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DESIGN, MODELING AND ANALYSIS OF A DOUBLE SEATED NOISELESS BUTT WELDED 3000 RATING GLOBE VALVE

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Abstract: - Globe valves are used for applications requiring throttling and frequent operation. In this study, a double seated noiseless butt welded 3000 rating globe valve is designed, modelled and analysed. 3000 rating valve is a very uncommon valve. It can withstand very high pressures up to 10000psi and it is very heavy. The designing standards like ANSI, API, ASME etc. are used for designing the various components. The 2D modelling is done in AutoCAD and 3D modelling is done in Solid Works software's. Flow area analysis is done to check whether the flow path area is nearly the same or not. Finite Element Analysis (FEA) is done to check whether the valve can withstand the high pressures under which it is going to work. FEA is done using Cosmos works. During FEA, a pressure of 15000psi is applied on the valve body and stress distribution, displacement distribution and strain distribution are found out and it is concluded that the design of the globe valve is within the safe limits.

Keywords: - globe valve, valve rating, flow co efficient, bonnet, cages, cosmos works

1. Introduction

Globe valves are named for their spherical body shape with the two halves of the body being separated by an internal baffle. The dimensions of components in the globe valve are either standards or arrived during assembly. The valves in any system are the common flow restrictors; hence, the design and analysis of valves are most critical tasks. A number of researchers have experimented and analysed valves for all its parts, fluid types, operating parameters and discharge coefficient and have improved the valve technology. Now with the emergence of finite element analysis (FEA) tools, the analysis of valve performance, and thus the job of designing valves to suit a particular application can be done much faster. The analyses of the flow behaviour inside a valve using CFD method have provided the relation between flow, geometry and pressure loses (Amirante et al, 2006 & 2007; Beeson et al, 2000; Chern et al, 2004; Vu et al, 1994). Valve-related problems like the stiction, erosion, vibration, cavitation etc. were also modelled for effective performance of the valve using CFD methods (Choudhury et al, 2006).In the present study, FEA of a specific globe valve design has been carried out to understand the stress distribution, displacement distribution and strain distribution during the high pressure flow of a liquid. Flow area analysis is also done to test the flow path area.

1.1 *Study Motivation*

- There is no standard software for the designing of valves, and its design is much complicated. So designing a valve will be helpful to know about the practical professional design and also the manufacturing processes.
- 3000 rating valve is a very uncommon valve
- It should withstand pressure up to 10000 psi
- It is designed with a noiseless trim
- Flow characteristic should be equal i.e. same output for same % of valve opening
- It is a multistage double seated valve
- It is to be used in a 8'' diameter pipe
- End connections are butt welded

2. Design Procedure

2.1 *Valve Rating*

From the *Standard ASME Boiler and Pressure Vessels* [2], valve rating based on pressure and temperature is shown in table 1.

Table 1.valve ratings
Temperature between 100 F and 200F

Rating	150	300	400	600	900	1500	2500	4500
Pre(psi)	260	675	900	1350	2025	3375	5625	10120

From the table it is clear that 3000 rating valve is not a standard valve.

2.2 *Parts of the Model*

- Body
- Bonnet
- Plug
- Cage – split cage(upper & lower) , noise reduced
- Stem
- Bush 1
- Bush 2

2.3 *Material Selection*

- Body , bonnet - WCB(weldable cast B-grade carbon steel)
- Plug - SS 316
- Cage - SS 316
- Stem - SS 316
- Bush – SS 316

2.3 *Selection of Dimensions from Standards*

- Pressure rating - ASME B 16.34
- Valve body minimum wall thickness - ASME B16.34
- Face to face dimensions for butt welded valves – ASME B 16.25
- Testing standards – API 598
- Dimensions of bonnet and stem – BS 1873
- Butt weld design – BS 1873
- Pipe line standard - ASME 16.1

- Required machining allowance - ISO 8062

2.4 *Design of 8" X 3000 Valve Body*

The standards for the design of the valve body are selected, which are BS (British Standard) and ASME (American Society of Mechanical Engineers). The two input parameters used for determining the values are 8 inch inlet diameter and 9000 psi pressure. As the initial step of designing of the valve body, from the values obtained from the standards, the constraints are fixed.

