SIZING OF ORIFICE USING DWSIM:

A FREE AND OPEN-SOURCE CHEMICAL PROCESS SIMULATOR

BY

VIRAJ DESAI, PROCESS ENGINEER

EMAIL: VIRAJ DESAI

LEVEL: ADVANCED

VERSION: 0.00

JANUARY 2023

PREFACE

The manual "Sizing of Orifice Using DWSIM" present a set of "Sizing of Orifice Calculation Using DWSIM" exercise using a free and open-source chemical process simulator "DWSIM" and can be utilized to establish process simulation laboratory as part of undergraduate chemical engineering degree or in allied degree curriculum. The problem statements are of intermediate level.

Prerequisite

- Must know about DWSIM UI/UX.
- Flow sheeting in DWSIM
- Selection of Thermodynamic Packages.
- Manipulating variables
- Orifice Sizing Fundamentals
- Basic Modules

Thanks

Viraj Desai

P.E. O&G

Disclaimer

All the exercises are strictly restricted to learning only and not meant to be used in real world application.

PROCESS SIMULATION USING DWSIM: A FREE AND OPEN-SOURCE CHEMICAL PROCESS SIMULATOR

PREAMBLE

DWSIM is an open-source CAPE-OPEN compliant chemical process simulator. It features a Graphical User Interface (GUI), advanced thermodynamics calculations, reactions support and petroleum characterization / hypothetical component generation tools. DWSIM can simulate steady-state, vapor–liquid, vapor–liquid-liquid, solid–liquid and aqueous electrolyte equilibrium processes and has built-in thermodynamic models and unit operations (https://en.wikipedia.org/wiki/DWSIM). It is available for Windows, Linux and Mac OS.

The objective of the course is to create awareness of the open-source process simulator "DWSIM" among prospective graduates and practicing process engineers. The course will cover Intermediate aspects of create flow sheet in DWSIM and simulation of simple Pressure changing module like pipe segment, Compressor, etc.

Target Audience

- Junior Interns in Process Firms
- III / Final year B. Tech. Chemical Engineering students
- M. Tech. Chemical Engineering students
- Practicing Process Engineers

Table of Contents

List of Figures

1 FLOW METERS

1.1 OVERVIEW OF FLOW METERS

A variety of fl ow meters are in use in chemical process industry. One category is the traditional differential pressure (DP) type volumetric fl ow meters. In many applications, the volumetric fl ow rate is of direct interest to the user. Because of its accuracy, simplicity, and relatively lower cost, these fl ow meters are popular in the chemical industry. By multiplying the fl ow rate with the actual density, mass fl ow rate can be obtained. Pitot tube, orifice meter, venturi meter and fl ow nozzles fall under this category. Among these, orifice meter is by far the most popular in the industry.

