CONTROL VALVE SIZING USING DWSIM:

A FREE AND OPEN-SOURCE CHEMICAL PROCESS SIMULATOR

BY

VIRAJ DESAI, PROCESS ENGINEER

EMAIL: VIRAJ DESAI

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PREFACE

The manual “Control Valve Sizing Using DWSIM” presents a set of “Control valve Sizing for incompressible fluid” 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
- Line Hydraulics
- 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

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1 BACKGROUND

1.1 OVERVIEW OF CONTROL VALVE SIZING

Standardization activities for control valve sizing can be traced back to the early 1960s when a trade association, the Fluids Control Institute, published sizing equations for use with both compressible and incompressible fluids. The range of service conditions that could be accommodated accurately by these equations was quite narrow, and the standard did not achieve a high degree of acceptance. In 1967, the ISA established a committee to develop and publish standard equations. The efforts of this committee culminated in a valve sizing procedure that has achieved the status of American National Standard. Later, a committee of the International Electrotechnical Commission (IEC) used the ISA works as a basis to formulate international standards for sizing control valves. The ANSI/ISA-75.01.01 and IEC 60534-2-1 valve sizing standards have been harmonized, so either standard may be used.

1.2 CRITICAL SIZING ELEMENTS

It is important to provide the following information in order to size a control valve properly:

- Physical details (pipe size, pressure class, trim type)
- Process conditions (upstream pressure, downstream pressure, temperature, noise limit)
- Fluid properties (flow rate, density)

2 Control Valve Sizing

Objective

Find the coefficient of discharge for the given control valve in the problem statement.

Data

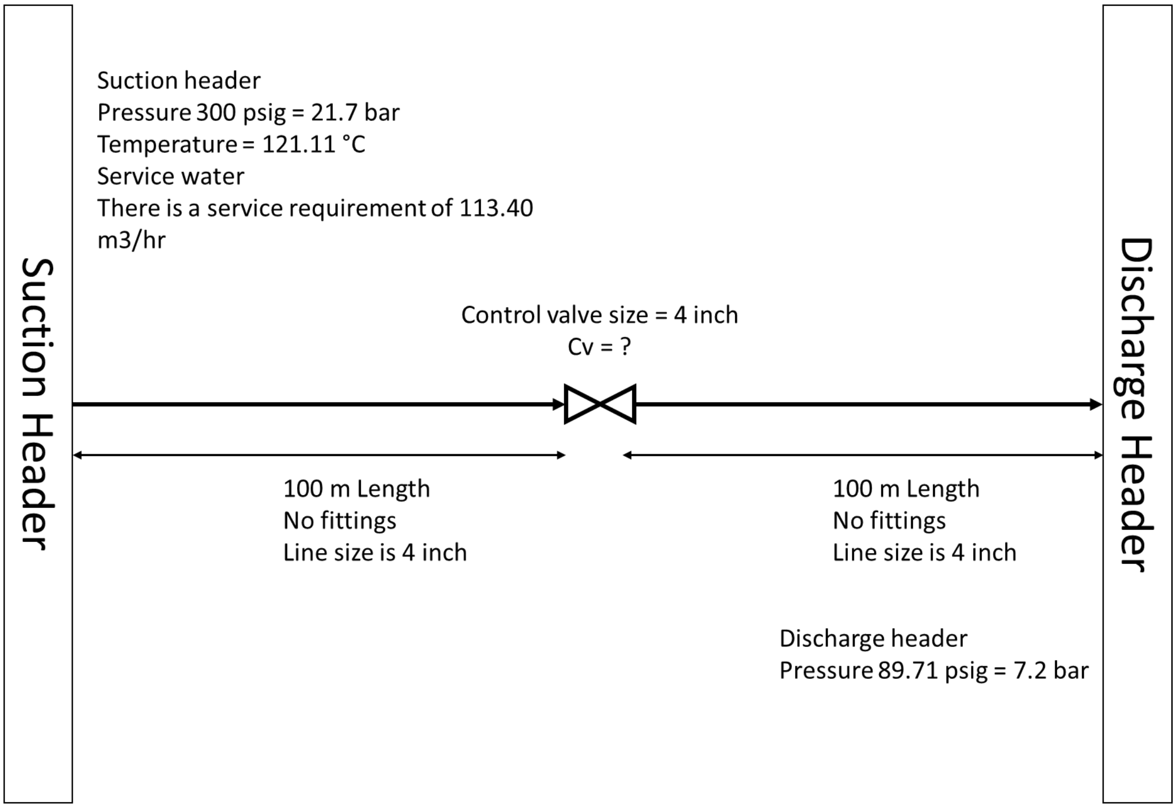


Figure 1 Problem Statement

DWSIM Blocks Used

- Pipe segment
- Material Stream
- Control valve

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) (1).
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 suction header, valve inlet, valve outlet and discharge header streams for the unit operation to be performed.
6. On clicking the “Suction 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 Suction header streams, the color of stream turns blue.

