Finite Element Analysis Of Butterfly Valve Disc

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Abstract

Valves are mechanical devices specially designed to direct, start, stop, mix or regulating the flow, pressure or temperature of a process fluid. A buttery valve typically consists of a metal disk formed around a central shaft, which acts as its axis of rotation. As the valve's opening angle is increased from 0 degrees (fully closed) to 90 degrees (fully open), fluid is able to more readily flow past the valve. These valves are commonly used to control fluid flow inside of piping systems.

The main objective of this study is to find out stresses developed in butterfly valve Disk. This work discusses Finite Element Analysis of Butterfly valve Disc. For the solid modelling of valve body CATIA V5 software is used. The solid model is discretized into finite elements and logical constrains are applied in boundary conditions. The stress results obtained in finite element analysis shows that there is chance for optimization of design.

Keywords: *Butterfly valves, finite element analysis*

1. Introduction

A butterfly valve, illustrated in Figure 1.1, is a rotary motion valve that is used to stop, regulate, and start fluid flow. Butterfly valves are easily and quickly operated because a 90^o rotation of the handle moves the disc from a fully closed to fully opened position.

Nowdays, there are various simulation techniques are availbele for static analysis. Song, Wang and Park[1] carried out the CFD and structural analysis of butterfly valve disc for stress determination. Based on this results they done

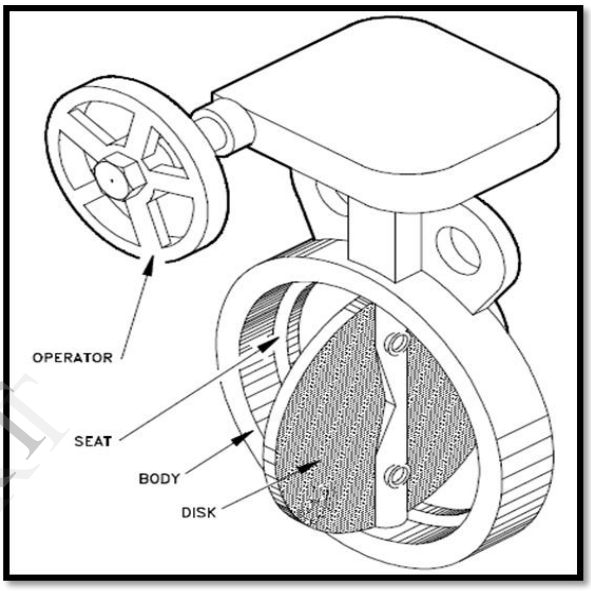

Figure 1.1 Butterfly Valve

weight optimization of butterfy valve disc by 7.05per cent of its initial value. Song, Wang and Park[2] examined valve for both CFD for various angle and structural analysis, and concludes that there is chance for weight reduction. Song et al.[3], they carried out fluid and structural analysis based on this they done optimization of disc by changing shape of disc.

In main objective of study is obtain stress generated in disc , static analysis of butterfly valve disc of 250mm diameter is carried out which is suitable for 1.3MPa pressure, is carried out using ANSYS. The aim of this is to find out stresses generated in disc under pressurized condition.

2.Finite Element Analysis:

2.1 3D modelling of valve disc:

There are various types of modeling software available like CATIA, Pro-E, and Solid Works. Here, 3D model of butterfly valve disc is prepared in CATIA because in ANSYS it's very difficult to model the part. The created 3D model of valve disc is as shown in fig 2.1.

