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DETERMINATION OF LOCAL LOSSES IN A GLOBE VALVE AT DIFFERENT OPENINGS

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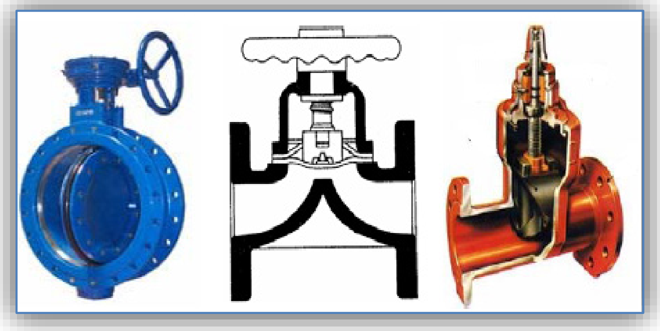
Abstract: Valves are devices of great importance in the operation of hydro systems, in particular, when is necessary to control the flow. The objective of this paper is to determine, through SolidWorks Flow Simulation module, the minor loss through a globe valve at different partially open settings. The Flow simulation allows an analysis of current lines and the hydrodynamic parameters of flow. Therefore we can determine the hydraulic energy losses and can appreciate the value of the main flow parameters.
Keywords: computational fluid dynamics, flow simulation, numerical analysis, hydraulic loss

INTRODUCTION

Valves are widely used in irrigation, energy, water distribution networks and process industries and in many other area [3]. All these are actually types of hydraulic systems. In generally a hydraulic systems are composed of a set of pipes, valves and other hydromechanical equipments necessary for adequate operational management, control and safety. Valves are devices of great importance in the operation of hydro systems, in particular, when is necessary to control the flow. The valves can be classified [3],[5], depending on the shutter movement, into two groups (see figure 1):

- valves with linear motion
- valves with angular motion

The butterfly valve, (figure 1a) is often used in water systems, under low hydraulic loads. They are valves suited for emergency shut-off, more specifically, for safety valves with overspeed closing disposal. The diaphragm valves are characterized by having a flexible membrane (diaphragm) whose periphery is fixed in the body of the valve (figure 1b). As for membrane valve (figure 1f), it works by pressing one side of the membrane through the actuator, restricting the passage of the flow. This type of valve is used, preferably, in situations of hostile operation. The spherical valves, the wedge (figure 1c) and shears are the most suitable for the task of stopping the flow. The globe valves (figure 1d) have a great use in automatic control of pressure and flow. They can present various shutter types and regulation hydraulic systems. Due to the pathway that the liquid makes inside, these valves have a large loss of hydraulic load, even in situations of total openness. The spherical valves (figure 1e) are, preferably, used at systems with high hydraulic load or for quick flow cuts under high pressure situations. These valves when fully opened induce a low loss of hydraulic load. A globe valve is a linear motion valve used to stop, start and regulate flow in a pipeline.



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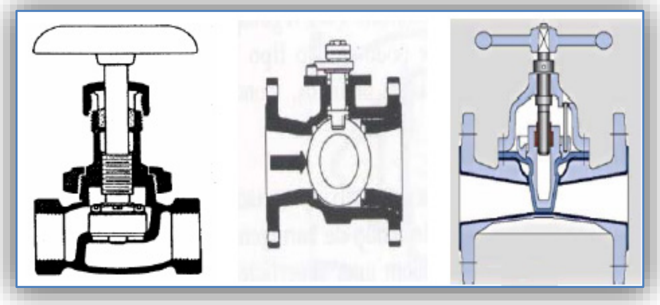


d) e) f)

Figure 1. Different types of control valves

The fundamental principle of the globe valve operation is the perpendicular motion of the disk away from the seat. The disk of a globe valve can be totally removed from the flowpath or it can completely close the flowpath. This ensures that the ring-shaped space between the disk and seat ring gradually close as the valve is closed. This property gives a globe valve reasonably good throttling capability. Therefore, the Globe Valve can be used for starting and stopping flow and to regulate flow.

MATHEMATICAL MODEL

In engineering practice the hydraulic loss in any piping system is traditionally split into two components: the loss due to friction along straight pipe sections and the local loss due to local pipe features, such as valves, throttles, elbow, bend, etc. Working fluid of our experiment was water. Water was allowed to pass through our target valve. The minor loss coefficient is usually calculated through the outlet and inlet total pressure difference Δp from the following formula [3] :

$$\xi = \frac{2\Delta p}{\rho v^2} \qquad (1)$$

where ρ is the water density, and v is water velocity. Since we already know the water velocity and the water density (998 kg/m^3), then the goal is to determine the total pressure value at the valve's inlet and outlet. The valve studied in this paper is mounted on the stand pipe in the laboratory of the department of fluid mechanics. Nominal diameter of pipiline is two inches.

