Radiator Flow Balancing

Automotive Industry

Challenge: When designing for flow through radiators it is important to ensure equal flow distribution through the various flow channels. The challenge is accurately sizing orifices required to ensure balanced flow in several parallel pipes connected by two headers.

Benefits:

- Size orifices
- Quickly design functionality
- Branched Flow

Solution: The Flownex Design functionality allowed designers to quickly determine the required orifice ratios to balance the flow system.

Automotive Industry

Header Balancing

Introduction

This case study demonstrates the capability of Flownex to determine the orifice sizes required to ensure balanced flow in several parallel pipes connected by two headers. In practice, this system could represent the cooling flow through a simple radiator.

System Description

The configuration considered in this example is shown in Figure 1. Six parallel pipes are connected by two headers. The inlet pressure and mass flow to the system is known.

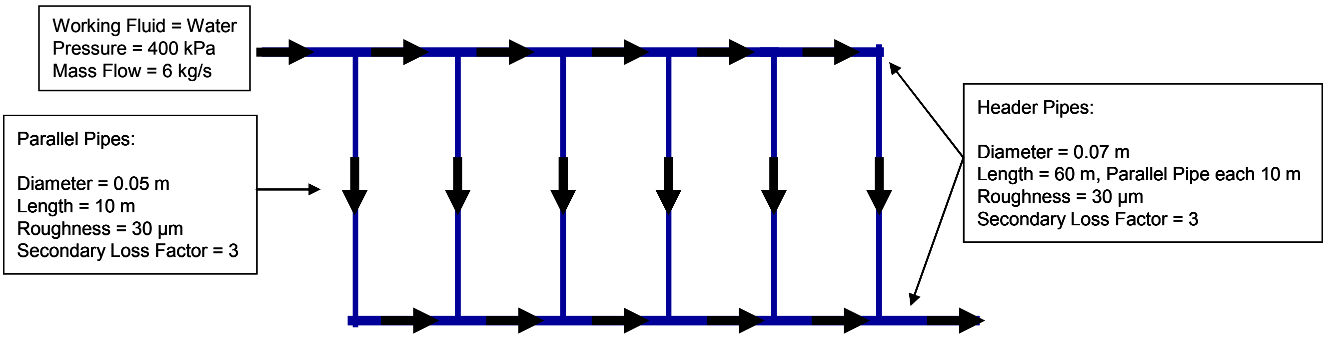

Figure 1: Schematic layout of a water system used to illustrate header flow balancing.

Objective of simulation

The objective of the simulation is to determine what size orifice should be fitted in each parallel pipe to obtain balanced flow (mass flow of 1 kg/s in each pipe) given appropriate input data for all the components as well as boundary conditions. The Flownex Designer functionality is used.

Flownex model

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

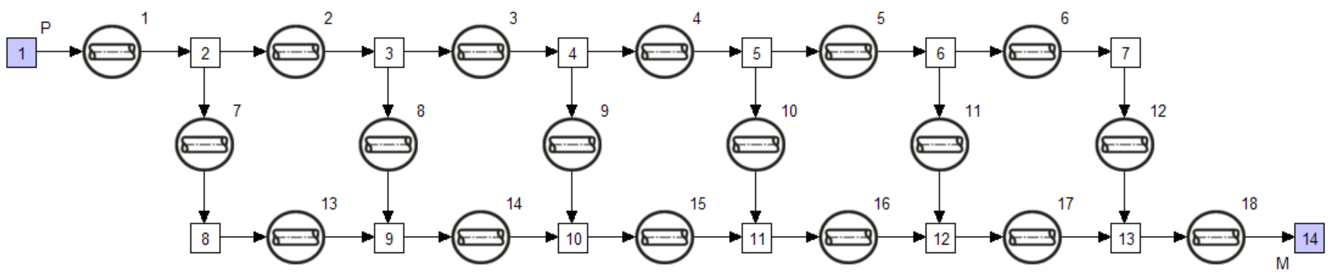

Figure 2: *Flownex network.*

The pipes are modeled in Flownex using the Pipe element and the boundary conditions are specified on the inlet and outlet nodes. The Pipe element has an integrated orifice model that is used for specifying the orifices.

Description of simulation

The boundary supply pressure is specified on the inlet node and the fixed mass flow is specified as negative value on the outlet node as to indicate that the fluid is 'sucked' out of the system.

For this case study, Flownex should calculate the orifice ratios (independent variable) so that the mass flow (equality constraint variable) through each parallel pipe is equal to 1 kg/s. The generic Flownex Designer dialog is used to specify this. When activated, the Flownex Designer automatically performs several steady-state runs to determine the values of the variables specified as independent variables to achieve the desired target function.

Results

Table 1 gives the required orifice ratios for each parallel pipe determined by the Flownex Designer. The pipe numbers coincide with the numbers given in *Figure 2*. The results are given in the Designer Result Manager, which shows the value of the specified independent values and the attained values (compared to the target values), for the equality constraint variables. It is also possible to specify which of the determined independent variable values Flownex should apply to the network for future simulations. The specific component inputs will then be altered accordingly.

Table 1: *Orifice ratios determined by the Flownex Designer*

Pipe number	Orifice Diameter
7	0.38
8	0.42
9	0.44
10	0.44
11	0.42
12	0.38

Conclusion

The use of the Flownex Designer to determine the orifice ratios to balance a flow system containing several parallel pipes connected with two headers is demonstrated in this example. It was shown how the generic Flownex Designer is used to specify the target function (flow of 1 kg/s through each pipe) and the independent variables (the orifice ratios). The Designer Manager gives the values of the determined independent variables and can be used to specify which of the calculated values should be applied to the network for future simulations.