International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.03, February 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

"ANALYSIS AND DESIGN OPTIMISATION OF 200MM-150 CLASS GLOBE VALVE BODY BY USING FEA AND VALIDATION BY USING EXPERIMENTAL STRESS ANALYSIS METHOD"- A REVIEW

Ms. Pataskar Snehal Krishna[1], Prof. Mr. E.N.Aitavade[2]

[1]Department of Mechanical Engg, Ashokrao Mane Group of Institutions, Vathar, Dist-Kolhapur, Maharashtra,

[2]Department of Mechanical Engg, Ashokrao Mane Group of Institutions, Vathar, Dist-Kolhapur, Maharashtra,

ABSTRACT

Globe valves are one of the oldest valve types used for throttling application for all sizes due to better controllability and range. This paper focuses on the design and analysis of 200mm-150 Class asymmetric globe valve with focuses on eliminating the problem faced by conventional globe mentioned above. 150 rating is the starting class of high pressure valve. Normally this is a closed valve used in between feed pump and boiler. Analysis of this globe valve takes place for high temperature applications. All the designs are based on BS and ASME standards.. All the main components are designed and detailed drawing is produced. Modeling is produced on CATIA and the stress analysis is performed on ANSYS Software. Validation of FEA results is done by using Experimental stress analysis method. Now-a-days cost of the materials is very high, so there is need to minimize the cost. For this purpose, it is necessary to optimum use of man, machine and material. So that it is very important to reduce the weight of the globe valve body.

Keywords:-CATIA, CFD, Finite Element Analysis, Globe Valve, Stress

I.INTRODUCTION

Globe valves are closing-down valves in which the closure member is moved squarely on and off the seat. It is customary to refer to the closure member as a disc, irrespective of its shape. By this mode of disc travel, the seat opening varies in direct proportion to the travel of the disc. This proportional relationship between valve opening and disc travel is ideally suited for duties involving regulation of flow rate. In addition, the seating load of globe valves can be positively controlled by a screwed stem, and the disc moves with little or no friction onto the seat, depending on the design of seat and disc. The sealing capacity of these valves is therefore potentially high.

International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.03, February 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

II.THEORY OF GLOBE VALVE BODY

A Globe Valves is a linear motion Valve and are primarily designed to stop, start and regulate flow. The disk of a Globe Valve can be totally removed from the flow path or it can completely close the flow path. Globe valves are extensively employed to control flow. The range of flow control, pressure drop, and duty must be considered in the design of the valve to avert premature failure and to assure satisfactory service. Valves subjected to high-differential pressure-throttling service require specially designed valve trim. Generally the maximum differential pressure across the valve disc should not exceed 20 percent of the maximum upstream pressure or 200 psi (1380 kPa), whichever is less. The basic parts shown in Fig.1 are as follows:-

1. Valve Body:

The Valve body is the first boundary of a pressure Valve. He serves as the main element of a valve assembly because it is the framework that holds all the parts together. Valve bodies are cast or forged in a variety of forms and each component have a specific function and constructed in a material suitable for that function.

2. Valve Bonnet

The cover for the opening in the body is the Valve Bonnet, and is the second most important boundary of a pressure Valve. Like Valve bodies, Bonnets are in many designs and models available. A Bonnet acts as a cover on the Valve body, is cast or forged of the same material as the body. It is commonly connected to the body by a threaded, bolted, or welded joint.

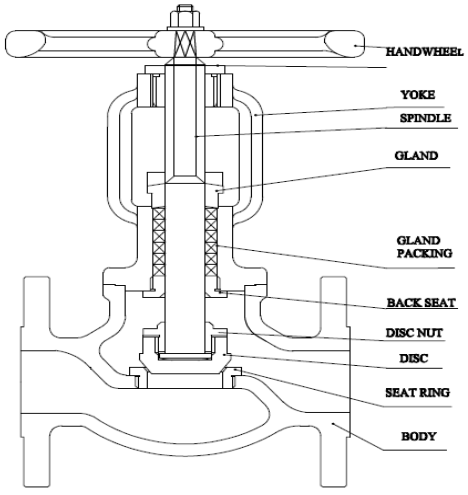

Fig.1.Diagram of Globe Valve body

3. Valve Disc

The disc is the part which allows, throttles, or stops flow, depending on its position. In the case of a plug or a Ball Valve, the disc is called plug or a ball. The disc is the third most important primary pressure boundary. With the Valve closed, full system pressure is applied across the disk, and for this reason, the disk is a pressure

related component. Discs are usually forged, and in some designs, hard surfaced to provide good wear properties.

