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NUMERICAL SIMULATION OF HYDRAULIC OIL FLOW THROUGH A VALVE WITH SEAT AREA TYPE A 10 FS1.0364

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ABSTRACT
Calculation and experimental determination of the fluid flow through the hydraulic valves can be very complex and demanding process. For the experimental determination of the fluid flow, as well as other physical and kinematic-dynamic properties of fluids, such as density, temperature, speed, pressure drop, a range of different methods and also expensive measuring devices are required. In addition to this, realization of the experiment requires a longer period of time. Therefore, numerical simulations are increasingly used by engineers nowadays, not only to reduce costs but also the time required for new product development. Using numerical simulations, this paper presents the calculation of flow and pressure drop in the flow of hydraulic oil through a valve with seat area type A 10 FS1.0364. Obtained results were compared with analytical and experimental values (from a catalogue). Observed 3D model of the valve was created in SolidWorks software, and the numerical simulations of the mentioned characteristics were done using SolidWorks Flow Simulation. After the calculation performed in the software, the results of pressure drop depending on the flow were presented in a diagram and compared with experimental and analytically calculated values. The main goal of this paper is to present the possibility of applying numerical simulations to solve the problem of calculation and determination of the fluid flow through the various hydraulic valves, which allows faster determination of the flow, reduces costs and time for new product development.
Keywords: valve, pressure drop, flow, numerical simulation, software

1. INTRODUCTION

Numerical simulation is now used in many industrial areas such as aviation, chemical, oil, automotive, machinery production, etc. According to the definition given by Fishman 1996, the computer simulation is an experiment in which sampling is done using computers. Simulation techniques are now used in almost all aspects of research. They are used to test new procedures and technologies. Using simulation techniques, the time between idea and final product is shortened, because it allows continuous testing using simulators. To speed development time of new products, designers use a variety of simulation techniques. Numerical simulation of hydraulic oil flow through the valve with seat type A 10 FS1.0364 [1] in this paper was presented in the software SolidWorks Flow Simulation. The results were compared with experimental (catalog) and analytical results. In the numerical simulation of oil flow through the valve, special attention was paid to determining the pressure drop Δp. Pressure drops Δp were obtained by calculation for different values of flow Q. Based on this, pressure drop diagram was defined trough the tasted valve. Besides the numerical calculation of pressure drop, analytic calculation for different values of flow was performed and obtained the corresponding Δp-Q diagram.

2. NUMERICAL SIMULATION

Results of numerical simulation of hydraulic oil through the valve with seat area type A 10 FS1.0364, Figure 11., were obtained in the software SolidWorks Flow Simulation These results are partially presented in Table 1. [4].

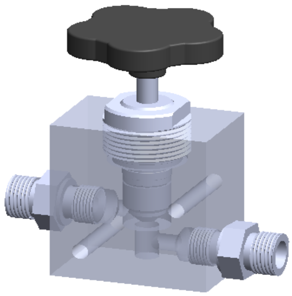

Figure 1. 3D Model of valve with seat area type A 10 FS1.0364

The results presented in Table 2.1. include the value of total pressure at the inlet and outlet of the valve, hydraulic oil flow velocity at the inlet and outlet of the valve and pressure drop for a nominal value of flow Q = 16 l / min.

Table 1. The results of numerical simulation of hydraulic oil flow through the valve with seat type A 10 FS1.0364 for nominal flow of 16 l / min

Measured values	Unit	Actual value	Mean value	Minimum value	Maximum value
Total pressure at the inlet	[Pa]	32000168,51	32000168,51	32000168,51	32000168,51
Total pressure at the outlet	[Pa]	31883964,57	31883745,25	31883549,27	31883964,57
Velocity at the inlet	[m/s]	8,03	8,03	8,03	8,03
Velocity at the outlet	[m/s]	8,21	8,20	8,20	8,21
Pressure drop Δp	[Pa]	116203,94	116423,26	116619,24	116203,94

In the same way, by using numerical simulation, the listed characteristics, for other values of Q of hydraulic oil flow through the observed valve, were obtained [4]. The obtained results can also be displayed by using diagrams. Figure 2. shows how total pressure depends on time, and Figure 3. shows the diagram depending the speed of hydraulic oil flow through the valve on the time.

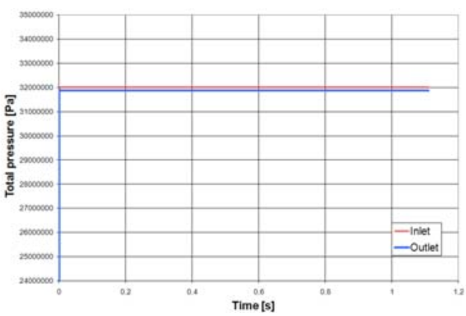

Figure 2. Diagram of changes in total pressure depending on the time at the inlet and the outlet of the valve

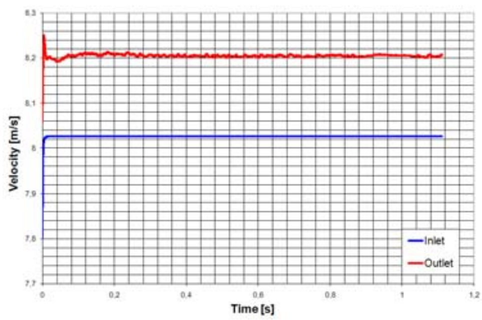

Figure 3. Diagram of changes in speed depending on the time at the inlet and the outlet of the valve

