NUMERICAL COMPUTATION OF STRESSES ON BUTTERFLY VALVE

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ABSTRACT

Butterfly valves are used to control discharge of fluids in penstock of hydropower plants or industrial pipe networks. It has a disc installed in between which can be made to rotate manually or automatically by pneumatic servomotors. These valves are also used as complete shut off valve. The disc of butterfly valve is subjected to pressure of fluid flowing in pipes which tries to deform it. The resistance to this pressure is offered by disc when stresses are induced in it.For safe working of butterfly valves, it is necessary that the stresses induced do not exceed elastic limit otherwise it will lead to its permanent deformation. Therefore it becomes necessary to study the stresses developed in butterfly valves for its proper working. In the present work, geometric modeling of multi lattice butterfly valve has been done in ICEM CFD and Pro E. Then pressure distributions on valve disc have been obtained in CFX for stated valve opening. There after these pressure distributions are imported in APDL for given opening and then stresses at valve disc and rib are obtained and studied.

Keywords-*Hydropower Plant, Penstock Valves, Pressure Contours, Icem, Cfx, Apdl.*

I INTRODUCTION

Valves are used to control the flow of fluids such as liquid, gas, slurries etc by opening, closing, or partially opening the flow path. Depending on the type of requirement, type of valve is installed. They are used for industries, residential and commercial purposes. In power plants they are generally used as shut off valves. In hydro turbines they are used at inlet to control the amount of fluid flowing from penstock to the runner of the turbine.Valves can be operated either manually or automatically. In the case of automatic valves change in pressure, temperature, or flow is acted upon the piston which is ultimately calibrated with the valve.

Butterfly valves are to control discharge of fluids in penstock of hydropower plants or industrial pipe networks. It has a disc installed in between which can be made to rotate manually or automatically by pneumatic servomotors. These valves are also used as complete shut off valve. They have disc installed in between which can rotate through different various angles by the help of hand wheel or pneumatic systems. They are installed in medium and high head turbines penstocks for regulating of discharge.

Figure1. Butterfly Valve with single plane disc

II MODELING

The term solid modeling means creating the body of the valve disc at 30^0 opening in any suitable CAD software. In this work, **Pro E** software has been used. For the sake of simplicity all the parts of valve are assumed to be Mild Steel.

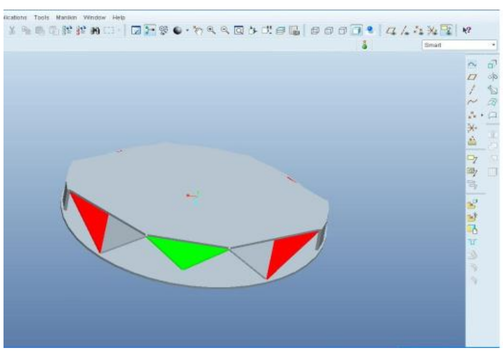

Figure2. Three dimensional view of valve

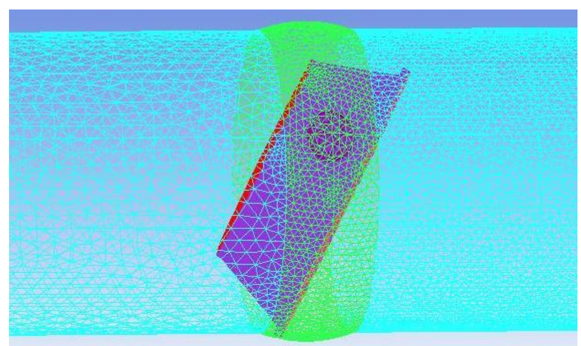

Figure3. Meshing of butterfly valve

III MESHING

Mesh generation of the full assembly butterfly valve have been done in ICEM. Part meshing has been done for all the parts, taking global element seed size as 16 and surface mesh size as 8. Different max size has been given to different part of the geometry. In this max size for pipe is given as 16, for pipe inlet and outlet it is 8 and for housing, trunion and valve is given as 4. Mesh data for valve opening as well as it's full assembledhas been shown in table below.