4. Valve Seat

A Valve may have one or more seats. In the case of a globe or a swing-Check Valve, there is usually one seat, which forms a seal with the disc to stop the flow. For a good sealing, a fine surface finish from the seating area is necessary. In some designs, the body is machined to serve as the seating surface, in other designs, forged seal rings are threaded or welded to the body. To improve the wear resistance of the seat or seal rings, the surface is often hard faced.

5. Valve Stem or spindle

The Valve stem provides the necessary movement to the disc, plug or the ball for opening or closing the Valve, and is responsible for the proper positioning of the disk. It is connected to the Valve hand wheel, actuator, or the lever at one end and on the other side to the Valve disc. In Globe Valves, linear motion of the disc is needed to open or close the Valve, To prevent leakage, in the area of the seal, a fine surface finish of the stem is necessary.

III. LITERATURE REVIEW

The aim of the literature review was to get the detail about the approach of methodology adopted in carrying out analysis and design optimization of 200mm-150 class globe valve body.

Sonawane etal. [1] have presented on CFD analysis of globe valve .The objective of this paper is to observe the flow patterns of the valve using CFD software, by varying the flow rate and constant pressure drop access valve in a valve system. The future scope includes that these results of 3D analysis can be used for design of low noise analysis and high efficiency valve for industrial applications .

Balpreet Singh etal.[2] have briefly explains the typical problems faced in the industry with the conventional globe such gland packing eyebolts at low temperature behavior of globe valve under higher or lower temperature conditions. It deals with directional deformation, equivalent elastic strain and equivalent von misses stresses with respect to changing temperature. It has been shown that how FEA tools help in analyzing valve behavior in different temperature conditions. Behavior of stainless steel material under higher or lower temperature condition is analyzed.

Dr. K. H. Jatkar etal.[3] have explained Finite Element Analysis of Gate Valve which is 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 valid action is supported by stress analysis using classical theory of mechanics.

Deokar Vinayak Hindurao etal. [4] have presented FEA analysis of Plug–valve body followed by Experimental stress analysis using strain gauge method for weight optimization. New optimized models were prepared on the basis of validation of the results obtained from stress analysis procedure. The weight reduction is done by changing the wall and rib thickness. The results clearly shows the maximum weight reduction is

24.86 kg (5.26%) weight of original weight while keeping maximum stress level up to 168.6 N/mm2 which is safe for the applied load.

James A. Davis etal.[5] have worked on Predicting Globe Control Valve Performance. An experimental study was undertaken to verify an axisymmetric numerical model of a control valve flow field. The numerical model, which utilized Computational Fluid Dynamics (CFD), was formerly developed to be used as a design tool by manufacturers of control valves. In this work the model was first tested by comparing its results to data taken on an axisymmetric flow field experiment. Then the model's application to actual three-dimensional control valves was tested by studying the pressure and flow field through a three-dimensional control valve. The results showed that the axisymmetric numerical model is accurately modeling an axisymmetric flow field. In addition, the results showed that control valves have a predominantly axisymmetric flow field for most of their plug travel which make them suitable for the model. Finally, the results showed details about the flow field such as where separation and reattachment may occur.

Pradnyawant K. Parase[6] has explained Weight optimization of 12"-150 Class Plug valve Casting Body by Finite Element Analysis, a computational technique used to obtain approximate solutions of boundary value problems in engineering. Simply stated, a boundary value problem is a mathematical problem in which one or more dependent variables must satisfy a differential equation everywhere within a known domain of independent variables and satisfy specific conditions on the boundary of the domain. Boundary value problems are also sometimes called field problems. The field is the domain of interest and most often represents a physical structure.

