**Exercise 6 Pipe flow temperature including friction**

Exercise 1.2 considered temperature in a pipe between wells completed on the seabed and processing platform. Cross section illustrated below



The following data were given

Inner pipe diameter: 0.2 m

Tubing wall thickness: 0.5 cm

Cement jacket around the pipe: 4cm

Pipe length: 10,000m

Oil rate: 5000 m3 / d

Oil density: 800 kg / m3

Temperature at the well head cluster: 40 C

The heat transfer coefficient was estimated: 43 w/m2K. Temperature along the pipe was predicted analytically, using heat capacity for paraffin: cp = 2.13 kJ / kgK. This neglects flow within the pipe: pressure drop and friction

1. Solve the energy conservation equation for pipe flow (6-11) numerically and verify by comparing to the analytic solution: 
2. Estimate temperature along the pipe including friction heating, for flow rates: 5000 and 15000 m3 / d. Oil viscosity 5cP may be used as an along-the-pipe average
3. Estimate the flow capacity for outlet pressure : 20 bar