uniform size and weight. A press can be used to manufacture tablets of a wide variety of materials, including pharmaceuticals, illicit drugs, cleaning products, and cosmetics. To form a tablet, the granulated material must be metered into a cavity formed by two punches and a die, and then the punches must be pressed together with great force to fuse the material together.

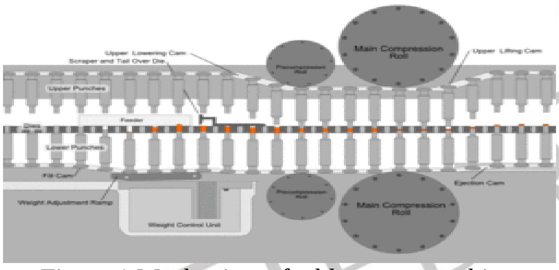

Figure 1 Mechanism of tablet press machine

A tablet is formed by the combined pressing action of two punches and a die. In the first step of a typical operation, the bottom punch is lowered in the die creating a cavity into which the granulated feedstock is fed. The exact depth of the lower punch can be precisely controlled to meter the amount of powder that fills the cavity. The excess is scraped from the top of the die, and the lower punch is drawn down and temporarily covered to prevent spillage. Then, the upper punch is brought down into contact with the powder as the cover is removed. The force of compression is delivered by high pressure compression rolls which fuse the granulated material together into a hard tablet. After compression, the lower punch is raised to eject the tablet.

M. Grujicic, G. Arakere, P. Pisu, B. Ayalew, Norbert Seyr, Marc Erdmann and Jochen Holzleitner [1] which represent Application of Topology, Size and Shape Optimization Methods in Polymer Metal Hybrid Structural Lightweight Engineering. Jennifer Wang , Hong Wen, Divyakant Desai [2] "Lubrication in tablet formulations" is described about theoretical aspects and practical considerations of lubrication in tablet compression are reviewed in this paper. Sunil Jain [3] "Mechanical properties of powders for compaction and tabula ting: an overview" is introduced mechanical properties that are critical to understanding powder processing for tabulating. Michael Levin.[4] "Tablet Press Instrumentation" projected the general principles of tablet press instrumentation and the benefits thereof by the formulators, process engineers, validation specialists, and quality assurance personnel. Fernando Fraternali, Andrea Marino, Tamer El Sayed, Antonio Della Cioppa [5] "On the Structural Shape Optimization through Variational Methods and Evolutionary Algorithms" is employ the variational theory of optimal control problems.

## II. TURRET

The central part of the rotary press is the turret which is equipped with a number of tool station consisting set of Upper punch-Die-Lower punch. Figure 1,2,3,4,5 shows the constraints and loads, von-Mises stress contour,maximum stress position, maximum principle stress contour, Total deformation contour respectively. Table 4.1 shows the material property.

| | |
|---|---|
| Material | SGI GGG(40) |
| Young's modulus | $1.7 \times 10^5$ MPa |
| Poisson's ratio | 0.25 |
| Density | $7.2 \times 10^{-6}$ kg/mm$^3$ |
| Tensile strength | 390A |

Table 1 Material Property

**FEA of turret**

Pressure acting on die port face in die during tableting operation which is very higher. Centrifugal force due to rotational speed (50 RPM)

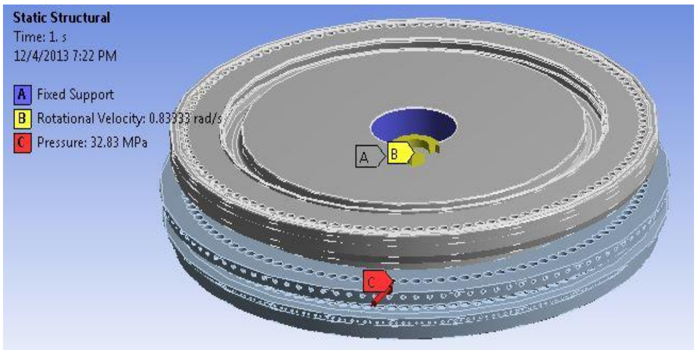


Figure 1 Constrain and Loads of Turret

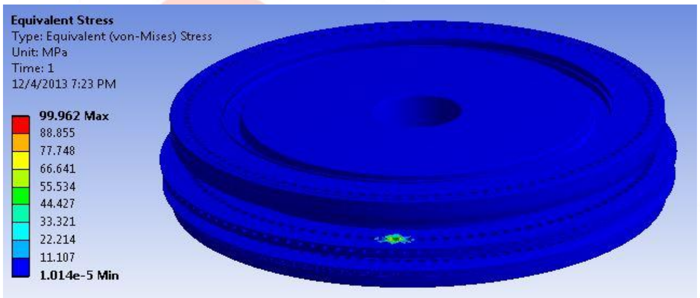


Figure 2 von-Mises Stress Contours for Turret (Mpa)

