

Pump Element Validation Case

Introduction

The pump model implemented in Flownex is a practical model giving the user the functionality to model centrifugal fans or pumps. The purpose of this validation case is to verify the operation of the pump model over the full range of the pump chart. An analytical pump comparison was used as benchmark.

Validation Specification

Figure 1 is an illustration of the hypothetical pump characteristic curve used in this validation case. It can be seen from the figure that more than one solution for volume flow through the pump, as a function of the pressure rise over the pump, is possible. This can cause numerical instabilities. This validation case demonstrates that Flownex accommodates systems involving pumps with this kind of behaviour.

In this validation case a pump supplying water to a system is modeled, with the system represented by a pipe. The system flow resistance is changed by adjusting the secondary flow losses in the pipe, resulting in the operating point of the pump shifting along the pump characteristic curve. This illustrates the operation of the pump over the full range of the pump characteristic curve.

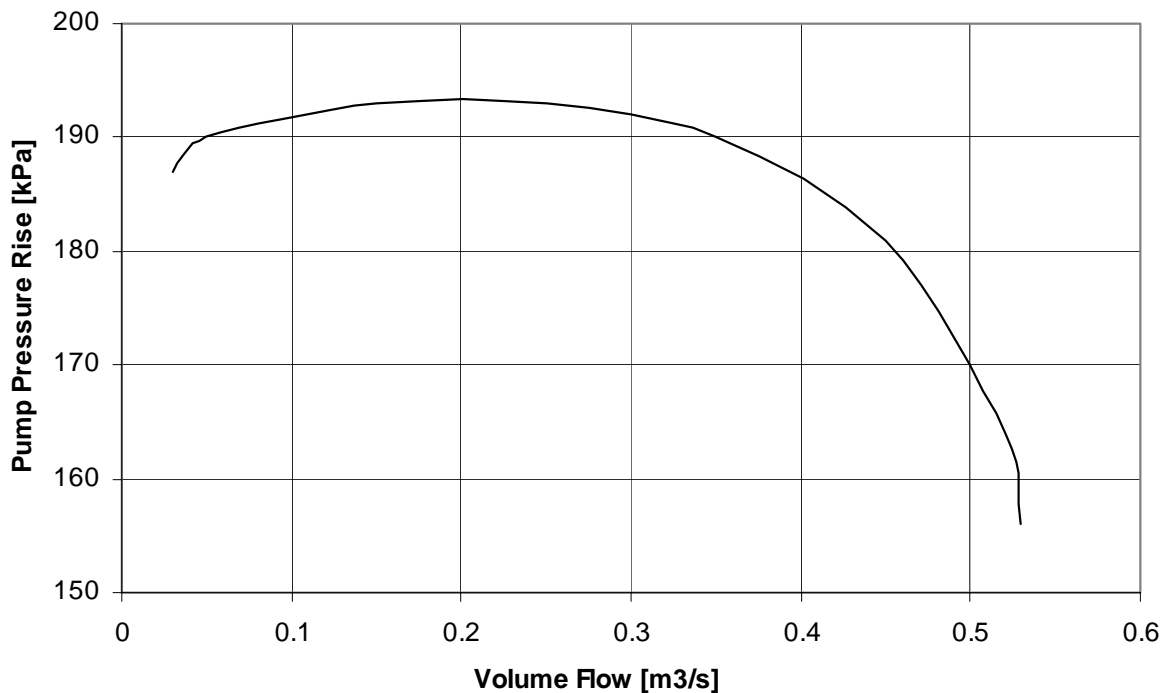


Figure 1: Characteristic curve for a pump.

Flownex model

Figure 2 shows the Flownex network used for this validation case. The upstream pressure and temperature of the pump was specified, as well as the downstream pressure of the pipe. The secondary loss factor for the pipe was varied, representing a change in the system resistance. The system represented by the pipe can be any complex network, and the change in the system resistance can be a transient event.

