

CHEM-C2150 PROCESS DESIGN

Exam: 8.4.2020

During the exam:

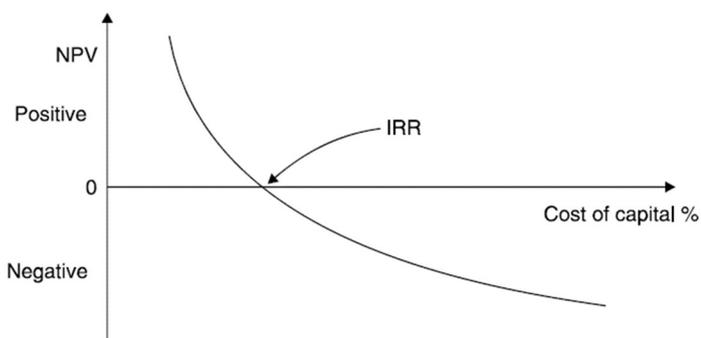
- Read the questions very carefully!
- Answer with pen and paper. Pay special attention to your handwriting and clarity of your answers! Answer in English, Finnish or Swedish.
- Clearly mark the question numbers to your papers.
- Use appropriate units in your calculations & answers.
- Avoid logging out from MyCourses during the exam.
- Avoid leaving the submission box during the exam.

Submitting your answers:

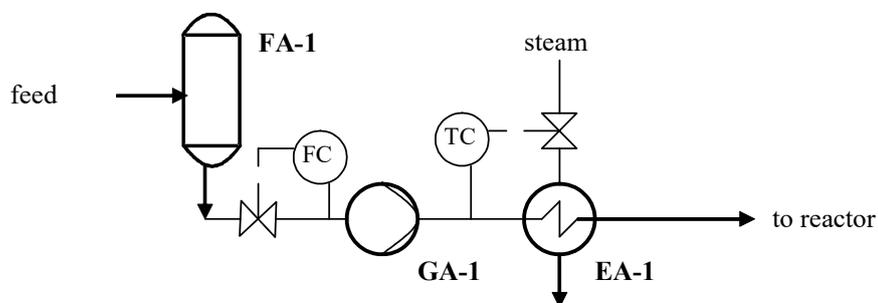
- Write your name and student number on each page.
- Take photo of each page with your smart phone.
- Name your photos with student number and page number, for example 123456_1.xxx

THEORY PART: (30 points)

1. (10p) Explain the below Figure Net present value (NPV) vs Internal rate of return (IRR)



2. (10p) Draw the following process and correct any errors in the process controls



3. (5p) For which purposes the flash operation are used?

4. (5p) How to size storage tank and separation tank?

CALCULATION PART: (45 points)

5. (15p) Design a heat exchanger network grid for maximum heat recovery at $\Delta T_{\min} = 10 \text{ }^\circ\text{C}$. By using the Pinch-analysis, it is known from the composite curves that the cold stream pinch temperature is $112 \text{ }^\circ\text{C}$ and the minimum hot and cold utilities are $\dot{Q}_H = 31.7 \text{ kW}$ and $\dot{Q}_C = 180.4 \text{ kW}$. The streams are shown in Table 1.

Table 1: Streams data

Stream	Heat-capacity flow rate, $\dot{m} c_p$ (kW/ $^\circ\text{C}$)	Supply temperature ($^\circ\text{C}$)	Target temperature ($^\circ\text{C}$)
H1 (hot)	3	122	33
H2 (hot)	1.9	175	52
C1 (cold)	2	40	135
C2 (cold)	1.8	70	160

6. (30p) In the following process, 2.5 t/h of fluid (density 800 kg/m^3 , $c_p=2.5 \text{ kJ/kg }^\circ\text{C}$) is pumped from S-1 (at atmospheric pressure) to S-2 (pressure 350 kPa). The stream is heated in EA-1 heat exchanger from $20 \text{ }^\circ\text{C}$ to $100 \text{ }^\circ\text{C}$. The fluid is a light hydrocarbon mixture with a vapor pressure similar to water. The heating agent is at 3 bar steam ($t=133.65 \text{ }^\circ\text{C}$, $h = 2725.7 \text{ kJ/kg}$ and $l = 2164.2 \text{ kJ/kg}$). The entire length of the pipe is about 100 m and you can assume that 30 m of the pipe is before the pump. The heights of the equipment from the ground are shown in the Figure.
- Size the pump GA-1 (head of the pump, NPSH_A, hydraulic and shaft power)
 - Size the heat exchanger EA-1 (duty, area, amount of steam needed)
 - Size all the pipes marked with solid line

