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A Review Paper on Design and CFD Analysis of Globe Valve

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Abstract: ***Stop valves are commonly used as fluid flow equipment in many of the engineering applications and Globe Valve Are Used as Regulating or Isolation Equipment in many pipe lines thus it is more important to know the flow characteristics of the valve. With the help of flow simulation and numeric technique, it becomes possible to observe the flows of valves, here we developed a method to obtain the plug design profile required to have desired flow.In this study CFD simulations will conducted to observe the flow patterns and to measure valve flow co-efficient when globe valve with different flow rate and constant pressure drop across the valve were used in a system. In industries it is essential to have accurate and perfect control on the flow of medium at various operations as per requirement for efficient output. This can be achieved by the accurate valve sizing and accurate plug design as per required flow characteristics.***

Keywords: Globe valve, valve coefficient, CFD.

I. INTRODUCTION TO VALVE

A. Definition of valve

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. stopping and starting fluid flow, varying (throttling) the amount of fluid flow, controlling the direction of fluid flow, regulating downstream system or process pressure, relieving component or piping over pressure. They are essential components of a piping system that conveys liquids, gases, vapors, slurries etc. different types of valves are available: gate, globe, plug, ball, butterfly, check, diaphragm, pinch, pressure relief, control valves etc. Each of these types has a number of models, each with different features and functional capabilities. Some valves are self-operated while others manually or with an actuator or pneumatic or hydraulic is operated. Regardless of type, all valves have the following basic parts: the body, bonnet, trim (internal elements), actuator, and packing.

Globe valve stands out among all due to fully closing and throttling purpose, shorter opening and less closing time due to shorter stroke, etc. all these possible due to the provision of plug's geometry, which not only gives us accurate flow control but gives a chance to obtain various flow characteristics.

Globe valve has three inherent flow characteristics [2]

1) Linear characteristics
2) Equal percentage characteristics
3) Quick opening characteristics

B. Plug Design

Above mentioned characteristics heavily depend on plug's geometry. The shape of the plug is designed after consideration of pressure drop across it, flow rate, property of the fluid used, etc. and after mathematical and fluid dynamic solution.

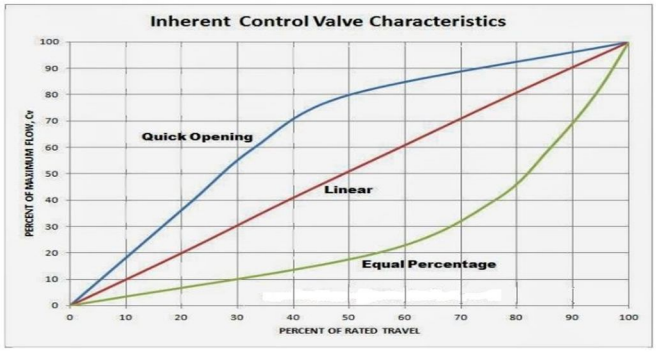

Figure 1: Flow characteristics

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The relation between flow rates through valve as the stem of the valve travels from 0 to 100% full close to open condition. Mainly two characteristics.

1) *Inherent flow Characteristics:* Defines the theoretical relationship between valve opening and flow rate under constant pressure drop.

a) *Linear Characteristics:* With lift of plug flow rate increases linearly called linear characteristics**.**

b) *Equal Percentage:* These valves have desired plug design so each increment in stem lift increases flow rate linearly by certain percentage of the previous flow ,provide a precise throttling control .[Figure 1]

c) *Quick Opening:* small opening of valve gives a large change in flow rate for a small valve lift from the closed position.

2) *Co Efficient Of Flow:* The flow coefficient of a device is relative measure of its efficiency at allowing fluid flow. the flow coefficient C_v is the volume of water at 60° F that will flow per minute through a valve with a pressure drop of 1 psi across the valve.

$$C_v = Q\sqrt{\frac{SG}{\Delta P}}$$

Here,
Q = Rate of flow (US gallons per minute)
SG = Specific gravity of the fluid
ΔP = Pressure drop across the valve

II. LITERATURE REVIEW

Qin Yanga, Zhiguo Zhanga, Mingyue Liua, Jing Hub[1] , 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. Flow system with stop valves is complex structure and has non-linear characteristics, because the construction and the hydraulic phenomena are associated with stop valves. The simulation results show that the main pressure drop is generated along the throat path of valve. Flow jet produced by the valve exit of the throat can be easily distinguished. Fluid velocity in the throat is about 2.5 times more than its velocity in the inlet boundary condition. To sum up, when the fluid flows in the throat path between the piston and its seat, circulation area diminishes quickly. Due to it, the fluid pressure falls rapidly and the fluid here has the maximum velocity magnitude. With the growth of the velocity, trends of the pressure and velocity distribution inside the valve body is completely the same. Their only difference is the magnitude change. On the other hand, Part of fluid is hampered because of the valve piston. Direction of flow can't suddenly change, so backflow appears near the throat path. Flow recirculation exists between the piston and valve body.

