

# Study of Structural Stability of Globe Valve in Petroleum and Sugar Industries

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**Abstract**— a globe valve is usually used to control the fluid flow in various engineering applications, where the incoming velocity is fast and pressure relatively high. The present work is to study the design and analysis of globe valve. The FEA is a tool commonly used to analyze the boundary of physics, mathematics, and engineering and computer science. This technique undergoes wide implementation and appreciates utilization in the structural, thermal and fluid analysis of area. Here in current work, the concentration is only on the study of stress distribution in the globe valve structure under the influential of thermal and structural loads and do the comparison study of stress under varying thermal load.

**Keywords**— Hypermesh, CAD, ABAQUS, Structural & Thermal analysis.

## I. INTRODUCTION

A globe valve is a mechanical device which controls the flow of oil, gas, and water. A globe valve is most common valve in process industries. It can be used for on off application but generally used for precise throttling application. The globe valve has a great pressure drops across the valve then other types. The globe valve typically works with high velocity of flow and pressure drops at valve opening from 0 to 90 degree turn the process must flow through within a valve. Particularly globe valve, the only method is to reduce the model at a perfect scale, then do the investigation in a laboratory. To obtain the mandatory flow and pressure drop characteristics for the valve, dissimilar types of internals were evolved for control type valves. Bolt and sleeve ring is one among them. My project is to study of structural stability of globe valve in petroleum and sugar industries, which can be used for controlling high pressure and high temperature.

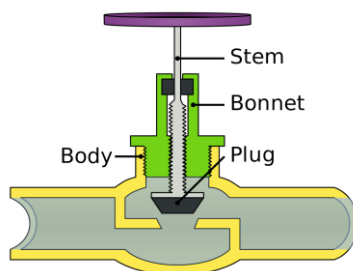


Fig. 1 General view of Globe Valve

## II. LITERATURE REVIEW

More than a few researchers have been accepted out on globe valve and on its attachments. For many studies I have referred the work accepted out by author named V. J. Sonawane [1] Authors presented their research paper in the year 2012. They discover the flow pattern of the valve using Computational Fluid Dynamics software by changing the flow rate and constant pressure drops valve in valve system, and they designed the 3D analysis generally used for low noise analysis and high efficiency valve for industrial application.

Another work carried out by authors Dr. Gurudutt sahani [2] Authors presented their research paper in the year 2014. They presented that the valve manufacturing industry has faced the different kinds of problem. Their work focuses investigating the effect of stress, strain with respect to the changing temperature. And it describes the effect of higher temperature on the globe valve along with the modern Finite Element Analysis procedure.

Aswin.s, k. ulaganathan [3] working on the design and analysis of high pressure control valve uses 3000 rating. They represents the design and analysis of multistage 3000 rating of globe valve, and they are observed the design of a globe valve which can control the high pressure required in the boiler which is used in thermal power plants and petroleum refiners. They clarify 3000 pressure rating of globe valve is redesigned and 2D and 3D design software are used and to analysis the flow rate and stress analysis is done using analysis software.

## III. METHODOLOGY

The globe valve is modeled using CAD tool that is solid edge and for pre-processing it is imported into hypermesh tool, where the geometry, meshing element, quality check, boundary and loading condition, material properties, are specified, for explanation purpose it is exported as inp file. The file is imported in ABAQUS software for solutions and to study the results.

### A. Loads acting on the globe valve

1. Thermal load (Temperature)
2. Structural load (Pressure)

Z1: outer part of the globe valve exposed to the atmosphere

Z2: Inner side of the globe valve which come in contact with the fluid domain.  
 Z3: Inner side of the globe valve subjected to pressure load (5.7 N/mm<sup>2</sup>)

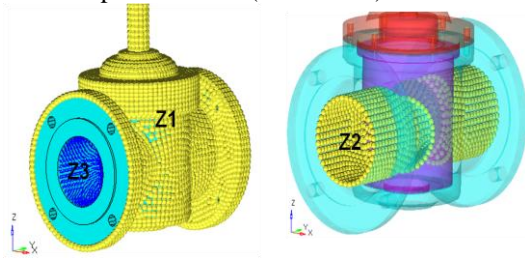


Fig 2: Loads acting on the globe valve

**B. the load analysis of the globe valve**

- Step1: The pre-tension load of 5000N is applied on a bolt which connects the parts Flange (F) and Body (B). And all the parts are assigned with normal atmospheric temperature of 40 degree.
- Step 2: Hold the bolt tight and then assign the outer surface (Z1) of the valve with 40 degree, and inner surface (Z2) of the valve with fluid temperature of 12 degree. Step 2 is called operating mode.
- Step 3: Apply the fluid pressure on the inner surface (Z3)