Pavel Macura etal.[7] have worked on Experimental Residual Stress Analysis of Welded Ball Valve. The paper is devoted to the issues of experimental analysis of residual stresses on the concrete part of pipelines – welded ball valve. A semi-destructive hole-drilling method was used for measurement, and experimental stress analysis and evaluation of residual stresses was made in accordance with the US standard ASTM E 837 – 01 as well as with use of an integral method. Residual stresses were measured both immediately after welding and after pressurizing of the ball valve. This has enabled observation of the influence of pressurizing on change of residual stresses in the neighborhood of the welded joint. Results of measurement of residual stresses served for further assessment of strength and service life of this component.

Ivica Galić etal.[8] have focused on the two-way globe valve housing DN50 PN160 subjected to internal pressure is investigated. Three-dimensional nonlinear finite element analyses are performed to obtain the plastic yield, collapse and instability pressures. For the determination of the plastic collapse pressure, twice-elastic-slope and the tangent intersection methods are used. The allowable pressure is obtained according to the limit design method. Unlike the previous investigation of the three-way globe valve housing DN100 PN40, it is shown that allowable pressure for the two-way globe valve housing calculated by the application of the EN 12516-2 standard is highly conservative in comparison with the one derived by the application of finite element results for the plastic collapse pressure, in accordance with the limit design method. Additionally, it is shown that the results for the failure pressure can be obtained by a simpler finite element analysis without taking into consideration the material hardening and geometrical nonlinearity.

Nenad Mitrovic etal.[9] have focused on the case of globe valve under internal pressure. Digital image correlation (DIC) method and software Aramis were used in the experiment for the verification of the globe valve model and further numerical simulation. Several valve models were created and analyzed, and the one that fits best the experimental results is presented. Finite element analysis (FEA) is used for numerical calculation of displacements, strains and stresses within the globe valve. 3D model of globe valve is discretized in fine mesh model consisting of 15131 tetrahedran finite elements and 49699 nodes. The experimental strain field results of the part of the globe valve subjected to 25 bar internal pressure are presented .

Prabha Kurian etal. [10] focused on the design and analysis of a 4x900 asymmetric globe valve with focuses on eliminating the problem faced by conventional globe mentioned above. 900 rating is the starting class of high pressure valve and this valve is used for 300MW power generation plant. Normally this is a closed valve used in between feed pump and boiler. All the designs are based on BS and ASME standards. The dimensions components in the globe valve is based on either standards or arrived during assembly. All the main components are designed and detailed drawing is produced. The stress and flow area analysis is performed on SOLIDWORKS COSMOSXPRESS AND FLUENT SOFTWARE. This design reduces the production and maintenance cost than the existing valves that used in the same application. Valve flow path design is normalized, therefore internal turbulence is reduced and noise levels are eliminated through cages with uniform holes instead of a large port area.

Mahesh C.[11] has explained a double seated noiseless butt welded 3000 rating globe valve which is designed, modeled and analyzed. 3000 rating valve is a very uncommon valve. It can withstand very high pressures up to 10000psi and it is very heavy. The designing standards like ANSI, API and ASME etc. are used for designing the various components. The 2D modeling is done in AutoCAD and 3D modeling is done in Solid Works software's. Flow area analysis is done to check whether the flow path area is nearly the same or not. Finite Element Analysis (FEA) is done to check whether the valve can withstand the high pressures under which it is going to work. FEA is done using Cosmos works. During FEA, a pressure of 15000psi is applied on the valve body and stress distribution, displacement distribution and strain distribution are found out and it is concluded that the design of the globe valve is within the safe limits .

Rajendra V. Bijwe[12] has explained Topology Optimization of Fabricated Globe valve. A globe valve generally is used to rheostat flow (stream) in a pipeline, containing of a mobile disk-type component and a fixed ring seat in a spherical body. It is about reducing the cost of the in-production Globe valve which used in Sugar industry. This Globe valve is produced by Scrolling Industries Pvt. Ltd. Kolhapur. The company wanted to reduce the weight of the globe valve without compromising on the performance parameters. For this it is vital to conduct thorough revision of the same using FEA codes. In this project He worked on the Optimization of design of Industrial Valve considering the physical parameters using topology optimization, this helped him to improve the existing designs of the valves by bringing down the cost. In present study, he created the CAD model of Globe valve. Then analysis of the existing design was performed. Then topology optimization of existing process parameters was performed. Then analysis of optimized (improved) design was performed. In final stage publishing of final design was performed.

