

A Review on Design and Analysis of Gate valve using Various Computer Aided Techniques

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Abstract

Gate valves are machine elements which are commonly used to control the flow of fluids as gate valve provides a positive sealing at high pressure of liquids and gases. Gate valves are used when a straight-line flow of fluid and minimum restriction is desired. Gate valves are so named because the part that either stops or allows flow of fluid through the valve acts somewhat like the opening or closing of a gate and is called, appropriately, the gate. The objective of this paper is to focus the design and analysis of critical components of Gate Valve. The critical components in the Gate Valve studied by many of the researchers are Body, Gate Stem and slab gate. The main purpose of design and analysis of any valve is to determine stresses and strains developed in the valve body, which is mostly done by using computer aided software tools. This paper gives detailed review on various techniques adopted by several researchers in the design and analysis of Gate valve. Generally, elements of Gate Valve are developed in CATIA and analyzed in ANSYS. Specially, Gate valve stress analysis is carried out by FEM using ANSYS which can be further validated and supported by stress analysis using classical theory of mechanics.

Keywords: Computer aided tools, Analysis techniques, Gate Valve

I. INTRODUCTION

A gate valve is a type of flow control device that controls the flow of gas, oil or water. Figure 1.1 shows a typical gate valve and its basic components. Gate valve analysis in the past was performed using experiment methods, which required a number of equipment, a lot of time, fund and so on. It is not a good way to investigate the flow characteristic of an actual prototype of any valve in a laboratory.

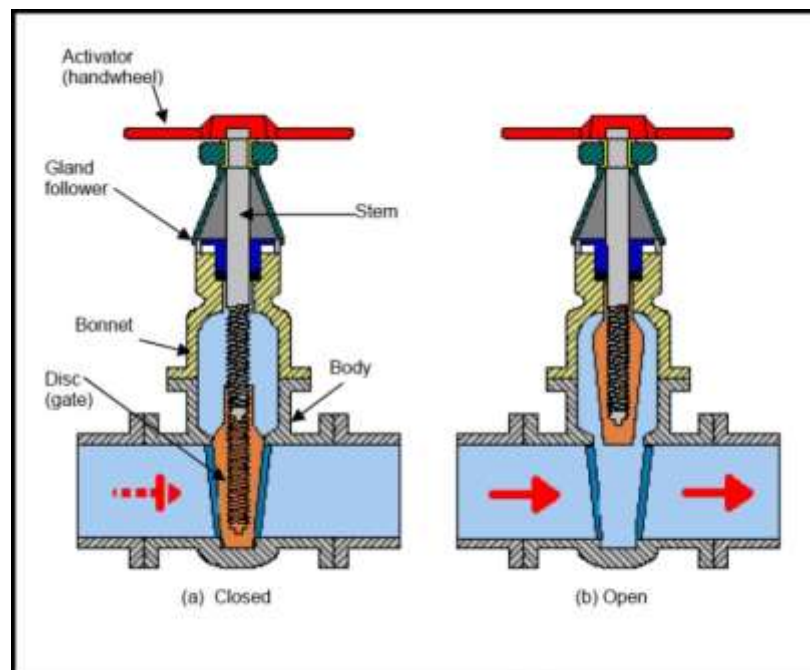


Fig. 1.1: Basic Components of Gate Valve

Nowadays, due to the fast progress of the computer visualization and numerical techniques, it becomes possible to do it by using simulation technique. Another method wherein valve performance factors can be obtained is by using Computational Fluid Dynamics (CFD) software to simulate the physics of fluid flow in a piping system around a valve. However, only studying the fluid characteristics is not enough for gate valve because, the pressure produced by the fluid is too high, which has great effect on the stress distribution in valve. Fluid Structure Interaction (FSI) occurs when the flow of fluid influences the properties of a structure or vice versa. It is a great challenge to deal with such problems due to its complexity in defining the geometries, nature of interaction between a fluid and solid, multi-physics facts and requirements of computational resources. It is tedious, time consuming and challenging work for a designer to measure the accurate stress distribution of any mechanical component which results in some deficiencies in the design of that particular component. To overcome these deficiencies, computer aided software like ANSYS, CATIA, SOLIDWORKS are used. According to the Research, analysis and optimization can be done by using analysis software for greater accuracy and also to minimize the time of designer.

II. LITERATURE REVIEW

A. Dr. K. H. Jatkar, et.al. [2013]¹:

According to this paper, Gate valves are used for straight-line flow of fluid with minimum restriction is desired. Objective of this paper is to perform Stress analysis of critical components of Gate valve like Body, Gate Stem and Slab Gate. It uses FEA technique to perform analysis of valve components. Modeling of valve component is done in CATIA V5R17, Which is further analyzed in ANSYS-11 by using FEM. Validation of software results are supported analytically by stress analysis using Classical theory of mechanics. Results show that, stress values obtained by FEM and Classical theory of Mechanics are approximately same.