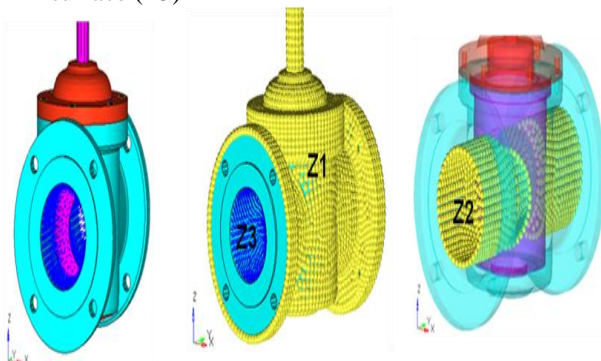


Fig 3: Load analysis of the globe valve

**IV. RESULTS AND DISCUSSION**

Globe valve analysis is carried out fewer than two different loading conditions with temperature difference of 28 degree in load case one and temperature difference of 50 degree in load case two, the pretension load and pressure load are kept constant in both the load cases the results of two load cases are displaced discussed as below

**A. Globe Valve gate fully opened with operating temperature of 12° to 40°**

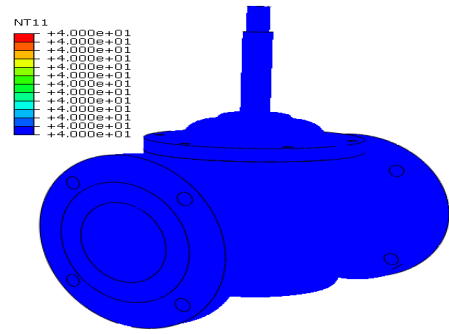


Fig 4: Initial temperature destitution

**i. Max von Mises stress on the bolt, after the pre-tensioning at atmospheric temperature (40°C)**

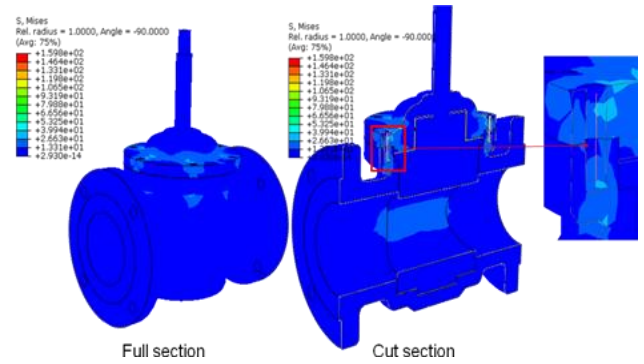
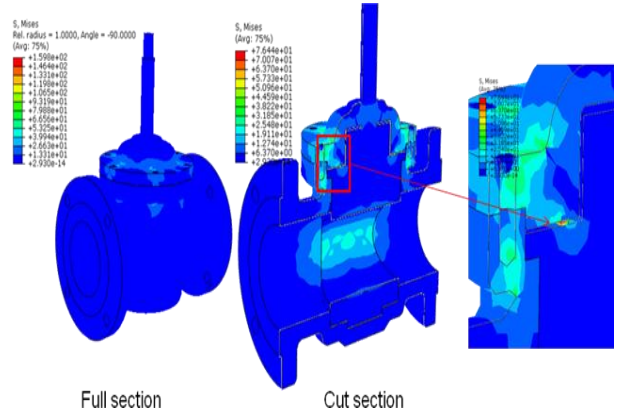


Fig 5: Max von Mises stress on bolt

**ii. Max von Mises stress on top sleeve ring, after bolt pre-tensioning at atmospheric temperature (40°C)**



**iii. Temperature distribution during the operation, Temperature ranges from 12°C to 40°C**

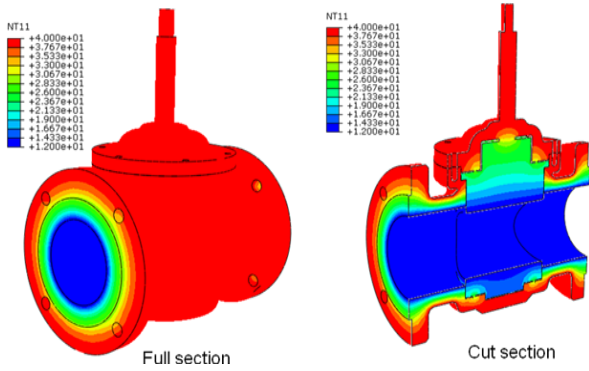


Fig 7: Temperature distributions on globe valve

iv. Max von Mises stress on bottom sleeve ring, during operating temperature and pressure

