

# Design & Analysis of Gate valve DN900 #150

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**Abstract-** Gate valve have industry leading shutoff and low maintenance performance designed for high pressure and high temperature conditions. Gate valves serves as efficient stop valve with flow in either direction. They are commonly used where minimum pressure drop is important. Throttling is not recommended because partially open gate valves exhibit flow characteristic not conducive to accurate and consistent flow control. Also the valve may be damaged due to high velocity across the seat. The function best suits for fully open of fully closed condition.

In this paper, Gate valve DN900 x 150 is designed and then analyzed using Simulation software for agreeable results.

## I. INTRODUCTION

Gate valves play an important role in today's generation. You can see valves from household to some big industries. The function of valves is to control the flow, pressure, velocity and direction of liquids. The size range of gate valve includes DN50 – DN1000 of class 150, 300 & 600 respectively. In this paper we are concentrating on the Design of DN 900 class 150 which is as per API and relevant ASME B16.5, ASME B16.34 standards.

### A. Salient Features

- ✓ Flexible Wedge
- ✓ Bolted bonnet construction
- ✓ Suitable for higher temperature

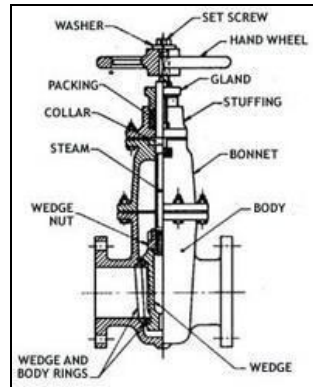


Figure 1. Cross sectional drawing of gate valve

The rest of the paper is organized as follows. Proposed theoretical calculation of body, wedge are explained in section II. Experimental results are presented in section III. Concluding remarks are given in section IV.

## II. PROPOSED THEORITICAL CALCULATION OF GATE VALVE

### A. Gate valve Body –

In this case we are going to determine theoretical shell thickness calculation of gate valve body. And also determine the effective stress and shear stress at bottom of the cavity and find factor of safety.



Figure 2. Gate valve Body

### B. Valve specification –

Working pressure class 150 -20 bar  
Size: DN 900  
Type: Flanged end

C. Shell thickness calculation –

Thin Cylinder concept:

$$t = \frac{p \cdot d_i}{2\sigma_{a1}}$$

Where p=Hydrostatic test pressure 2.95 N/mm<sup>2</sup>  
di = Maximum inside diameter of valve body casting (876mm)  
σa1=Maximum allowable stress 161 N/mm<sup>2</sup> (For WCB Material)

Substituting we get.,

$$t = (2.95 \cdot 876) / (2 \cdot 161)$$
$$t = 8 \text{ mm}$$

As per ASME B16.34:

$$t = 0.0163d + 4.7$$

d = Maximum inside diameter of valve body casting (876mm)

Substituting we get.,

$$t = 0.0163 \cdot 876 + 4.7$$

$$t = 19 \text{ mm}$$

As per ASME SEC VIII:

$$t = \frac{p \cdot d_i}{2(\sigma_{a1} \cdot \eta_{eff} - 0.6p)}$$

Where p=Hydrostatic test pressure 2.95 N/mm<sup>2</sup>  
di = Maximum inside diameter of valve body casting (876mm)  
σa1=Maximum allowable stress 161 N/mm<sup>2</sup> (For WCB Material)  
ηeff = joint efficiency is one

Substituting we get.,

$$t = (2.95 \cdot 876) / (2 \cdot (161 \cdot 1 - (0.6 \cdot 2.95)))$$
$$t = 8.1 \text{ mm}$$

