Design and Analysis of High Pressure Globe Valve Body with Two Elements

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Abstract-Globe valves are one of the oldest valve types used for throttling application for all sizes due to better controllability and range. There are different types of globe valve available. The major limitations associated with the globe valves in liquid application is difficulty in manual operation due to higher value torque, stem bending issue , packing performance deterioration by rotating stem design, leakage etc. At present the globe valves designed for various purposes are of these 150/300/600/900/1500/2500/4500 classes. My project is the design and analysis of a 3000 globe valve with focuses on eliminating the problem faced by conventional globe mentioned above. All the designs are based on BS and ASME standards. This valves are connected to 8inch pipe .All the main components are designed and detailed drawing is produced. The stress and flow area analysis is performed on SOLIDWORKS COSMOSXPRESS .

Keyword:Bonnet Design, Cage Design, Flow Analysis, Globe Valve, High Pressure Globe Valve, Plug Design

I. INTRODUCTION

Control valves are used to control conditions such as flow, pressure, temperature, and liquid level by fully or partially opening or closing in response to signals received from controllers that compare a "set point" to a "process variable" whose value is provided by sensors that monitor changes in such conditions. The opening and closing of control valves is done by means of electrical, hydraulic or pneumatic systems. Positions are used to control the opening or closing of the actuator based on Electric or Pneumatic Signals. The most common and versatile types of control valves are sliding-stem globe and angle valves. Their popularity derives from rugged construction and the many options available that make them suitable for a variety of process applications, including severe service. Globe valve are widely used for throttling applications in the process industry for both liquid and gaseous applications. The main advantages are relatively low cost, linear characteristics and good controllability and range. To obtain the required flow and pressure drop characteristics for the valves, different types of internals were evolved for globe type valves. Cage and plug internal is one among them. At present the available classes of control valves are 150/300/600/900/1500/2500/4500. My project is the Design and Analysis of a 3000rating duel split trim low noise Globe Valve., which is the starting class of high pressure, and it can be used wherever high temperature, high pressure and high volume output, is required.

WORKING OF A GLOBE VALVE

A normal globe valve is operated with the help of a hand wheel which is attached to the stem. Anti-clockwise rotation of the hand wheel moves the stem over the threads, lifting the valve from its seat and thus opens the valve. Clockwise rotation results in the reverse process. greater than the pressure of the valve, the valve lifts off its seat. There is no reverse flow allowed in this type of valve. The globe valve is suitable for use on a wide variety of applications, from flow rate control to flow shut-off. When the valve plug is in tight contact with the valve seat, the valve is closed. When the valve plug is away from the valve seat, the valve is open. Thus, flow rate control is determined not by the size of the opening in the valve seat but rather by the lift of the valve plug (the distance the valve plug is from the valve seat). A feature of this type of valve is that even if used in the partially open position, there is little chance of damage to the valve seat or valve plug by the fluid. In particular, the main type of globe valve used for flow rate control is the needle valve. It must be noted, however, that because the passageway in this valve is S-shaped, the pressure drop is greater than that of other types of valves. In addition, the valve stem must be turned many times in order to open and close the valve, and there is therefore a tendency for the gland seal to leak. Furthermore, because closing the valve requires turning the valve stem until the valve plug presses down tightly onto the valve seat, it is difficult to tell the exact point at which the valve is fully closed. There have been cases where accidentally turning the valve shaft too far has damaged the seating surfaces. Another option is that, the stem slides along the valve instead of rotation. This will help to reduce the thrust on the stem and hence it will help to prevent the bending problem of stem.

II. PROBLEM DEFENITION AND OBJECTIVE

PROBLEM DEFENITION: Valves are used in the piping systems and on processing vessels or tanks for a variety of reasons. Globe valves are named for their spherical body shape with the two halves of the body being separated by an internal baffle. They are used for applications requiring throttling and frequent operation. Design and analysis of valves is a very complicated process in the mechanical engineering industry. Since valves are components that can experience multiple types of stresses, it is very important to satisfactorily design and analysis them.

There is no standard software for the designing of valves and its design is much complicated. The main class of valves are 150/300/600/900/1500/2500/4500. 2500 rating valves are use in low power plants and 4500 rating valves are use in high power plants. Now the requirements of globe valves are to control high pressure and high temperature, which doesn't come under these classes. There are no classes present in the rating of 3000 for medium power plants. This valve is used for 300MW power generation plant.300MW thermal power plants are under developing condition. Normally this is a closed valve used in between feed pump and boiler. The main advantages are relatively low cost, linear characteristics and good controllability

OBJECTIVE: To design and analysis of 3000 rating control valve body .To conduct a flow area analysis and stress analysis of the 3000 pressure rating globe valve body using software

III. EXPERIMENT AND RESULT

MATERIAL SELECTION AND SELECTION OF STANDARDS

Material selection is a step in the process of designing any physical object. In the context of product design, the main goal of material selection is to minimize cost while meeting product performance goals. Systematic selection of the best material for a given application begins with properties and costs of candidate materials
Nowadays wide varieties of materials are available to make the different components of globe valve. Typically globe valves are made of metallic alloys, although some synthetic materials are available. These materials are chosen based on pressure, temperature, and controlled media properties. Corrosive or erosive process streams may require a compromise in material selection or exotic alloys or body coatings to minimize these material interactions and extend the life of the valve or valve trim components.
Packing material must also be considered during valve selection. Typically the requirement for a low friction packing conflict with a durable material that will provide low maintenance requirements during service life. Corrosive applications can further complicate packing material selection as the typical packing materials may or may not be compatible with the processed materials. This packing helps to meet contemporary environmental laws.