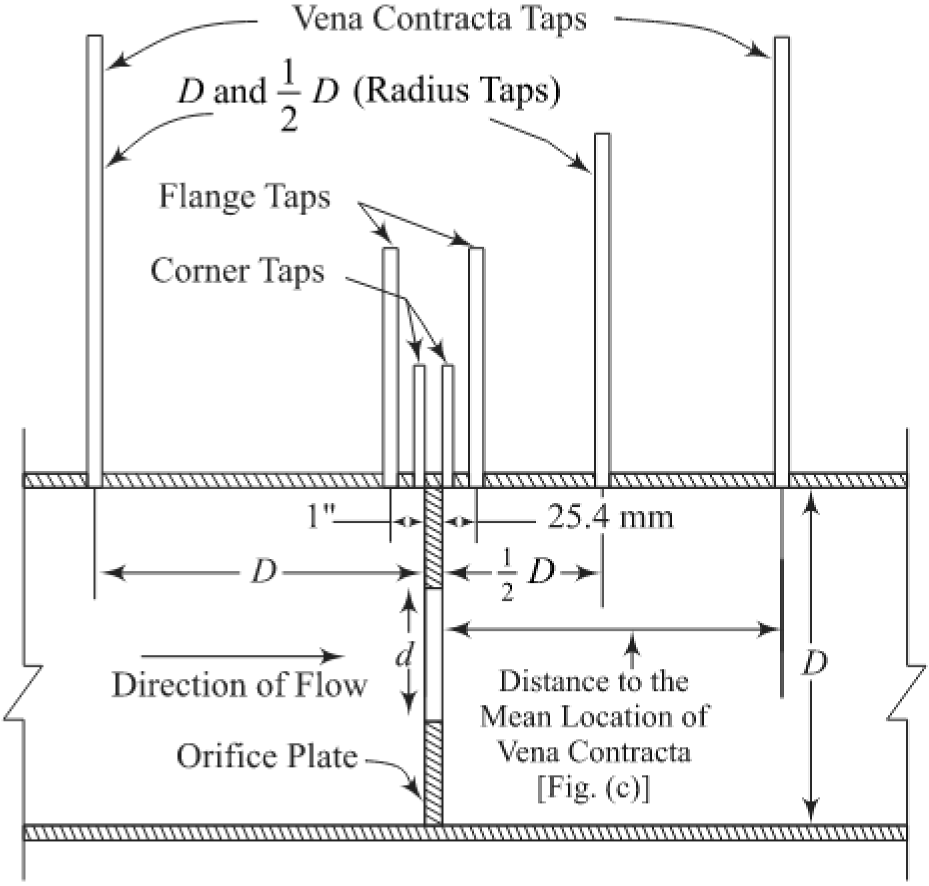

Figure 1 Various Tap Locations for Orifice Meter

1.2 PROCESS DESIGN OF ORIFICE METER

Orifice meter is a widely used fl ow meter in chemical industry, compared to venturi meter and rotameter.

Advantages of orifice meter are:

1. Fixed cost is less.
2. Easy to fabricate and install.

3. Occupies less space as compared to the venturi meter.
4. Provides more flexibility. Orifice plate can be easily replaced.

Disadvantages of orifice meter is higher power consumption and hence operating cost of orifice meter is higher than the same of venturi meter and of rotameter.

There are total five standard locations of pressure taps (3 standard location are discussed in this manual):

1. **Corner taps:** Static holes made in upstream and downstream flange. They are very close to the orifice plate. With corner taps, it is possible to drill both static holes in the orifice plate itself. Then entire orifice meter can be easily inserted in any flanged joint without drilling the holes in pipe or flanges.
2. **Flange taps:** Static holes made at a distance 25.4 mm on upstream side and 25.4 mm on downstream side.
3. **Radius taps:** Static holes located at a distance one pipe diameter on upstream side and 1/2 pipe diameter on downstream side. Radius taps are the best from practical standpoint of view as it gives reasonably good pressure difference, compared to other taps except vena contracta taps. Higher pressure difference means more accurate measurement of flow rate.

2 SIZING OF ORIFICE CALCULATION

Objective

Design an orifice meter based on the following data:

Data

- Name of fluid = Water
- Flow rate = 100,000 kg/h
- Inside diameter of pipe = 154 mm (6 in, SCH-40 pipe)
- Operating temperature = 32°C
- Density of water at 32°C = 995.026 kg/m3
- Viscosity of water at 32°C = 0.765 mPa.s or cP

Assumption

- B = 0.5
- Tapping Considered are radius tapings.

DWSIM Blocks Used

- Material Stream
- Pipe Segment
- Orifice Plate

Procedure

1. Start a new DWSIM Simulation (DWSIM VER 8.3 - CLASSIC UI). Click on “New steady state Simulation” as a template for new simulation.
2. The simulation configuration window will be opened. It shows a specification page. Add components required to solve the problem statement. In the present case, add water. Ensure the component is added from the same property database. For instance, in this case, both components are added from “ChemSep” database.
3. Specify the thermodynamic package as Steam Tables (IAPWS-IF97).
4. Customize the system of units for the simulation and click “Next”.
5. The flow sheeting section of simulation window will be opened. First, let provide Header, Orifice Inlet, Orifice Outlet & Discharge streams for the unit process to be performed.
6. On clicking the “Header” stream, general information about the stream will be displayed on the left side of screen. Specify the feed compositions, temperature, and pressure for the

inlet streams. Once credentials are specified for the Header stream, the color of stream turns blue.