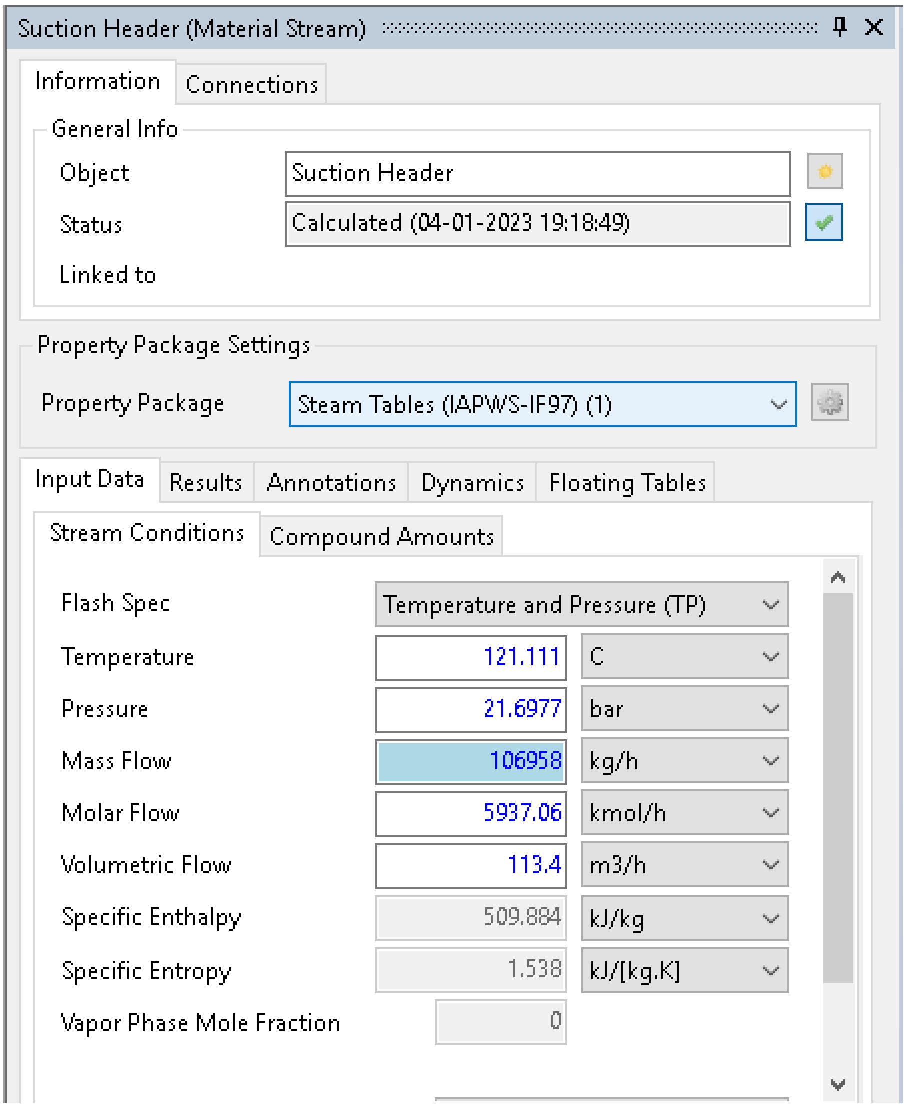


Figure 2 Suction header stream specs

7. Below the Unit Operation tab on left, locate the pipe segment block. Drag and drop into the flow sheet. Rename it as “Upstream line”.

