

Review on Modeling and FEA Analysis of Ball Valve

Parth Mandanaka¹ Prof. Hitesh Raiyani²

¹P.G. Student ²Assistant Professor

²Department of Mechanical Engineering

^{1,2}L.J. Institute of Engineering & Technology, Ahmedabad

Abstract— The valves are frequently used for controlling the flow within different medium. Due to the interaction between the sealing elements of the valve, wear occurs that directly affects the life cycle of a valve in service. Specifically, in ball valves a seal is created between the valve ball, usual a metal material, and the valve seats made of a softer material. Due to the mismatch in material hardness, the valve seats exhibit wear. In this report several different methods of examining the loading configuration and the affect it has on the wear the valve components will be studied. The mechanical and chemical properties ball valve studied through experiments. An application of valve body was analyzed by using finite element method(FEM) to evaluate the structural safety. An optimization containing several variables based on different method was conducted to find the optimum dimension of the valve.

Key words: Ball valve, Seat, Structural safety, FEM

I. INTRODUCTION

Valves are essential type of fitting to any system as they regulate control and regulate fluid flow within that system. As a valve is designed to regulate flow it is critical that the plug properly contacts the seat surface to create a seal that is leak-proof. Seats are classified in two separate categories: hard seats and soft seats. Hard seats, made of metal and integral to the valve body

Hard seat ball valves are not typically used as it is difficult to obtain a leak proof seal due to the metal on metal contact between the seat and ball. However, with the improvements of modern machining using CNC devices, hard seat ball valves now have applications in power plants where soft seat ball valves fail due to high temperature and pressure. Soft seat ball valves are often advantageous due to low cost as well as being small in nature they are easy to design into a system. As these are seats are made of a much softer material than the metal ball, the design life of the valve seats must be taken into consideration due to seat wear the material property and fluid use in this valve are big part of selection valve. A solution to this problem is to replace the plastic seats with metal seats, which can make effective seals, but this is not as easy might sound. The fundamental requirements of a high performance valve are that it works well at high pressure, at high temperature, and in environments with corrosive or hazardous materials. So that need to FEA analysis of the high pressure ball valve Determining the compressive strength of the sealing cups for each material by applying compressive force on the sealing cups. Here some of research paper reviews for that FEA analysis.

II. LITERATURE REVIEW

Gheorghita TOMESCU, Iuliana IAȘNICU (STAMATE) (2015) [1] “Finite element analysis of ball valves.” This paper gives methodology of ball valve design by using CAD

design and FEA verification at maximum loading pressure. The main purpose is structural analysis to be carried out of determining stress and strains developed in the valve body and other elements. The result shows that Extreme values of static stress obtained in the points in the near to the generator plan through hole of the sphere decreasing the size of the mesh element or using finite elements by higher order. The static displacements values on the sealing area is compared with the displacements of nodes selected by the metal sealing ring with the exception of nodes that are in the passage opening, where in the wall thickness of the sphere is smallest. It can be seen that static stress and displacement nodal are not changed significantly and this may be explained by the large size and high temperatures significantly affect the sealing area.

Dong-Soo KIM, Myoung - Sub KIM September, 2008) [2]“Analysis and design of cryogenic ball valve”

In this study, a high-pressure, cryogenic ball valve that can achieve zero leakage was designed. To acquire the safety along with durability of cryogenic ball valve, we should consider the structural mechanics such as stress, deformation and dynamic vibration characteristics and identify those important aspects in the stage of preliminary design engineering. For the cryogenic 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 study, analytical approach and results using finite element analysis and computational method are here in presented to evaluate the aspects of structural integrity along with operability of cryogenic ball valve. Moreover, we have done the optimal design through special processing and heat treatment and so on. Finally, we designed the high pressure cryogenic ball valve that accomplishes zero leakage. In this study, a numerical analysis is conducted for the structural safety and the distribution of thermal stress and deformation by thermal shock under high pressure and very low temperature conditions, in order to assess the safety and reliability of the ball valves for LNG to provide a basis for the design and manufacturing of products which are safe from leakage under conditions of extreme temperature variance.

