Task 1 – Pumping (40 points)

Hanz is a small undersaturated oil reservoir satellite to the Ivar Aasen platform. The reservoir will be developed using oil producers and a pipeline connected to a separator on the platform. Assume the wells does not produce any water.





Question 1. Calculate the pressure required at the inlet to the pipeline to produce a total oil rate of 5 000 Sm3/d

Question 2. The pressure estimated in **Question 1** is much higher than the pressure the reservoir can provide at the wellhead when producing 5000 Sm3/d (20 bar). Therefore, it has been decided to place a pump station at the inlet of the pipeline to give energy to the fluid coming from the well. The performance map of a single pump is given in the "additional information" section. Estimate how many pumps are needed in the pump station, their configuration (parallel or in series), their (approximate) rotational speed and the power of the motor to install in each pump.

ADDITIONAL INFORMATION:

For the pressure drop calculations in the pipeline and riser assume that there is only oil flowing in the pipes, that the oil is incompressible and neglect the presence of gas. For the calculation of friction energy losses along the pipeline consider the equation:

$$h_f = \frac{V^2}{2 \cdot g} \cdot f \cdot \frac{L}{D}$$

- V, flow velocity in the pipe (m/s)
- L, pipeline length (m)
- D, pipeline internal diameter (m)
- *f*, Darcy friction factor. **Use the provided excel calculator**.
- g, Gravity: g = 9.81 m/s²

Oil properties:

Density: 861 kg/m³

Viscosity: 1.03 E-03 Pa s

Pipeline and riser data:

Pipeline and riser roughness = 1.5 E-05 m

Pump curve



Assume pump a hydraulic efficiency of 0.65.

Task 2 – Oil-gas separation flash calculations (40 points)



The topside of a platform has the following separation process:

At some point in time in the past, the following compositions were measured of separator oils and gasses:

1st Stage Separator			
Components	zi	xi	yi
N2	1.600E-03	1.264E-04	3.367E-03
CO2	9.100E-03	3.184E-03	1.619E-02
C1	3.646E-01	6.551E-02	7.232E-01
C2	9.670E-02	5.709E-02	1.442E-01
C3	6.950E-02	7.038E-02	6.844E-02
i-C4	1.440E-02	1.870E-02	9.240E-03
C4	3.930E-02	5.484E-02	2.067E-02
i-C5	1.440E-02	2.286E-02	4.260E-03
C5	1.410E-02	2.296E-02	3.479E-03
C6	4.330E-02	7.539E-02	4.824E-03
F1	1.591E-01	2.900E-01	2.119E-03
F2	1.428E-01	2.619E-01	1.256E-06
F3	3.110E-02	5.704E-02	2.847E-13

	2nd Stage Separator		
Components	xi	yi	
N2	9.984E-07	6.556E-04	
CO2	2.409E-04	1.560E-02	
C1	1.641E-03	3.350E-01	
C2	9.835E-03	2.564E-01	
C3	3.339E-02	2.265E-01	
i-C4	1.431E-02	3.726E-02	
C4	4.768E-02	8.503E-02	
i-C5	2.447E-02	1.605E-02	
C5	2.548E-02	1.232E-02	
C6	9.024E-02	1.273E-02	
F1	3.582E-01	2.544E-03	
F2	3.240E-01	6.105E-08	
F3	7.056E-02	2.967E-17	

Consider that, at current date, the composition of surface oil and gas is:

	Surface	
Components	Oil	Gas
N2	7.281E-07	2.880E-03
CO2	2.030E-04	1.619E-02
C1	1.261E-03	6.551E-01
C2	9.480E-03	1.663E-01
С3	4.003E-02	9.761E-02
i-C4	1.869E-02	1.396E-02
C4	6.250E-02	3.084E-02
i-C5	3.007E-02	5.678E-03
C5	3.030E-02	4.422E-03
C6	9.501E-02	5.174E-03
F1	3.403E-01	1.931E-03
F2	3.056E-01	1.087E-06
F3	6.657F-02	2.460F-13

And the following molars flow have been measured:



Question 1. Assuming that the densities of surface gas and oil keep are more or less constant in time, has the GOR increased or decreased? Explain your answer.

Question 2. Estimate the current wellstream composition at the inlet of the separation process.

ADDITIONAL INFORMATION:

HINT: Assume that, at pressure and temperatures used in this exercise, K values are independent of composition.

Task 3 - Oil water separator design (20 points)

Design a horizontal vessel separator.

Batch separation experiments indicate that 3 ½ min retention/residence time is required to separate oil from the water. The water production is 40 000 bbl/d.

Start with vessel ID 2m and assume nominal water level of 0.8m.

Find the required vessel length, i.e. the length from the inlet to the weir plate, L in the figure.

Check the L/D (use inner diameter). Is it acceptable?



Information: 1 bbl is equal to 0.159 m³