ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

IPESE
Industrial Process and Energy Systems Engineering

Advanced Energetics

Project '05'

Pinch study of a dairy project: Production of Mascarpone and Ice Cream

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1 Description

Mr Maraldo, a dairy owner, decides to invest money into the Mascarpone and Ice Cream production. Your group was asked to make an energy study on his process. You will find below all given data.
c_p values:

- c_p of milk 3.8 kJ/kgK (milk after centrifuge)
- c_p of cream 3.4. kJ/kgK (cream after centrifuge)
- c_p of concentrated milk 2.61 kJ/kgK (milk after evaporation)
- c_p of chocolate $1.6kJ/kgK$,
- c_p of sugar $1.244kJ/kgK$
- c_p of egg $3.16kJ/kgK$.

The dry matter ratio is 12.1%wt. after pasteurization and 50%wt. after evaporation.

Table 1: Price of utilities

Parameter	Units	France (subgroup 1)	Germany (subgroup 2)
Fuel (natural gas)	[€/kWh]	0.038	0.050
Electricity	[€/kWh]	0.081	0.124

Process units are:

- Milk pasteurisation (Fig.1)
- Milk evaporation (Fig. 2)
- Mascarpone production (Fig. 3)
- Ice cream production (Fig. 4)
- Cleaning in Place (CIP) (Fig. 5)
- Cold stores and Hot water (Fig. 6)