The wall thickness of the body is also validated using the equation (ASME 2001) for calculating minimum thickness required for spherical shells under pressure. Equation is given below

$$t = \frac{PR}{2SE - .2P} \quad (1)$$

Where t = minimum shell thickness

P = Internal design pressure

R = Inside radius of the shell under consideration

S = Maximum allowable stress value, psi (kpa)

E = Joint efficiency for appropriate joint

The valve body with all the dimensions is shown in Fig 1

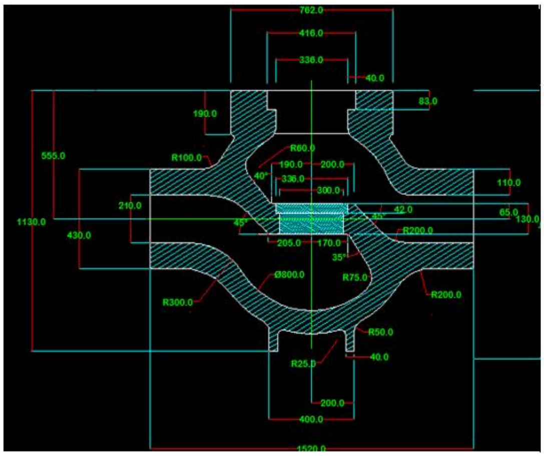


Fig.1.Valve body with all dimensions

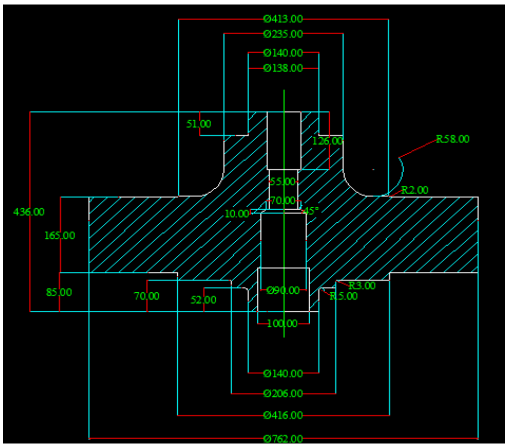


Fig. 2. Bonnet with dimensions

2.4 *Design of Bonnet*

The design of the bonnet starts from the top of the body which is to be matched by the bottom of the bonnet. Sizing of the bonnet is obtained after considering the sizes of gland packing, gland bush, stem nut etc. Stem diameter decides the dimensions of stuffing box, packing width etc. The bonnet with all dimensions is shown in fig.2

2.5 *Design of Cages*

The lower cage dimensions are arrived from the inner valve body dimensions. Lower cage is of cylindrical shape and to make the operation noise less the lower cage consists of lot of holes in it.

The holes are designed in such a way that

Total hole area = Pipe cross sectional area

This will give equal percentage flow characteristic i.e. when the valve opens at some % of the full valve opening, the flow value will also be that much % of full flow value

When water flows through these holes the bubbles formed due to cavitation will be bursted and noises will be reduced. Thus a noiseless operation is possible

Since the lower cage is inside the shell, pressure acting will be less compared to body and bonnet. So a much less thickness given to the lower cage, which is a safe thickness for its operation. The upper cage and lower cage are shown in figure.3 and figure 4 respectively.