*D. Stress Analysis:*

*Longitudinal wall stress:*

$$\sigma_l = \frac{p * d_i}{4t}$$

Where p=Hydrostatic test pressure 2.95N/mm<sup>2</sup>  
 di = Maximum inside diameter of valve body casting (876mm)  
 t= shell thickness including allowance (28mm)  
 σl=longitudinal stress in the body

$$\sigma_l = (2.95 * 876) / (4 * 28)$$

$$\sigma_l = 23.1 \text{ N/mm}^2$$

*Tangential wall stress of the body:*

$$\sigma_t = \frac{p * d_i}{2t}$$

$$\sigma_t = (2.95 * 876) / (2 * 28)$$

$$\sigma_t = 46.1 \text{ N/mm}^2$$

*Radial wall stress of the body:*

$$\sigma_r = -p$$

$$\sigma_r = -2.95 \text{ N/mm}^2$$

*Effective stress in a body:*

$$(\text{max of } |\sigma_l - \sigma_t| \text{ or } |\sigma_l - \sigma_r| \text{ or } |\sigma_r - \sigma_l| )$$

$$\text{Max Stress } 49.1 \text{ N/mm}^2$$

*E. Determine the Bearing Stress and Shear Stress at the weaker section of the Gate.*

*Bearing Stress at the base of Flexible Wedge Gate:*

$$\sigma_{base} = \frac{\Delta P * \pi / 4 * D_i^2}{\pi / 4 * d^2}$$

Where,

$\Delta p$ = pressure drop when wedge is completely closed.

$D_i$ =inner seating diameter

$d$ = bore diameter of valve body

$$\sigma_{base} = (13.78 * 876^2) / (876^2)$$

$$\sigma_{base} = 13.78 \text{ N/mm}^2$$

Shear Stress at the bottom cavity:

$$t_{base} = \frac{\Delta P * \pi / 4 * D_i^2}{\pi * d * t_{gate}}$$

Where,

$\Delta p$ = pressure drop when wedge is completely closed.