Gheorghita tomescu, radu iatan, iuliana iașnicu (stamate) (2015)[3] “optimization of dimension and shape for ball valve Body in fire safe design “The fire safe valves are designed for petroleum and petrochemical complexes and allied industries because working fluid characteristics result in a high fire risk, detonation and / or explosion. Fire Safe Certification is achieved through a standardized fire testing. This article aims to show how to optimize the shape and size of the main body of a ball valve in sequence CAD – FEM - testing and evaluation of the performance of valves when exposed to fire. The results of finite element analysis allowed correcting deficiencies in design and manufacturing. The difference between the classic ball and the optimize done are: the valve body is modified by

increasing the radius of connection of cylindrical area with the spherical area, resizing of sealing metal ring into the body valve, ring size above the stem collar correlated with arrow tensioners of disc springs, replacement materials for seals.

IonelPopescu, Radu Mihai Negriu, Sorin George Badea, CristinelBesleaga, Mihai Stefanescu(May-2012)[4]“Ways of deteriorating the balls with structural gradient from the valves used in the oil extraction industry.”Valves is formed from ball and seat in system. The balls must withstand the complex erosive-abrasive wear determined by corrosive environments, the effect of high temperature will also occur. Several experimental batches of balls with structural gradients are made using different extremely hard alloys. This analysis, using finite elements, of the tension states that occur during the process is performed and the life span of the balls is estimated. This present the analysis of the ways of deterioration caused not only by usage in the process, but also by the manufacturing defects of balls with a structural gradient. The complex analyses that are performed to determine the causes and the mechanisms of deterioration are presented and also technological ways to improve the life span. Here The main cause of deterioration is the wear phenomenon that no longer allows the correct closing and because of this, loss of fluid occurs. Serious deteriorations can still occur due to wear phenomena or internal defects produced in the manufacturing process which, combined with the thermo-mechanical state of stress can lead to breakage of the valve’s components.

Dr. K.H. Jatkar, Sunil S. Dhanwe(April 2013)[5]“Finite Element Analysis of Gate Valve”The objective of this paper to perform a stress analysis of the critical component of Gate Valve. The critical components in the Gate Valve are Body, Gate Stem and slab gate. This paper comprises Finite element analysis of Gate Valve. A model of each element of Gate Valve is developed in CATIA V5R17, and analyzed in ANSYS 11. Gate valve stress analysis is done by FEM using ANSYS 11 and validation is supported by stress analysis using classical theory of mechanics. Finally, the result obtained from FEM software and classical analytical theory is compared. From the obtained results the stress values obtained by classical theory of mechanics & stress values obtained by Finite element method (FEM) are approximately same, so we conclude that the above results are correct valve is safe to produce and we can use these results in further development of Gate Valve.

A. TUDOR, R. NEGRIU, I. RADU, V. DUMITRU (December 2003).“A Wear Study Case of Ceramic Ball Seat Valve”This paper describes an erosion- corrosion wear model of carbide materials in crude petroleum fluid flow. The wear model is based by elastically or plastically fatigues, when the corrosion fluid has solid particles. The velocities of solid particles are evaluated by the Reynolds equation. Mathematical model for solid particle has been combined with those for crude petroleum corrosion. This has been addressed through the ball valve of crude petroleum extraction pump. The paper describes some new theoretical developments on the above work. The synergic effect of erosion and corrosion rate was observed for carbide and ceramic composites. Theoretical erosive-corrosive wear

model has been used to define the possibility to increase the durability of ball and seat valve. This model is able to solve the contact problem under flow of contaminated corrosive fluid with abrasive particle. It is in the angular gap between the ball and the seat valve.

Ming-JyhChern, Chin-Cheng Wang, Chen-HsuanMa(April 2006)[7]“Performance test and flow visualization of ball valve.”The main purpose of this study is to provide flow characteristics and flow patterns inside ball valves using an experimental approach. In general, the openings of a ball valve and the inlet velocity play vital roles in the flow characteristics of ball valves. The following sections describe the details of the proposed experimental procedure. By employing the particle tracking flow visualization method and the flow rate/pressure measurement technique, the performance characteristics and the inside-valve flow patterns are studied in this paper. The following conclusions are drawn from the results. First of all, features of flows in a ball valve, including three vortices and cavitation, can be observed by experimental results at varying inlet flows and valve openings. Subsequently, the valve performance can be determined by the loss coefficient K and the flow coefficient C_v using the pressure and flow rate information in experimental data.

