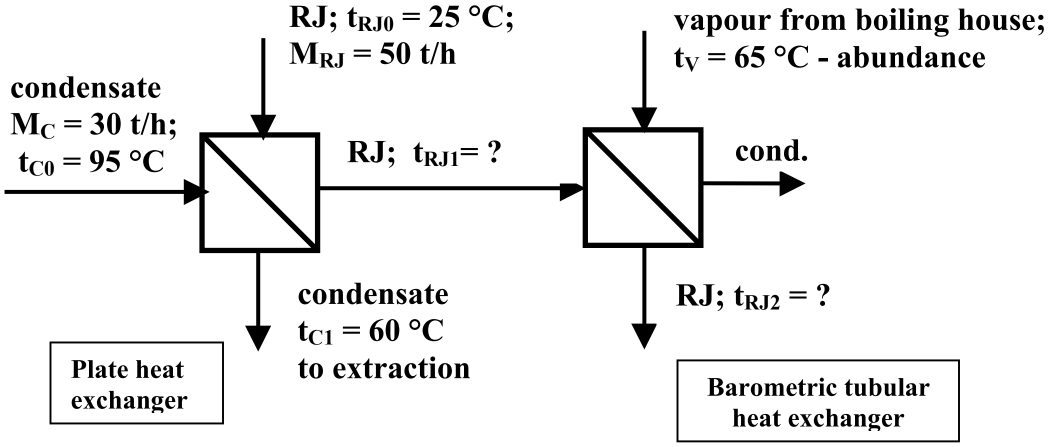
Effect of integration of barometric and plate heat exchangers in line for raw juice heating – waste heat utilisation

VLP – Processing lines of food industry - Example

Present integration of heaters flow sheet



Maximal raw juice heating up in the 1st HE (plate HE) is limited by given temperatures and an amount of condensate, or by a minimal difference between an entering condensate temperature and a leaving heated up juice temperature (for counter-current flow). We are limited with a usable heat in the condensate, in our case (recommended temperature of condensate going to an extraction is c. 60 – 65 °C). For the 1st HE it is valid that $Q_{Cusable} = Q_{RJ1}$.

$$Q_{Cusable} = c_C * M_C * (t_{C0} - t_{C1}) = 4{,}18*30*(95-60)/3600 = 1{,}219 \text{ MW}$$

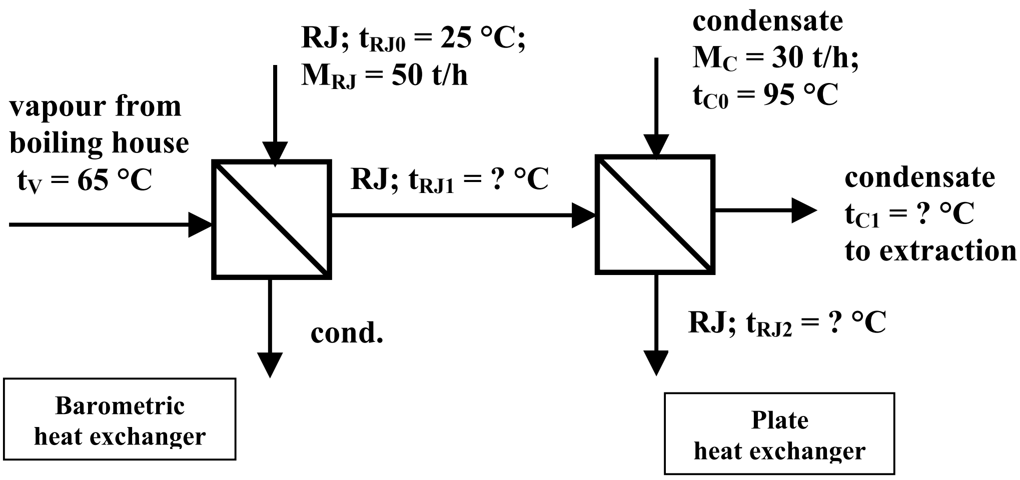
$$t_{RJ1} = t_{RJ0} + c_C * M_C * (t_{C0} - t_{C1}) / (c_{RJ} * M_{RJ}) = t_{RJ0} + Q_{Cusable} / (c_{RJ} * M_{RJ})$$

$$t_{RJ1} = 25 + 4{,}18*30*(95-60) / (3{,}8*50) = 48 \text{ °C}$$

As there is an abundance of a vapour from a boiling house is the maximal heating up in the barometric heat exchanger (2nd HE) limited only with a minimal temperature difference between the vapour (c. 65 °C) and the heated up juice temperatures. For tubular HE is usually the difference c. from 5 to 15 °C, for plate HE is usually from c. 3 to 5 °C. For the value of 5 °C results the temperature of the heated up raw juice c. 60 °C.

The temperature of the heated up raw juice from such integrated two HE is c. t_{RJ2} = 60 °C.

Optimised integration of the two HE



The maximal raw juice heat up in the 1st HE is limited only with a minimal temperature difference between the vapour (c. 65 °C) and the heated up juice. For such cases is usually 5 °C (like in the previous). An amount of vapour is not a limiting factor as there is an abundance of it. Maximal temperature of the raw juice heated up in the 1st HE is c. $t_{RJ1} = t_V - 5 = 65 – 5 = 60$ °C.

The maximal raw juice heat up in the 2nd HE (plate HE) is limited with condensate temperatures and the amount and the minimal difference between entering condensate and the heated up raw juice temperatures (for counter-current flow).

$$t_{RJ2} = t_{RJ1} + c_C * M_C * (t_{C0} – t_{C1}) / (c_{RJ} * M_{RJ})$$

$$t_{RJ1} = 60 + 4{,}18*30*(95 – 60) / (3{,}8*50) = 83\ °C$$ **unrealistic !**

$$t_{RJ1} = 60 + 4{,}18*30*(95 – 65) / (3{,}8*50) = 80\ °C$$ **realistic**

Pozn.:

- **The 1st calculation is for theoretical values.**
- **The 2nd calculation is for realistic values for a plate HE, as it is impossible to cool down the condensate to a temperature of an entering juice (i.e. 60 °C). From it follows that in the case it is impossible to use the all waste heat in condensate, but that we are limited with the minimal temperature difference in the HE (for example 5 °C → $t_{C1} = t_{RJ1}+5=65$).**

The temperature of the heated up raw juice from such integrated two HE is c. t_{RJ2} = 80 °C → better waste heat recovery (energy saving in the line and in the extraction too – temp. of condensate is higher).