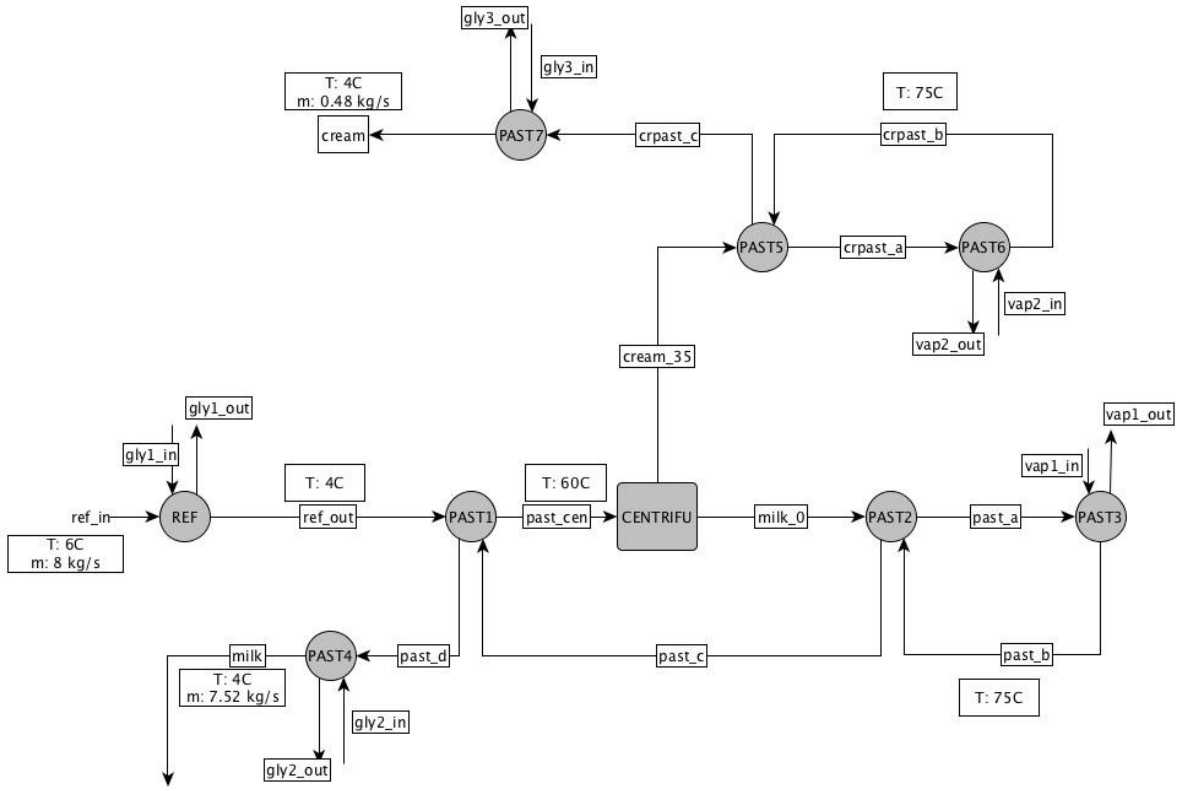

Figure 1: Pasteurisation section

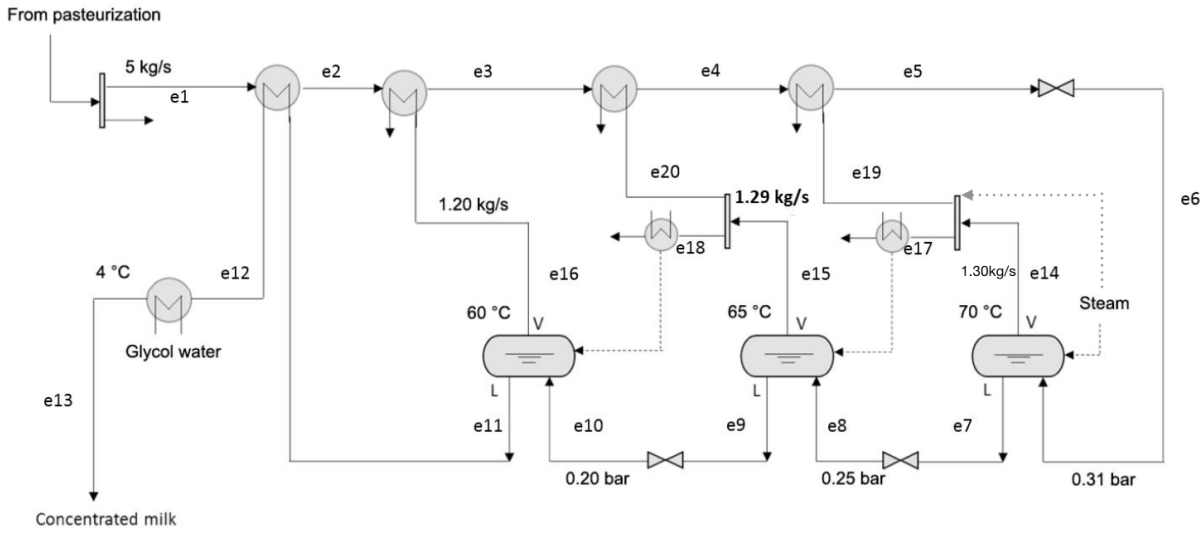

Figure 2: Evaporation section

Hints:

- Assume $\Delta T = 5K$ when needed.
- Steam is not injected to the evaporators, it is only used as a heating fluid.
- Steam is injected in the first splitter unit as a backup mass flow.
- Assure zero pressure drop across all the evaporators.
- Assume that the streams $e17$, $e19$ and $e20$ leave the heat exchangers as saturated liquid.
- Milk can be considered as a mixture of vapor and liquid with dry matter.

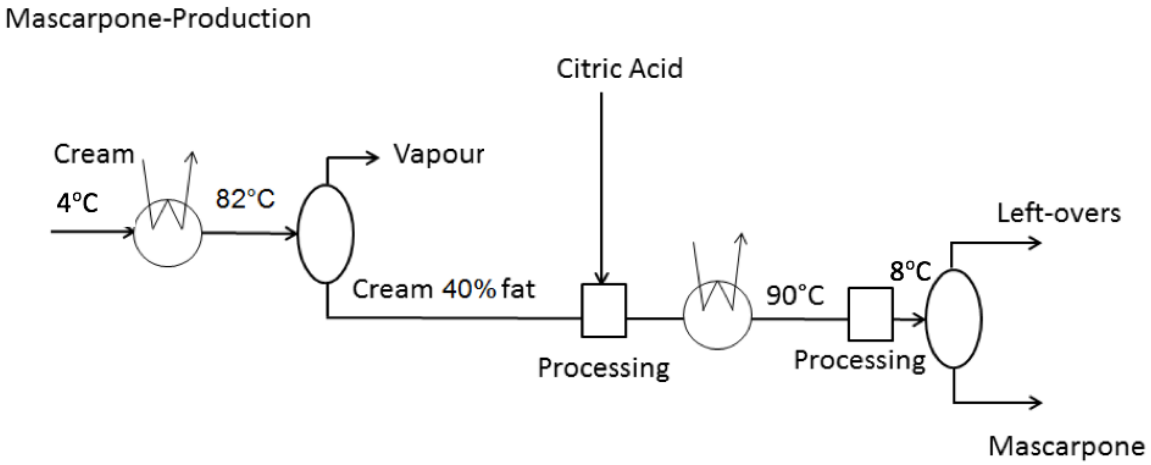

Figure 3: Mascarpone production

Hints:

- Mascarpone is 80% fat, citric acid flow rate is negligible. Left-overs are water, fat is dry matter. The left-overs and mascarpone are stored at 8°C