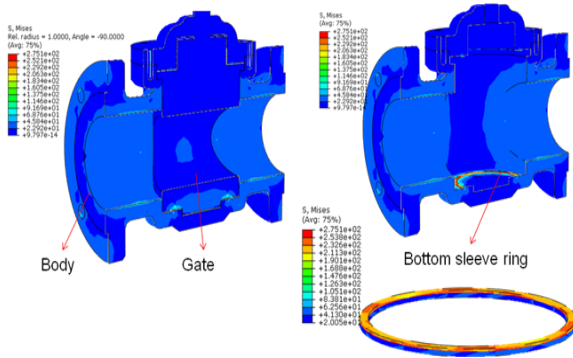


Fig 8: Max von Mises stress on bottom sleeve ring

v. When the fluid pressure is applied on the inner surface of the globe valve, Max von Mises stress observed at the bottom sleeve ring.

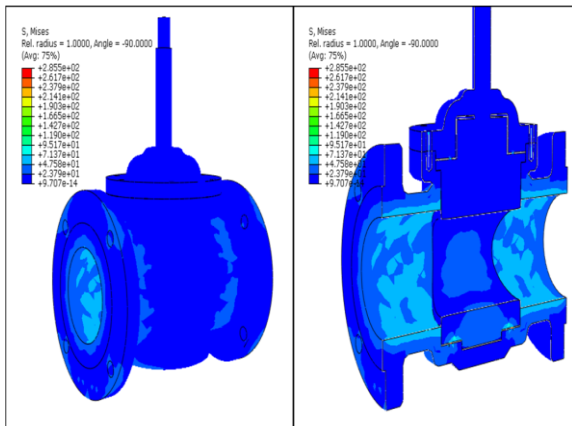


Fig 9: Fluid pressures on globe valve

B. Valve gate fully opened with operating temperature of  $-10^{\circ}$  to  $40^{\circ}$

i. Temperature distribution during operation, the globe valve Temperature ranges from  $-10^{\circ}$  to  $40^{\circ}\text{C}$

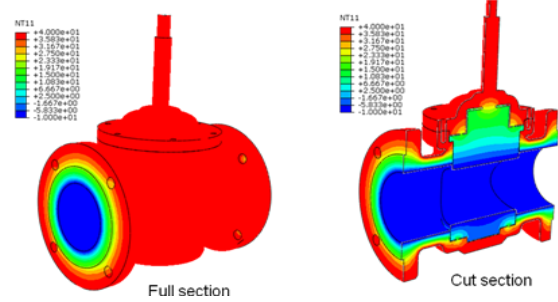


Fig 10: Temperature distribution

ii. Max von Mises stress on Globe valve bottom sleeve ring, during operating temperature and pressure

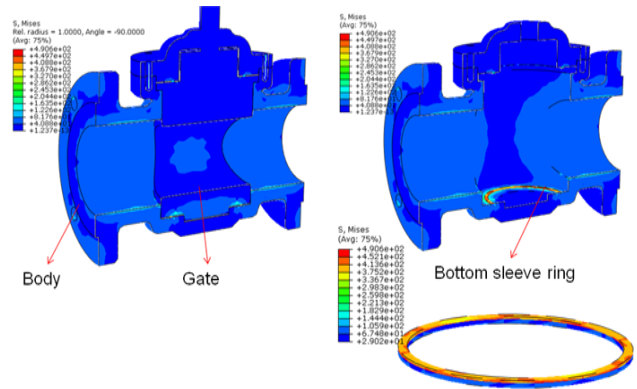


Fig 11: Max stress on bottom sleeve ring

iii. When the fluid pressure is applied on the inner surface of the globe valve. Max von mises stress observed at bottom sleeve ring

