Exercise 2: Gas pipeline

Pipe and insulation data

Total length l	1000 m
Inner diameter d	0.05 m
Absolute roughness k_s	0 m
Surface uniformity factor u_s	1
Pipe wall thickness	0.020 m
Insulation thickness	0.100 m
Pipe wall thermal conductivity	50 W/(m K)
Insulation thermal conductivity	1.2 W/(m K)

Environment

Submerged, water current	0.5 m/s
Water temperature	278 K

Fluid

Gas, As in table 14.1.1 in the book.

Pipe elevation

Horizontal

1. Start the simulations with the fluid pressurized to 10 MPa in the whole pipe. Choose Nx = 10 and start the simulations. Increase the inlet pressure to 12.1 MPa, while the outlet pressure is kept as-is. Run until steady-state conditions have stabilized. Study all primary and secondary variables. Does the mass flow curve become horizontal? Is the flow isothermal?
2. Run the simulations again. Consider using a higher Nx, for instance Nx = 40. Study how the temperature profile develops when the pressure is increased at the inlet. What happens?
3. If the average dynamic viscosity *is* $\mu = 16.9 \cdot 10^{-6}$ kg/(m·s²), what is the Reynolds number? (Hint: Use equation 2.1.10 and insert average values from the simulation results). What is the Darcy-Weisback friction factor according to the modified Moody diagram, figure 2.9.1? How well do the results agree with equation manual capacity estimation, for instance by using equation 6.4.17? Can we expect good agreement in this case?
4. Suppose the speed of sound is as illustrated in figure 14.1.3. Does it look like disturbances propagate at that speed in the simulations?
5. The gas composition in this example is the same as the one shown in table 14.1.1 and further elaborated in figure 14.1.1-14.1.3. Are we in this case able to perform the Joule-Thompson test, as it was outlined in chapter 14.2?
6. If time permits, try running the simulations with the same data as the long pipeline in chapter 14.1. How do the results compare to those of figure 14.1.4 and 14.1.5?