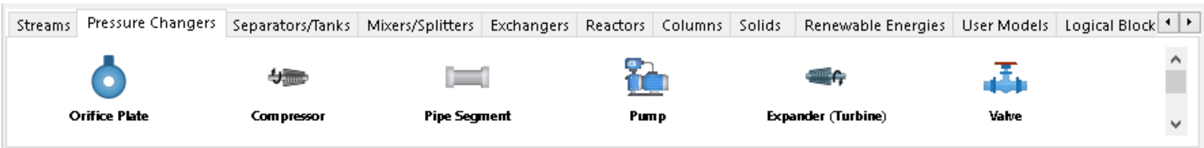


Figure 3 Pipe segment

8. Under specification for pipe segment add the data as follows.

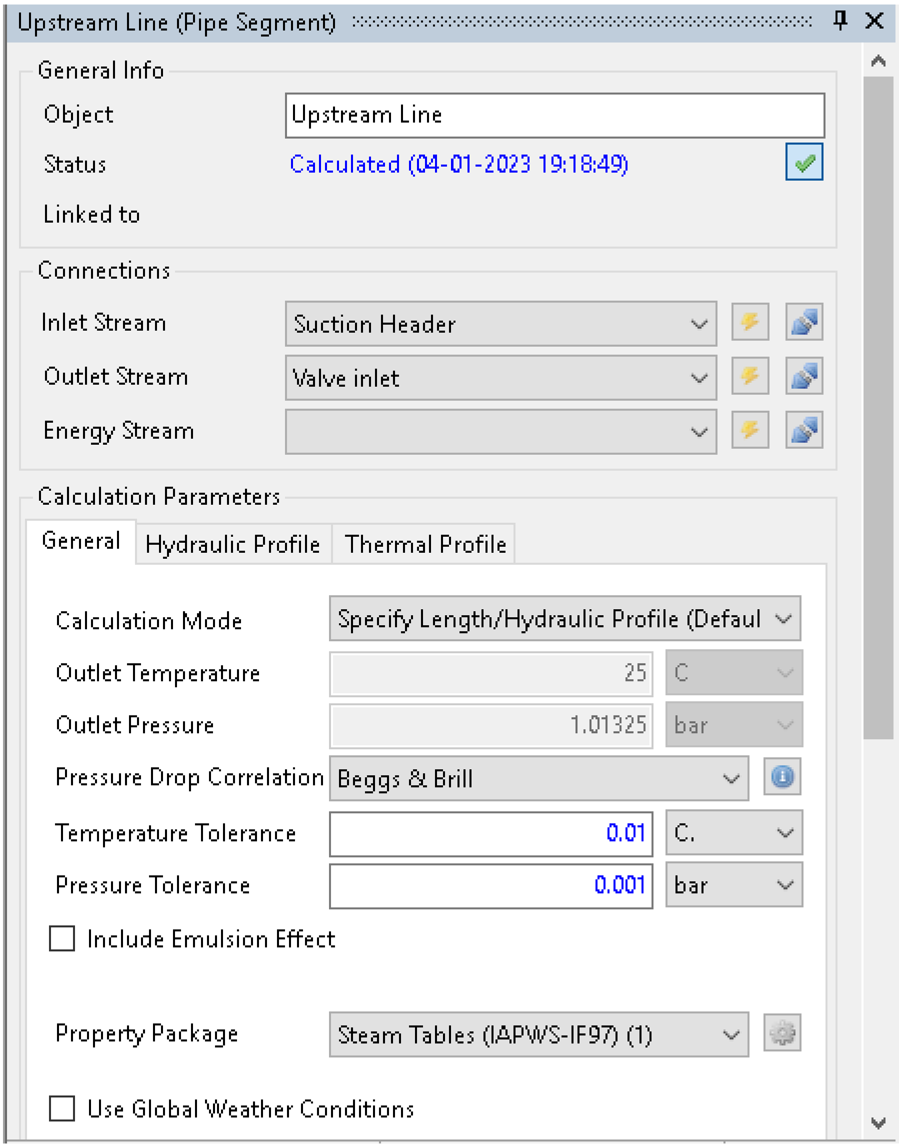


Figure 4 Upstream Inlet Line Specs

9. Click on the hydraulic profile as shown in the image

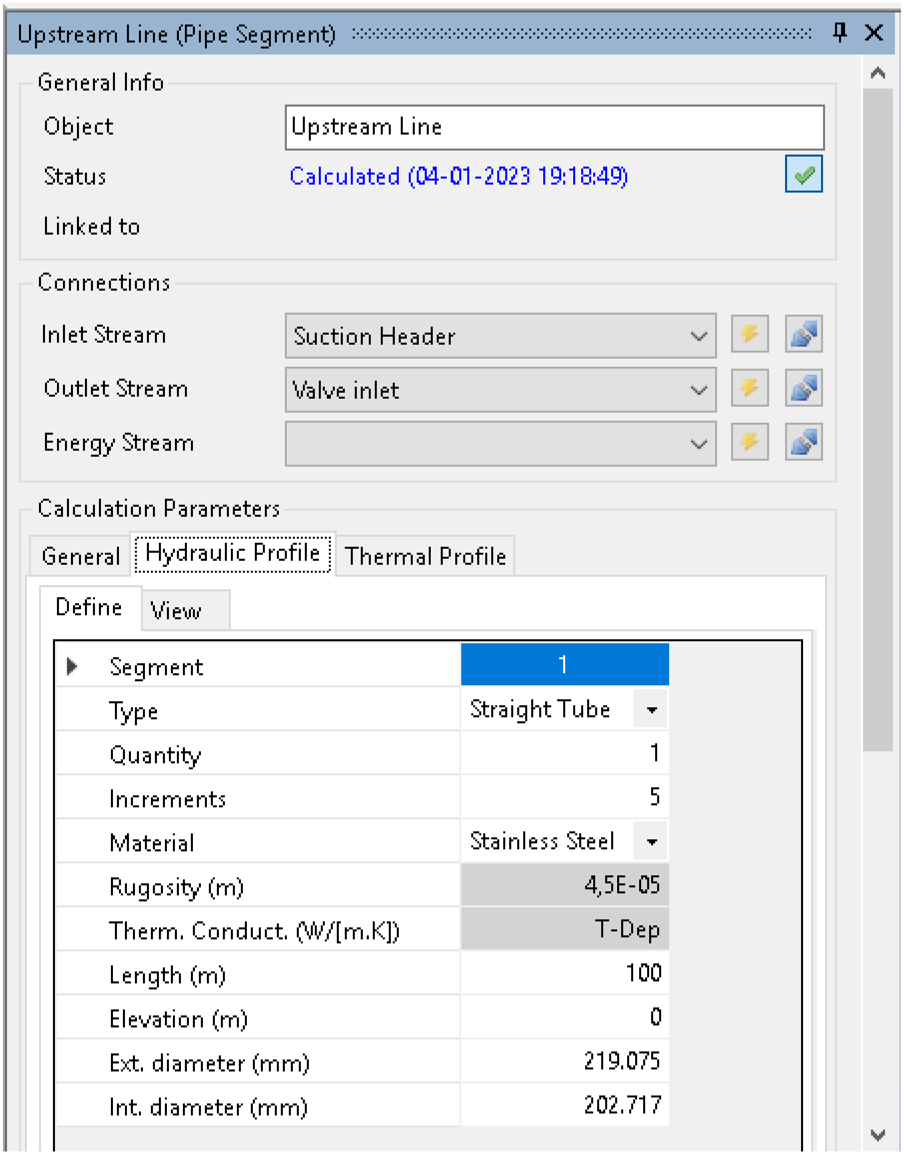


Figure 5 Adding specs for hydraulic profile |Valve Inlet Pipe |.