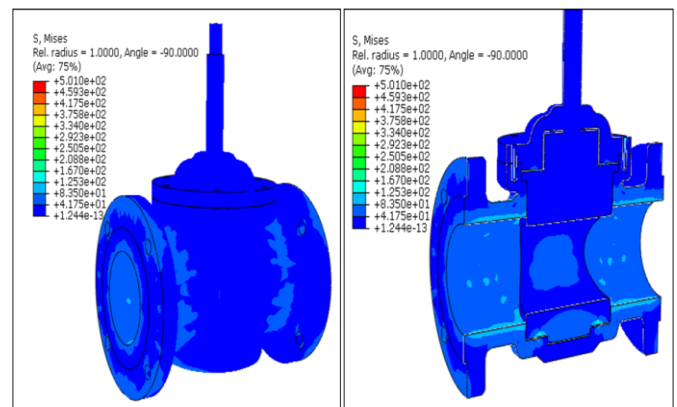


Fig 12: Fluid pressure is applied on globe valve

**C. Valve gate partially opened with operating temperature of 12° to 40°**

i. When the Temperature distribution during operation of globe valve, Temperature ranges from 12° to 40°C

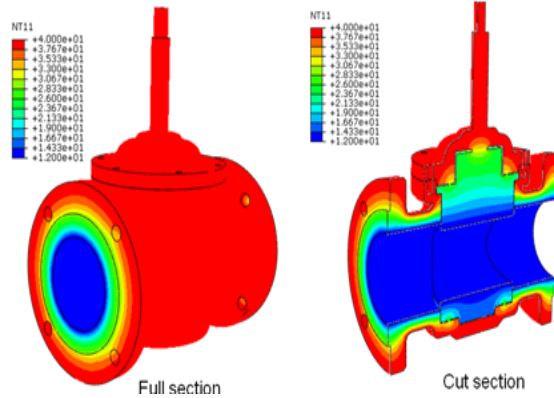


Fig 13: Temperature distributions during the operation

**D. valve gate partially opened with operating temperature of -10° to 40°**

i. Temperature distribution during operation of the globe valve, the Temperature ranges from -10°C to 40°C

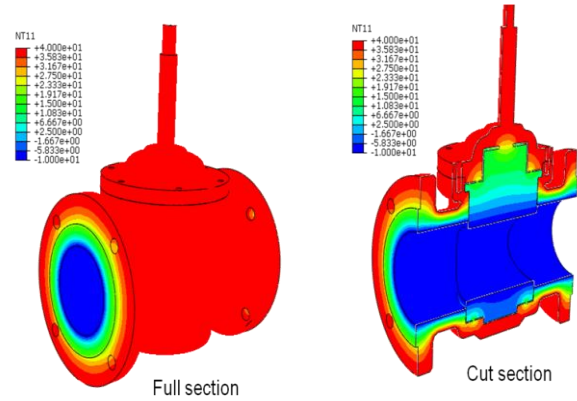


Fig 16: Temperature distribution

ii. Max von Mises stress on Globe valve bottom sleeve ring during operating temperature and pressure

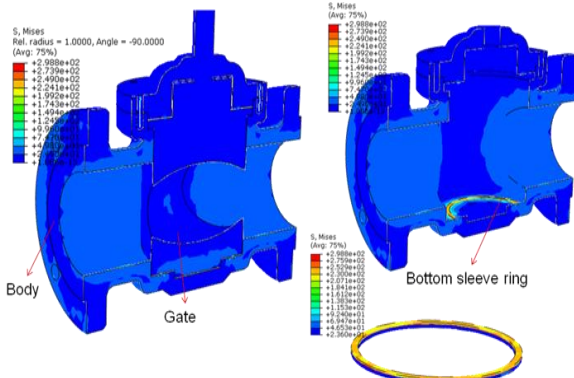


Fig 14: Max stress acting on bottom sleeve

ii. Max von Mises stress on Globe valve bottom sleeve ring during operating temperature and pressure

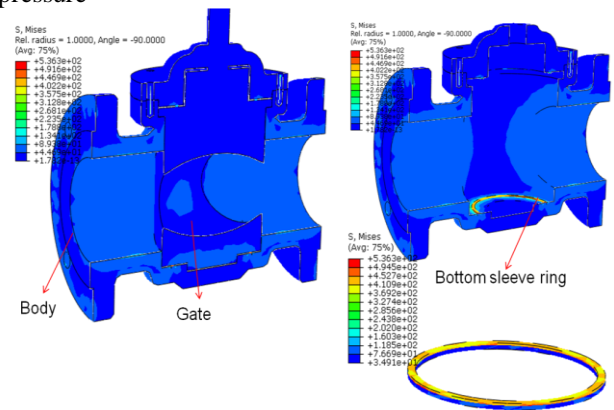


Fig 17: Globe valve bottom sleeve ring

iii. When the fluid pressure is applied on the inner surface of the globe valve. Max von Mises stress is observed at bottom sleeve ring

