EPFL

IPESE
Industrial Process and Energy Systems Engineering

Heat Exchanger Design Network

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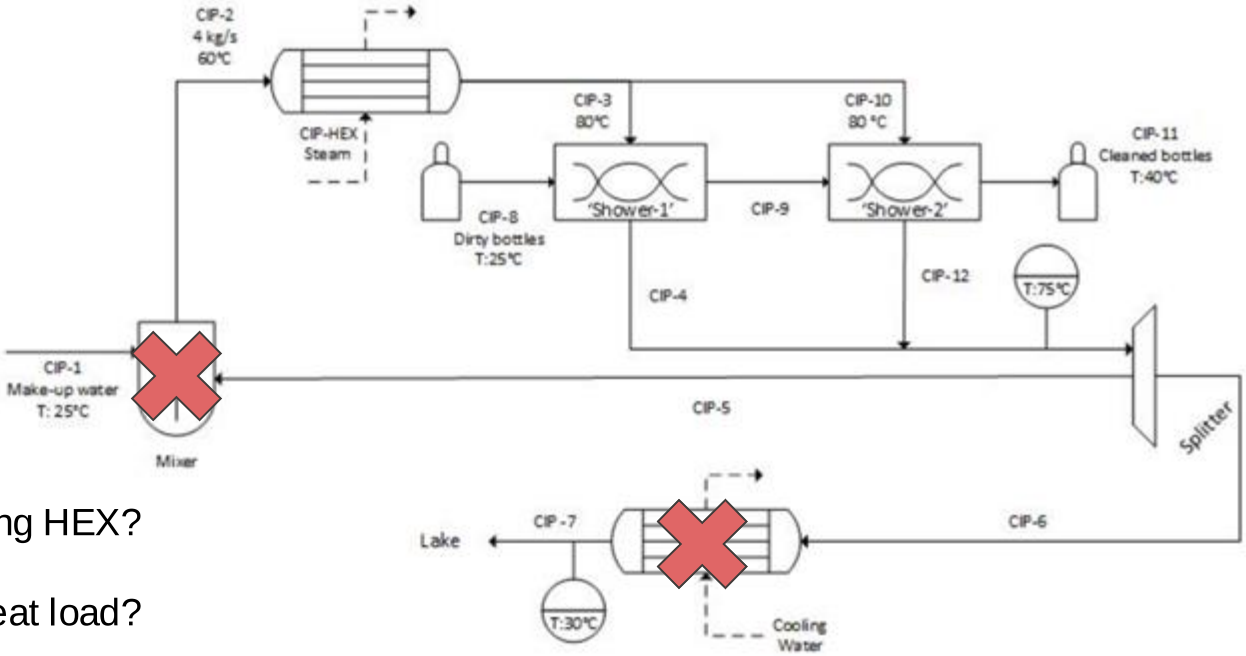
Identify penalizing HEX

Let's assume the pinch point is at 50°C

Penalizing HEX



Which types of penalizing HEX?

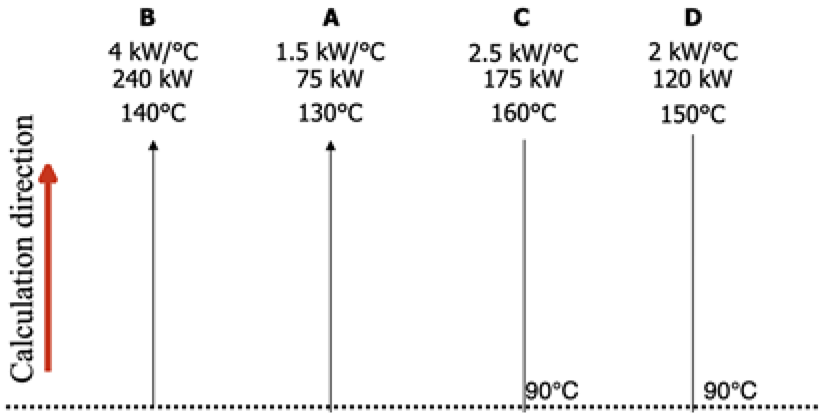
How much penalized heat load?