3. ANALYTICAL CALCULATION OF PRESSURE DROP

Based on experimental data from the expression for the flow of hydraulic oil through the valve, the flow cross-section area can be calculate, i.e.

$$A = \frac{Q}{\alpha\sqrt{\frac{2\Delta p}{\rho}}} \left[m^2\right]. \qquad (1.)$$

Substituting the numerical data for the nominal flow of 16 l / min is obtained

$$A = \frac{0{,}26666667}{0{,}75 \cdot \sqrt{\frac{2 \cdot 121000}{873}}} = 0{,}02144 \left[m^2\right].$$

If in the expression for the pressure drop

$$\Delta p = \frac{Q^2 \cdot \rho}{2 \cdot \alpha^2 \cdot A^2}, \qquad (2.)$$

put the numerical data of flow from 5 to 20 l/min, pressure drop values will be obtained - Table 2.

Table 2. Analytical defined pressure drop in the flow of hydraulic oil through the valve with seat type A 10 FS1.0364

Flow Q (l/min)	5	7	9	11	13	15	17	19	20
Pressure drop Δp (Pa)	11817,3	23161,9	38288	57195,7	79884,9	106355,7	136607,9	170641,7	189076,7

Based on the data shown in Table 3.1. Δp-Q diagram was obtained - Figure 4. [4]

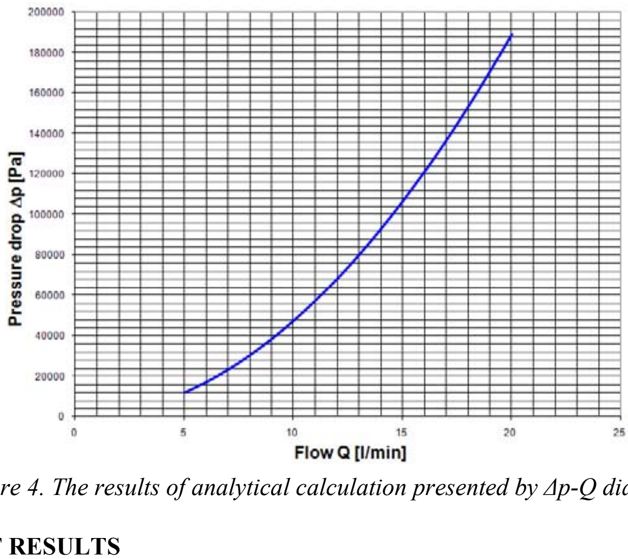

Figure 4. The results of analytical calculation presented by Δp-Q diagram

4. ANALYSIS OF RESULTS

If we make a comparison of the obtained analytical, numerical and experimental results, it can be observed very good overlap of the analytical and numerical results, and experimental results for certain values of the flow slightly deviate from them. Deviation from the experimental results may be due to a number of influential factors such as inadequate and inaccurate measuring device, the environmental impact, the result of poor reading, etc. In Figure 5. the results of analytical calculation, numerical simulations and experimental investigations of Δp-Q characteristics of the valve with with seat type A 10 FS1.0364 are presented.

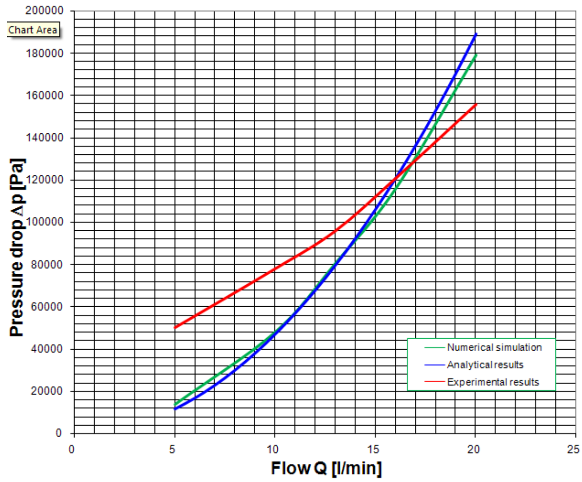

Figure 5. Δp-Q diagram of the analytical calculation, numerical simulation and experimental research on the valve with seat type A 10 FS1.0364

5. CONCLUSION

Using SolidWorks Flow Simulation software, numerical calculation of pressure drop for nominal flow of 16 l / min through a valve with seat type A 10 FS1.0364 were conducted. In comparison with the experimental values, the obtained results differs 3.96%. Comparing the results obtained by numerical simulation for flow 5-20 l / min leads to mean deviation compared to the experimental value of 29.3%, respectively for flow 12-20 l / min mean deviation in comparison with the experimental results is about 9.8%. On the basis of the presented results can be concluded that the pressure drop diagram obtained from experimental studies in relation to the diagram obtained by numerical simulations, for flows less than 12 l / min, has greater than 10% deviation. Decreasing the flow value, deviation is greater. The cause of this deviation may be errors in numerical simulations (incorrect dimensions of the model, incorrectly defined the characteristics of the fluid, poorly defined initial and boundary conditions, etc.) or errors in experimental studies (inadequate and inaccurate measuring device, an adverse environmental impact, poor reading of the results, etc.). Observing the differences of the results obtained by analytical calculation, numerical simulation and experimental research, because of the very good overlap between the analytical results with results of numerical simulations, it can be concluded that the difference in the results were most likely caused by imperfection in experimental research. In addition, for the valve with seat area type A 10 FS1.0364, deviation between the results of numerical simulations and experimental studies for flow 12-20 l / min is around 10% which is quite acceptable in engineering practice.

6. REFERENCES

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