FLOWNEX®
SIMULATION ENVIRONMENT

WATER HAMMER

This case study demonstrates the capability of Flownex to simulate the water hammer effect by simulating the sudden closure of a valve at the outlet of a long pipe in which water is flowing. In practice, this closure could be facilitated by a fast acting valve or similar device. The model takes the fluid and pipe wall elasticity into account.

WATER RETICULATION

CHALLENGE:

This case study demonstrates the ability of Flownex to simulate the water hammer effect by simulating the sudden closure of a valve at the outlet of a long pipe in which water is flowing. In practice, this closure could be facilitated by a fast acting valve or similar device. The model takes the fluid and pipe wall elasticity into account.

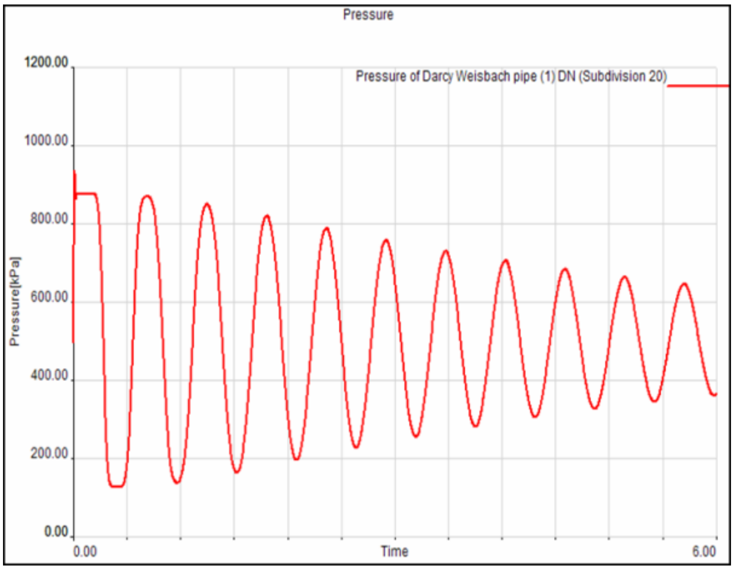
The objective of the simulation is to investigate the pressure variation at different positions along the length of the pipe due to the water hammer effect resulting from the sudden closure of the outlet of the pipe.

BENEFITS:

- Elasticity of the fluid and pipe wall taken into account.
- Simulation of Water Hammer ensures proper counter measures are taken.

SOLUTION:

The capability of Flownex to simulate the water hammer effect in a system due to a transient event such as the sudden closure of the outlet end of a long pipe was demonstrated in this example. In this case, Flownex takes the elasticity of the fluid and pipe wall into account. It was also shown that results can be obtained for different positions along the length of the pipe.



Flownex takes the elasticity of the fluid and pipe wall into account

WATER HAMMER

SYSTEM DESCRIPTION

The configuration considered in this example is shown in Figure 1. It consists of a long pipe in which water is flowing due to a pressure difference over the pipe. The outlet end of the pipe is closed suddenly during a transient event.

For the initial steady-state situation, the inlet and outlet pressure is known.

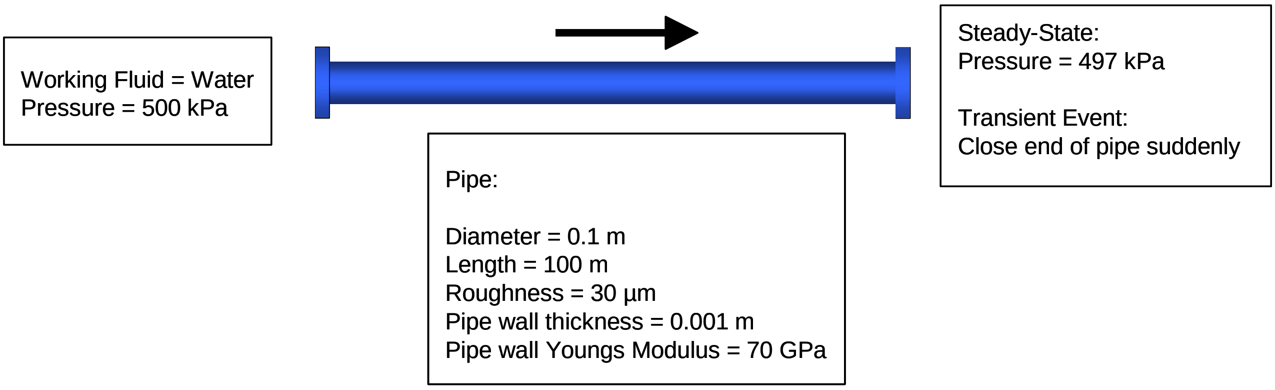


Figure 1: Schematic layout of a pipe in which water is flowing, and a valve is suddenly closed at the outlet end.

For this case study, a basic system is presented, to clarify the water hammer simulation capability of Flownex. However, it should be noted that Flownex can easily perform similar simulations in complex networks.

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OBJECTIVE OF SIMULATION

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FLOWNEX MODEL

The Flownex model of the system is shown in Figure 2.

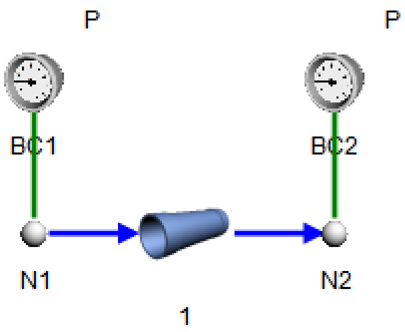

Figure 2: Flownex network.