DESIGN OF 3000# VALVE BODY

The standards for the design of the valve body are selected, which are BS and ASME. The two input parameters used for determining the values are 4inch inlet diameter and 3000 pressure rating From standards, primary constraints are fixed and are listed as follows;
Bore diameter (B4) – 183mm

Wall thickness (WT) – 90mm (Appendix A BS 1873)

Face to Face dimension (B1) – 762 mm (ASME B 16.10)(long type high pressure, Butt weld)

Body height (B2) – 219mm

End connection thickness (B6) – 63mm (BS1873:1975)
Sideview are placed and the origin is located at the intersection point of axis on it. The front view is then placed to the origin thereby ensuring correct trajectory. The inlet flow path is generated by first selecting correct profiles and then applying proper constraints which are generally normal to the profile. Guide curves are set and then lofting is done. The same procedure is repeated for outlet path also. The various commands used for making solid model of the body are revolve, extrude, revolve cut, loft cut, mirror, chamfer, fillet etc

Fig 1 valve body

STRENGTH ANALYSIS

The strength analysis in COSMOS expresses guides in a 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.

Material selection: -Stainless Steel 304

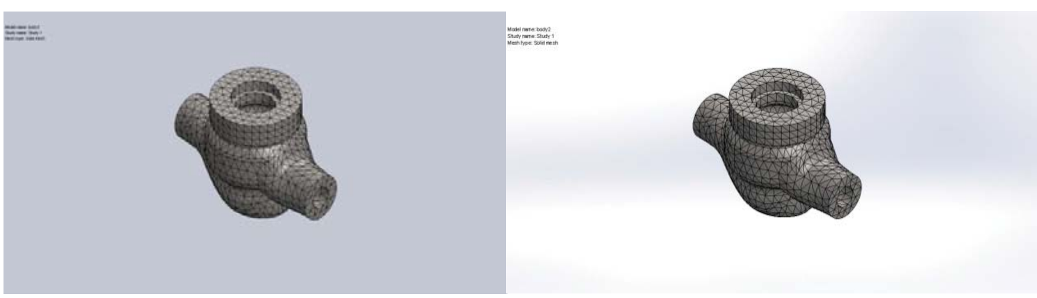
Restraints: - Restraints are added at 3 open faces of the body. Restraint faces are constrained in all directions.

Loading:-Pressure of 2000 psi is applied on all interior surfaces

Cosmos express subdivides the model into a mesh of small shapes called elements .Greater the element number greater the accuracy but computation load is more. Here the analysis is performed with two element size.

Table 1 element size

Item	Case 1	Case 2
Element size	4.85mm	4.51mm
Number of node	17035	17085
Number of elements	10485	10533



Case 1 Case 2

Fig 2 meshing of body

Table 2 material properties

Properties	Case 1	Case 2
Name	Stainless Steel 304	Stainless Steel 304
Model type	Linear elastic isotropic	Linear elastic isotropic
Default failure criterion	Max von mises stress	Max von mises stress
Yield strength	1.7233e+008N/m^2	1.7233e+008N/m^2
Tensile strength	5.1361e+008N/m^2	5.1361e+008N/m^2
Elastic modulus	2e+011N/m^2	2e+011N/m^2
Poisson ratio	.28	.28

Mass density	7800kg/m^3	7800kg/m^3
Shear modulus	7.7e+010N/m^2	7.7e+010N/m^2
Thermal expansion coefficient	1.1e-005/k	1.1e-005/k

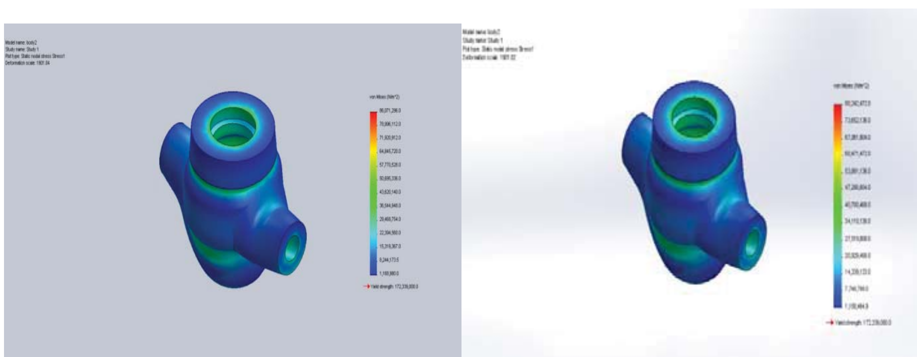
Table 3 element properties

Details	Case 1	Case 2
Total nodes	17035	17035
Total elements	10485	10533
Maximum aspect ratio	17.323	17.303
% of elements with aspect Ratio<3	95.7	94.8
% of elements with aspect ratio>10	0.0858	0.104
Time to compete Mesh(hh;mm;ss)	00:00:06	00:00:08