Figure 2 shows the equivalent stress is around 100 Mpa and figure 4 shows maximum principal stress is around 88 Mpa. The capacity of material is up to 390 Mpa so it is very safe stress.

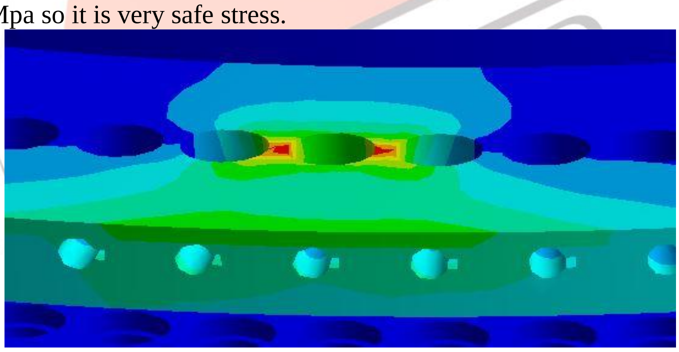

Figure 3 Showing Stress Position

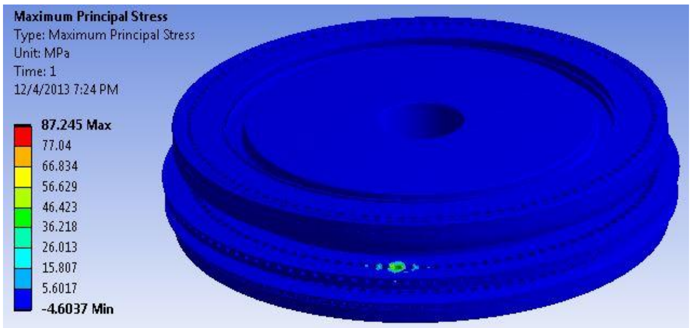


Figure 4 Maximum Principle Stress Contour

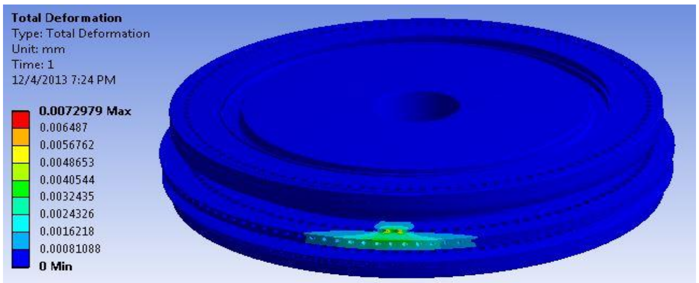


Figure 5 Total Deformation Contour for Turret

**Optimization of turret**

Topology optimization is carried out in the HYPERMESH.09. Shows in figure 6 shows the constrain and Loads for turret. Here white area shows load and fixed support acting on turret.

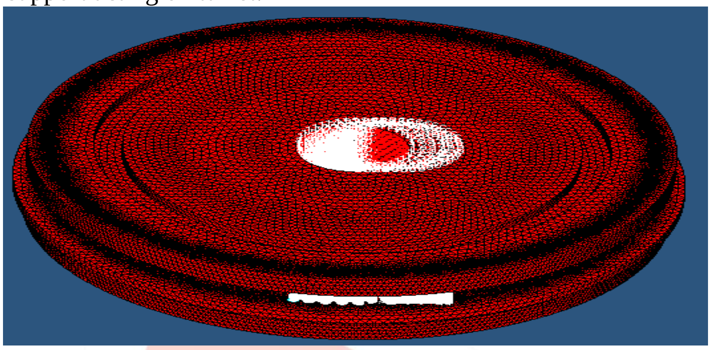

Figure 6 Constrain and Loads of turret

After applying boundary condition and forces to the component do the optimization in the HYPERMESH. To solve this problem 19 iteration took place and at different iteration the density distribution is shown in Figure 7. It can be seen at final iteration of optimization, some of the design area is fall in blue zone which shows the state of void but its not possible to remove all the material from the blue zone of the component, some density threshold is defined to keep the material in optimized result.

