# Tutorial 1: Steady State Flow Distribution in a Water Network

# Problem Description

As shown in Figure 3, a flow circuit filled with water is considered. The flow distribution in the network must be estimated for the given boundary condition; The pressure is fixed as 1 bar in node 11, and the mass sources in various circuit nodes are given in Table 2 (a negative mass source implies a mass sink). The geometric details of the pipes in the circuit are given in Table 3. Hazen Williams equation is to be used for friction loss estimation.

Diagram, schematic

Description automatically generated

Figure 3: Schematic of Flow Circuit for Problem 3.1.1.

Table 2: Mass Sources for Problem 3.1.1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Node number | 1 | 4 | 5 | 6 | 9 |
| Mass source (kg/s) | 104.1 | -31.55 | 34.7 | -25.24 | -37.85 |

Table 3: Geometric Details for Problem 3.1.1

|  |  |  |  |
| --- | --- | --- | --- |
| Element number | Diameter (m) | Length (m) | Roughness |
| 1 | 0.305 | 457.2 | 130 |
| 2 | 0.203 | 304.8 | 130 |
| 3 | 0.203 | 365.8 | 120 |
| 4 | 0.203 | 609.6 | 120 |
| 5 | 0.203 | 853.4 | 120 |
| 6 | 0.203 | 335.3 | 120 |
| 7 | 0.203 | 304.8 | 120 |
| 8 | 0.203 | 762.0 | 120 |
| 9 | 0.203 | 243.8 | 100 |
| 10 | 0.152 | 396.2 | 100 |
| 11 | 0.152 | 304.8 | 100 |
| 12 | 0.254 | 335.3 | 130 |
| 13 | 0.254 | 304.8 | 130 |
| 14 | 0.152 | 548.6 | 120 |
| 15 | 0.152 | 335.3 | 120 |
| 16 | 0.152 | 548.6 | 120 |
| 17 | 0.254 | 365.9 | 130 |
| 18 | 0.152 | 548.6 | 120 |
| 19 | 0.152 | 396.2 | 120 |

# Steps for input file creation

(Note the input file for this tutorial problem is saved in /docs/tutorials/tutorial1.py)

1. Create a new flow circuit with the following commands:

circuit1 **=** comp**.**Circuit**(**"circuit1"**)**

circuit1**.**assign\_fluid**(**"water1"**,**"User"**)**

Note user defined fluid library is used here for defining water properties. User-defined fluid “water1.py” must be present in the working directory. Instead CoolProp library can also be used.

1. Add nodes to the circuit with the following commands:

node1 **=** circuit1**.**add\_node**(**"node1"**)**

node2 **=** circuit1**.**add\_node**(**"node2"**)**

…

Note that only 12 nodes are added.

1. Add pipes to the circuit with the following commands:

pipe1 **=**circuit1**.**add\_pipe**(**"pipe1"**,** 0.305**,**457.2**,**"node1"**,** "node2"**,** 'HW'**,**130.**,**1**)**

pipe2 **=**circuit1**.**add\_pipe**(**"pipe2"**,** 0.203**,**304.8**,**"node2"**,** "node3"**,** 'HW'**,**130.**,**1**)**

…

(Note that the directions indicated in the figure are only assumed directions. If the actual direction is the opposite of the assumed direction, negative flow rate values will be obtained.)

Note that the pipe geometry data given in the table is used in these commands. Only 1 increment is used for all the pipes since only steady state flow distribution is required.

1. Attach boundary conditions to the nodes

bc1 **=** comp**.**BC**(**"bc1"**,**"node1"**,**'msource'**,**104.1**)**

bc2 **=** comp**.**BC**(**"bc2"**,**"node9"**,**'msource'**,-**37.85**)**

bc3 **=** comp**.**BC**(**"bc3"**,**"node6"**,**'msource'**,-**25.24**)**

bc4 **=** comp**.**BC**(**"bc4"**,**"node5"**,**'msource'**,**34.7**)**

bc5 **=** comp**.**BC**(**"bc5"**,**"node4"**,**'msource'**,-**31.55**)**

bc6 **=** comp**.**BC**(**"bc6"**,**"node11"**,**'P'**,**1.E5**)**

# Results

The nodal pressures and the element flow rates obtained are shown in Table 4 and Table 5, respectively. Verify these values from the simulation.

Table 4: Nodal Pressure Values (bar) for Problem 3.1.1

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Node no. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| PINET | 1.4386 | 1.3323 | 1.0463 | 0.9773 | 1.0183 | 0.9711 | 1.0043 | 1.0415 | 1.0780 | 1.0909 | 1.0000 | 1.0036 |

Table 5: Element Volumetric Flow Rate Values (l/s) for Problem 3.1.1

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Element | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| PINET | 60.66 | 44.15 | 17.15 | -9.83 | -8.84 | 12.11 | 13.55 | 8.17 | 43.44 | -2.59 |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Element | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| PINET | 8.55 | -7.17 | -16.03 | 5.37 | 16.51 | -1.44 | 27.00 | 4.29 | -4.57 |