Utsav Patel, Jignesh Muchhadia, Kashyap Patel, Vishal Advani, [2],This paper present the fluid flow faces many fixed as well as varying restrictions, in order to measure the pressure drop, the Computational Fluid Dynamics software helps to calculate as well as visualize distribution of pressure, temperature, velocity, etc. CFD helps to solve fluid dynamics problems with help of powerful processors so we don't have to solve countless iteration by numerical methods. Although assumptions have to be made and the solutions are very near to accurate, but the purpose is served as CFD analysis gives us the extreme parameter's analysis. Here, with help of CFD and basic mathematical relations, a new method is introduced for shape of the plug to achieve desired characteristic. The new proposed methodology for designing the plug of the control valve for the given inherent characteristics mainly depends upon the invariability of valve flow co-efficient at particular valve configuration. The results shown in this paper show that the value of valve flows co-efficient at particular valve opening remains constant for different flow parameters. This implies that the valve flow co-efficient remains constant for given fluid flow area, which is shown in this paper. In the new proposed methodology, for any valve body, random plug shape is chosen and CFD analysis at different valve openings is done. The results obtained by performing the CFD analysis at different valve openings help to establish a relation between valve flow co-efficient and fluid flow area.

Sreekala S. K., Thirumalini S [3], Valves control the fluid flow and pressure in a system or a process. Globe valves have good throttling ability, which permits its use in regulating flows. Detailed understanding of flow in Globe valve with cage apertures of various shapes and its impact on the flow characteristics and optimization was carried out. The computational study was carried out using FLUENT, a finite volume based code. Grid sensitivity test were done and the results validated experimentally. The effect of aperture configuration on flow characteristics and valve coefficient was studied to arrive at optimum value. Valve coefficient was found to be dependent on aperture shape and is maximum for the valve with triangular shaped aperture. Methodology to improve flow performance of a globe valve with highest valve coefficient is established.

Yousef Sedaghat, Afshin Ahmadi Nodooshan , Gholam Hossain Montazeri[4],This paper present the One of the most important components of fluid transfer systems are control valves which are seen in different routes oil and gas pipelines and etc. The most important issue of control valves is flow property to achieve good behavior of valve for controlling the flow rate or pressure. In the present study, a flow control valve with appropriate flow property is designed and modeled in order to reduce the effect of vibration and intensive noise. Using fluid modeling of control valve, the valve flow is simulated by numerical solution in CFX software to develop analytical result for designing the internal profile of the flow control valve such that the flow properties and flow rate considering needs. In this study, an internal profile of a valve sample with certain control properties is designed in Catia software and then analyzed using CFX software. To assess the accuracy of the modeling results, the results obtained here are compared with information on the location of the pipeline.

Dr Gurudutt Shani a , Balpreet Singh b [5],This paper present the valve manufacturers use FEA simulation tools to effectively optimize the design. This paper 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 mesis stresses with respect to changing temperature. Finite element analysis is done on the temperature subjected components like body, bonnet & disc using FEA package. Thermal analysis ensures that the stresses and deflection induced are within the allowable limits. The thermal loads are applied on the body and disc surfaces exposed to the line fluid these gives the realistic picture of how the valve behaves under the temperature conditions. Fixed constraints are given on the end flanges of the body to stimulate that it is fixed on the pipe flanges. The following Figure shows the FEA analysis on body. 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.

Ms. Pataskar Snehal Krishna, Prof. Mr. E.N.Aitavade [6],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. 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 6.88m³/hr to 32.397m³/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. It has been shown that how FEA tools help in analyzing valve behavior in different temperature conditions.