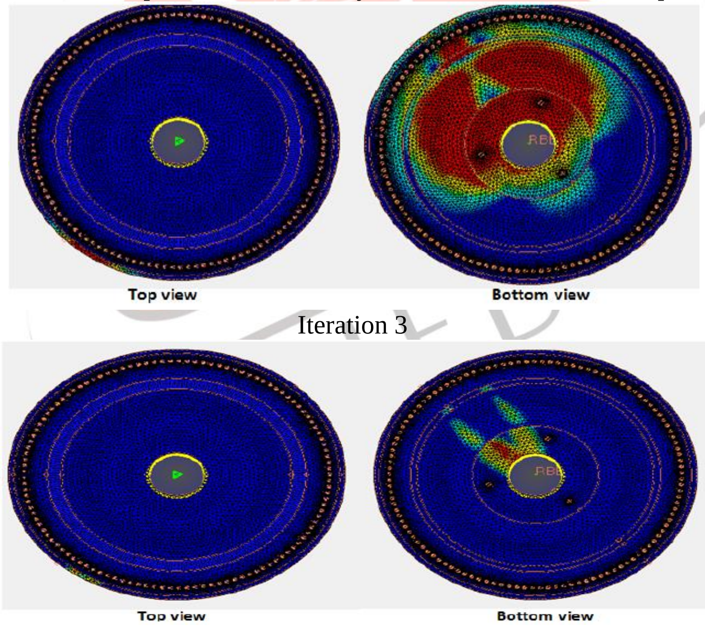


Figure 7 Topology Optimization of Turret

**Iteration of Turret**

After complete topology optimization, remove the material approximately from the top surface and do analysis again in ANSYS Figure 8 shows the model after removing excessive material.

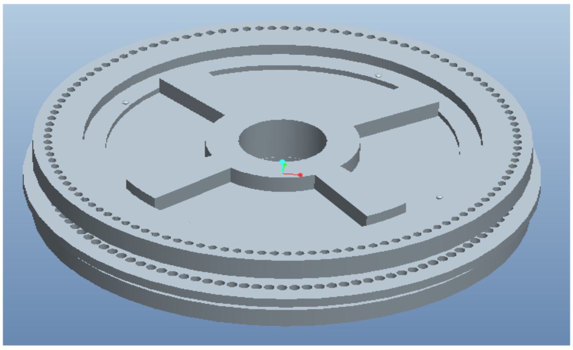

Figure 8 Optimized Turret

Shows in figure 9 shows the constrain and Loads for Turret in which A indicate Fixed Position and B indicates 0.833 r/s rotation velocity and c indicate pressure acting in hole.