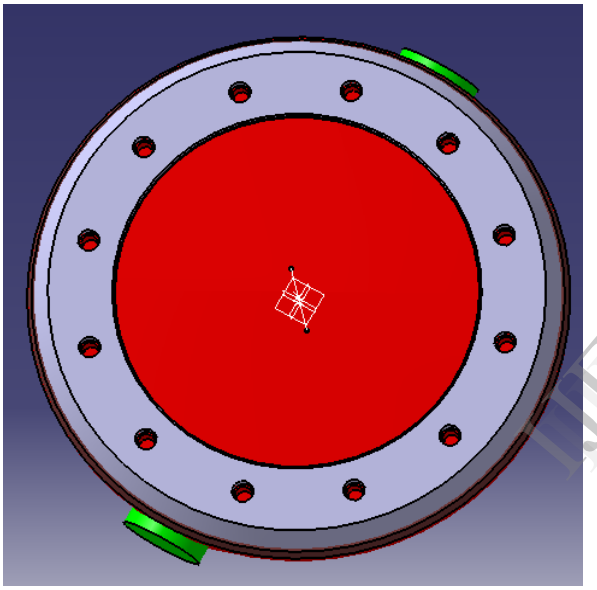

Fig.2.1 3D CATIA Model of Disc

2.2 Meshing:

Meshing has been done by using the method of Tetrahedron. In Tetrahedron method the component is been divided into small triangle on its surface which gives number of nodes and elements of that component. The meshing has been done by changing the mesh size of disc. Due to change in the density of the meshing, it results in the variation of the number of nodes and elements of the meshed parts.

The result of this mesh density change affects the value of the stress and deformation of the component. For fine meshing that is for small mesh size the values of number of nodes and elements are high but as the element size is gradually increased it result in increase in the value of number of nodes and elements. When more the number of elements taken, better accuracy is obtained but simultaneously the computational time increases tremendously.

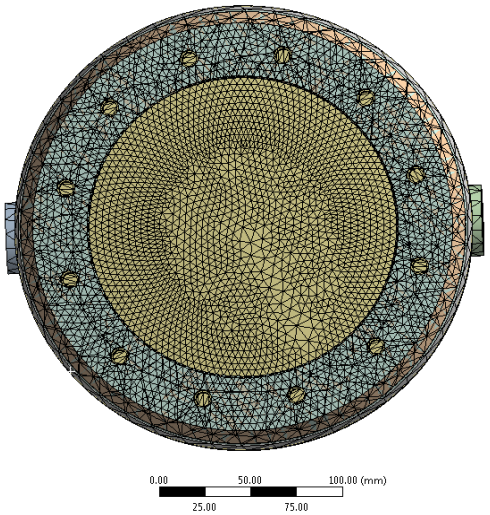

Fig.2.2 Meshed model

2.3 Define Material properties:

While designing and manufacturing of any component, the first step is material selection for component. This Material selection is usually based on the applied pressure, temperature to component and corrosive properties and erosive properties of the flow media which comes in contact with component. Mostly in control valve applications which handle relatively non-corrosive fluids at reasonable pressures and temperatures or some additives are added to fluid for reducing

corrosion of component. Therefore, cast carbon steel is the most commonly used valve body and disc. The following description and table provide basic information of material used for making casting of valve disc.

Material used- ASTM A351 Grade CF8M

Mechanical Properties:-

Young's Modulus= 195000MPa

Poisons Ratio =0.28

2.4 Pressure (load) and Boundary Condition:

Structural loading means applying internal hydraulic pressure to valve body or disc. Hydro test Pressure 1.3 M disc, which is shown in the figure.2.3 by 'B' in red colour.

The disc is supported between two shafts which one is the fixed support for disc in analysis that one is the constraint, where the all degrees of freedom are restricted which is shown in the figure.2.3 by 'A' in blue co Pa was applied on the all inner surface of a valve lour.