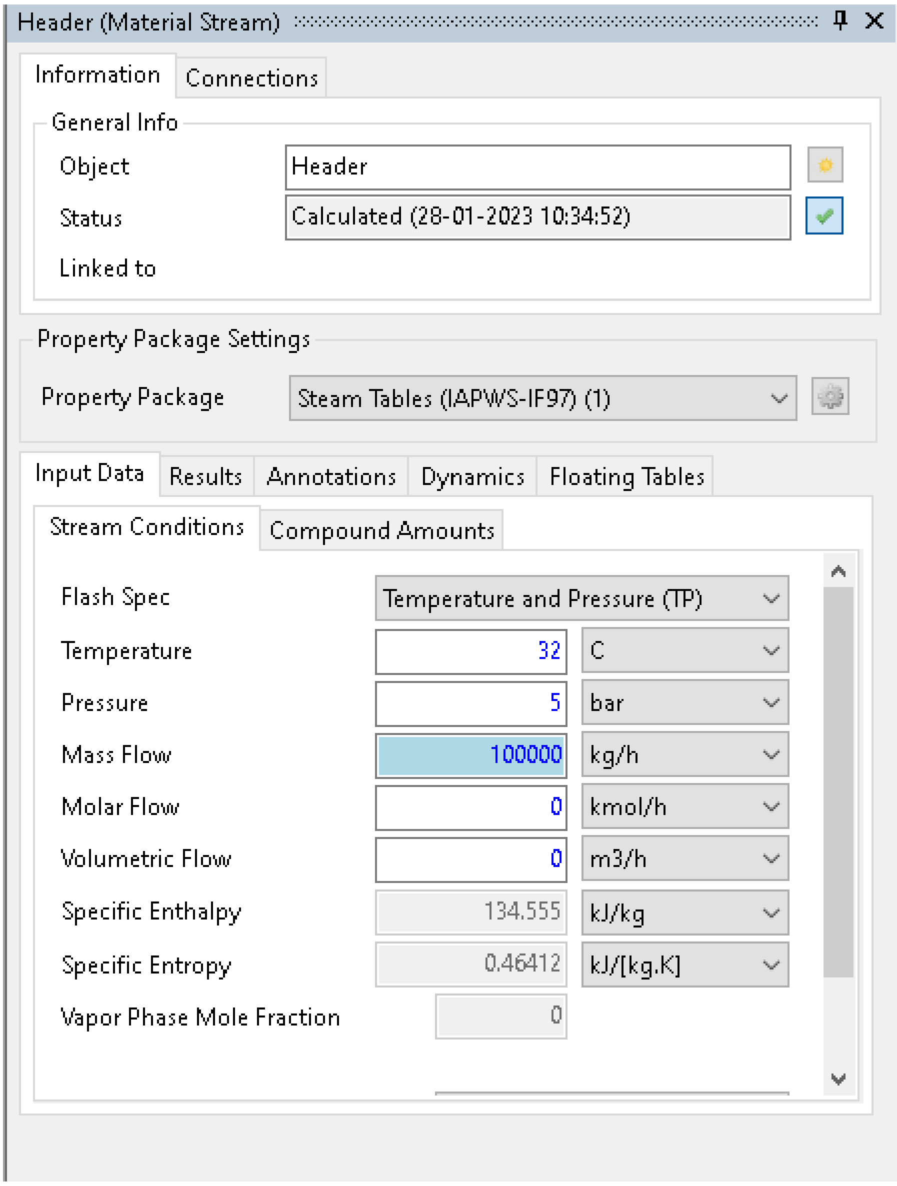

Figure 2 Header Stream Specs

7. Below the Unit Operation tab on left, locate the Pipe Segment. Drag and drop into the flow sheet. Rename it as “Inlet Pipe”.

