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FLUID CONTROL RESEARCH INSTITUTE

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Numerical prediction and experimental verification of cavitation of Globe type Control Valves

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ABSTRACT

Globe valves are one of the oldest types of valve used for throttling applications for all sizes due to better controllability and wider range. One of the major limitations associated with the use globe valves in liquid application is cavitation and it takes place both in part open and in fully open conditions due to varied reasons. There are different designs of globe valves available but for control valve applications, cage and plug designs are widely employed. Cage and plug design consists of body, valve cage, plug and an actuating mechanism. Actuating mechanism is connected to the valve plug which is a moving part, through valve shaft. There are many investigations reported about the flow visualization and numerical simulation of normal type globe valves. But study on valves with cage and plug design are not reported in detail. The objective of the present study is to provide a three dimensional analysis of flow.

KEY WORDS

Cavitation, globe valve, numerical simulation, experimental validation

1.0 INTRODUCTION

Valves are widely used in irrigation, energy, water distribution networks and process industries and in many other areas. Among the different types of valves used in the process industry, control valves play a vital role in the functioning and profitability of the plant. Trouble-free operation of control valves in the piping network is essential to avoid a situation leading to the total closure of the concerned industrial activity. Further, their efficient working leads to an effective use of the available resources. The abundant improvements in the design and performance of control valves are still insufficient to claim perfection in the agreement of theory and practice. The phenomenon of cavitation in control valves is the one in which some more progress can be achieved.

Globe valves are widely used for throttling applications in the process industry for both liquid and gaseous applications. The main advantages are relatively low cost, linear characteristics and good controllability and wider range. 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. To combat cavitation in valves, valve manufactures have evolved different solutions including design improvement, use of harder materials to reduce erosion rate, limiting the valve operation to some critical values so that downstream pressure never goes below vapour pressure etc.

2.0 NUMERICAL SIMULATION

Multi phase cavitation enabled mixture, RNG k-epsilon model was employed for analysis. The flow was governed by continuity and momentum equations with turbulence and multiphase (cavitation) modeling. Flow, volume fraction and turbulence equations were solved for the study. Following assumptions are made in the cavitation model:

- The system under investigation involves only two phases (a liquid and its vapor), and a certain fraction of separately modeled non-condensable gases.

- Both bubble formation (evaporation) and collapse (condensation) are taken into account in the model.
- The mass fraction of non-condensable gases is known in advance.

The summary details of the boundary conditions and the solver details of simulation employed for the solution of the present problem is shown in Table 1. The working fluid is assumed to be a mixture of liquid, vapor and non-condensable gases. Standard governing equations in the mixture model and the mixture turbulence model describe the flow and account for the effects of turbulence.

A vapor transport equation governs the vapor mass fraction, f, given by:

$$\frac{\partial}{\partial t}(\rho f) + \nabla(\rho \vec{v_v} f) = \nabla(\gamma \nabla f) + R_e - R_c \quad - \quad (1)$$

where ρ is the mixture density, $\vec{v_v}$ is the velocity vector of the vapor phase, γ is the effective exchange coefficient, and R_e and R_c are the vapor generation and condensation rate terms (or phase change rates). The rate expressions are derived from the Rayleigh-Plesset equations, and limiting bubble size considerations (interface surface area per unit volume of vapor). When liquid enters the region of higher pressure implosion of bubble takes place and the rate of condensation, Rc, is given by,

$$p > p_{sat} \qquad R_c = C_c \frac{V_{ch}}{\sigma} \rho_l \rho_l \sqrt{\frac{2(p - p_{sat})}{3\rho_l}} f \quad - \quad (3)$$

2.1 Details of valve tested

The type of valve used for the study was a normal 75 mm nominal bore (NB) Globe type control valve with cage and plug design. These types of valves are prone for cavitation in the liquid applications. Figure 1 shows a valve cage with 4 holes drilled with combination plug. The diameter of the holes drilled were 17.5 mm with an effective total flow area of 981.11 mm². For the numerical studies, the valve was connected to pipe at both ends as shown in Figure 2.
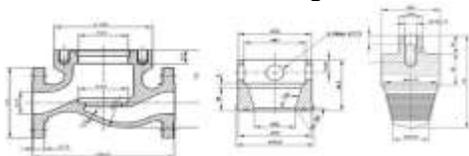

Figure1-Details of valve body, cage and plug.