Table1 : Mesh data for valve assembly

Parts	No of nodes	No of element	Type of element
Trunion	813	323	Triangle
Valve	25455	11620	Tetrahedral
Housing	4214	2095	Triangle
Down Surface	1672	1112	Triangle
Up Surface	3163	1325	Triangle
Pipe	28227	14316	Tetrahedral

IV BOUNDARY CONDITIONS AND SIMULATION ON VALVE

In **ICEM CFD** after meshing of butterfly valve at required opening Pre Processing is done in **CFX Pre**, where all the boundary conditions are defined for further simulation. The domain conditions for whole valve assembly is shown in table below

Table 2: Preprocessing Conditions for valve assembly

Location	Pipe
Domain type	Fluid
Material	Water
Reference pressure	0 atm
Buoyancy Model	Non buoyant
Domain motion	Stationary
Heat Transfer Model	Isothermal
Fluid Temperature	2.5000e+01 [C]
Turbulence Model	k epsilon
Turbulent Wall Functions	Scalable

Further boundary conditions on the valve for different regions are mentioned as below

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Mass And Momentum	No Slip Wall
Wall Roughness	Smooth Wall

Table 3: Inlet properties

Boundary1: The boundary 1 has been taken as **inlet to butterfly valve** with following conditions

Flow Regime	Subsonic
Mass And Momentum	Normal Speed
Flow velocity	2 m/s
Turbulence	Medium Intensity and Eddy Viscosity Ratio

Table 4: Outlet properties

Boundary 2: The boundary 2 has been taken as **outlet to butterfly valve** with following conditions

Flow Regime	Subsonic
Mass And Momentum	Average Static Pressure
Relative Pressure	100 kPa
Pressure Averaging	Average Over Whole Outlet

Table 5: Wall Boundary Condition

Boundary 3: The boundary 3 has been taken as **wall of butterfly valve** with following conditions:
Post processing is done in CFX Solver which produces pressure contours in CSV.format which can be imported to structural solver APDL in IGES format. The pressure contour has been imprinted on valve surface as shown below.

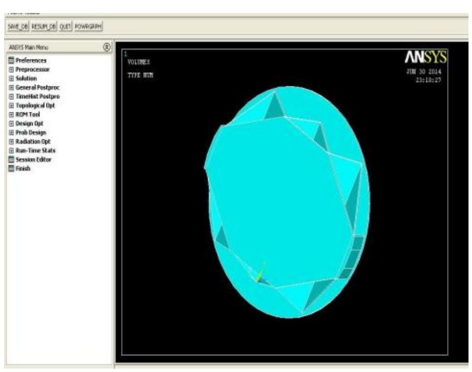


Figure 4: IGES format of valve in APDL

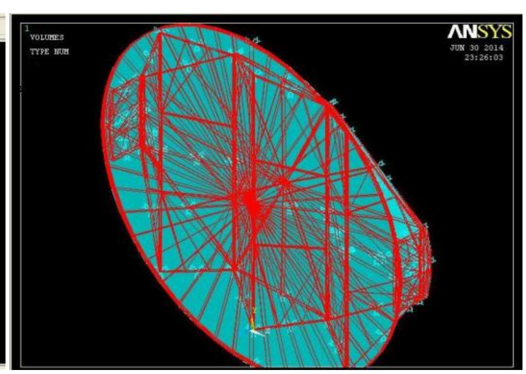
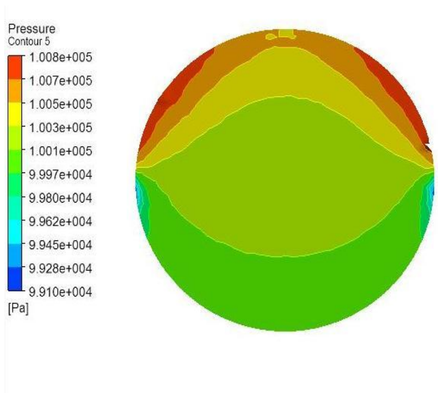


Figure 5: Pressure contour in APDL

V RESULTS AND CONCLUSION

The pressure distribution calculated in CFX Post after flow simulation on the two end faces of disc for **30^0 opening** is shown below



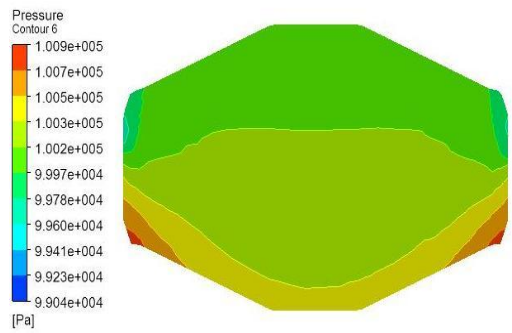


Figure 6: Pressure contour on up surface **Figure 7: Pressure contour on down surface**