B.Krishna Murthy, N. Hari Babu , Swami Naidu Gurugubelli [7] ,
Flow analysis is performed to observe the flow across different cross sections. With the given input velocity and the flow of the Blow off cock is determined. From the results obtained in analysis, a comparison is made between Taper and modified cross sections (Ellipse, Circle, Square).Higher velocities were observed with elliptical cross section. Hence we recommend to use elliptical cross section. Pressure developed is higher using elliptical cross section. Hence we recommend to use elliptical cross section.

Nenad Mitrovica, Milos Milosevicb, Nikola Momcilovic a, [8] , Local mechanical properties is determined in the transition area that can be approximated as the sphere to cylinder junction. 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 (Digital image correlation) DIC method.

Rodrigo Alvite Romano, Claudio Garcia [9],According to the situation in which the estimation procedure is to be applied, some differences arise: the method can be used with data obtained from the valve operating in closed-loop. Another advantage of this method is that, as it is implemented by means of computer software, where the user is only responsible for a few decisions, the

entire procedure is automatic. On the other hand, the method proposed by Garcia is simpler to use and the parameters of the Karnopp friction model are calculated analytically through force balance equations, providing accurate results. Another aspect concerning the linear regression based method is that identification techniques based on least squares algorithms provide well-known interesting statistical properties that lead to accurate estimations even when measurement noise is present.

Anil Rathod, Dr. S N Kurbet [10],The FEA is a tool commonly used to analyze the boundary of physics, mathematics, and engineering and computer science. This technique undergoes wide implementation and appreciates utilization in the structural, thermal and fluid analysis of area. Here in current work, the concentration is only on the study of stress distribution in the globe valve structure under the influential of thermal and structural loads and do the comparison study of stress under varying thermal load. The file is imported in ABAQUS software for solutions and to study the results-Loads acting on the globe valve a) Thermal load (Temperature) b) Structural load (Pressure). The thermal loads are more influential in increasing the stress level in the structure. Higher the difference in the temperature more is stress observed. The structural loads like pretension and pressure loads are not predominant to cause stress in globe valve.

S.Rammohan, S. Saseendran, S.Kumaraswamy, [11], To obtain the required flow and pressure drop characteristics for the valves, different types of internals have been evolved for globe type valves. Cage and plug internal is one among them. One of the major limitations associated with the use of globe valves in liquid application is cavitation. This limits the operating regime of valves.,A 75 mm NB valve was analyzed for flow capacity and cavitations 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.

Mahesh.C [12], Design, Modeling and Analysis of a Double Seated Noiseless Butt Welded 3000 Rating Globe Valve Globe valves are used for applications requiring throttling and frequent operation. In this study, a double seated noiseless butt welded 3000 rating globe valve 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, ASME etc. are used for designing the various components.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.

S K Sreekala, S Thirumalini [13], CFD simulation was carried out for the valve having cage with 8 nos. of apertures for full opening at different pressure ratios and validated with the experimental results Simulation was also carried out for valve with cage having 16 nos. of apertures at full opening condition to compare the sound pressure levels outside the valve. clearly show the reduction in Mach numbers with change in cage configuration and which indicates the noise level reduction and hence noise attenuation. it is clear that with the same valve flow area, as the number of apertures increased noise levels decreased and which shows the effect of multi holed trim aiding in attenuation of noise level of valves. Unsteady compressible flow simulations are carried out using FLUENT for sound pressure level evaluation. Percentage error between computational and experimental results is found to be less than 10%. From the results it is clear that noise levels are within the IEC standard limits in general. 10% noise attenuation can be achieved by doubling the number of flow apertures in the cage.

Rajendra V. Bijwe[14], 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.

Pradnyawant K. Parase[15], 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.

III. CONCLUDING REMARKS

The present work just gives an overview of previously done researches and also for new research, it gives a direction for design and modification of present globe valve plug design.

The conclusions drawn are discussed below,

1) The current plug and seat arrangement of globe valve is according to quick opening characteristics summary.

2) For small lift of plug gives large flow. The Plug And Seat Arrangement Using Computational Fluid Dynamics To Obtain Proper Flow Control Of Fluid In Given Range Of Lift Of Plug .

3) This simulation results show that the main pressure drop is generated at the throat. fluid velocity in the throat is about 2.5 times its velocity in the inlet boundary condition. Spectra characteristics of pressure wake induced the vibration of valve and pipe system. modification of the geometry inside the valve which improved the performance of the valve.