B. V. J. Sonawane, et.al. [2013]²:

It is more and more essential to know the flow characteristics inside the valve. Due to the fast progress of the flow simulation and numerical technique, it becomes possible to observe the flows inside a valve and to estimate the performance of a valve. This paper presents the modeling and simulation of globe valves. The flow system with globe valves is a complex structure and has non-linear characteristics, because the construction and the hydraulic phenomena are associated of globe valves. In this paper, three-dimensional CFD simulations were conducted to observe the flow patterns and to measure valve flow coefficient when globe valve with different flow rates and constant pressure drop across the valve were used in a valve system. Globe valve requires higher valve torque due to high thrust force acting on disc hence there are difficulties while operating these valves manually and there may be stem bending problems. High frictional forces at stem threads and yoke collar sleeves also shorten the valve life. Due to these problems, analysis of valve is required. Valves parts are first need to be modeled in CATIA or PRO/E which are excellent CAD software. The model is then transferred in IGES format and exported into the Analysis Software CFD 11.0. CFD Analysis is then carried out in three steps namely, Pre-Processing to define geometry of problem, Meshing to determine the volume occupied by fluid and Post-Processing to analyze and visualize the resulting solution.

C. Mr. Pradip Patil, et.al. [2014]³:

This paper gives basic methodology of gate valve body design by using CAD Technologies and FEA at maximum operating pressure. The main purpose of structural analysis is to determine stresses and strains developed in the valve body. ANSYS program which has been used in this study, can make the analysis of the substances in many subjects including static, dynamic, thermal, harmonic and electromagnetic. In this study, the structural analysis of gate valve body is developed by using CAD software CATIA. Discretisation of valve body has been done by importing CAD model into hyper mesh10 software. Meshed valve body is imported for structural analysis into computer aided engineering software. The solver tool is used to solve the equation from ANSYS. FEA is carried out on the valve at the end. This paper concludes that, Maximum principal stress founds in the inner wall end line flow connection at operating as well as testing pressure and minimum principal stress found at outer surface.

D. Pujari A. A., et.al. [2016]⁴:

A Gate valve can be used for a wide variety of fluids and provides a tight seal when closed. Gate valves are used from high quality carbon steel castings and embody design features that contribute to strength and durability. The objective of this paper is to perform analysis and design optimization of gate valve body using FEA and Stress Analysis. There are five steps in FEA namely, 3D modeling of gate valve body, Meshing of 3D valve Body model, Material properties assigned, Loads and Boundary conditions are applied and Results and their physical interpretation. As the internal pressure acts on the internal effective pressurizing area of valve body, in original position so ribs tries to hold the valve body in original position, so ribs subjected to heavy tensile stress. As the internal pressure increases, stresses in the valve body increases linearly. If physical model is available then it is more flexible and reliable to use strain gauge method for ESA. Results of FEA for structural analysis of valve body are well in agreement with experimental results, as the deviation is within the limit. As the maximum stress level is much lower than the yield stress value of material, FEA results for this optimized model shows that stresses in flange are not effectible because of reducing flange thickness.

E. Dayong Wang [2014]⁵:

Gate valve is widely used for regulating flow and pressure of the pipeline in water conservation and chemical industry. High-precision, safe and efficient gate valve is a challenge for pipeline transportation. Suffered from the impact of the fluid, the gate valve is apt to be abraded and cause failure. This paper was based on the CAD/CAE (Computer Aided Design/ Computer Aided Engineering) system. Besides, this paper carried out researches on the influence of factors, including the fluid medium, the flow velocity, the wall thickness of gate valve body and the cross brace. In addition, the stress of the gate valve body is also studied. The simulation based on UG is demonstrated for the improvement of the gate valve stress.

III. CONCLUSION

From the study of several literatures, this paper concludes that, there are remarkable works carried out in the field of analysis of valves. FEA, CFD and FSI were carried out for the design and analysis of gate valve. The major focus of researcher's work is to carryout design and analysis of valves by using computer aided tools for the determination of flow characteristics and other performance measures of various components. The basic components of gate valve which need to be analyzed are valve body, Gate stem and slab gate. CATIA can be used for designing of the valve and ANSYS can be effectively used for analysis. The results of computer aided tools can also be validated analytically by using classical theory of mechanics. Traditionally, Gate valve analysis was performed using experiment methods, which required a number of equipments, prototype, more time, funds and many other resources. Therefore, traditional experimentation is not a good way to investigate the flow characteristic of an actual prototype of any valve in a laboratory hence a need of using computer aided tools arises. Fluid structure interaction (FSI) is one of the emerging areas of numerical simulation and calculation. There is scope for researching the accurate performance of the valve and hence the combination of CFD with the structural analysis must be considered.

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