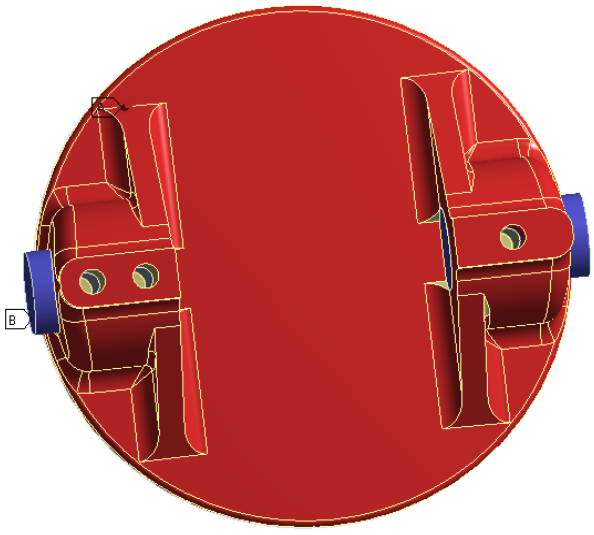

Fig.2.3 Pressure and boundary condition

2.5 Solver or Solution:

After applying material properties and boundary conditions, problem was solved by the ANSYS solver. ANSYS solver formulates the governing structural stress strain equations for each and every element those formulated governing equation are solved for deformation. With this governing equation other quantities such as stresses, strains can be calculated. Results are shown with the different colour strips of the stresses at the side of figure. Principal stresses, von-mises stresses are the logical checks for structural valve disc analysis.

2.5.1 Analysis Results and their interpretation

Results of FEA for internal pressure 1.30 MPa are shown in following figures.

FEA results for 1.3 MPa internal pressure applied on disc:

