

COMPARISON BETWEEN FLOWNEX[®] SE AND EXPERIMENTAL DATA FOR A WATER HAMMER EVENT

Keywords: Water hammer, transient simulation, benchmark, experimental data.

ABSTRACT

This case study will describe how Flownex[®] was used to model a water hammer event in a pipe. The results are compared with experimental data to show the accuracy of the simulation.

CHALLENGE

Water hammer in pipe networks results from an abrupt change in flow velocity. A water hammer event can cause extremely high pressures which can damage pipelines. Thus, the need exists for a tool to investigate this phenomenon to ensure that it can be mitigated.

BENEFITS

A design tool that can model a water hammer event in pipelines can aid engineers in investigating this phenomenon during operation or design. This can help the engineer understand the cause and severity of the water hammer event and the effectiveness of possible measures to mitigate the occurrence thereof. This will improve the lifespan of pipes and equipment.

SOLUTION

Flownex can be used to investigate the occurrence of water hammer in pipelines, the severity thereof and possible measures to mitigate them. Flownex takes the elasticity of the fluid and pipe wall into account when calculating pressures in pipelines. From this case study, one can see that Flownex compares well with experimental data and is an ideal tool to model water hammer in pipelines.



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Flownex network**

INTRODUCTION

The experimental data presented in the “*Hydraulic Transients Analysis in Pipe Networks by the Method of Characteristics (MOC)*” article by Roman Wichowski¹ was used as a benchmark to compare the Flownex simulation results.

A model was built in Flownex representing the experimental setup described in the article, and a transient simulation was conducted.

The maximum and minimum amplitude of the first water hammer pressure pulsation, and the frequency between the first two pressure waves obtained from the experiment and Flownex simulation will be compared.

METHODOLOGY

The experimental setup in the article consists of a pressure tank (2) connected to a horizontal pipe (1) and a ball valve (4) at the end of the pipe. The volume above the water in the tank is filled with pressurized air to maintain a constant pressure in the tank during unsteady flow (water hammer). A pressure transducer (5) is located just before the ball valve (4).

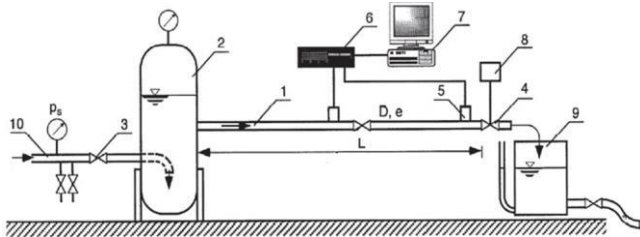


Figure 1: Experimental setup used in the article.

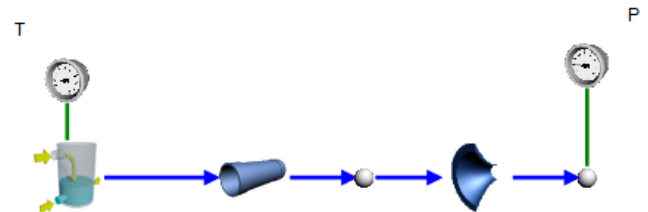
The pipe (1) has a total length of $L = 41$ m and an inner diameter of $D_{in} = 42$ mm. The valve closing time was measured to be $T_c = 0.034$ s. The initial pressure head in the pressure tank (2) is 50 m H₂O gauge and is designed to remain at this pressure head throughout the experiment.

Other data considered during the experiment include the following:

- Pipe wall thickness $e = 3$ mm,
- Modulus of elasticity of the pipe material $E = 2.06 \times 10^{11}$ Pa,
- Bulk modulus of water $K = 2.19 \times 10^9$ Pa,
- Water temperature $T_w = 4.5^\circ\text{C}$.

The Flownex model consists of the Pipe component, an Open Container component, a Restrictor with Discharge Coefficient component and two Boundary Conditions. The Open Container component is used to represent the pressure tank (2).

The Restrictor with Discharge Coefficient is set up to represent the ball valve (4) with the discharge coefficient calculated as 0.0104 such that the same initial flow of 0.453 l/s as that measured in the benchmark is achieved. An action is set up to reduce the discharge coefficient linearly in the same closing time as that of the valve, as measured in the benchmark.



The parameters used as inputs to the model in Flownex were based on the experiment¹.

The pipe roughness and Poisson's ratio are assumed to be that of normal commercial steel. The restraint type of the pipe is assumed to be “Longitudinal”. The number of pipe increments was chosen as 44 to obtain grid independence. The time step size was specified as 0.64 ms to ensure a CFL number of less than 1.

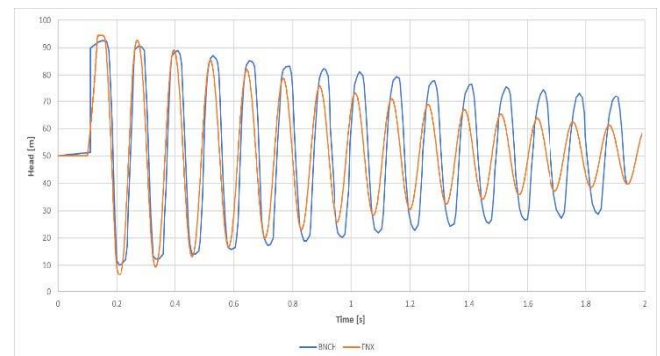


Figure 2: Comparison between Flownex and experimental data.

CONCLUSION

Parameter	Experiment	Flownex	Difference
Hmax [m]	92.66	94.66	+2.23%
Hmin [m]	10.18	6.12	-4.54%
Frequency [Hz]	7.99	7.25	-9.00%

The percentage errors calculated for the compared parameters are acceptable for pipeline design. This shows the accuracy of Flownex as a tool to simulate water hammer events in pipelines.