WEIGHT OPTIMIZATION AND ANALYSIS OF TRUNNION MOUNTED BALL VALVE

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Abstract **-** There are many kind of valves used in industries now a days. But trunnion mounted ball valve is used, to control the flow of petroleum fluids whose temperatures are higher with higher supply pressure, due to its own helpful characteristics. To acquire the safety along with durability of ball valve, we should consider the structural mechanics such as stress, and identify the important aspects in the stage of preliminary design. For the ball valve, the assurance of structural integrity and operability are essential to meet not only normal, abnormal loading conditions but also functionality during a seismic event. In this dissertation work, topology optimization will carried out based on which we should conclude the results that using this process mass of valve will be reduce as well as the removed material will reduce the overall cost of the given valve. Structural analysis of existing ball valve and also the topological optimization was carried out by using ANSYS Package.

Keywords **– Ball Valve, Structural Analysis, Trunnion, Topology Optimization**

1. INTRODUCTION

A valve is a mechanical device that controls the flow of fluid and pressure within a system or process. A valve controls system or process fluid flow and pressure by performing any of the following functions:

(a) Stopping and starting fluid flow
(b) Varying (throttling) the amount of fluid flow
(c) Controlling the direction of fluid flow
(d) Regulating downstream system or process pressure
(e) Relieving component or piping over pressure

There are many valve designs and types that satisfy one or more of the functions identified above and design safely accommodate a wide range variety of Industrial Application. (e.g., Butterfly valve, Globe valve, Gate valve, Ball valve, Diaphragm valve, etc.)

1.1 Ball Valve

A ball valve is a device with a spherical disc, the part of the valve which controls the flow through it. The sphere has a hole, or port, through the middle so that when the port is in line with both ends of the valve, flow will occur. When the valve is closed, the hole is perpendicular to the ends of the valve, and flow is blocked. The handle or lever will be in line with the port position letting you see the valve's position. The ball valve, along with the butterfly valve and plug valve, are part of the family of quarter turn valves.

Ball valves offer very good shut-off capabilities. A simple quarter-turn (90º) completely opens or closes the valve. This characteristic minimizes valve operation time and decreases the likelihood of leakage due to wear from the gland seal.

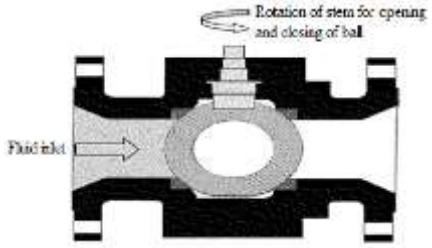

Figure-1 ball valve

1.2 Trunnion Mechanism for Ball Valve

A trunnion mounted ball valve has additional mechanical anchoring at the top and bottom on the ball. This design allows for reduction in valve torque as the ball is supported in two places. The trunnion mounted stem absorbs the thrust from the line pressure, preventing excess friction between the ball and seats, so even at full rated working pressure operating torque remains low. Special mounting is suitable for larger and higher pressure valves.

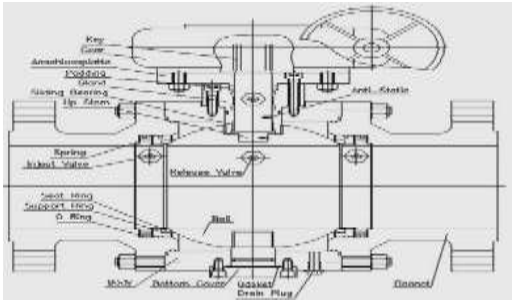

Figure-2 ball valve with trunnion mechanism

2. LITERATURE REVIEW

Some research work has been focused in the related area of analysis and optimization of valves as follows:

Jun-Oh Kim, Seol-Min Yang, Seok-HeumBaek, Sangmo Kang "Structural Design Strategy of Double-Eccentric Butterfly Valve using Topology Optimization Techniques". In this paper, the shape design process is briefly discussed the use of topology optimization in the conceptual design stage.

The basic idea is to view feasible domains for sensitivity region concepts. In this method, the main process consists of two steps: as the design moves further inside the feasible domain using Taguchi method, and thus becoming more successful topology optimization, the sensitivity region becomes larger. In designing a double-eccentric butterfly valve, related to hydrodynamic performance and disc structure, are discussed where the use of topology optimization has proven to dramatically improve an existing design and significantly decrease the development time of a shape design. Computational Fluid Dynamics (CFD) analysis results demonstrate the validity of this approach. By suitably selecting design variables for the modified design and performing an optimization will be our future work.[1]

Shailesh Wamanrao Lokhande, Dr.A.M. Langde "Optimization of Industrial Valve Design Considering Flow Parameter using CFD". In this research work they carried out the characterizing of valve's performance such as pressure drop, flow co-efficient, etc. Research methodology in this research work is as,