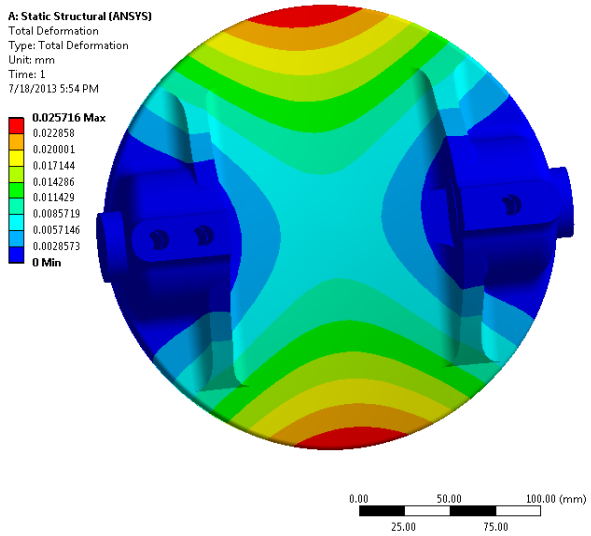

Fig.2.4 Deformation of disc

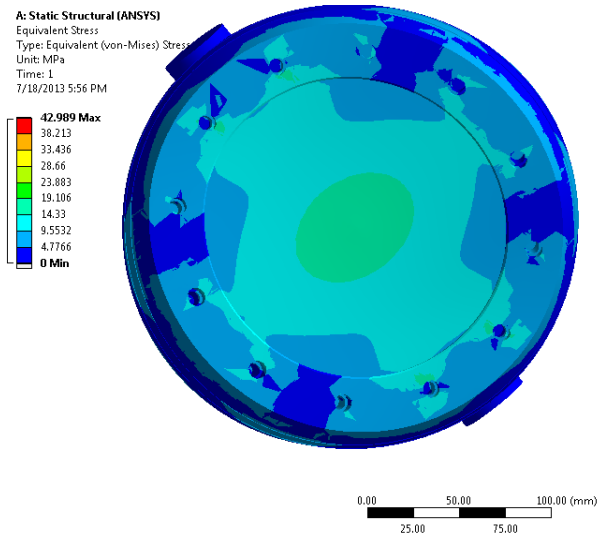

Fig.2.5 Equivalent stresses

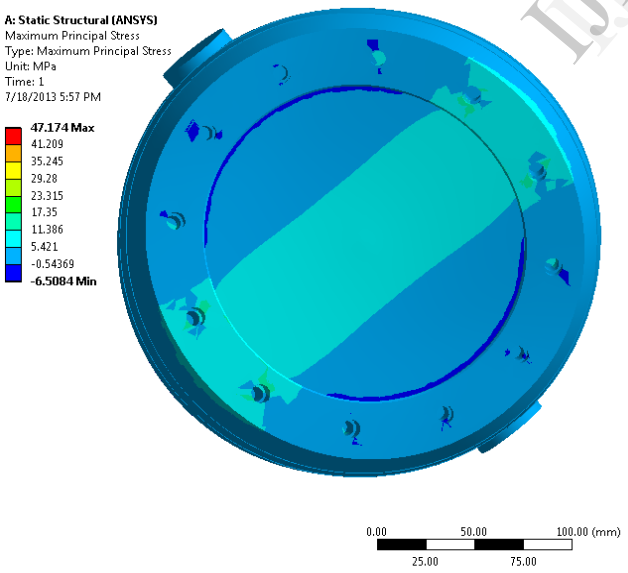

Fig.2.6 Maximum Principle stresses

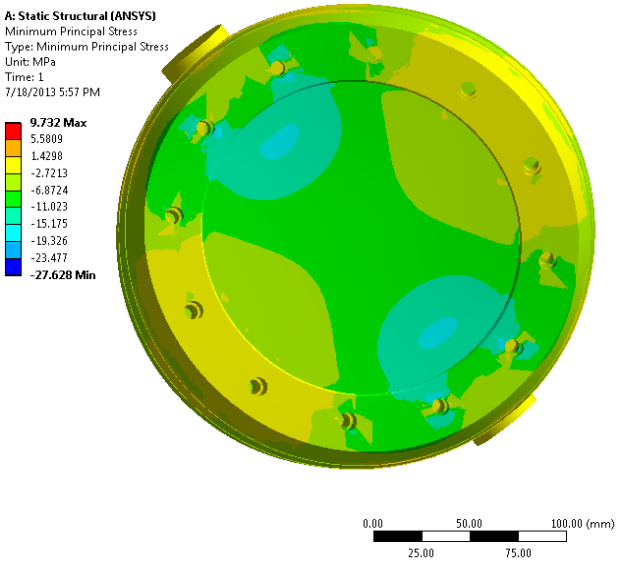

Fig.2.7 Minimum Principle stresses

At left hand side of above analysis figure, there is a vertical column of various colours which indicates the stress pattern with different values. Out of this various colours, there is some indications for respective colour like 1) the red colour indicates high stress value, if this red colour is in point form then this form known as singular stresses which are neglected here. 2) faint brown colour which one below to the red colour which indicates the region of moderately stresses (tensile stress) and 3) blue colour which is at lower indicates the region of low stresses (compressive stresses). This is about the various colour pattern and there indication.

From the FEA analysis we got some stress values in particular region as maximum principal stress 47.174 N/mm^2 at 1.30 MPa internal pressure

and the minimum principal stress 9.732 N/mm^2 at 1.30 MPa internal.

As the internal pressure acts on the internal effective area of valve disc, results to expand the valve disc, but shaft hold the valve disc in original position. As the internal pressure increases stresses in the valve disc increases linearly.

Conclusion:

From above analysis of disc, it is found that the maximum principle stress value 47.174N/mm2 is below yield stress of material. So the valve disc is very safe under working condition. But this stress value is very less as compared to yield stress, so it's found that there is much chance for weight reduction of disc in future.

References:

1) X G Song, L Wang and Y C Park, 'Analysis and optimization of a butterfly valve disc', Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering, 223: 81, 2009.

2) Xue Guan Song, Lin Wang, Young Chul Park, 'Fluid and structural analysis of a large diameter butterfly valve', Journal of Advanced Manufacturing Systems, Vol. 8, No. 1, 81–88, 2009.

3) Xue Guan Song, Lin Wang, Seok Heum Baek, Young Chul Park, 'Multidisciplinary optimization of a butterfly valve', ISA Transactions, 48, 370-377, 2009.

4) Philip L. Skousen, 'Valve Handbook', Second Edition, McGraw-Hill