Qin Yang etal. [13] have worked on Numerical Simulation of Fluid Flow inside the Valve Stop valves are commonly used as fluid flow control equipments in many engineering applications. In this paper, three-dimensional numerical simulations were conducted to observe the flow patterns and to measure valve flow coefficient and flow fluctuations when stop valve with different flow rate and uniform incoming velocity were used in a valve system. The spectra characteristics of pressure fluctuation on the flow cross section were also presented here to investigate the wake induce of the valve part. These results not only provided people with the access of understanding the flow pattern of the valve with different flow rate, but also were made to determine the methods which could be adopted to improve the performance of the valve. Furthermore, the results of the three-dimensional analysis can be used in the design of low noise and high efficiency valve for industry.

Claudio Alimonti[14] has explained Experimental characterization of globe and gate valves in vertical gas–liquid flows. Valves are mechanical devices commonly used in pipelines and pipe networks for industrial applications, including petroleum, power and process industries. In two-phase flows more complex flowing conditions occur and special attention must be paid to predict pressure losses. To date, studies on two-phase flows through valves have been mainly devoted to safety relief valve (SRV). This paper presents the results of an experimental characterization study of a globe and a gate valves 200 DN. The aim of the study is to investigate the flow through this type of valve, to understand the phenomena that occur inside and to improve models to calculate pressure drops in two-phase flow conditions. The valve has been preliminary characterized in single phase flow obtaining quite good results. The flow coefficient of the valve has been determined in order to proceed in two phase tests. Comparison between two phase flow measured data and predictive models has been considered. The Chisholm model seems to give the best agreement with the data in the observed interval for the globe valve. The best model for the gate valve seems to be the Lockart –Martinelli modified model. Predicting pressure drops in both cases, the average error is close to zero and less than ±10%.

IV.CONCLUSION

From the papers referred above many conclusions can be drawn. These are summarized below:

1. CFD analysis is performed to analyze the effect of shapes of plug and seat on the flow. From the analysis it is observed that for quick opening valve, trial 1 & trial 4 set can be used. For linear opening valve Trial 2 set can be used. For control valve, trial 3 set can be is proposed from which it seen that when lift varies from 4mm to 20mm, the discharge increases from 6.88m^3/hr to 32.397m^3/hr, hence it is concluded that the control of fluid obtained is approximately matches the equal percentage curve as compared to Trial1, Trial 2 & Trial 4 set.

2. It has been shown that how FEA tools help in analyzing valve behavior in different temperature conditions. Behavior of stainless steel material under higher or lower temperature condition is analyzed.

3. it is clear that 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 and we can use these results in further development of Gate Valve.

4. Various models are created by changing the design parameters and analyzed these models for better results. Experimental structural strains and stresses measured by actual pressurizing the valve body, and compared it with FEA results. Strain gauge technique gives good results for the measurement of strain and stress at the point

of interest. The best optimized model is that, in which wall thickness is reduced by 8 mm and rib thickness is increased by 8 mm reduces 24.86 kg (5.26%) weight, because maximum stress level is much lower than the yield stress value of the material. FEA results for this optimized model shows that stresses in ribs also decreased because of increased rib thickness.

5. Local mechanical properties and behavior of valve housing under loading are important basis for further valve analysis and design improvements. DIC method and 3D optical system Aramis are powerful tools enabling mapping of full strain fields in industrial pipeline fittings. Experimental analysis and numerical simulation indicate that local deformation field on globe valve surface has the same nature at cylinder/sphere junction. Analysis shows that the differences between two methods in the area of the highest strain values, in the cylinder sphere intersection, vary 30 % and in the spherical and cylindrical parts result variation is 14.8 %. Obtained results indicate that it is possible to analyze local strain fields of geometrically complex globe valve housing using DIC method.

6. Results of finite element method for the structural analysis of the plug valve body are well in agreement with experimental results, as the deviation is maximum deviation is up to 9.75 % and minimum deviation is up to 6.23 % which is allowable. Results of decreasing the wall thickness and increasing the neck size are better than only reducing the wall thickness. The best optimized model is that, in which wall thickness is reduced by 2 mm and reduced wall thickness by 2 and increase neck radius to 180 mm, reduces 9.95 kg (7.11 %) weight, because maximum stress level is much lower than the yield stress value of the material.