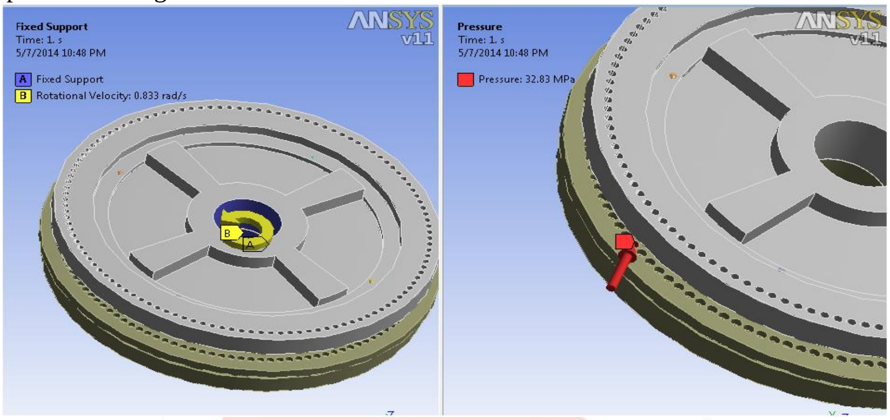


Figure 9 Constrain and Pressure applied on Turret

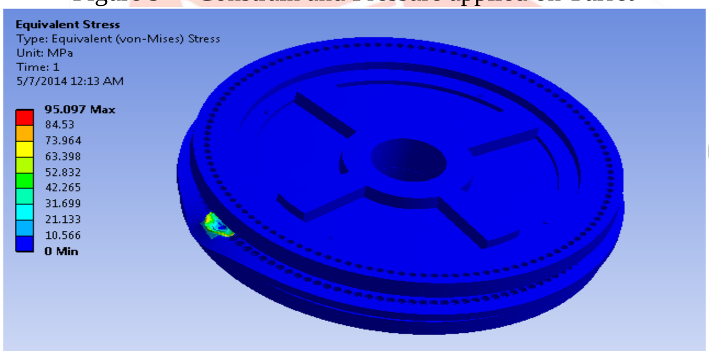


Figure 10 Equivalent Stress of Turret

Figure 10 and Figure 11 shows von-Mises Stress contour and Maximum Principle Stress Contour for Turret showing values around 95 MPa and 77.3 MPa and it is well below 390 MPa. So it is safe.

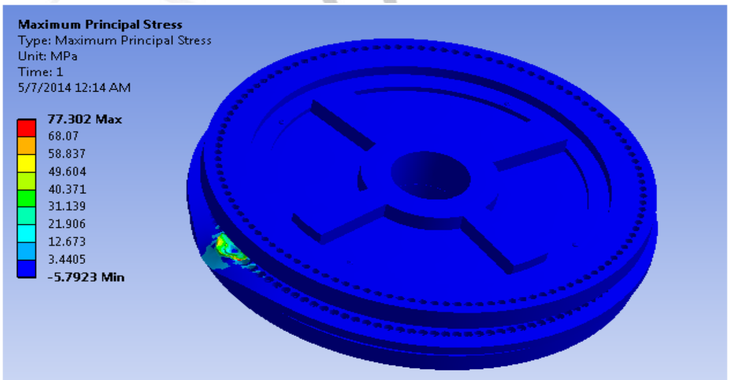


Figure 11 Maximum Principal Stress of Turret

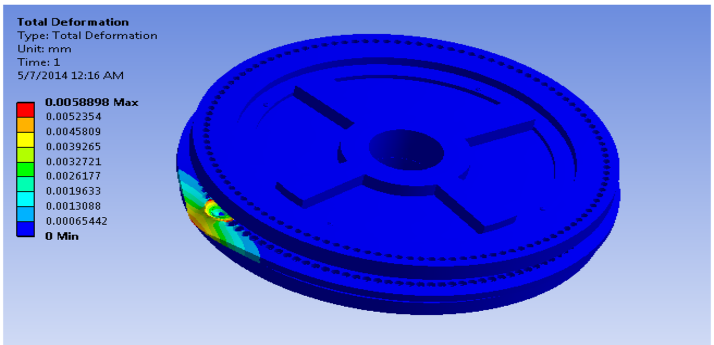


Figure 12 Total Deflection of Turret

Figure 12 shows the total deflection of component is 0.006 which is safe deflection. Here maximum material is removed from the turret as consider of the components assembly. So iteration 1 is final selected optimized component.

## III. RESULT AND COMPARISON

Table 2 shows the displacement and stresses of turret which are analyzed under the maximum loading condition.

| Sr No | Existing Component | Modified Component | % Reduction |
|---|---|---|---|
| Max Principal Stress | 87 Mpa | 77.3 Mpa | 11.1 % |
| Equivalent Stress | 100 Mpa | 95 Mpa | 5.26 % |
| Total Deflection | 0.007 mm | 0.006 mm | 16.66 % |
| Weight | 1346 kg | 1320 kg | 2 % |

Table 2 Comparison of turret

## IV. CONCLUSION

In rotary tablet press machine UNIC I FC, turret and upper plate are the major components and static analysis of some of the component has been carried out with FEA tools, which shows the stresses and deflection on these component are less than the permissible values.

After analysis, shape optimization is carried out by using ANSYS and topology optimization is carried out by using HYPERMESH.

## REFERENCES

[1] M. Grujicic, G. Arakere, P. Pisu, B. Ayalew, Norbert Seyr, Marc Erdmann and Jochen Holzleitner, "Application of Topology, Size and Shape Optimization Methods in Polymer Metal Hybrid Structural Lightweight Engineering".

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