Segment	1
Type	Straight Tube
Quantity	1
Increments	5
Material	Stainless Steel
Rugosity (m)	4,5E-05
Therm. Conduct. (W/[m.K])	T-Dep
Length (m)	100

Elevation (m)	0
Ext. diameter (mm)	219.075
Int. diameter (mm)	202.717

10. Click on “View” in hydraulic profile tab to see layout of pipe network

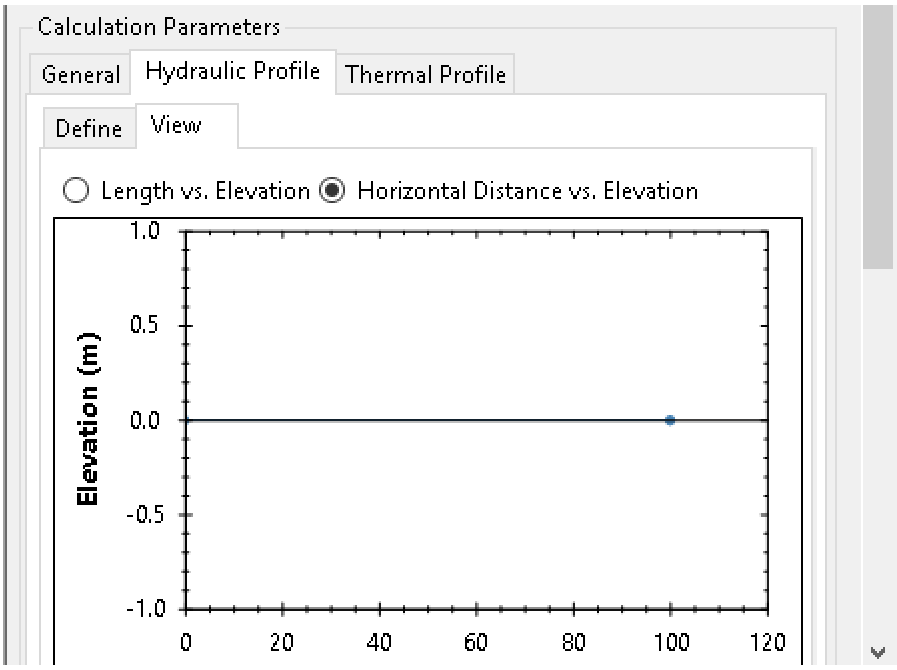
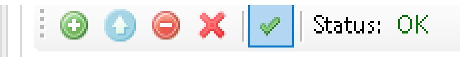


Figure 6 Elevation vs horizontal distance profile for Valve inlet pipe

11. Once all segments are added with the data provided as reference in the table above click on green tick mark to apply changes 