$D_i$ =inner seating diameter

$d$ = bore diameter of valve body

$t_{gate}$ = minimum thickness of gate

$$t_{base} = 13.78 * (0.785 * 876^2) / (3.142 * 876 * 75)$$

$$t_{base} = 40.2 \text{ N/mm}^2$$

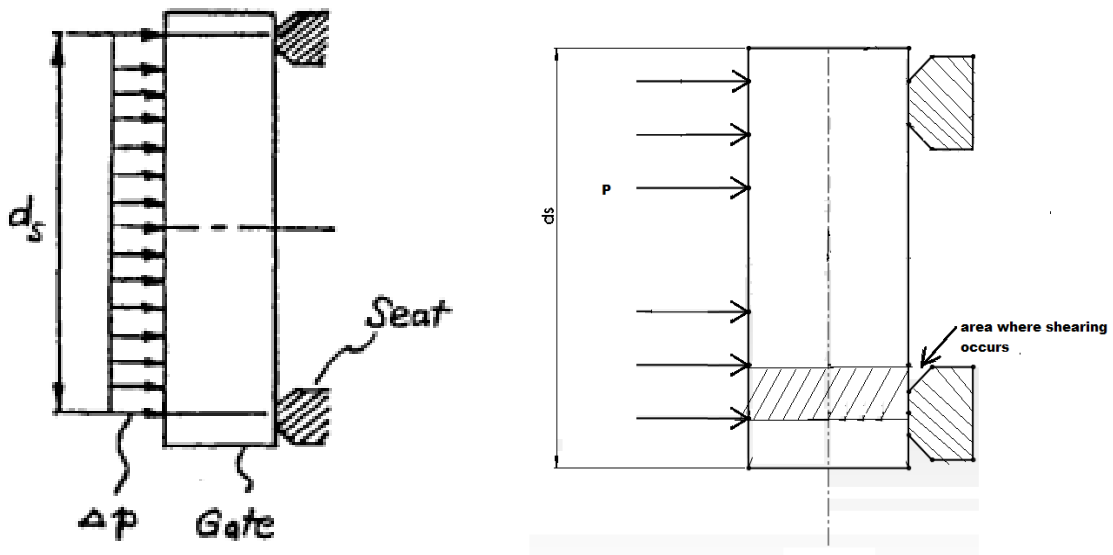


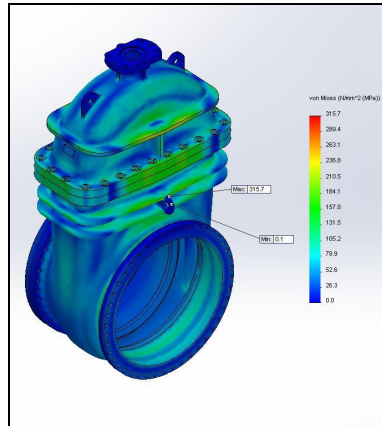
Figure 3. Drawing reference for wedge of gate valve

### III. RESULT AND DISCUSSION

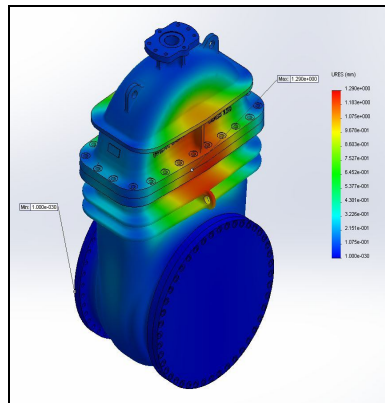
As per industry norms displacement must be within 2000 microns. Since the size is larger and displacement obtained from analysis is 1290 microns at 30 bar pressure & 232 microns at 20 bar pressure. Hence it is within the permissible limits.

Factor of safety (FOS): Yield strength/Allowable stress

$$\text{FOS} : 248/181 = 1.37$$



(a)



(b)

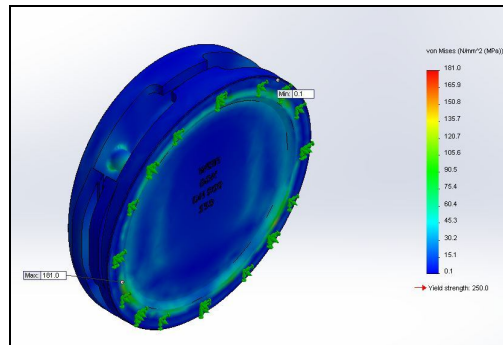
Figure 4. (a) Stress behaviour of body (b) Deformation of body

#### Wedge Analysis:

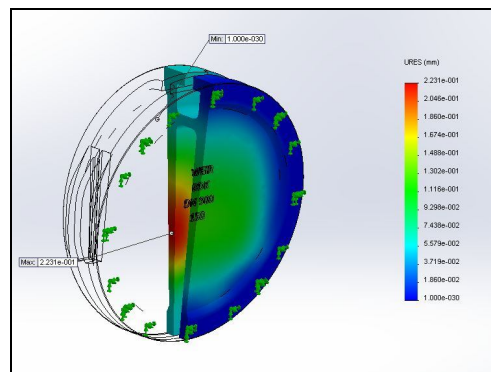
As per industry norms displacement must be within 2000 microns. Since the size is larger and displacement obtained from analysis is 200 microns and induced stress is 181 Mpa. Hence it is within the permissible limits.

Factor of safety (FOS): Yield strength/Allowable stress

$$\text{FOS} : 248/181 = 1.37$$



(a)



(b)

Figure 5. (a) Stress behaviour of body (b) Deformation of body

#### IV. CONCLUSION

The components used in gate valves DN900 x 150 are modeled, detailed and analyzed for the given pressure, using software package solid works and solid works simulation. This models are theoretically calculated and analyzed whether the design is safe or not using relevant standards like ASME SEC VIII, ASME SEC II Part D, and relevant API standards. The overall design was cross checked with cross functional team and approved for prototype and production

Along with the summary analysis the von mises stress and displacement was found to be suitable for working conditions.

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