4) The valve body is designed internally to reduce the additional and useless redirection of fluid, resulting in reduced eddies generation, and reduced pressure drop.

5) Computational analysis was carried out for valve with four type of flow passage geometries at a different opening as a result different flow rate achieved. After simulation it was found that the performance of the valve with triangular aperture was better as compared to other geometries.

6) Higher velocities were observed with elliptical cross section. Hence we recommend to use elliptical cross section. Pressure developed is higher using elliptical cross section. Hence we recommend to use elliptical cross section.

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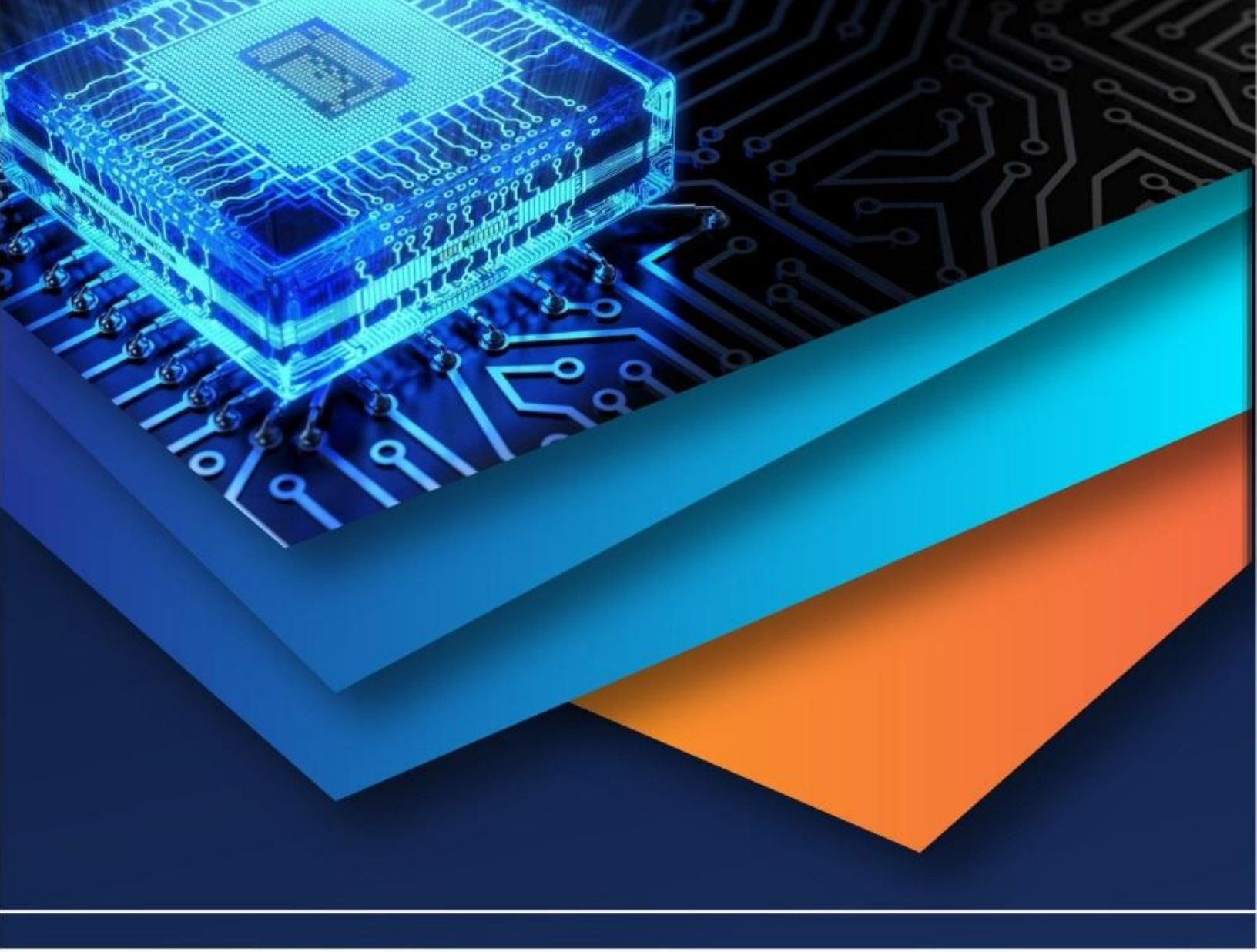

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