Prof. Sanjeev. A. Janawade , Mr. Venukumar R Bankapur (July 2015)[8]“Design and Analysis of High Pressure Ball Valve Sealing Cup with Different Sealing Materials”Generally ball valves used have operational pressure range 10 bar to 1000 bar. When the flow line pressure exceeds 150 bar, the valves are known as high pressure valves. With the increasing pressure, the design of the various components of the valve becomes critical. The design of high pressure valve components depends on the pressure, temperature ratings and also on other factors. Here the design calculation is done for sealing cup. The maximum stress and deflection is calculated for different sealing cup materials for a test pressure. Sealing cup is modeled using catia modeling software and analyzed by use of Ansys software for test pressure. The analyses are done for different sealing cup materials with different element sizes. The above research work we can get the difference in stress and deformation value for all material in high pressure ball valve. the result depends on the Design of sealing cups that will be based on the compressive strength of the material.

Shinji Kajiwara (April 2014)[9]“Effect of the check ball and inlet position on hydraulic L-shaped check ball behavior”The spring-driven ball-type check valve is one of the most important components of hydraulic systems: it controls the position of the ball and prevents backward flow. To simplify the structure, the spring must be eliminated, and to accomplish this, the flow pattern and the behavior of the check ball in the L-shaped pipe must be determined in this paper, that present the relationship between the initial position of the ball, the position of the inflow port, and the kinematic viscosity of oil. The objective of this research is to realize hydraulic ball valves that do not use a spring. Tests were conducted to measure the check flow rate and rotational speed under different hydraulic fluid inflow positions, ball positions, and hydraulic fluid kinetic viscosities as well as to visualize the flows in the vicinity of the ball. The results showed that using inflow from the side

to actively cause a swirling flow made it possible to raise the ball at low flow rates. However, because the various parameters such as swirling flow strength, relative position of the ball, and hydraulic fluid viscosity mutually interact.

Mahesh Kamkar, Prof. S. R. Basavaraddi (June 2015)[10] “Conceptual design and analysis of high pressure ball valve” This paper involves designing the high pressure valve of nominal diameter 25mm. When the flow line exceeds 150bar, the valves are known as high pressure valves. With the increasing the pressure, the design of various components of the valve become critical. The designing of high pressure ball valve components depends on pressure, temperature ratings and also other factors. The design calculation is done for sealing cup, ball, connection adaptor, valve housing and operating lever. The maximum stress and deflection is calculated for different sealing cup materials under high pressure. The torque required to operate the valve, which includes breaking torque, running torque and ending torque are calculated and compared with technical information from research study.

Xue-Guan SONG, Seung-Gyu KIM, Seok-Heum BAEK, Young-Chul PARK (May 2009)[11] “Structural optimization for ball valve made of CF8M stainless steel.” In this paper researcher evaluate the structural safety. An optimization containing several variables based on the response surface method(RSM) was conducted to find the optimum dimension of the valve. The main purpose of this study is to optimize the fluid coefficient, the mass and structure safety of a ball valve at the same time. First, the material experiment was carried out to research the properties of CF8M, of which the ball inside valve was made. Then, CFD and FEM analyses of this type of ball valve were performed, respectively, to calculate the pressure loss coefficient and the maximum stress on the valve disc. At last, the computer experiments and optimization method were conducted to obtain the optimum result.

S. Bagherifard, I. Fernández Pariente, M. Guagliano a (March 2013)[12] “Failure analysis of a large ball valve for pipe-lines” In this work the failure of a sub-sea ball valve, used in an oil-piping line, is analysed. The valve was of the same type and material already used for the construction of valves that were worked in service without any problem. The valve failed in the first pressure cycles during the preliminary laboratory tests, although the applied pressure was less than the design value. Metallographic and microstructural analysis of the fracture surfaces performed by means of optical and scanning electron microscope (SEM), residual stress and hardness measurement, tensile, toughness and Charpy tests, were executed in order to identify the causes of the failure. The results allowed assessing that the failure was due to two concomitant factors: a severe notch effect and an incorrect thermal treatment.

G. Gokilakrishnan, S. Divya, R. Rajesh, V. Selvakumar 4 (December-2014)[13] “Operating torque in ball valves.” Ball valve is a one way valve with a spherical disc, which controls the flow through it. Torque is the main factor for operating ball valves. Most of the ball valves require high operating torque for its operation, some external devices are required to overcome this torque. Hence more research is necessary to reduce the operating torque; thereby one can reduce manual effort. This paper deals with

basics, advantages and disadvantages of ball valve, torque and its importance in ball valves, torque measuring and applying instruments used for ball valves. The basics of operating torque and ball valves were presented in this paper. Each ball valve requires minimum torque for its operation. If ball valve needs more torque than required minimum torque, during its operation, manual handling will be very tough. To reduce the manual effort and eliminate the use of external device more research work is needed.