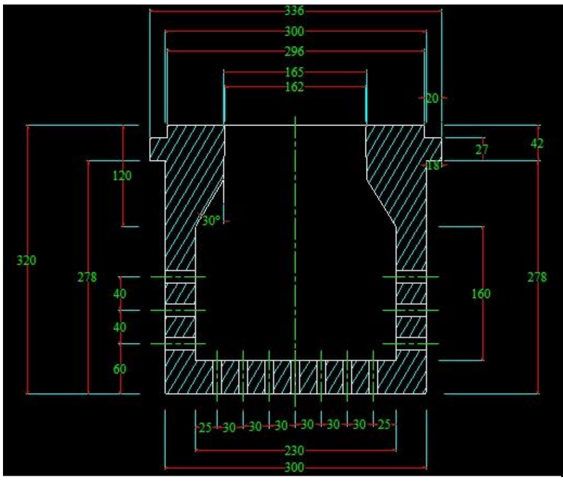


Fig.3.Lower cage

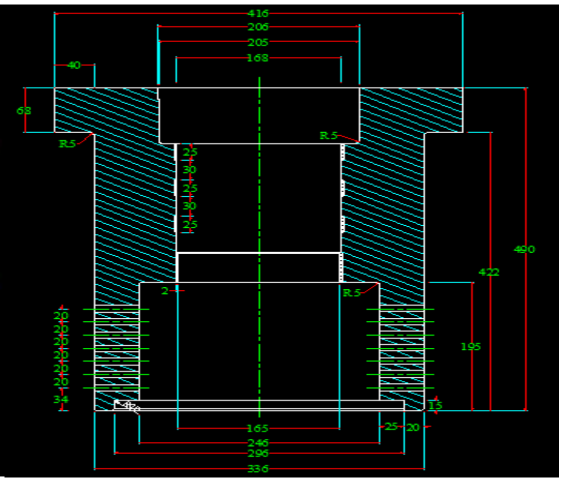


Fig 4. Upper cage

2.6 *Design of Plug*

The plug moves inside the upper and lower cages. The position of the plug determines whether the valve is in 'open' or 'closed' position. It also consists of holes in it. The plug with all dimensions is shown in fig.5

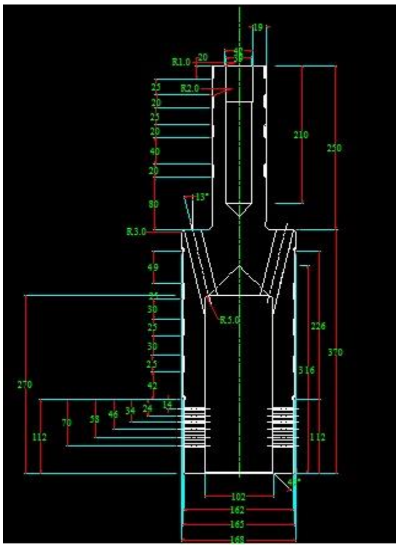


Fig 5. Plug

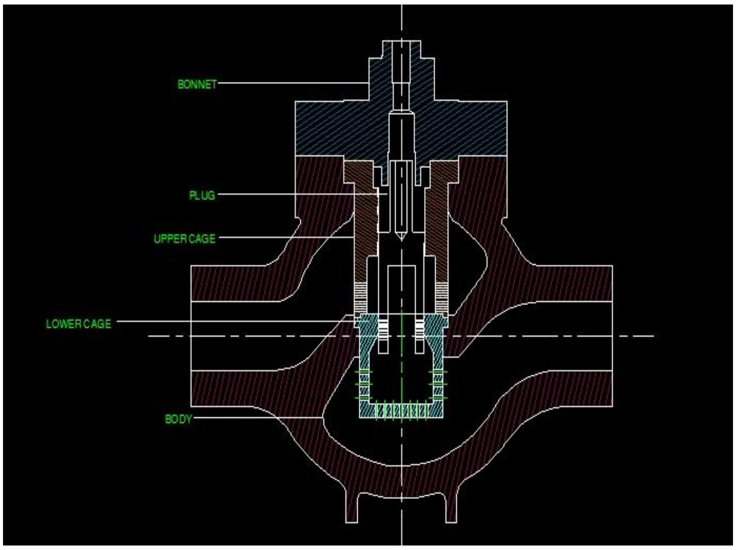


Fig 6.Valve assembly

2.7 *Valve Assembly*

The completed valve assembly is shown in fig.6

2.8 *Flow Characteristic*

The design of the valve is in such a way that the flow characteristic is equal percentage as shown in the graph i.e. when the valve opens at some % of the full valve opening, the flow value will also be that much % of full flow rate. The flow characteristic is shown in fig.7