RESULTS OF SIMULATION

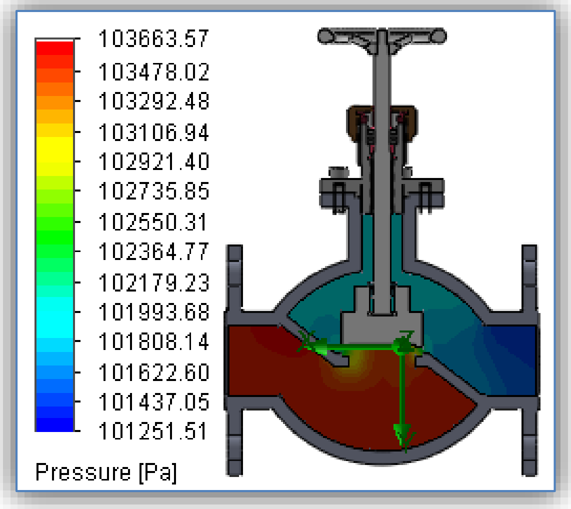
The flow was simulated through flow control valves for different valve closure positions. For the simulation and therefore the determination of the coefficient of local losses were considered three situations relating to the degree of openness.

Results of simulation is presented: for case 1, d = 4.33 mm (figure 2), case 2, where d = 8,66 mm (figure 3) and case 3, where d = 13mm (figure 4). In case of simulation „d" is the distance between disk and seat.

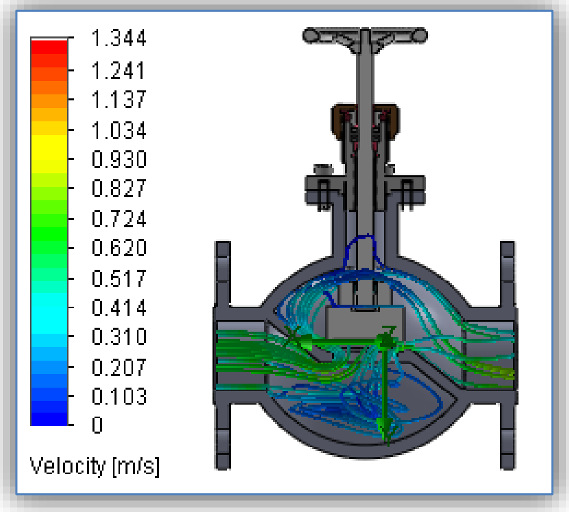
The variation of valve head loss coefficient with valve closure position was obtained. This variation shows the energy dissipation induced by the valve in the flow for different valve opening positions.

From velocity vector distribution, represented in figure (2b), can be concluded that the flow trajectories converge upstream of the valve which can lead to flow separation in the same region and to rotational movement with high turbulence inside the valve. The flow through the valve results in the contraction of the liquid vein (figure 2a) immediately upstream and downstream of the closure and therefore in the flow velocity increase in these regions. This fact explains the pressure decrease from the region immediately upstream of the actuator towards downstream.

Table 1 presents the numerical results obtained from the simulation and the value of the coefficient of local losses for case 1.



a)



b)

Figure 2. Variation of pressure (a) and velocity profile (b) for the case 1 of simulation;

Table 1: Results for case 1 of simulation

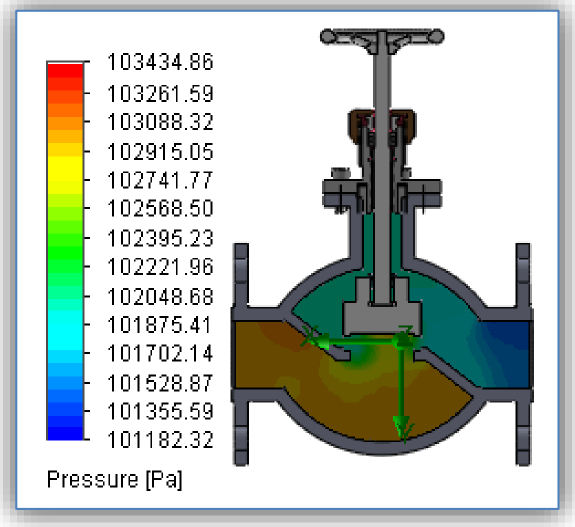
Inlet pressure [Pa]	Outlet Pressure [Pa]	Pressure drop Δp [Pa]	Velocity v [m/s]	Local loss coefficient ξ=2Δp/ρv²
103771,74	101718,25	2053,49	0,677	9,11

For the second case of the simulation increase the flow space. According to the graph in Figure 3a, is found in the upstream pressure drop compared to the previous case.

In the table 2 is show the results obtained and the value of the local losses coefficient for case 2 of simulation.