7. The aim of the measurement was to determine the magnitude of results after welding and to assess their influencing by the test pressurizing. Process of pressurizing is currently used for reduction of residual stresses, however, in those cases the applied pressures are much higher than in case of the measured ball valve. Measurement was made with use of a semi-destructive hole-drilling method, which makes it possible to measure also the courses of residual stresses under the surface of the component. Procedure and method of evaluation are given by the US standard ASTM E 837-01, which is probably the most widely used method for measurement of residual stresses.

8. Two-way globe valve housing DN50 PN160 subjected to internal pressure is investigated in this paper. Three dimensional nonlinear FE analyses are performed to obtain the plastic yield, collapse and instability pressures. The real material hardening and geometrical nonlinearity were modeled . The numerical model used in this paper is similar to the one experimentally verified in the previous investigation. Based on the numerical results, the housing plastic collapse pressure was determined by means of two methods: the twice-elastic-slope and the tangent intersection. It is shown that allowable pressure for the globe valve housing calculated by the application of the EN 12516-2 standard is highly conservative compared with the one derived by the application of FE results for the plastic collapse pressure, in accordance with the limit design method. As presented in this paper, the wall thickness in the crotch areas of the two-way globe valve housing, according to the EN 12516-2 standard, is calculated only in a symmetry plane. Although critical location obtained by the FEM is located in the crotch area, it is located away from the symmetry plane and thus away from both critical locations proposed by the EN 12516-2 standard. Therefore, it can be concluded that EN 12516-2 standard is not precise enough for designing of the two-way globe valve housing details.

9. Finite element analysis (FEA) is used for numerical calculation of displacements, strains and stresses within the globe valve. 3D model of globe valve is discretized in fine mesh model consisting of 15131 thetrahedarn finite elements and 49699 nodes. experimental strain field results of the part of the globe valve subjected to 25 bar internal pressure are presented. Differences between experimental and numerical results are negligible.

10. A 75 mm NB valve was analysed for flow capacity and cavitation performance using numerical simulation with CFD package FLUENT. Five different cage configurations were tried to study the effect of prediction accuracy on valve configuration. Sufficient upstream and downstream lengths of pipe were provided for fully developed flow. Simulation was performed for varying differential pressure across the valve. The flow rate, turbulent kinetic energy, vapor fraction of vapor phase and mixture density were monitored during simulation. To validate the simulation results, experiments were conducted on a 75 mm NB globe valve with same cage and plug configurations employed in simulation. The overall root mean square values of vibration of valve and hydraulic pressure fluctuations created by cavitation were used to study the cavitation characteristics of the valve. The valve capacity factor was employed to study the flow behavior.

11. The stress analysis shows that the design is able to withstand the over load and the flow path analysis shows that generated profiles do not have any drastic reduction in cross-sectional areas. The further scope of analysis includes the analysis using the Engineering fluid dynamics (EFD), which can give detailed information about the stability of the design. Casting stimulation can also be conducted to ensure the correctness of riser and gating design. Further tests can be conducted before manufacturing, like flow analysis to rectify the occurrence of turbulence which requires more sophisticated software.

12. With effective accomplishment of this project, the company Scrolling Industries Pvt. Ltd. Kolhapur will be directly benefited, this solution can reduce the cost of the in-production Globe valve which is used in Sugar industry and will significantly decrease the weight of the globe valve without compromising on the performance parameters.

13. This paper has provided a numerical investigation of the fluid flow inside a stop valve, including the modeling and the simulation of the stop valves. The flow system with stop valves is complex structure and has non-linear characteristics, because the construction and the hydraulic phenomena are associated of stop valves. The simulation results show that the main pressure drop is generated along the throat path. Flow jet produced by the valve exit of the throat can be easily distinguished. Fluid velocity in the throat is about 2.5 times its velocity in the inlet boundary condition.

14. In two-phase flow, better pressure drop prediction for the gate valve have been obtained with the HEM, the Morris model and the Chisholm model. Some adjustments of the coefficients were needed for the Lockhart–Martinelli model and the Chisholm one. In both cases in pressure drops prediction the average error is close to zero and less than ±10%. The valve geometry does not produce high pressure drop for openings larger than 40%. No influence of the opening have been observed on pressure drop prediction. For the globe valve, the HEM and the Morris model give better pressure drop prediction. After adjustments on coefficient, The Chisholm model and the Lockhart–Martinelli modified model seem to give the best agreement with the data in the observed range. Influence of the opening has not been detected.