12. Similarly add a pipe segment name it as "Valve outlet line" And add the following specs.

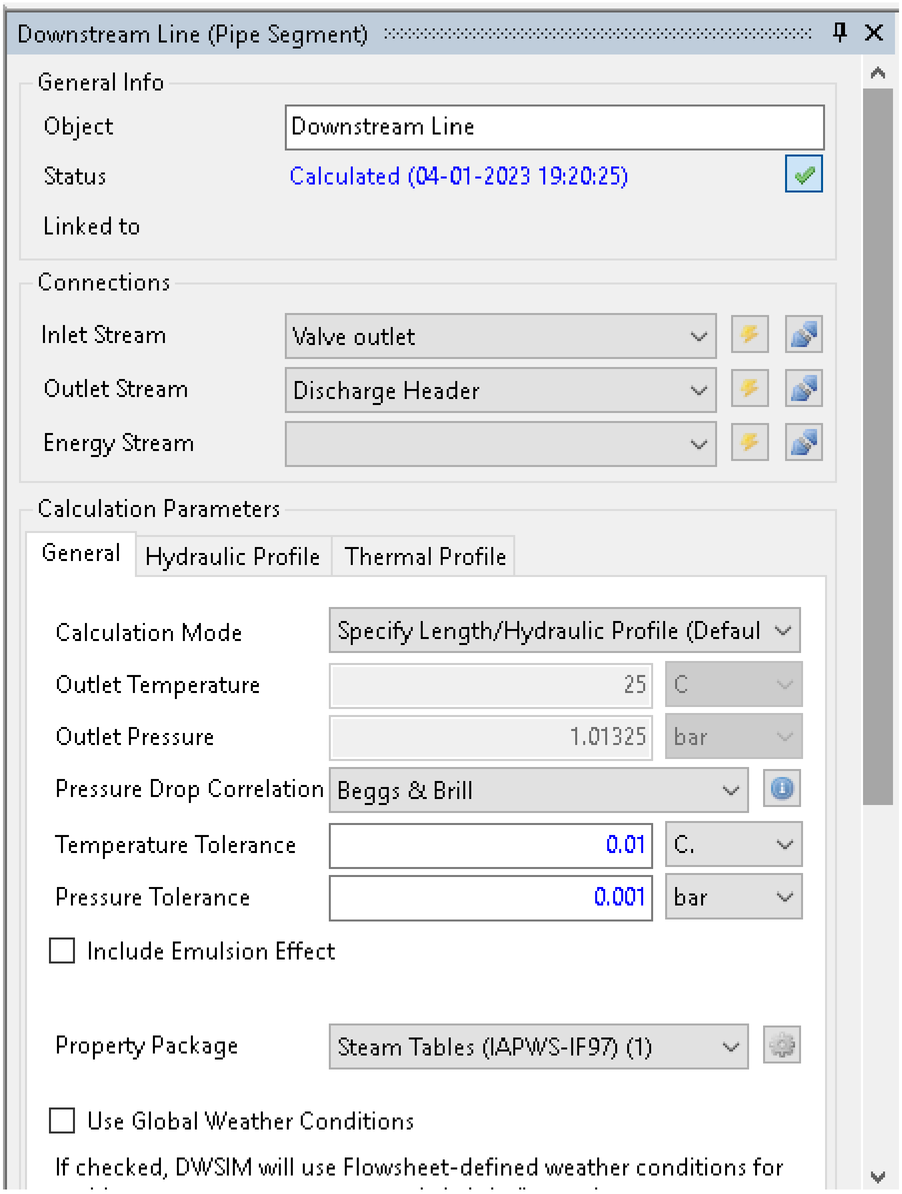


Figure 7 Pipe segment of Valve Outlet Specs

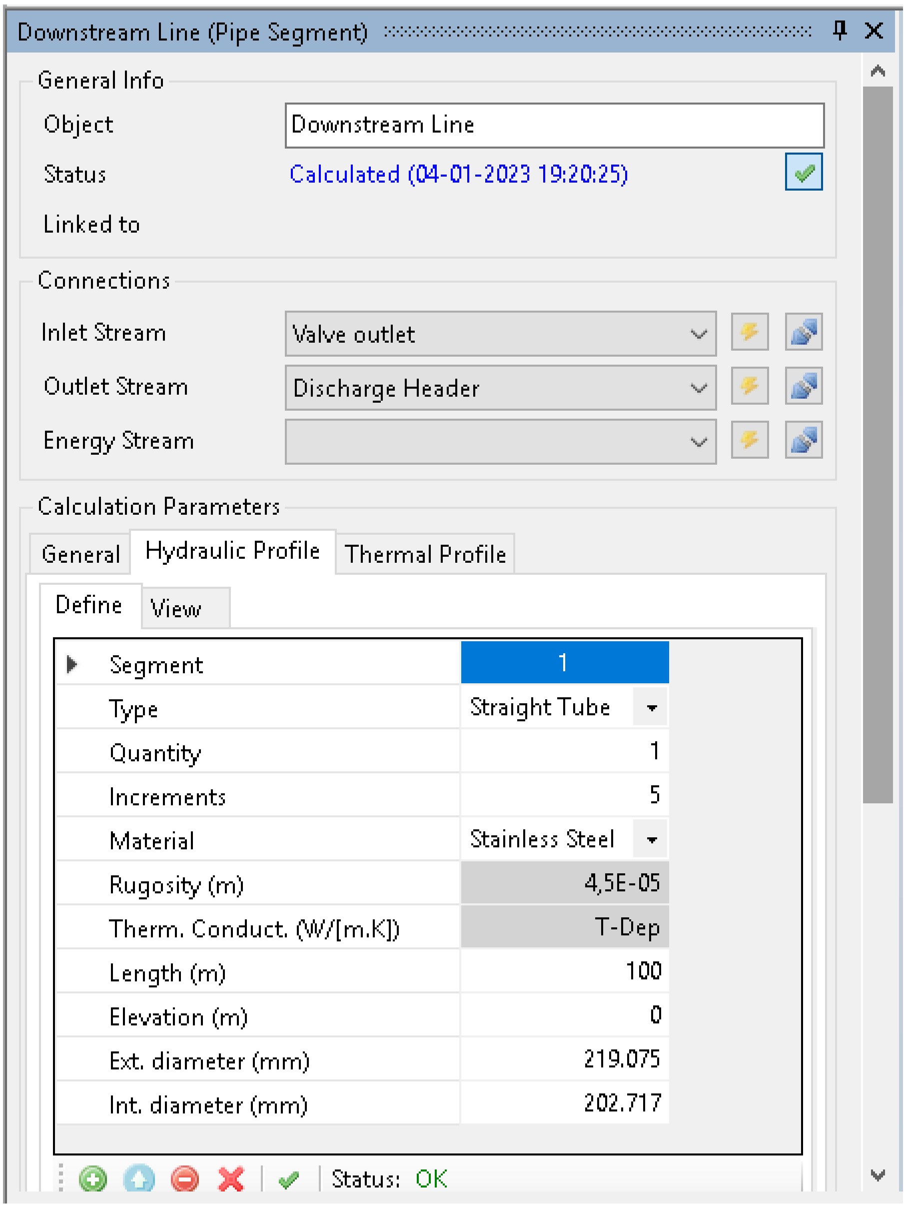


Figure 8 Adding specs for hydraulic profile |Valve Outlet Pipe |

Segment	1
Type	Straight Tube
Quantity	1
Increments	5
Material	Stainless Steel
Rugosity (m)	4,5E-05
Therm. Conduct. (W/[m.K])	T-Dep
Length (m)	100