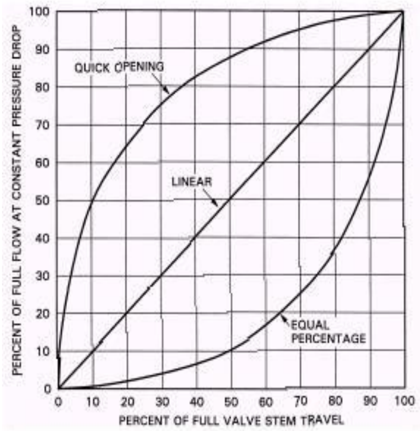


Fig 7.Flow characteristic

3. Analysis

3.1 *Flow Area Analysis*

Flow area analysis is conducted to ensure that 90% of the inlet area is available throughout the flow path. For that, three sections each from the inlet and outlet are cut from the solid model and transferred to AutoCAD to obtain 2D figures of the sections and the area for each section is calculated. If the area of the section is less than 90% of the inlet area then the design of the flow path is redesigned. And satisfactory design is obtained by trial and error.

The area obtained from Auto Cad drawing is shown in fig.8

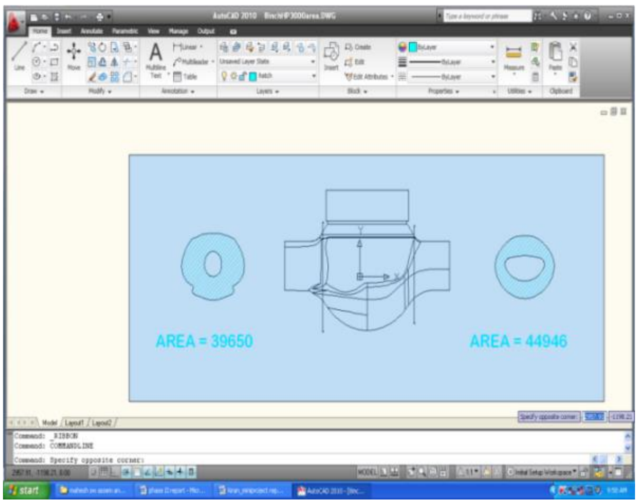
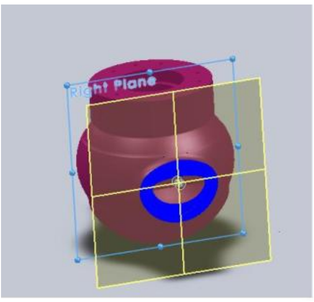
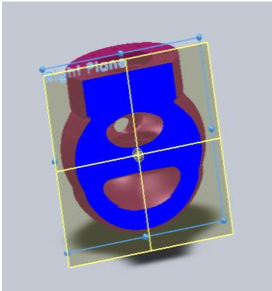


Fig 8. Section areas

The shape of the flow path can be seen from the different cross sections shown in fig.9, fig 10 and fig.11.





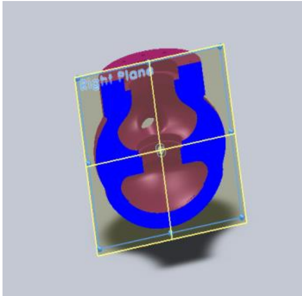


Fig 9 cross section 1 Fig 10 cross section2 Fig 11 cross section 3

The flow area analysis shows that there is no abrupt change in cross sectional area anywhere inside the body

3.2 *Strength Analysis*

Finite element analysis (FEA) is done to check whether the valve is suitable for the prescribed application. FEA of the valve is done using the application *cosmos works.*

The strength analysis in *cosmos works* can guide in step by step manner to determine how design performs under particular applications. It shows where the parts breaks or will it deforms under applied stress or pressure. This analysis provides stress analysis in the early stages of design to catch potential problems before extensive work is done.