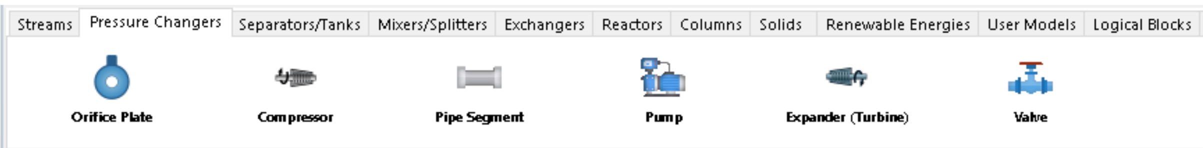

Figure 3 Pipe Segment block

8. Under specification for Inlet Pipe Segment add the data as follows.

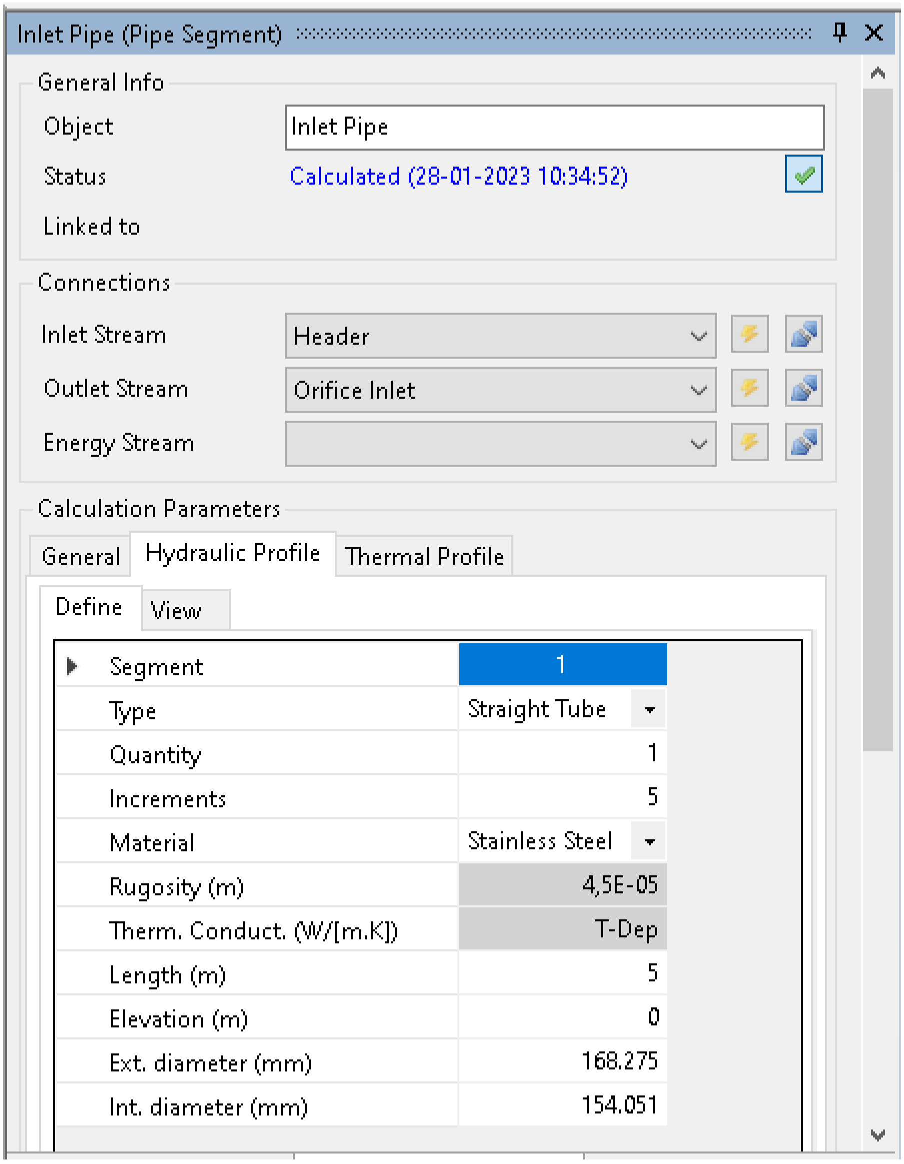

Figure 4 Inlet Pipe Segment Specs

9. Once done right click on the inlet pipe