RESULTS

Analysis is successfully done for two element size and the results are compared. The results are mainly obtained using COSMOSXpress. Von Mises Stress, strain and displacement were plotted. In the analysis, we can see there was no much deviation between the results when two element sizesareconsidered.The analysis showed that the design is able to withstand the over load and the generated profiles does not have any drastic reduction in cross-sectional area.

Stress



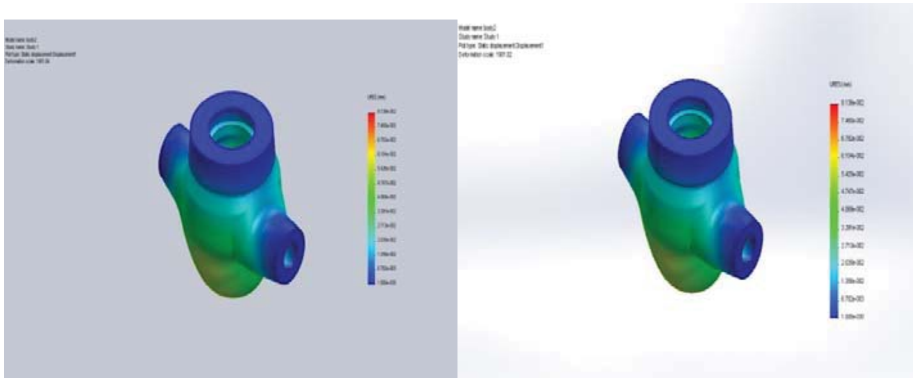
Case 1 Case 2

Fig 3 stress

Table 4 stress details

Name	Type	Minimum	Maximum
Stress (case 1)	VON:von mises stress	1.1689e+006N/m^2 Node:1207	8.60713e+007N/m^2 Node:16387
Stress (case 2)	VON:von mises stress	1.1584e+006N/m^2 Node:357	8.02425e+007N/m^2 Node:248

Displacement



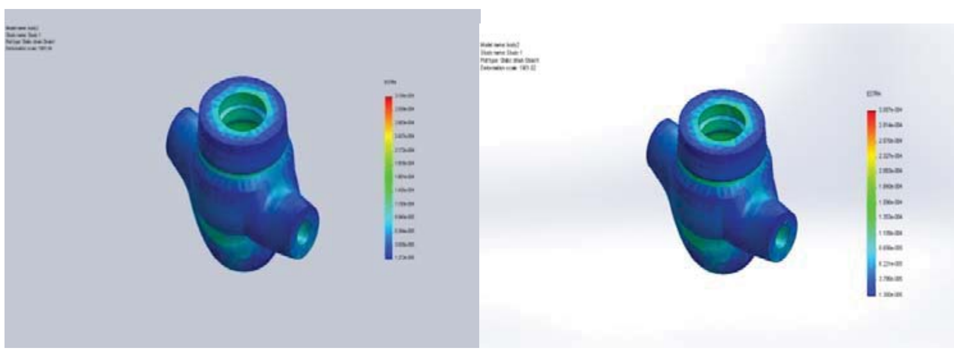
Case 1 Case2

Fig 4 displacement

Table 5 displacement details

Name	Type	Minimum	Maximum
Displacement (case1)	Resultant displacement	0mm Node :73	0.0813835mm Node :10406
Displacement(case2)	Resultant displacement	0mm Node:75	0.0813812mm Node :10422

Strain distribution



Case 1 Case 2

Fig 6 strain

Table 6 strain distribution

Name	Type	Minimum	maximum
Strain (case 1)	ESTRN:equivalent strain	1.27224e-005 Element :1261	0.000319421 Element :10121
Strain (case 2)	ESTRN: equivalent strain	1.35041e-005 Element :1244	0.00030573 Element: 9673

From the analysis we get the maximum stress ,strain and displacement are obtain in the inner portion of the valve . red colour indicts the maximum distribution. the reason of this is the liquid applied more stress in the inner portion of the valve . and the edge portion of the inner side acts more stress.the bottom portion of the valve.its due to more stress are incident on the bottom wall.

IV. CONCLUSION

The project helps in familiarizing the professional approach of designing the globe valve which made us familiarize the use of standards in the designing. The hands on experience on AutoCAD, for designing help to make a detailed drawing for globe body and solid model was 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 is used to do the Flow Path optimization and Strength Analysis which were successfully done and the results are acquired. The analysis showed that the design is able to withstand the over load and the generated profiles does not have any drastic reduction in cross-sectional area. The analysis showed that the pressure distribution and velocity distribution inside the valve is within the limit and therefore the design is safe.

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