III. CONCLUSIONS

In general, the researchers give different methods for modelling ball valve and develop models for different material. One of the researchers Dr. K.H. Jatkar, Sunil S. Dhanwe has carried out on FEA analysis for ball valve in ANSYS. Which helpful for study the effect of fluid flow and pressure load on valve during operation.

Following are some points which shows the entire review of the above research’s papers and thesis.

- From the first paper we get the stress maximum where the thickness of cylinder less and temperature effect on sealing cups.
- From research work we can get the difference in stress and deformation value for all material in high pressure ball valve which based on the compressive strength of the material.
- Some researchers have developed Conceptual design and analysis of ball valve to understanding maximum stress and deflection for different materials under high pressure
- Other papers are for give performance test and improved method to reduce the valve wear

As per review of research papers, we can see that no one has focus on wear of ball valve during operation cause of different soften material carried out which should be change with high strength material in sealing element. After study of many research papers and market survey, it should be need to understand that design of valve. In this project work, try to improve ball valve over leakage cause of wear inside the ball seat and ball.

REFERENCES

- [1] Gheorghita Tomescu, Iuliana Iasnicu (Stamate), “finite element analysis of ball valves” The Scientific Bulletin of Valahia University – Materials And Mechanics Nr. 10(2015)
- [2] Dong-Soo KIM, Myoung-Sub KIM “Analysis and design of cryogenic ball valve”, 7th JFPS SAE TP 910960, pp.1-26(2008)
- [3] Gheorghita Tomescu, Radulatan, Iuliana Iasnicu (Stamate) “optimization of dimension and shape for ball valve Body in fire safe design” Journal of Engineering Studies and Research – Volume 21 No. 3(2015)
- [4] Ionel Popescu, Radu Mihai Negriu, Sorin George Badea, Cristinel Besleaga, Mihai Stefanescu “Ways of deteriorating the balls with structural gradient from the valves used in the oil extraction industry.” New Trends in Fatigue and Fature UDK/UDC:620.19:621.65.(May-2012)

- [5] Dr. K.H. Jatkar, Sunil S. Dhanwe, "Finite Element Analysis of Gate Valve International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 10, April (2013).ISSN:2277-3754
- [6] A. Tudor, R. Negriu, I. Radu, V. Dumitru, "A Wear Study Case of Ceramic Ball Seat Valve"1995 Tribology in industry, Volume 25, No. 3&4, (2003)
- [7] Ming-JyhChern, Chin-Cheng Wang, Chen-Hsuan Ma., "Performance test and flow visualization of ball valve", Journal of experimental thermal and fluid science 31(2007)pp.505-512
- [8] Prof. Sanjeev. A. Janawade , Mr. Venukumar R Bankapur "Design and Analysis of High Pressure Ball Valve Sealing Cup with Different Sealing Materials"International Research Journal of Engineering and Technology (IRJET) Volume :02 Issue: 04 July-2015 e-ISSN: 2395 -0056
- [9] Shinji Kajiwara "Effect of the check ball and inlet position on hydraulic L-shaped check ball behavior". Journal of Fluids and Structures 39,pp.237–257,2013-2014.
- [10] Mahesh Kamkar , Prof.S.R.Basavaraddi " Conceptual design and analysis of high pressure ball valve" International Research Journal of Engineering and Technology (IRJET) Volume: 02 Issue: 03 June-2015 e-ISSN: 2395-0056
- [11] Xue-Guan SONG, Seung-Gyu KIM, Seok-Heum BAEK, Young-Chul PARK "Structural optimization for ball valve made of CF8M stainless steel."Trans. Nonferrous met. Soc. China 19 pp.258-261(2009)
- [12] S. Bagherifard a, I. Fernández Pariente b, M. Guagliano a (March 2013)[12]"Failure analysis of a large ball valve for pipe-lines" Engineering Failure Analysis 32 pp.167–177 (2013)
- [13] G. Gokilakrishnan, S. Divya, R. Rajesh, V. Selvakumar (December-2014) "Operating torque in ball valves." International Journal For Technological Research in Engineering Volume:2 Issue :4(2014) ISSN-2347-4718.