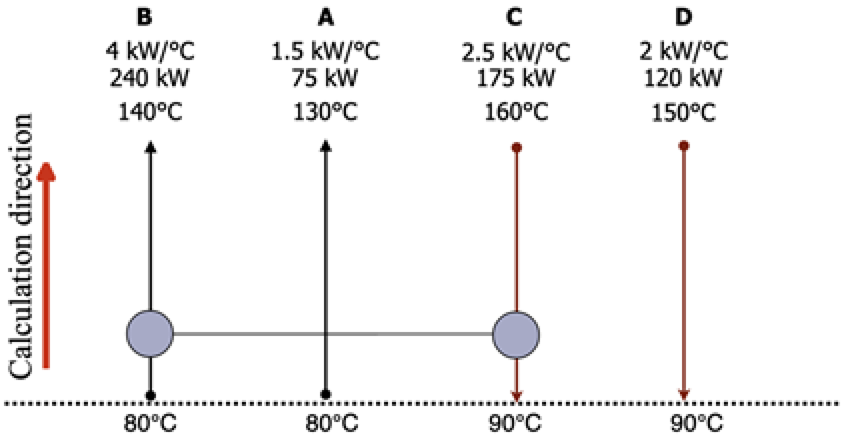
How it affects the energy bill?

Build the HEN representation

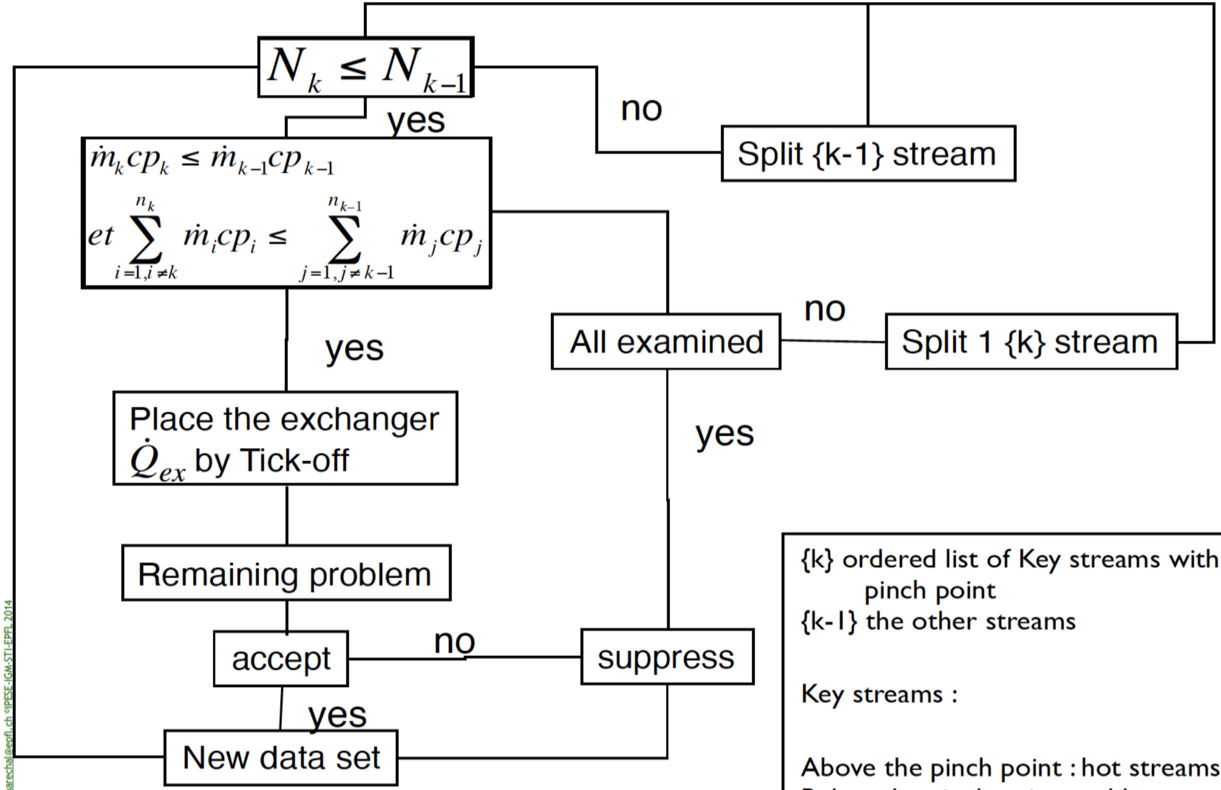
- Draw the grid representation for the pasteurization and cleaning in place sections. Use corrected temperatures.