- Data gathering of the existing industrial ball valve
- FEA of existing ball valve
- Optimization of existing valve
- Comparison of existing and optimized valve
- Recommendation

From the optimization results it is concluded that due to pressure drop in optimized design we can achieve high efficiency of flowing.[2]

Dong-Soo KIM, Myoung-Sub KIM had used Cryogenic ball valve to control the liquefied natural gas which temperature is -196ºC and supplied pressure is 168kg/cm2. In this paper analytic approach, finite element analysis and computational method are herein presented to evaluate the aspects of structural integrity along with operability and optimal design through special processing and heat treatment for cryogenic ball valve that accomplished zero leakage. The flow analysis on the ball valve was carried out using FLUENT in which ball valve were analyzed with inlet and outlet pressures of 168kg/cm2 and 80kg/cm2, respectively, to obtain the velocity distribution and eddy flow of LNG according to the valve position.

The design of the constituent parts of the ball valve including the body, seat, bonnet, ball and spring, were optimized and high-pressure cryogenic ball valve that can achieve zero leakage was designed.[3]

Mr. Shridhar S. Gurav, Dr. S. A. Patil, this paper gives the brief look on the suitability of gate valve weight reduction by using finite element analysis and compare with experimental stress analysis with matching principal stress one and two and von-mises stress theoretical and actual and according to that weight reduction of valve body using constrains of valve body pressure and stress. A review suggests that in forthcoming efforts analysis of gate valve could be best possible with Finite Element Method with ANSYS. The future work is to design the gate valve body for weight optimization the Principal stress first, second and von-mises stress value are find out by using FEA and using Experimental stress analysis(strain gauge rosette) we will find value of Principal stress and von-mises stress and compare value actual and theoretical and we will optimize weight.[4]

Xue-Guan SONG, Seung-Gyu KIM, Seok-Heum BAEK, Young-Chul PARK Ball valve has been used widely in various industries and which is usually work to achieve perfect shut-off the fluid flow in the pipe. In this paper to optimization carried out on the fluid coefficient, the mass and structure safety of a ball valve. The material experiment was carried out of ASTM A296, CF8M of which the ball inside valve was made in which CFD and FEM analysis performed to calculate the pressure loss coefficient and the maximum stress on the valve disc.

The FE model meshed with tetrahedral elements and CFD model in which seven analyses has been carried out when the valve had opened at different angles. It is found that the maximum stress of 158.1MPa and the pressure distribution at 50º in the ball occurs at the connection place between ball and upper stem when the valve is closed.

The mass of ball is optimized by,
Minimize;
Mass of ball, m;
Pressure loss coefficient, K1;
Maximum stress σ max
Subject to,
σ max ≤ 205 MPa;
K1 ≤ 1.0;
x lower ≤ xi ≤ x upper (i=1,…, 6)

By performing the optimization the mass of ball valve is reduced from 2.34 kg to 1.95 kg while the maximum stress and pressure loss coefficient are still kept in the available range.[5]

C.C. Tsai, C.Y. Chang and C.H. Tseng, the objective of this paper study is to design a new metal seat mechanism for the ball valve. The design optimization is completed by the ANSYS package. The novel design of the metal-seated ball valve provides low torque, low wear and long life. This study used the Quality Function Deployment (QFD) technique and the Theory of Inventive Problem Solving (TRIZ) method to design a new metal seat mechanism in a ball valve. TRIZ offers powerful tools for clarifying a problem and for concept generation. It offers an alternative to traditional thought processes, leading to innovative solutions. CAD and CAE software plays an important role in the design phase. The geometry and dimensions of the prototype can be easily defined with the help of CAD software. CAE software simulates and optimizes the prototype condition in a ball valve.[6]

P. Ebenezer Sathish Paul, G. Uthaya Kumar, S. Durairaj, D. Sundarrajan, the CFD analyses performed for both ball valve and gate valve is necessitated with input parameters that outfit the application such as pressure, density, viscosity and temperature. The verification studies put forth for the pressure distribution generated due to fluid flow through the valve system is in stripe with end results. Furthermore FEA has become a solution to the task of predicting failure due to unknown stresses by showing problem areas in a material and allowing designers to see all of the theoretical stresses within. This method of product design and testing is for superior to the manufacturing costs which would accrue if each sample was actually built and tested.[7]

3. SOLID MODELING OF BALL VALVE PARTS & ASSEMBLY

Design and solid modeling of ball valve is done as per standards API 6D, ASME B16.34 & BS 5351 using PTC CREO software.