segment and make a clone and rename it as outlet pipe.

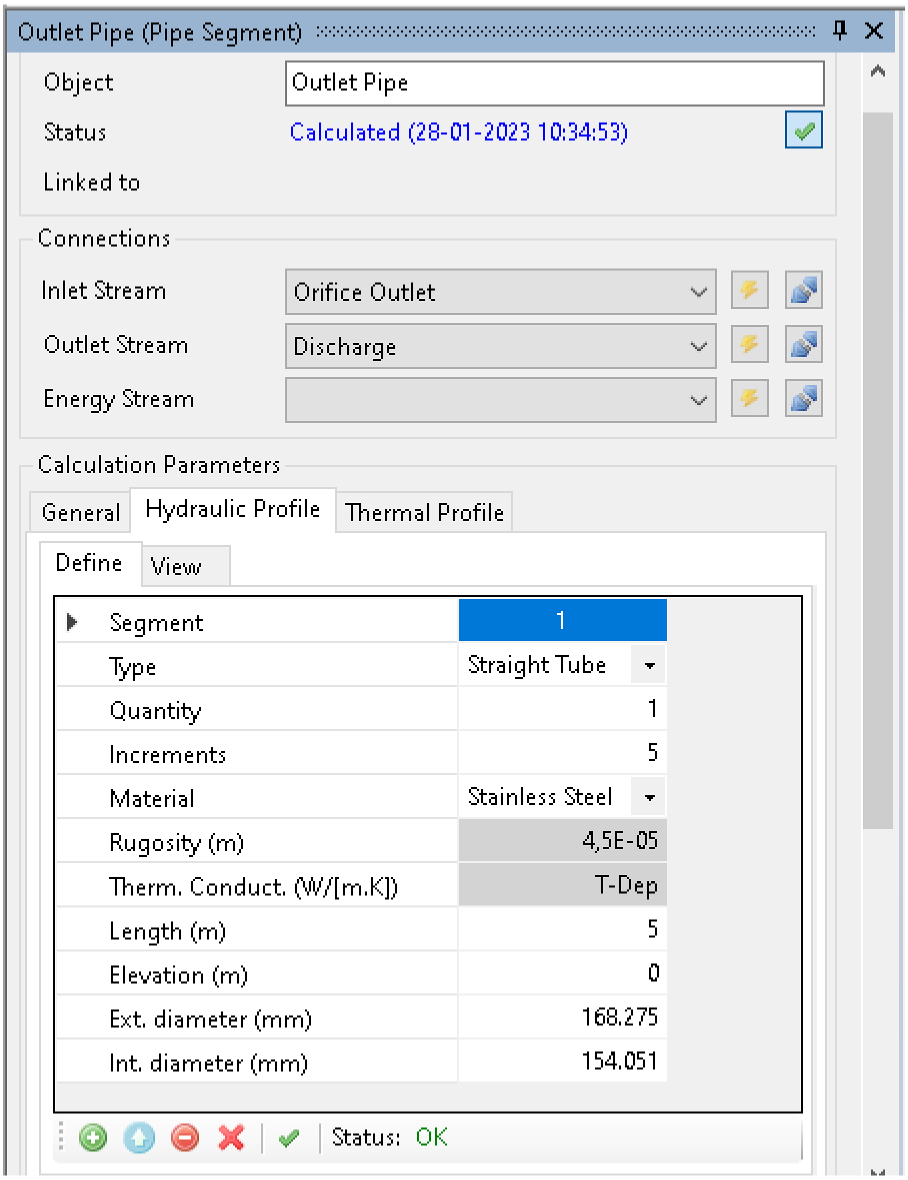

Figure 5 Outlet Pipe Segment Specs

10. Below the Unit Operation tab on left, locate the Orifice Plate. Drag and drop into the flow sheet. Rename it as "Orifice Plate".