- Fix the non-penalizing heat exchanger.
- Finalize the design by applying the pinch design method.





HEN synthesis algorithm



{k} ordered list of Key streams with decreasing Cp at the pinch point
{k-1} the other streams

Key streams :

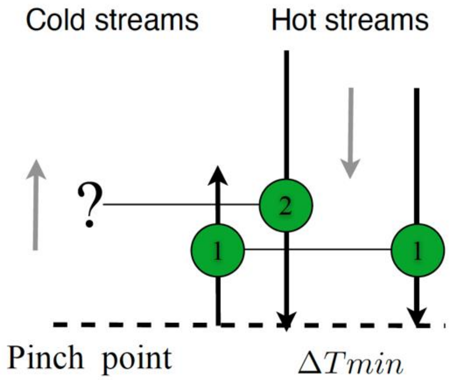
Above the pinch point : hot streams
Below the pinch point : cold streams

Feasibility rules for connection

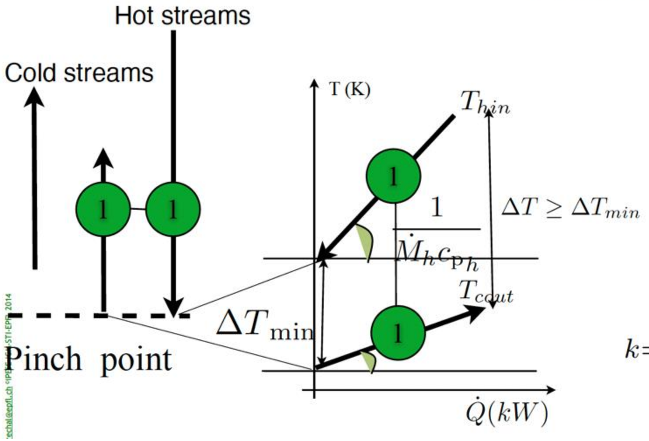
For pinch heat exchangers – The temperature difference is ΔT_{min} on one side.

Case 1 – Above the pinch point

No. of stream rule



$$N_{pinch,c} \geq N_{pinch,h}$$



Feasibility rules

Connexion feasibility between c and h

$$\dot{M}c_{p_h} \leq \dot{M}c_{p_c}$$

AND

$$\sum_{k=1,k\neq h}^{n_k} \dot{M}c_{p_k} \leq \sum_{j=1,j\neq c}^{n_{k-1}} \dot{M}c_{p_j}$$

Tick-off rule and Remaining problem analysis

After deciding the two streams for placing a HEX based on the feasibility rules, the heat load of the HEX is decided by the tick-off rule

$$\dot{Q} = min(\dot{M}_c c_{p_c}(T_{cout} - (T_p^* - \Delta T_{\min}/2)), \dot{M}_h c_{p_h}(T_{hin} - (T_p^* + \Delta T_{\min}/2)))$$
$$\Rightarrow T_{hin,ex}, T_{cout,ex}$$

$$T_{hin,ex} = T_p^* + \Delta T_{\min}/2 + \frac{\dot{Q}}{\dot{M}_h c_{p_h}} \qquad T_{cout,ex} = T_p^* - \Delta T_{\min}/2 + \frac{\dot{Q}}{\dot{M}_c c_{p_c}}$$

One of the two flows will be ticked off (meaning, the other stream supplies all of its heating or cooling needs)

Above the pinch

Calculation starts from the pinch and goes to higher temperatures

Both side !!!