Cosmos works subdivides the model into a mesh of small shapes called elements .Greater the element number greater the accuracy but computation load is more.

Since the valve will be used in applications where a pressure of 10000psi is applied, the given design should withstand much more pressure than that. So during the FEA a pressure of 15000psi is applied on the valve. Stress distribution details, displacement distribution details and strain distribution details are available after the FEA. Those are explained below.

Stress Distribution

The stress distribution in the valve body after a pressure of 15000psi is applied is shown in fig.12. The stress acting on the body is shown with different colors. Red color means the acting stress is more than the prescribed value. Blue, light green and yellow means the stress acting is less than that of the prescribed value. Since the whole part of the valve body is either blue or green, the stress acting is within the safe limits.Table2 shows maximum and minimum values of the stress(Von Mises Stress) acting and also their locations on the body.

Table 2. Maximum and minimum stresses

Name	Type	Min	Location	Max	Location
Stress1	VON: von Mises Stress	3.65538e+006 N/m^2 Node: 18962	(-647.611 mm, -310.452 mm, 182.494 mm)	6.01453e+008 N/m^2 Node: 352	(3.55662 mm, 359.505 mm, -523.573 mm)

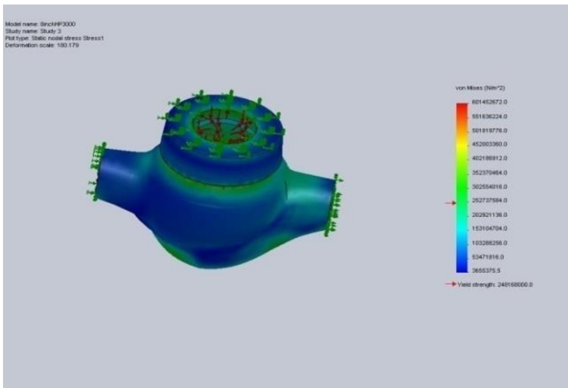
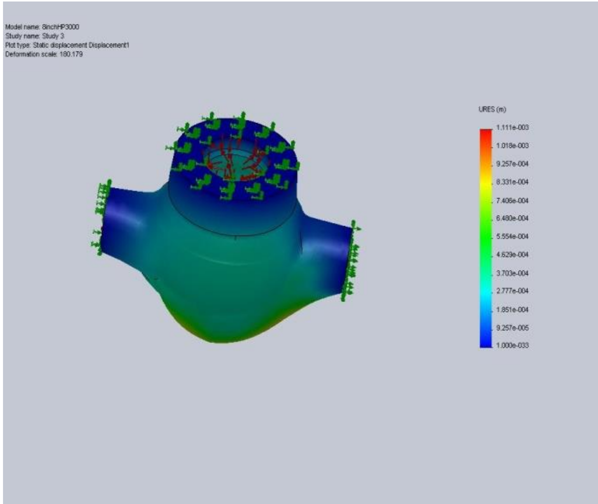


Fig.12. Stress distribution on the valve body

Displacement Distribution

The displacement distribution on the valve body is shown in fig13. The blue and green color shows that the valve is safe for a pressure of 15000psi. Table 2 shows that minimum displacement is zero and maximum is .00111086. Its node number and location are also shown in the table