Elevation (m)	0
Ext. diameter (mm)	219.075
Int. diameter (mm)	202.717

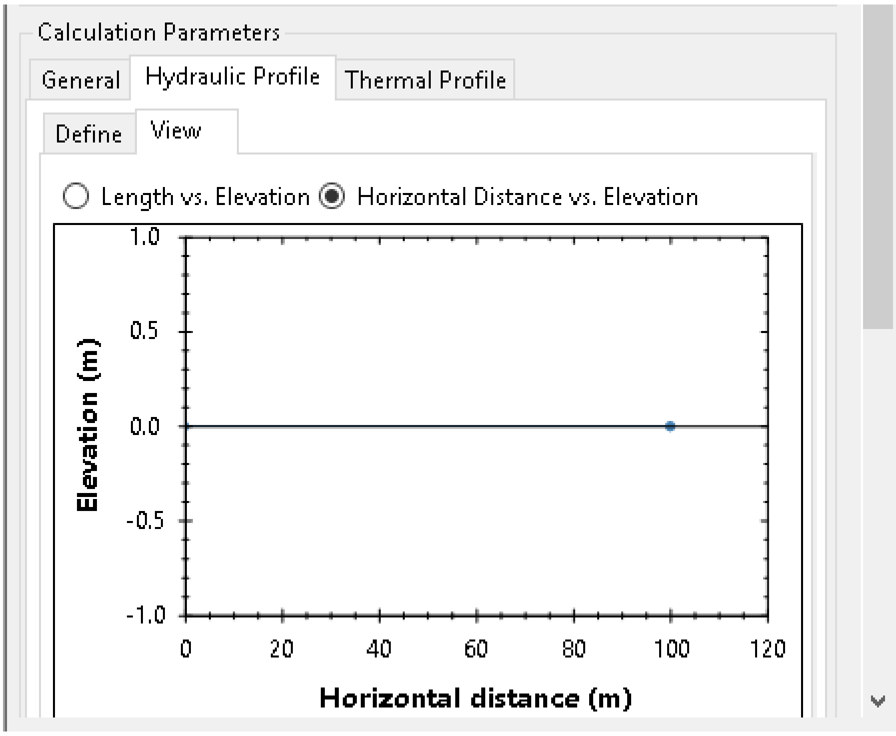


Figure 9 Elevation vs horizontal distance profile for Compressor outlet pipe

13. Once all segments are added with the data provided as reference in the table above click on green tick mark to apply changes 

14. Add a valve from the pressure changes ribbon and connect the "Upstream line" and "Downstream line". And rename it as FCV-1. And add the following specs

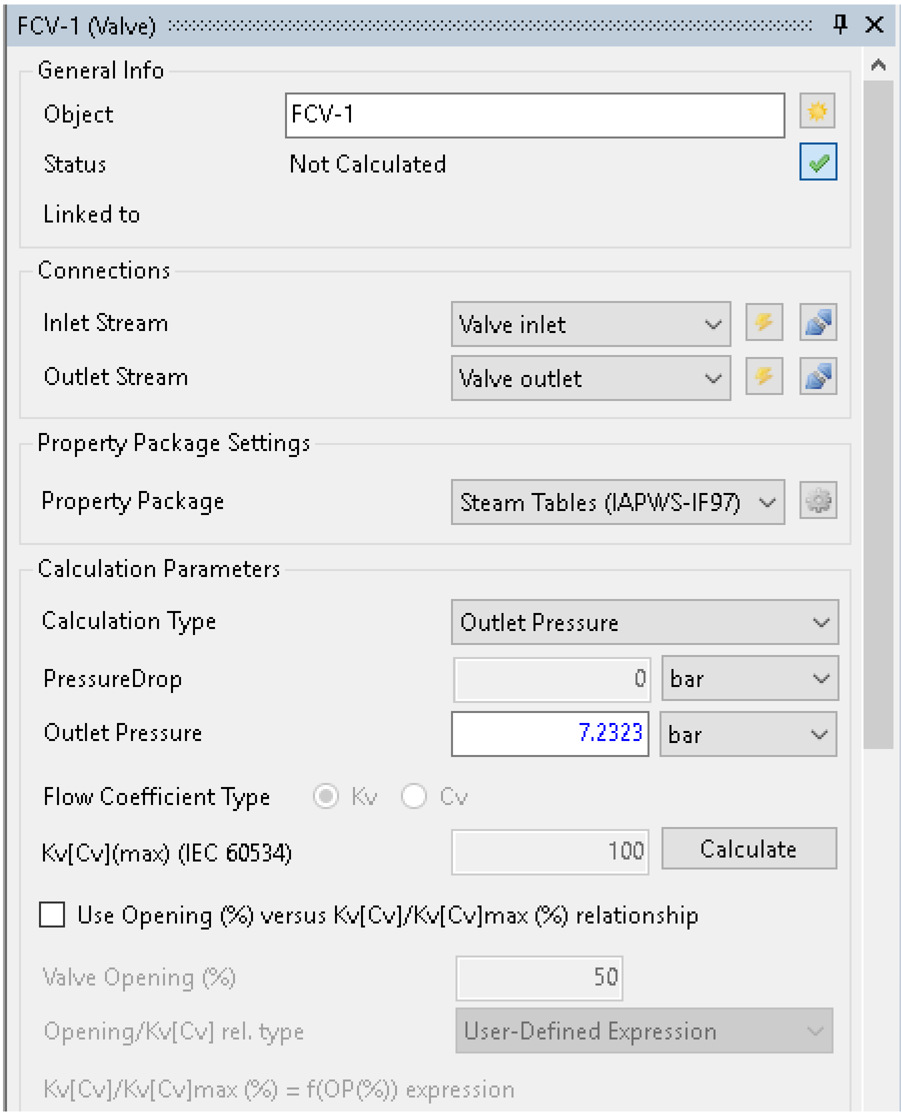
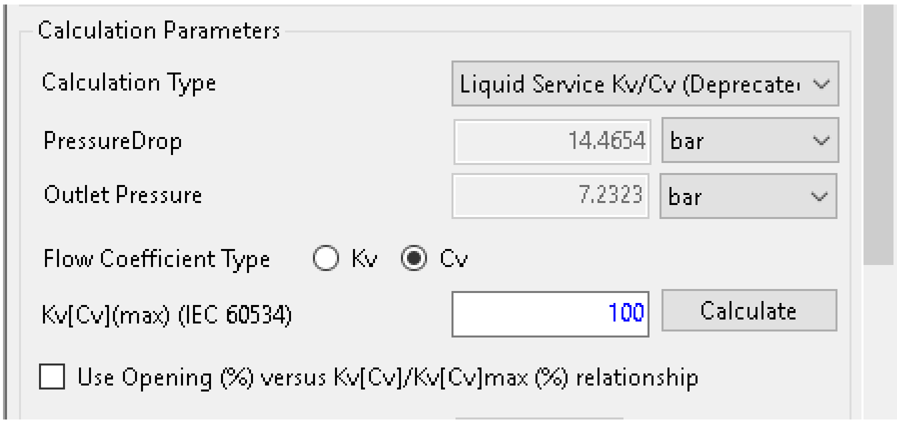