We calculate the inlet conditions of the hot stream and the outlet conditions of the cold stream

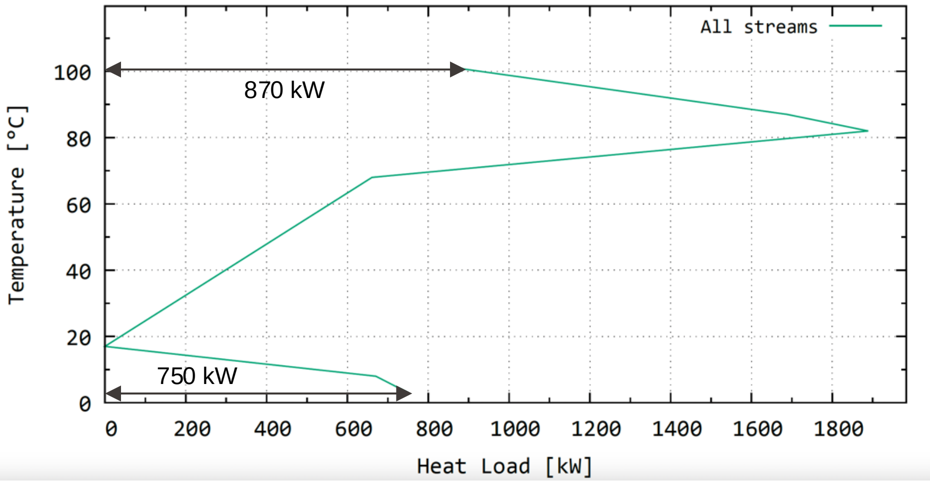
After placing the heat exchanger and calculating the new temperatures of the hot and cold streams, the **Remaining problem analysis** calculates the Minimum energy requirement with and without the heat exchanger. If MER does not change, the heat exchanger is well placed.

