Stresses and Displacement FEM Analysis on Biplane Disks of the Butterfly Valves

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Abstract: - This paper has the purpose to analyse the equivalent stresses and the displacements resulted at the disk of butterfly valve. We used a butterfly valve ND2800 NP1.91 type, loading with the nominal water pressure of 1.91 MPa, using the Finite Element Method (FEM). After solving the FEM analyses, were obtained the equivalent stress von Misses, and the total deformation, for a half of the disk of the butterfly valve. The von Misses equivalent stress determined values not exceed the given admissible value.

Key-Words: - von Misses equivalent stresses, displacements, biplane disks, butterfly valve, FEM

1 Introduction
The Finite Element Method (FEM) is a powerful analytical tool that has applications in a multitude of physical problems, such as acoustics, electrical and magnetic fields, fluid flow, heat transfer, micro fluidics, stress analysis and others, and it remains the method of choice for complex systems.

In the Finite Element Method, the structural system is modelled by a set of appropriate finite elements interconnected at points called nodes. These elements may have physical proprieties [1].

Nowadays, in the design of hydro butterfly valves are commonly used as body type Francis turbine isolation or regulating the water flow.

Due to the simple design, compact and robust and low price, they are best used in hydropower.

The butterfly valve is a safety element for the turbine, having the role of tight closing of water admission into the turbine under normal operation conditions and emergency conditions.

The butterfly valves ND2800 NP1.91 types are mounted in the valve chamber of the hydropower plant, between the penstock and the turbine spiral case.

In this paper we present some results obtained by using Finite Element Method, to determine stresses and main deformations on a butterfly valve ND2800 NP1.91 type.

Static analysis of the disk by the finite element method allows a quantitative and qualitative assessment of the state of stress and strain to highlight critical areas.

2 The butterfly valve
Main elements of butterfly valves are: the housing and a jointly biplane disk mounted on two trunnion, which rotating in the cylindrical shell. The disk of the butterfly valve is shaped to the direction of hydraulic flow, to ensure minimum hydraulic losses, and to balance the forces in the housing of the valve.

The modern solutions for this type of disks have a 0.07 coefficient of hydraulic losses.

The disk is done in welded construction; the trunnion made of cast manganese steel, and rolled steel for general use sheets.

The valve body is made welded; hubs made of cast manganese steel, and rolled steel for general use sheets. Sealing seat is made by stainless steel. The main valve seal is on the circumference of the disk: a stainless steel chair located on the valve...
body, and a rubber gasket. Disk trunnion area is sealed with gaskets kit socket in V shape.

The main characteristics of this butterfly valve are: nominal diameter $D_n=2.900$ mm, nominal pressure $P_n=1.91$ MPa, hydraulic test pressure $P_h=2.856$ MPa.

### 2.1 Main data for the disk calculations

The disk has the cast hubs made from G20Mn5 QT EN 10293, which has the yield strength $R_y=240$ MPa, the tensile strength $R_t=450$ MPa, and admissible stress $\sigma_a=150$ MPa.

On the other hand, the S355J2+N EN 10025-2 rolled profile has the yield strength $R_y=315$ MPa, the tensile strength $R_t=470$ MPa, and admissible stress $\sigma_a=156.6$ MPa.

For this butterfly valve the disk was calculated using the finite element method – or FEM.

### 2.2 Boundary condition (BC)

For considered disk, the boundary conditions are:

- frictionless support, symmetry for the half of the disk (Fig. 1);
- zero displacement in the axial direction on the surfaces after contact with stopper and valve body (Fig. 2);
- zero displacement after X and Y directions for a point located in the middle of the trunnion (Fig. 3).

### 2.3 Loads

At normal pressure on the disk surface $P_n=1.91$ MPa, the load on the disk is shown in figure 4.
3 FEM analyses and results
The FEM static analyze was used to obtain the stress and displacements.

After solving the FEM analyses, were obtained the von Misses equivalent stress (Fig. 6), and the total deformation (Fig. 9), for a half of the disk of the butterfly valve.

It can be observed that the maximum von Misses equivalent stress not exceeds the allowable stress 150 MPa.

The maximum values (Fig. 7 and Fig. 8) for the equivalent stress appear in the transition area between trunnion and disk hub.

The major parts of equivalent stresses do not exceed $\sigma=225 \text{ N/mm}^2$, which are smaller than admissible stress value $\sigma_a=1.5\times150=225 \text{ N/mm}^2$.

The maximum deformation value for disk in closed position is 5.7263 mm at lower side of the disk.
4 Conclusion

As we pointed, the static analysis of the disk for the butterfly valve using the finite element method allows a quantitative and qualitative assessment of the state of stress and strain to highlight critical areas.

The maximum deformations appear in the bottom of the disk and not exceed the value of 5.73 mm.

The butterfly valve disk type ND2800 NP1.91 as critical areas were highlighted areas for connection to the hub disk spindles.

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