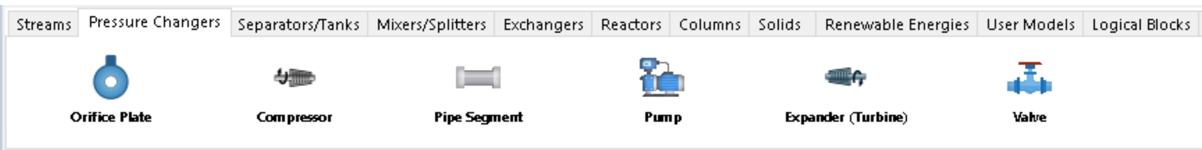

Figure 6 Orifice Plate

11. Under specification for Orifice Plate add the data as follows.

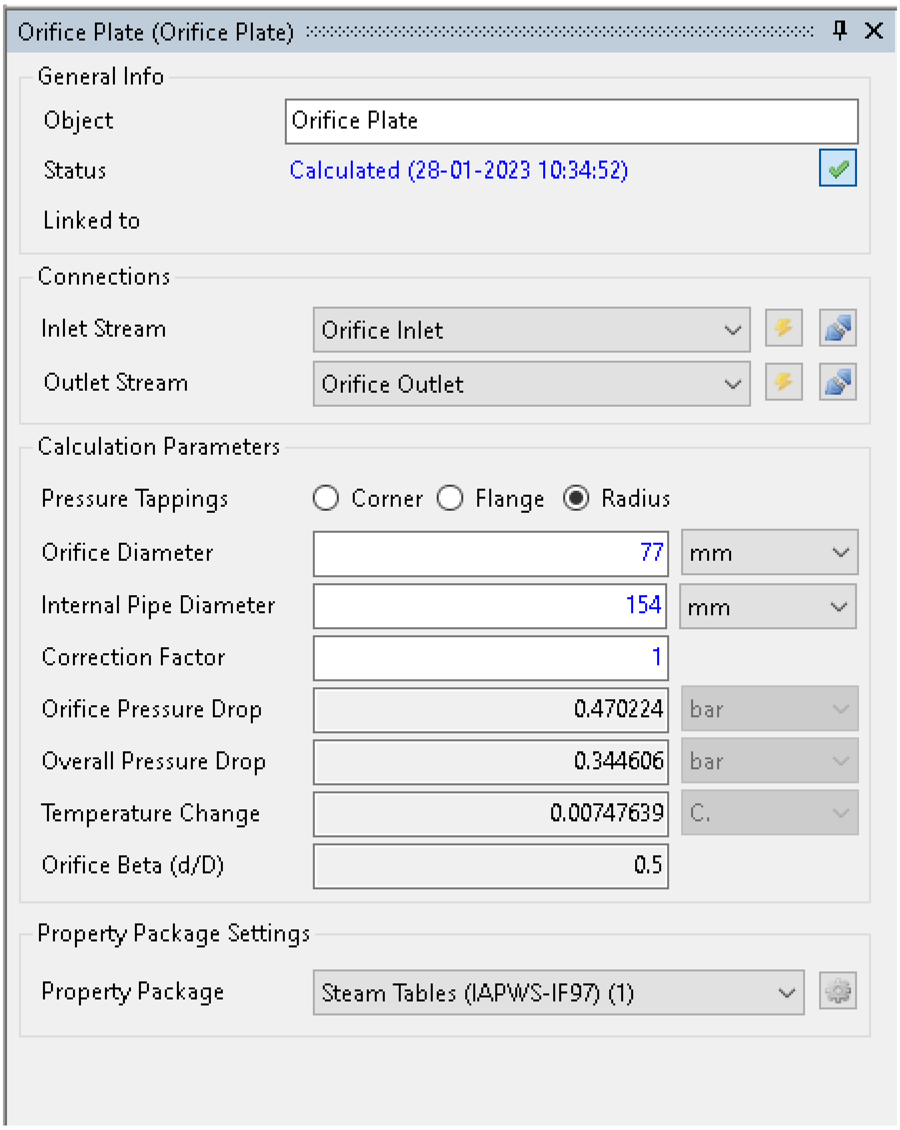

Figure 7 Orifice Plate Specs

12. Run the simulation by pressing “Solve flow sheet” button on the top corner of the screen