Von Mises Stress on full assembly disc can be analyzed as shown below

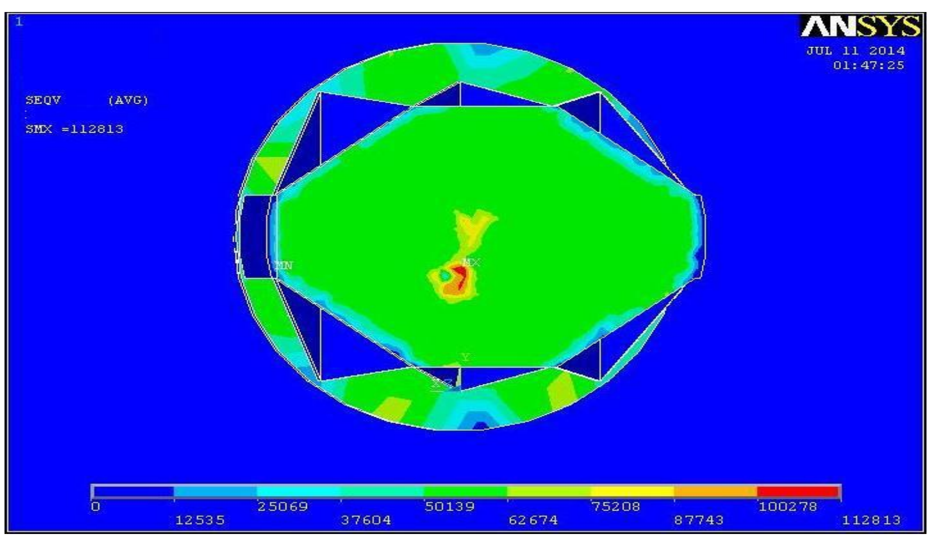
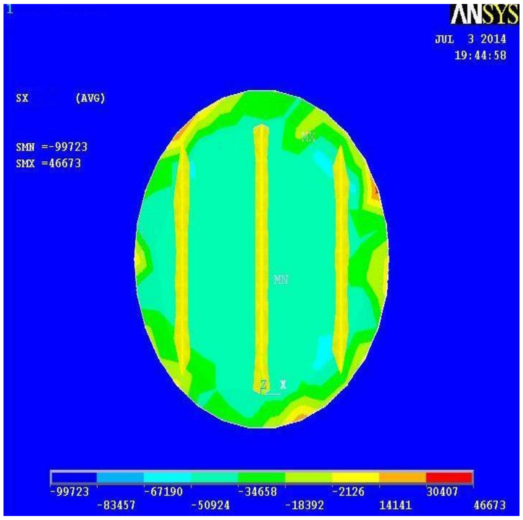


Fig 8 Von Mises stress distribution on valve body for 30^0 opening

Variation of Von Mises stress on disc plane can be analyzed as shown below



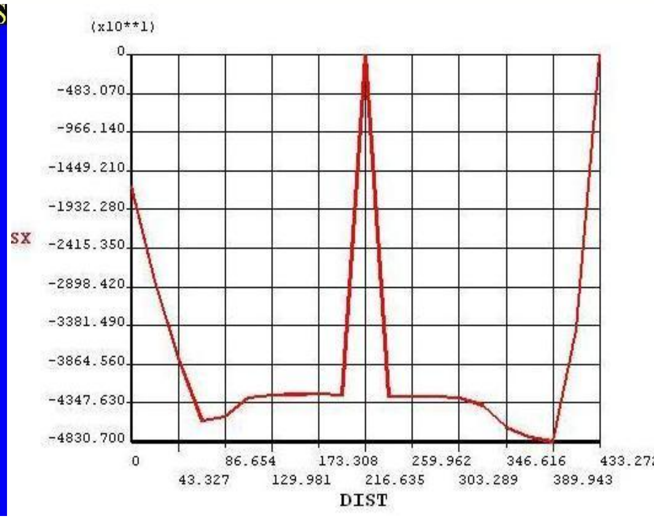


Fig 8: Von Mises stress distribution and graph on disc plane for 30^0 opening

There is stress concentration along three ribs attached to the circular disc. The reason for stress concentration is due to sudden change in area behind the disc. The minus sign in stress means stress developed is compressive while the positive sign means the stress is positive. In x direction along diameter; the compressive stress is about 19320 N/m^2 at x=0 which increases at uniform rate linearly up to 63 mm, remains steady to the value of 43470 N/m^2 up to 194mm.Thereafter it decreases suddenly to **neutral stress** at 216 mm in linear fashion. Afterwards it again increases from zero to 43470 N/m^2 in linear fashion up to 238 mm. The stress remains constant at 43470 N/m^2 up to 303 mm but attains maximum value at 48300 N/m^2 at 389 mm.

When the stresses in the body of valve exceeds beyond a limit then it will lead to its permanent deformation. In worse case, this deformation can lead to the rupture of penstocks too resulting into undesired head at turbine runner in hydropower plant. Therefore the stress computation on disc can be used for design of valve body in butterfly valve.

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