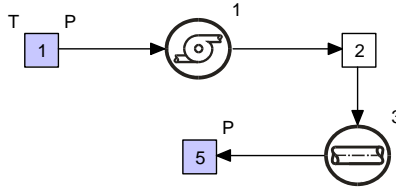


Figure 2: Flownex network of a pump with a pipe element representing the system resistance.

Benchmark

The theory for the pump element, as described in the Flownex theory document for the Fan/Pump model, was implemented in EES [1] and serves as an analytical benchmark.

Results

The pump outlet pressure and the mass flow through the pump are the important results that were compared in this validation case. Figure 3 shows the pressure rise results for this validation case together with the pump characteristic curve. The results confirm that Flownex produces the correct result in regions where numerical instabilities could be encountered.

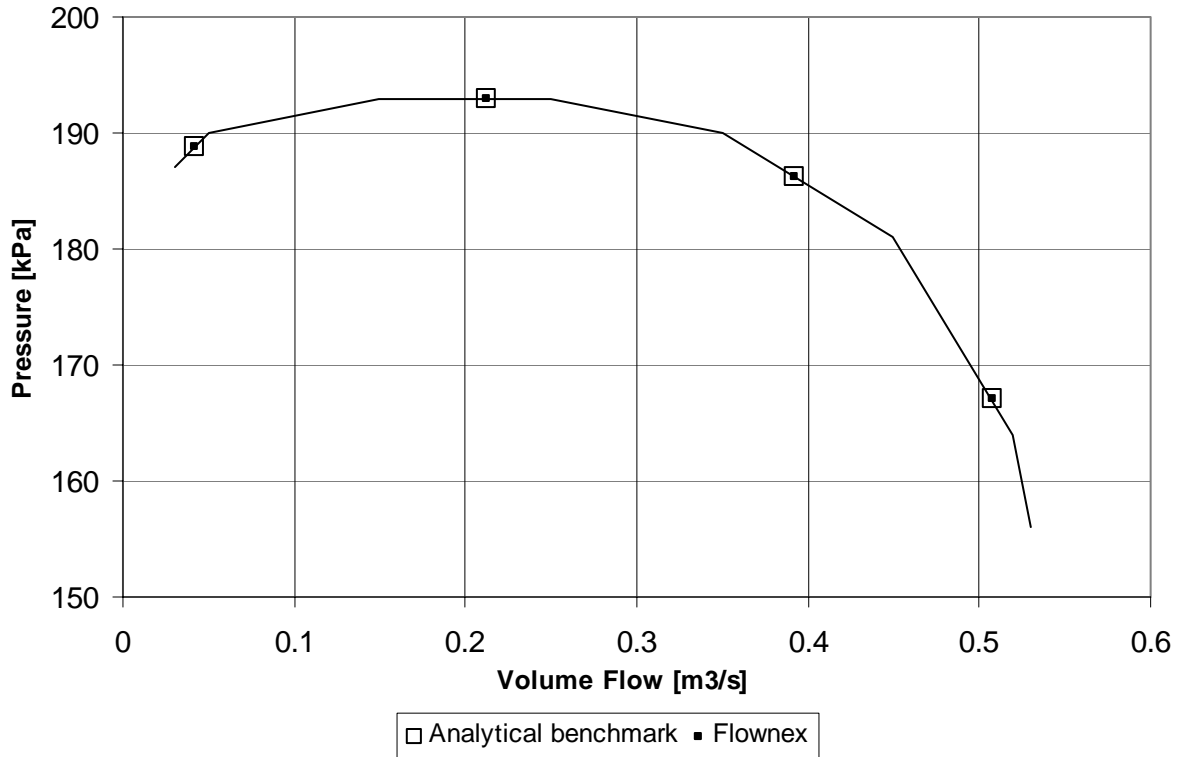


Figure 3: Flownex network of a pump with a pipe element representing the system resistance.

Conclusion

It is clear that the pump model in Flownex accurately and stably solves the pressure-mass flow relation of a simple network with the pressure rise of the pump matching the system pressure losses as a function of system volume flow rate.

References

- [1] Engineering Equation Solver, www.fChart.com