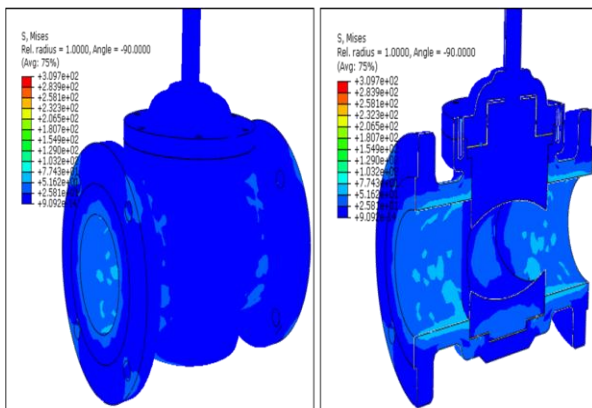


Fig 15: Fluid pressure is applied on the globe valve

iii. When the fluid pressure is applied on the inner surface of the globe valve then the Max von Mises stress is observed at the bottom surface of the sleeve ring

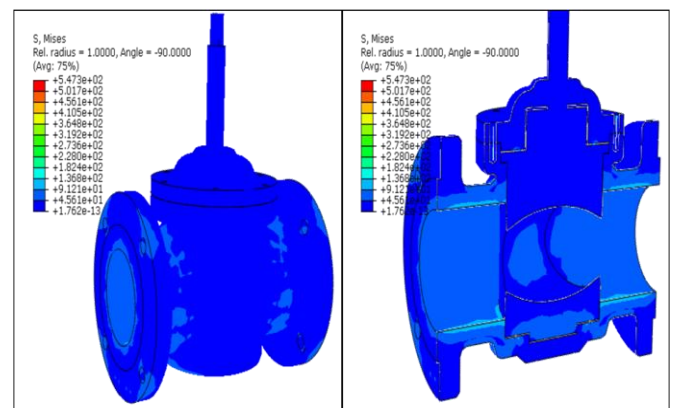


Fig 18: Max stress on bottom sleeve ring

**I. Table I**

Summary of strength analysis report on globe valve

| Sl. No | Valve gate position | Mass (kg) | Material  | Pretension Load N | Operating temperature °C | YS (MPa) | Max Von-Mises Stress | FOS  |
|--------|---------------------|-----------|-----------|-------------------|--------------------------|----------|----------------------|------|
| LC1    | Fully opened        | 20.71     | Cast Iron | 5000              | 12 °C - 40 °C            | 650      | 285                  | 2.28 |
| LC2    | Fully opened        | 20.71     | Cast Iron | 5000              | -10 °C - 40 °C           | 650      | 501                  | 1.29 |
| LC3    | Partially opened    | 20.71     | Cast Iron | 5000              | 12 °C - 40 °C            | 650      | 309                  | 2.10 |
| LC4    | Partially opened    | 20.71     | Cast Iron | 5000              | -10 °C - 40 °C           | 650      | 547                  | 1.18 |

From the result summary chart, it is evident that the maximum stress observed is 547 MPa for load case 4, which is partially opened condition from the above table following observations are made.

### CONCLUSION

1. The thermal loads are more influential in increasing the stress level in the structure.
2. Higher the difference in the temperature more is stress observed.
3. The structural loads like pretension and pressure loads are not predominant to cause stress in globe valve.
4. Among the 4 load cases the maximum stress observed in load case four is higher that is 547 MPa, but it is well below the yield strength of 650 MPa, so the structure is safe to operate and can be recommended for manufacturing.

5. The least FOS among the 4 load cases is 1.18.

### FUTURE SCOPE

In all the 4 load cases the maximum stress is observed in the bottom sleeve ring, but in rest of the parts of the globe valve the stress is much below the yield strength. So there is scope to redesign to reduce the sections of the globe valve or do the design of experiments by considering the sections as parameters so as to optimize the valve with respect to reducing the cost and weight of the structure without compromising the factor of safety.

### REFERENCES

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