V. FUTURE SCOPE OF WORK

A review suggests that in forthcoming efforts analysis of globe valve could be best possible with Finite Element Method with ANSYS. The future work is to design the globe valve body for weight optimization deformation, stresses and strains are find out by using FEA and using Experimental stress analysis(strain gauge rosette) we will find value of deformation, stresses and strains and compare value actual and theoretical and we will optimize weight.

REFERENCES

[1] V. J. Sonawane1, T. J. Rane, A.D. Monde, R.V. Vajarinkar, P. C.Gawade. ''*Design And Analysis Of Globe Valve As Control Valve Using CFD Software'', IOSR Journal Of Mechanical And Civil Engineering (IOSR-JMCE), pp: 63-71.*

[2] Balpreet Singh, Dr Gurudutt Sahni, 2014. *''Behavior Analysis Of Stainless Steel Globe Valve Under Different Temperature Conditions Using FEA", International Journal Of Engineering And Innovative Technology (IJEIT), Vol 3, pp: 113-116.*

[3] Dr. K.H. Jatkar, Sunil S. Dhanwe, 2013. ''*Finite Element Analysis Of Gate Valve", International Journal Of Engineering And Innovative Technology (IJEIT), Vol 2, pp: 277-281.*

[4] Deokar Vinayak Hindurao, D.S.Chavan *''Optimization Of 16" Plug Valve Body Using FEA And Experimental Stress Analysis Method" International Journal Of Mechanical Engineering, Vol 1,pp: 79-83.*

[5] James A. Davis, and Mike Stewart, (2002) *"Predicting Globe Control Valve Performance – Part II:Experimental Verification" which was published in "Journal of Fluids Engineering" Vol 124, by ASME.*

[6] Pradnyawant .K. Parase, Prof. Laukik B. Raut, (2014). *"Weight optimization of 12"-150 Class Plug valve Casting Body by Finite Element Analysis", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 3 Issue 12, December-2014.*

[7] Pavel Macura, Frantisek Fojtik, Radomir Hrncar *"Experimental Residual Stress Analysis of Welded Ball Valve". Faculty of Mechanical Engineering, VSB-TU Ostrava, Czech Republic. XIX IMEKO World congress, Fundamental and Applied Metrology, September 6-11, 2009, Lisbon, Portuga.*

[8] Ivica Galić, Krešimir Vučković, Zdenko Tonković, *"Nonliner Numerical Analysis Of Two-Way Globe Valve Housing" University of Zagreb Faculty of Mechanical Engineering and Naval Architecture English version of DINEN10002-1:2001, DIN, 2003.*

[9] Nenad Mitrovic , Milos Milosevic , Nikola Momcilovic, Aleksandar Sedmak , Aleksandar Petrovic , Tasko Maneski, *"Experimental – digital image correlation method and numerical simulation of standard globe valve housing" Faculty of Mechanical Engineering, University of Belgrade, Kraljice Marije 16.*

[10] Prabha Kurian[1], C R Krishnamurthy[2], Rajesh R[3], "*Design and Analysis of High Pressure Globe Valve" ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 10, October 2014.*

[11. Mahesh C, *"a double seated noiseless butt welded 3000 rating globe valve". International journal of research in computer applications and robotics. Vol.3 issue.7, pg.: 56-63 july 2015, issn 2320-7345.*

[12] Rajendra V. Bijwe and Dr. V. N. Bhaiswar, *"Review on Topology Optimization of Fabricated Globe valve" International Journal of Innovations in Engineering and Science, Vol. 2, No.4, 2017, e-ISSN: 2456-3463.*

[13] Qin Yang,Zhiguo Zhang,Mingyue Liu,Jing Hu, *"Numerical Simulation of Fluid Flow inside the Valve", Procedia Engineering 23 (2011) 543 – 550.*

[14] Claudio Alimonti, *"Experimental characterization of globe and gate valves in vertical gas–liquid flows", Experimental Thermal and Fluid Science 54 (2014) 259–266.*