Figure 10 Valve Specs

15. Once done click on calculation type drop down and select Liquid Service Kv/Kc deprecated and select Cv. Then again select outlet pressure from drop down of calculation type



16. Run the simulation by pressing "Solve flow sheet" button on the top corner of the screen

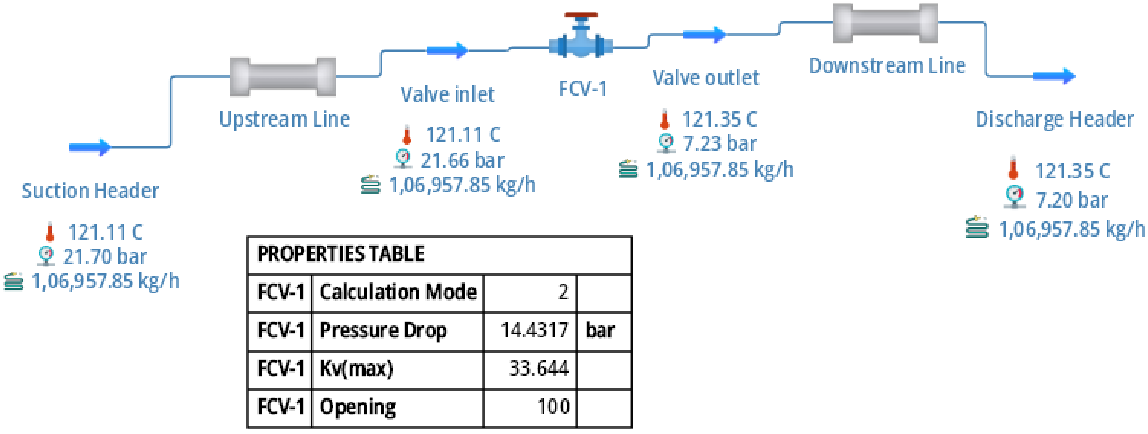
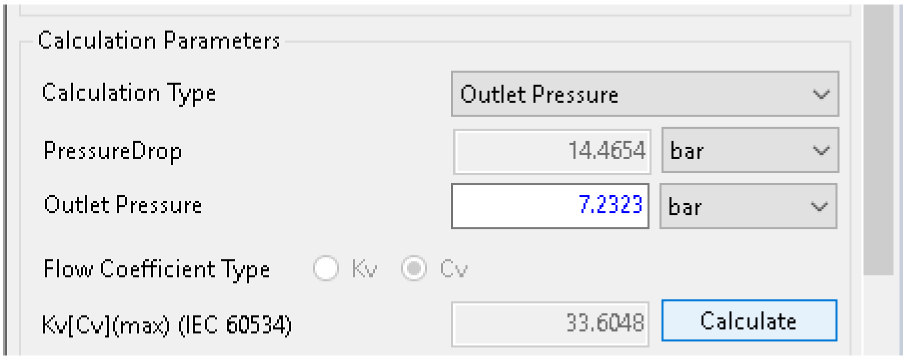


Figure 11 Flow Sheet

17. Click on FCV-1 and click on calculate to get Cv of valve.



18. Click on report generation to get control valve characteristics

Simulation Report
DWSIM 8.3

Details

Title: MySimulation_18

Comments:

Object: FCV-1
Type: Adiabatic Valve

Property	Value	
Actuator Delay	0	h
Calculation Mode	2	
Pressure Drop	14.4317	bar
Outlet Pressure	7.23237	bar
Temperature Drop	0.238067	C.
Kv(max)	33.644	
Opening	100	
Characteristic Parameter	50	

Figure 12 Coefficient of discharge

	Valve inlet	**Valve outlet**	**Discharge Header**	**Suction Header**
Temperature (C)	121.112	121.35	121.35	121.111
Pressure (bar)	21.6641	7.23237	7.1988	21.6977
Mass Flow (kg/h)	106958	106958	106958	106958
Molar Flow (kmol/h)	5937.06	5937.06	5937.06	5937.06
Volumetric Flow (m3/h)	113.4	113.51	113.511	113.4
Density (Mixture) (kg/m3)	943.189	942.273	942.271	943.191
Molecular Weight (Mixture) (kg/kmol)	18.0153	18.0153	18.0153	18.0153
Specific Enthalpy (Mixture) (kJ/kg)	509.884	509.884	509.884	509.884
Specific Entropy (Mixture) (kJ/[kg.K])	1.53801	1.54189	1.5419	1.538
Molar Enthalpy (Mixture) (kJ/kmol)	9185.71	9185.71	9185.71	9185.71
Molar Entropy (Mixture) (kJ/[kmol.K])	27.7077	27.7776	27.7778	27.7075
Thermal Conductivity (Mixture) (W/[m.K])	0.684457	0.683619	0.683617	0.684459

3 Cross-Checking in KORF hydraulics

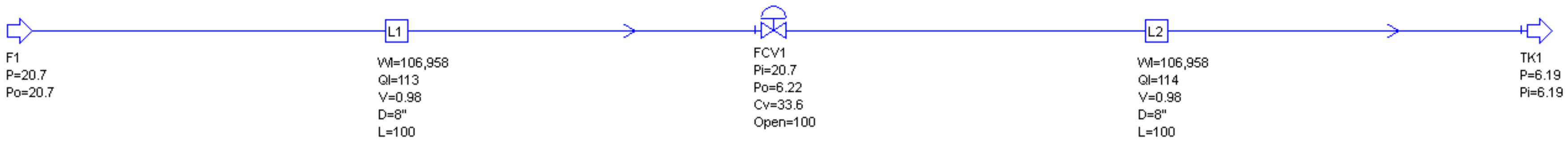


Figure 13 Control valve Coefficient of discharge calculation in KORF

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Sizing for Incompres

[Control Valve Calculations Korf Results]

UPSTREAM LINE PROFILE DATA														
Length (m)	**Inclination (degrees)**	**Pressure (bar)**	**Temperature (C)**	**Liquid Velocity (m/s)**	**Vapor Velocity (m/s)**	**Heat (kW)**	**Liquid Holdup**	**Flow Regime**	**Overall HTC (W/[m2.K])**	**h (Internal) (W/[m2.K])**	**k/L (Wall) (W/[m2.K])**	**k/L (Insulation) (W/[m2.K])**	**h (External) (W/[m2.K])**	**External Temperature (C)**
0	0	21.6977	121.111	0.975977	0	0	1	Liquid Only	0	0	0	0	0	25
20	0	21.691	121.111	0.975978	0	0	1	Liquid Only	0	0	0	0	0	25
40	0	21.6842	121.111	0.975978	0	0	1	Liquid Only	0	0	0	0	0	25
60	0	21.6775	121.111	0.975979	0	0	1	Liquid Only	0	0	0	0	0	25
80	0	21.6708	121.112	0.975979	0	0	1	Liquid Only	0	0	0	0	0	25
100	0	21.6641	121.112	0.97598	0	0	1	-	0	0	0	0	0	25

DOWNSTREAM LINE PROFILE DATA														
Length (m)	**Inclination (degrees)**	**Pressure (bar)**	**Temperature (C)**	**Liquid Velocity (m/s)**	**Vapor Velocity (m/s)**	**Heat (kW)**	**Liquid Holdup**	**Flow Regime**	**Overall HTC (W/[m2.K])**	**h (Internal) (W/[m2.K])**	**k/L (Wall) (W/[m2.K])**	**k/L (Insulation) (W/[m2.K])**	**h (External) (W/[m2.K])**	**External Temperature (C)**
0	0	7.23237	121.35	0.976928	0	0	1	Liquid Only	0	0	0	0	0	25
20	0	7.22565	121.35	0.976929	0	0	1	Liquid Only	0	0	0	0	0	25
40	0	7.21894	121.35	0.976929	0	0	1	Liquid Only	0	0	0	0	0	25
60	0	7.21223	121.35	0.97693	0	0	1	Liquid Only	0	0	0	0	0	25
80	0	7.20551	121.35	0.97693	0	0	1	Liquid Only	0	0	0	0	0	25
100	0	7.1988	121.35	0.97693	0	0	1	-	0	0	0	0	0	25

4 MANUAL CALCULATION IN SMATH STUDIO

29 Control Valve
Sizing for Incompres

[Smath Studio Manual Calculations]

5 REFERENCES

1. Control Valve Sizing Emerson