The pipe is modeled in Flownex using the Pipe element and the boundary conditions are specified on the inlet and outlet nodes. To ensure simplicity, the working fluid (water) is specified with fixed properties and the Bulk Modulus is specified as 2000 MPa (fluid elasticity). The thickness of the pipe wall and the Young's modulus of the pipe material need to be specified for the pipe.

The Pipe element is incremented into 20 equal lengths of 5 m each. This allows for a more accurate result and allows the user to see results at various sections of the pipe. The number of increments to used are based on accuracy and speed considerations defined by the user.

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DESCRIPTION OF SIMULATION

For the initial steady-state condition, the fixed inlet pressure of 500 kPa is specified on the inlet node, and the fixed outlet pressure of 497 kPa is specified on the outlet node. A transient event is specified that is executed from the initial steady-state condition in which the pressure of the downstream node is specified to be solved, rather than being fixed. This, in effect, simulates the sudden closure of the outlet of the pipe.

A Graph Set is specified to represent the pressure variation over time at the pipe outlet and in the middle of the pipe (increment 10) for the first 6 seconds after the transient event.

RESULTS

The graph showing the pressure variation with time at the pipe outlet for the specified simulation is shown in Figure 3.

From the results, it can also be seen that the maximum pressure at the outlet of the pipe due to the water hammer effect will be equal to 877 kPa.

The graph showing the pressure variation with time in the middle of the pipe (increment 10) for the specified simulation is shown in Figure 4.

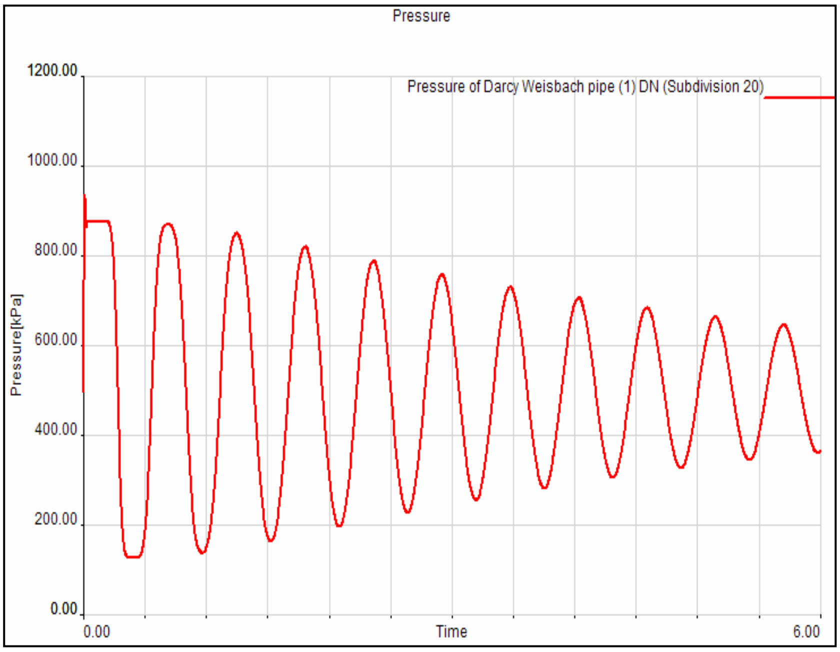

Figure 3: Water hammer simulation results.

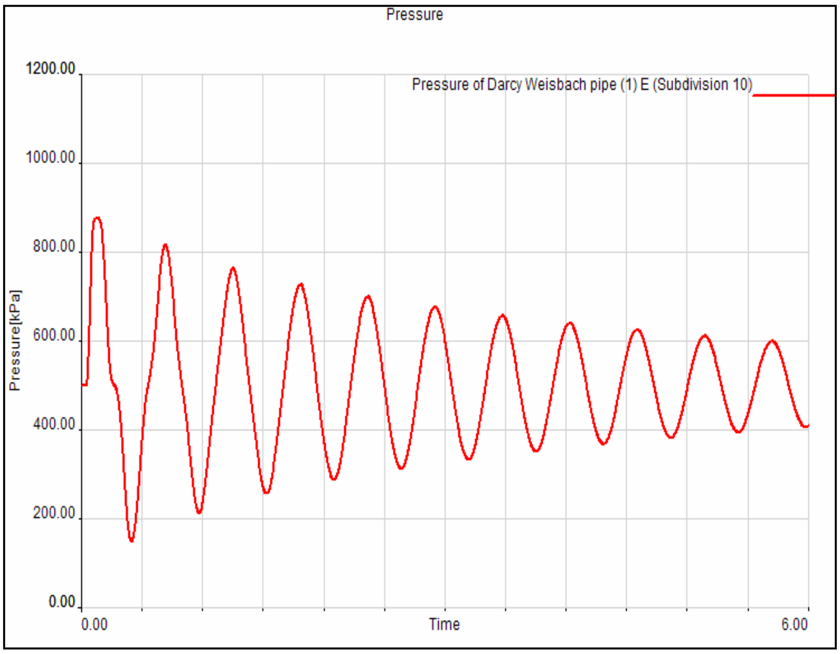

Figure 4: Water hammer simulation results.

Conclusion

The capability of Flownex to simulate the water hammer effect in a system due to a transient event such as the sudden closure of the outlet end of a long pipe was demonstrated in this example. In this case, Flownex takes the elasticity of the fluid and pipe wall into account. It was also shown that results can be obtained for different positions along the length of the pipe.