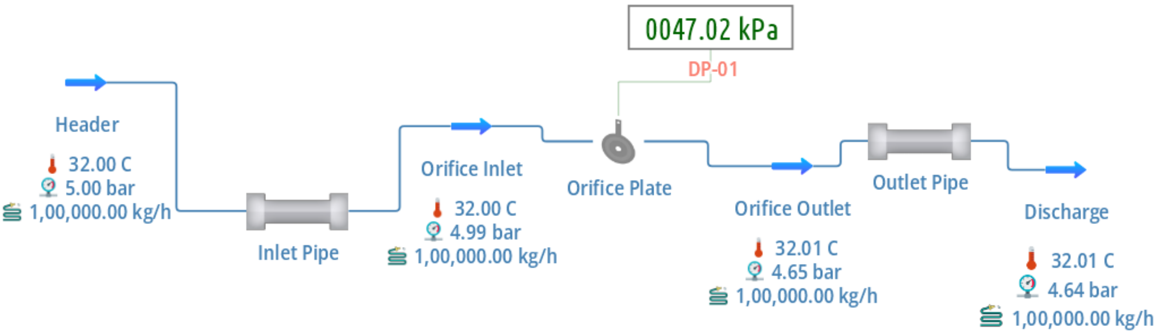

Figure 8 Flow Sheet

3 SIZING OF ORIFICE USING KORF HYDRAULICS

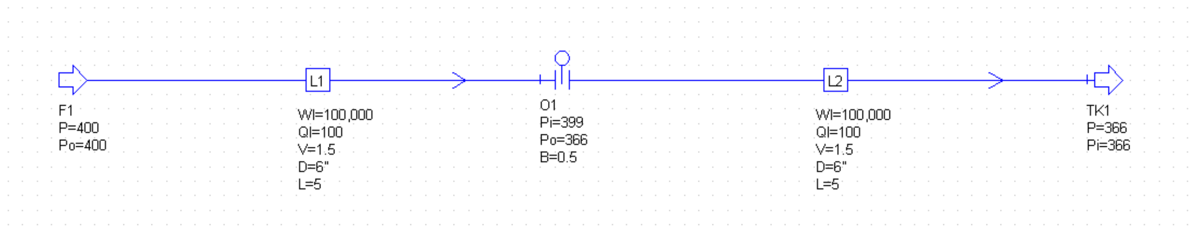

Figure 9 Orifice Sizing in Korf Hydraulics

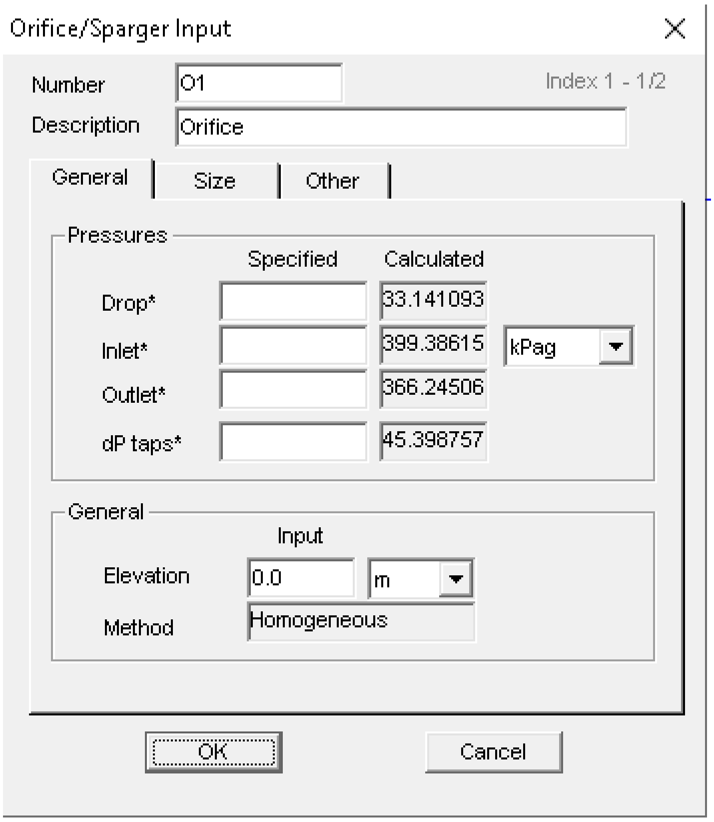

Figure 10 Orifice Sizing Results (dP taps)