if $\dot{Q}^{+^r} = \dot{Q}^{+^0}$

=> Exchanger is well placed

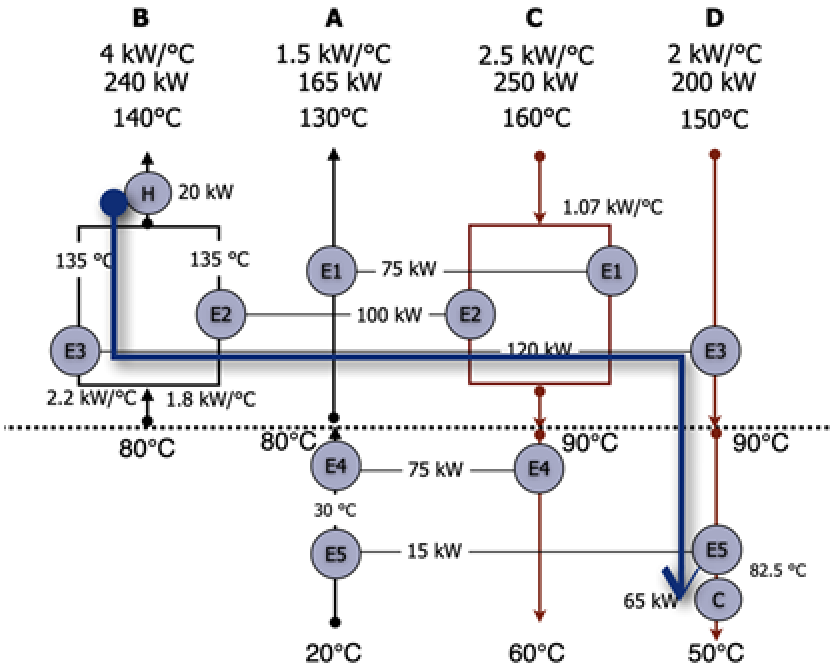
Brewery example

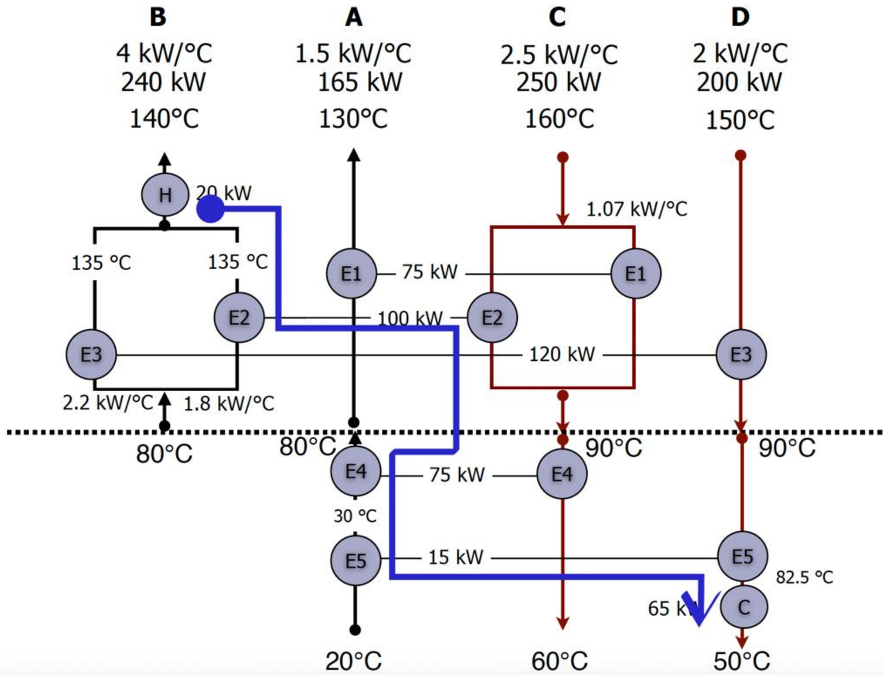
Name	Description	T_{in}(ºC)	T_{out} (ºC)	Q (kW)	MCp (kW/ ºC)
A	Wort cooling	103	10	5435	58
B	Cold bath	70	5	4854	74.4
C	Water filter	15	80	1609	24.8
D	Pasteurization	15	80	4854	74.4
E	Water bath	15	85	1287	18.3
F	CIP	15	80	1841	28.4
G	Beer preheating	1	15	822	58



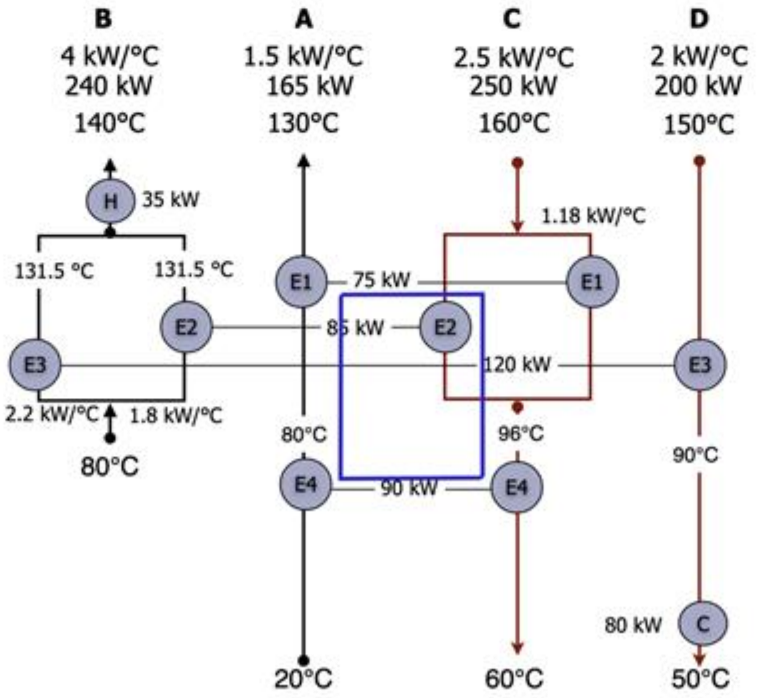
We have the heat exchange network design for the selected streams of the brewery. The minimum energy requirement (MER) as computed above is 870 and 750 kW of hot and cold utility respectively. The total cost of the system is computed by annualising the cost of the proposed six heat exchangers (CAPEX) and the operating cost for satisfying the MER (OPEX).