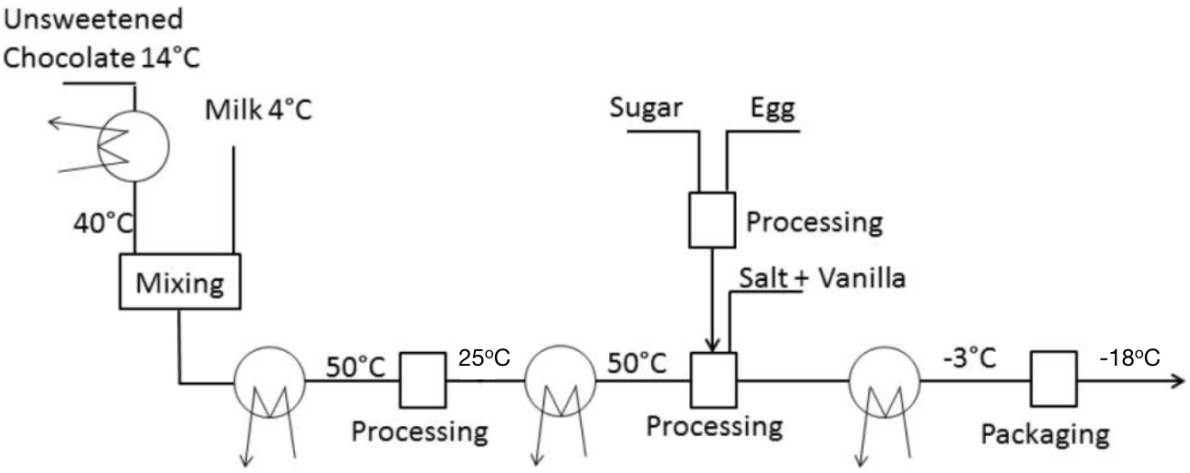

Figure 4: Ice cream production

Hints:

- Sugar and egg are at 20°C.
- Chocolate to milk ratio is 1:9,
- icecream has 21 % sugar and 4 % egg content.
- Salt and vanilla flow rates are negligible.

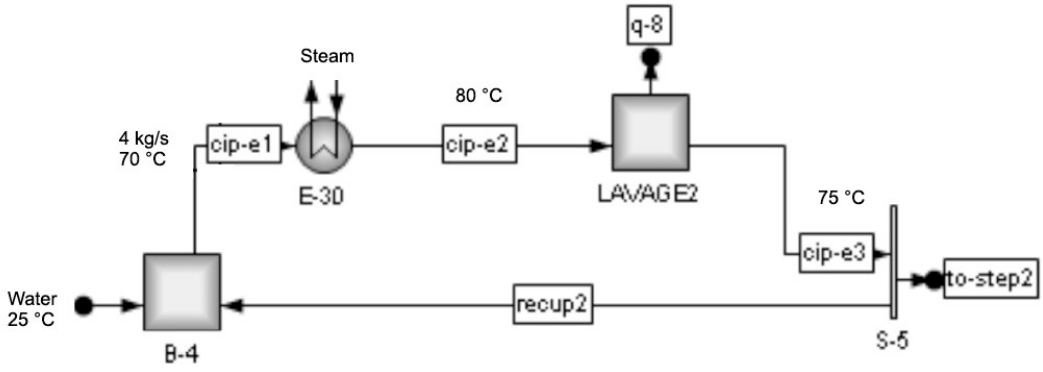

Figure 5: Cleaning in place section

Figure 6: Cold storage and hot water

2 Tasks

1. Mass and energy balances: identification and estimation of missing parameters and data.
2. Calculation of current energy bill: different economic assumptions (German and French market)
3. Optimisation of ΔT_{min} (ΔT_{min} in *past1* and *past5*, considering only the pasteurization process for the system boundaries)
4. Building composite and grand composite curves:
   - Calculation of the maximum heat recovery potential,
   - Calculation of the minimum energy requirement,
   - Identification of pinch points.
5. Identification of penalising heat exchangers and non-isothermal mixers.
6. Utility integration and optimisation.
7. Evaluation of energy saving scenarios.
8. Exergy analysis of the process:
   - Calculation of the exergy losses in different process operations,
   - Proposing process modifications to reduce the exergy losses.
9. Heat Exchanger Network Design using pinch method (description of problem will be given)

Additional data

- Refrigeration cycle $COP = 4$
- Boiler efficiency 90%
- No losses in the centrifuge
- Use cost constants from exercise 01
- Use $CEPCI_{2015} = 556.8$