[Orifice Sizing in Korf]

4 Cross-Checking in Python

31 Orifice Sizing in Python.docx

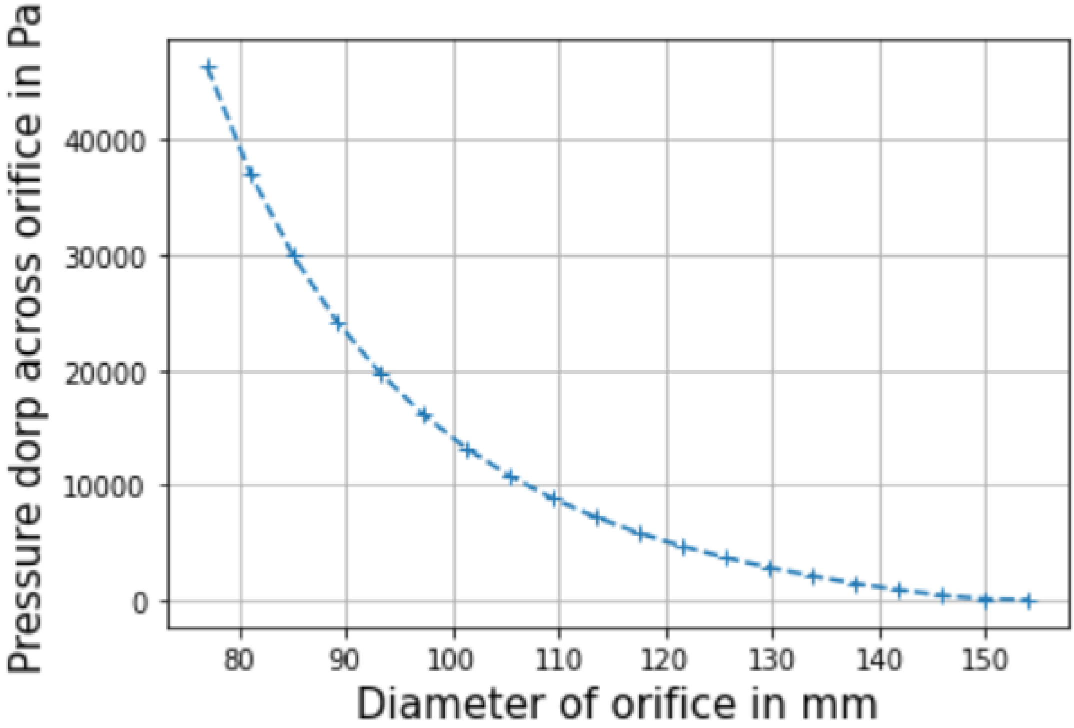

Figure 11 Relation of Diameter of Orifice vs Pressure drop in Pipe.

[Orifice Sizing in Python]

5 RESULTS OF DWSIM

	Header	Orifice Inlet	Orifice Outlet	Discharge
Temperature (C)	32	32.0001	32.0076	32.0077
Pressure (bar)	5	4.99385	4.64924	4.64309
Mass Flow (kg/h)	100000	100000	100000	100000
Molar Flow (kmol/h)	0	5550.84	5550.84	5550.84
Volumetric Flow (m3/h)	0	100.482	100.483	100.483
Density (Mixture) (kg/m3)	995.208	995.208	995.19	995.19
Molecular Weight (Mixture) (kg/kmol)	18.0153	18.0153	18.0153	18.0153
Specific Enthalpy (Mixture) (kJ/kg)	134.555	134.555	134.555	134.555
Specific Entropy (Mixture) (kJ/[kg.K])	0.46412	0.464122	0.464235	0.464237
Molar Enthalpy (Mixture) (kJ/kmol)	2424.04	2424.04	2424.04	2424.04
Molar Entropy (Mixture) (kJ/[kmol.K])	8.36125	8.36129	8.36333	8.36337
Thermal Conductivity (Mixture) (W/[m.K])	0.618875	0.618875	0.618871	0.618871

6 REFERENCES

1. Flow Meters