The diameter of the pipe and the thickness of the valve were same for the model and the one used for experimentation. Upstream and downstream lengths considered for the experimental set up were 750 and 1500 mm corresponding to 10 and 20 diameters of the pipe. This was selected so that the flow is fully developed at the valve inlet and full pressure recovery takes place in the pipe after the valve. Five different configurations of the valve internals were employed during simulation. Table 2 shows the details of orifices provided in the cage of the valve for simulation and experimental purpose. In all the configurations, the flow area and height of the openings were kept constant. During analysis, valve was kept in full open condition.

Table 1- Details of orifices in cage.

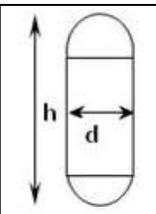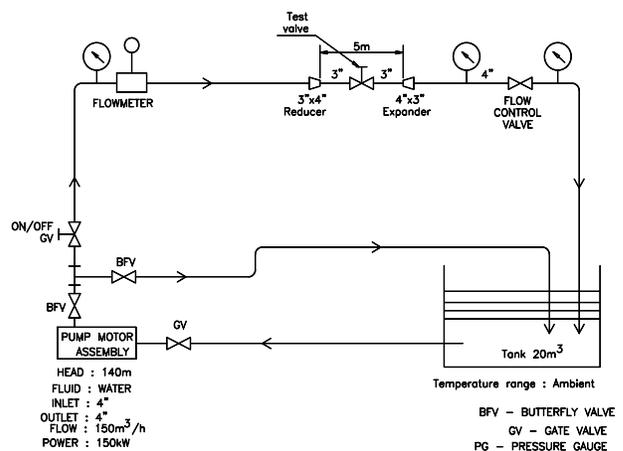| Total area = 981.1 mm²			
Height of hole (h) = 17.5 mm			
Sl. No.	No. of orifices	Diameter of orifice(d)	
1	4	17.50	
2	6	10.50	
3	8	7.60	
4	12	4.87	

Figure 2 Schematic of experimental set up

3.0

on a 75 mm NB globe valve with cage plug

details described in Table 2 to validate the simulation results. The schematic of the experimental test setup is shown in Fig.3. The test setup was designed as per Tullis [11, 12]. It is an open loop re-circulating system which includes an underground sump that holds about 300 cubic meters of water, a 150 kW, multi stage centrifugal pump and valves to control and bypass the flow.

4.0 RESULTS

During simulation, flow rate through the valve, turbulent kinetic energy, vapour fraction (ratio of vapour phase in the mixture), mixture density and velocity of vapour were analysed. These were performed for varying differential pressure across the valve and different valve internal configurations.

5.0 CONCLUSION

A 75 mm NB valve was analysed for flow capacity and cavitation performance using numerical simulation with CFD_4 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, vapour fraction of vapour phase and mixture density were monitored during simulation.

ACKNOWLEDGMENTS

NOMENCLATURE

C_c Empirical constant (Condensation) -

C_e Empirical constant (Vapourisation) -

C_v Valve capacity factor $(Q/DP^{0.5})$ -

D   Pipe diameter (mm)

d   Width of hole (mm)

REFERENCES

[1] Brennen, C.E. 1995, *Cavitaion & bubble dynamics*, Oxford University Press.

[2] Wang, Y.C. and Brennen, C.E. 1998, "One–dimensional cavitation flow through a converging diverging nozzle", *Trans. ASME J. of Fluids Engineering.*, 120, 166-170.

[3] Takehashi, K., Matsuna, H. and Miyamoto, H. 2001, "Cavitation characteristics of restriction orifices", Proc. of 4th international symposium on cavitation, CAV 2001.

[4] Ishimoto, J. and Kamiyama, S. 2005, "Numerical study of cavitating flow of magnetic fluid in a vertical converging-diverging nozzle", *J. of Magnetism and Magnetic Materials*, 289, 260-263.