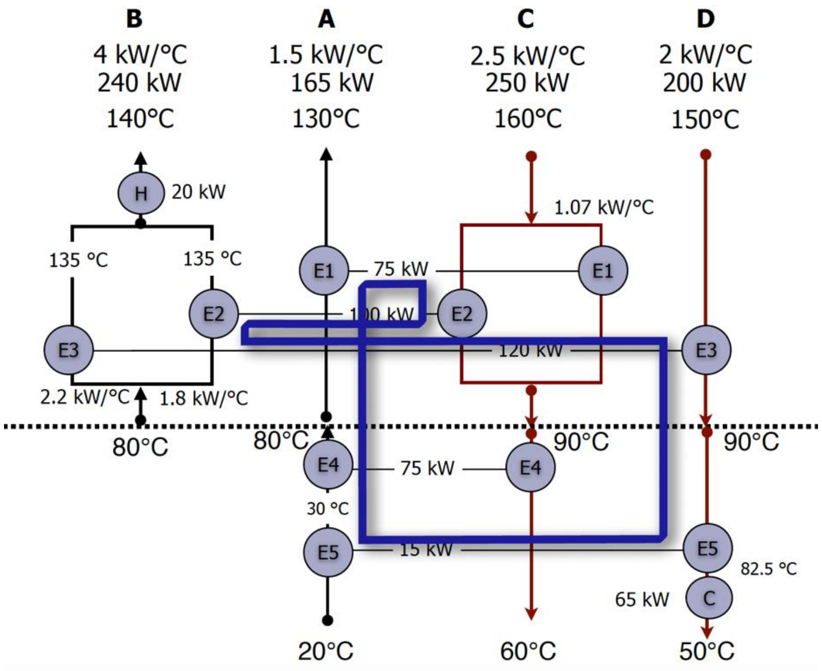
Path and loop following methods





Path and loop following methods





Path and loop following methods

	Invest $[CHF]$	CAPEX $[CHF/year]$	OPEX $[CHF/year]$	Total $[CHF/year]$	Nb Ex.
0	173905	20340	2352	22692	7
1	189859	22206	2352	24558	6
2	190001	22222	2352	24574	6
3	145847	17058	4118	21176	6
4	**133491**	**15613**	**4118**	**19731**	**6**
5	147924	17301	4118	21419	5
6	99723	11664	16471	28135	6

Expected final result format of the Heat exchanger network design in the report

TODO Summary

- Based on the pinch point of the overall process, **find the penalizing heat exchangers in every section**. Don't forget to mention the type of penalizing HEX. **Calculate the penalized heat loads and the associated operating costs.**

- Draw the grid representation of the heat exchanger network for the **pasteurization, hot water, and cleaning in place**. Since your boss doesn't want to change all the layout of the factory, fix the nonpenalizing heat exchanger. Ideally, you won’t change them.

- Apply the pinch design method to design the HEN. Use corrected temperature for the HEN design and the real ones to calculate the area of the HEXs

- Once you have a design, improve it using the path and loop following methods

- **Compare the costs, the total heat exchange area, and the total heat being exchanged** for your different layouts (initial layout, new layout, optimized new layout)