Table 2: Results for case 2 of simulation

Inlet pressure [Pa]	Outlet Pressure [Pa]	Pressure drop Δp [Pa]	Velocity v [m/s]	Local loss coefficient ξ =2Δp/ρv²
103280,89	101793,62	1487,27	0,703	6,03



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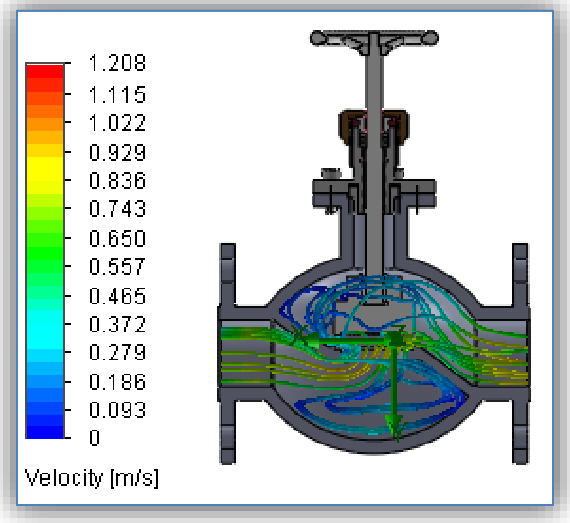


b)

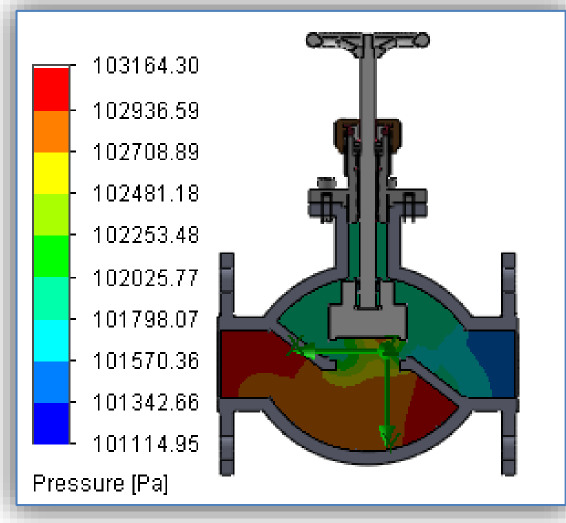
Figure 3. Variation of pressure (a) and velocity profile (b) for the case 2 of simulation;

Table 3: Results for case 3 of simulation

Inlet pressure [Pa]	Outlet Pressure [Pa]	Pressure drop Δp [Pa]	Velocity v [m/s]	Local loss coefficient ξ =2Δp/ρv²
103230,84	101802,47	1428,37	0,718	5,55

Simulation for the third case, when the opening is maximum in figure 4a is seen as a pressure difference between upstream and downstream it is not so great.

Observe also the uniformity of flow velocity between upstream and downstream. Numerical results obtained from simulation and local resistance coefficient for case 3 are presented in table 3.



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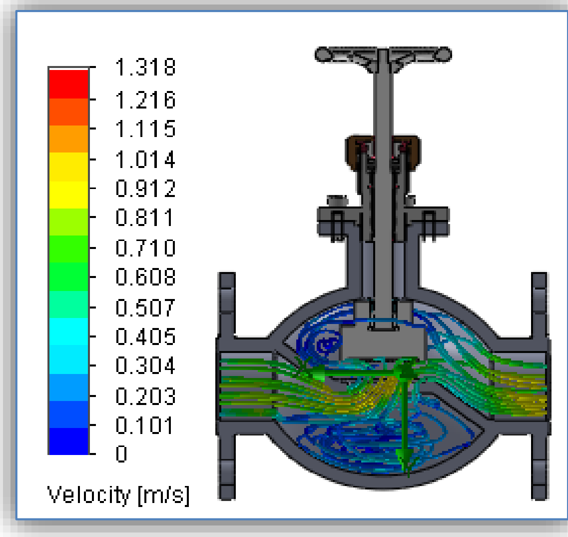

b)

Figure 4. Variation of pressure (a) and velocity profile (b) for the case 3 of simulation;

CONCLUSIONS

After simulations can be seen as the flow velocity of the fluid increases with the degree of openness. With increasing degree of openness also increases the coefficient of local losses.

Computational fluid dynamics continues to be an impressive tool in helping model real world problems.

The solid works flow simulation module, can be used to give insight into visualization of complex flows.

Three-dimensional simulation technique is used to observe the fluid field and to denote flow velocity and hydrodynamic pressure through valve at different opening settings.

The visualization of power lines using a simulation program, shows the variation of the main hydrodynamic parameters and can give us information on appearance and maintenance of the local loss.

Minor head loss across the valve is directly proportional to the square of the flow velocity through the valve.

The values obtained for the coefficient of local losses are within the limits specified by the literature.

Note

This paper is based on the paper presented at The 1st International Conference "Experimental Mechanics in Engineering" - EMECH 2016, organized by Romanian Academy of Technical Sciences, Transilvania University of Brasov and Romanian Society of Theoretical and Applied Mechanics, in Brasov, ROMANIA, 8 - 9 June 2016

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