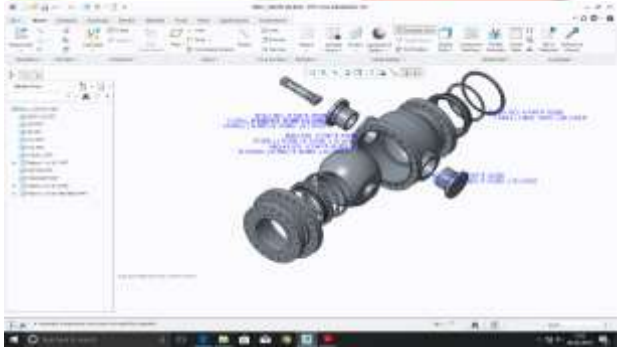

Figure-3 solid models (with expandable view)

Expandable view of the valve assembly is shown in Fig-3. Fig-4 shows the sectional view of valve when it is in fully open condition while Fig-5 shows fully closed condition of the valve.

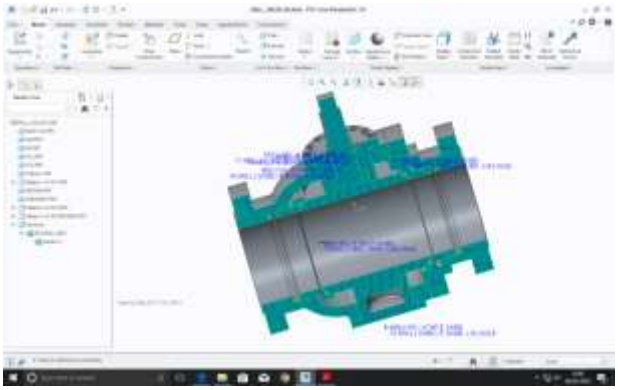

Figure-4 sectional view of valve assembly (fully open)

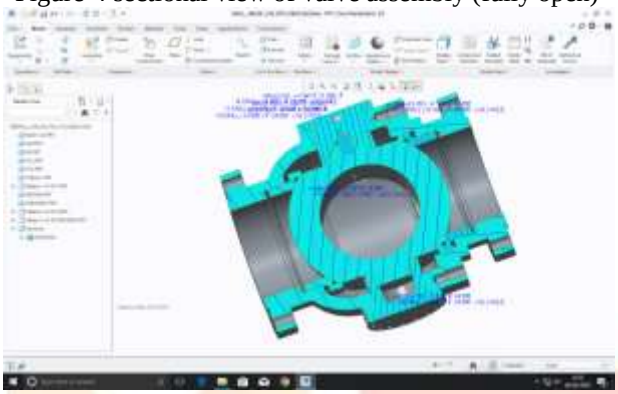

Figure-5 sectional view of valve assembly (fully close)

4. ANALYSIS AND TOPOLOGY OPTIMIZATION OF VALVE

Structural analysis is done after calculating pressure on the body of the valve, which is carrying more weight than any other parts, using ANSYS 18.1 software.

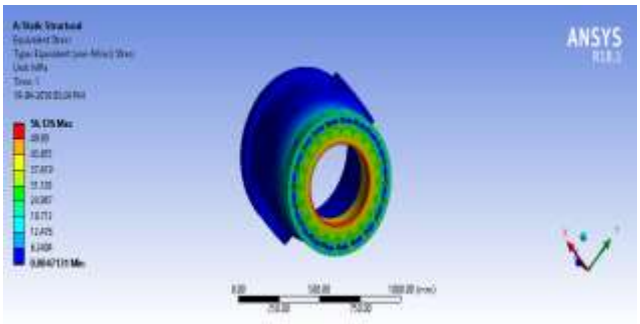

Figure-6 structural analysis after applying boundary conditions

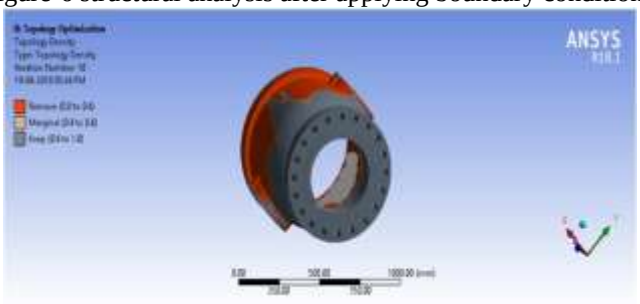

Figure-7 topology optimization final result after 10 iterations

After structural analysis, topology optimization of ball body is carried out to reduce its mass and re-flow the material density. From above Fig-7 we can see that there is some material which can be removable.

5. CONCLUSION

In this project work, ball valve model is created from existing design as per standards for valves. Modeling is done in CREO software and then the structural analysis is carried out on ANSYS. From the results of analysis, we see the equivalent stress (Von-Mises Stress) for valve body which is used for analytic calculations. After that at next stage from structural analysis results topology optimization was carried out for 10 iterations. The solution of the topology optimization shows the regions in different shade which provides the information on which area keeps the material and at which area we could remove the material.

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