Table 3. Maximum and minimum displacements



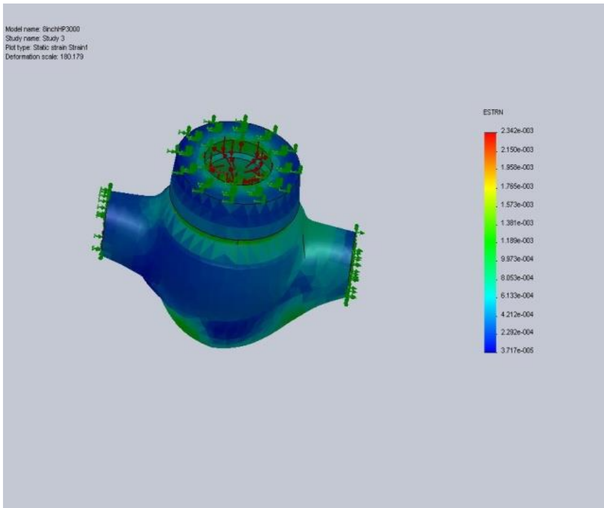
Name	Type	Min	Location	Max	Location
Displacement1	URES: Resultant Displacement	0 m Node: 5	(339.899 mm, 691.16 mm, -209.588 mm)	0.00111086 m Node: 15544	(215.851 mm, -687.235 mm, 14.5219 mm)

Fig 13.Displacement distribution

Strain Distribution

The details of the strain distribution on the valve body is shown in fig.14.Since the color of the body after applying the pressure is only blue and green, the strain distribution is also within the safe limits. The maximum and minimum strains are shown in table 4.

Table 4. Maximum and minimum strains



Name	Type	Min	Location	Max	Location
Strain1	ESTRN: Equivalent Strain	3.71684e-005 Element: 6314	(-578.769 mm, -332.223 mm, -212.844 mm)	0.00234157 Element: 13211	(684.784 mm, -56.9489 mm, -191.726 mm)

Fig 14.Strain distribution

4. Conclusion

Detailed drawing is prepared for each component and the solid model is generated. The tolerances are given depending on the part, the material used for casting and the surface finish required. The 3D solid model is generated from the machine drawings and was used to do the Flow Path analysis and Strength Analysis which were successfully done and the results are acquired.

The stress analysis shows that the design is able to withstand the over load and the flow path analysis shows that generated profiles do not have any drastic reduction in cross-sectional areas. The further scope of analysis includes the analysis using the Engineering fluid dynamics (EFD), which can give detailed information about the stability of the design. Casting stimulation can also be conducted to ensure the correctness of riser and gating design.

Further tests can be conducted before manufacturing, like flow analysis to rectify the occurrence of turbulence which requires more sophisticated soft wares.

REFERENCES

[1] American Society of Mechanical Engineers, New York, 2001 edition "Rules For Construction of Pressure Vessel", July 01, 2001, Page 23.
[2] Standard ASME boiler and Pressure vessels, Volume 7, Division 1 Amirante, R., Moscatelli, P.G. And Catalano, L.A.
[3] "Evaluation of the flow forces on a direct (single stage) proportional valve by means of a computational fluid dynamic analysis", Energy Conversion and Management Vol. 48, 2007, Pg. 942–953.
[4] Amirante, R., Del Vescovo, G. and Lippolis, A., "Evaluation of the flow forces on an open Centre directional control valve by means of a computational fluid dynamic analysis" Energy Conversion and Management Vol. 47, 2006, Pg. 1748–1760.
[5] Beeson, H. D., Stewart, W. F., and Woods, S. S., "Safe Use of Oxygen and Oxygen Systems: Guidelines for Oxygen System Design, Materials Selection, Operations, Storage, and Transportation", ASTM Manual 36, ASTM International, West Conshohocken, PA, 2000.
[6] Chern, M. and Wang, C., "Control of Volumetric Flow- Rate of Ball Valve Using V-Port", Journal of Fluids Engineering (ASME), Vol. 126, 2004, Pg. 471-481.
[7] Vu, B., and Wang,T., "Navier-Stokes Flow Field Analysis of Compressible Flow in a High Pressure Safety. Relief Valve", Applied Mathematics and Computation Vol. 65, 1994, Pg.345-353.
[8] Choudhury, S. M. A. A, Thornhill, N. F. and Shah, S. L., "Modeling valve stiction", Control Engineering Practice Vol. 13, 2005, Pg. 641–658.
[9] Choudhury, S. M. A. A, Thornhill, N. F. and Shah, S. L.,"Automatic detection and quantification of stiction in control valves", Control Engineering Practice Vol. 14,2006