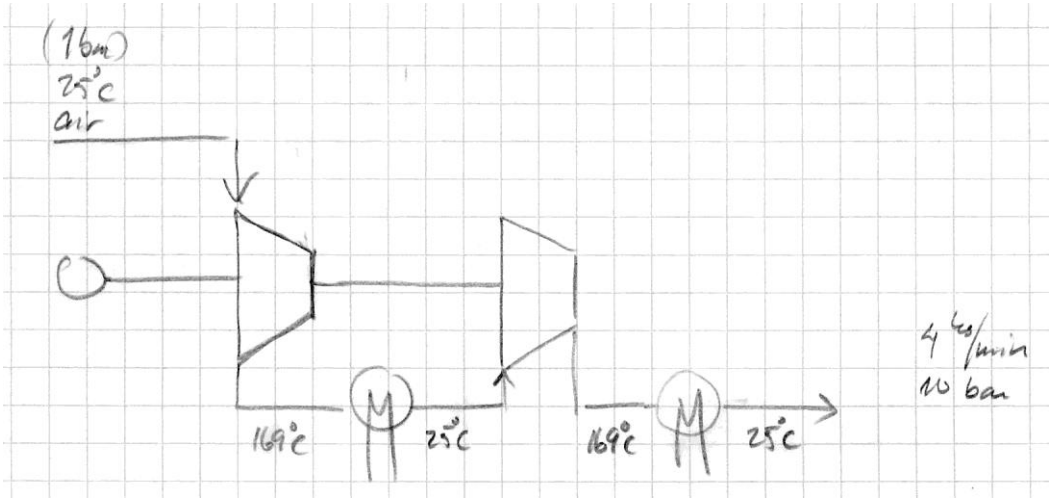
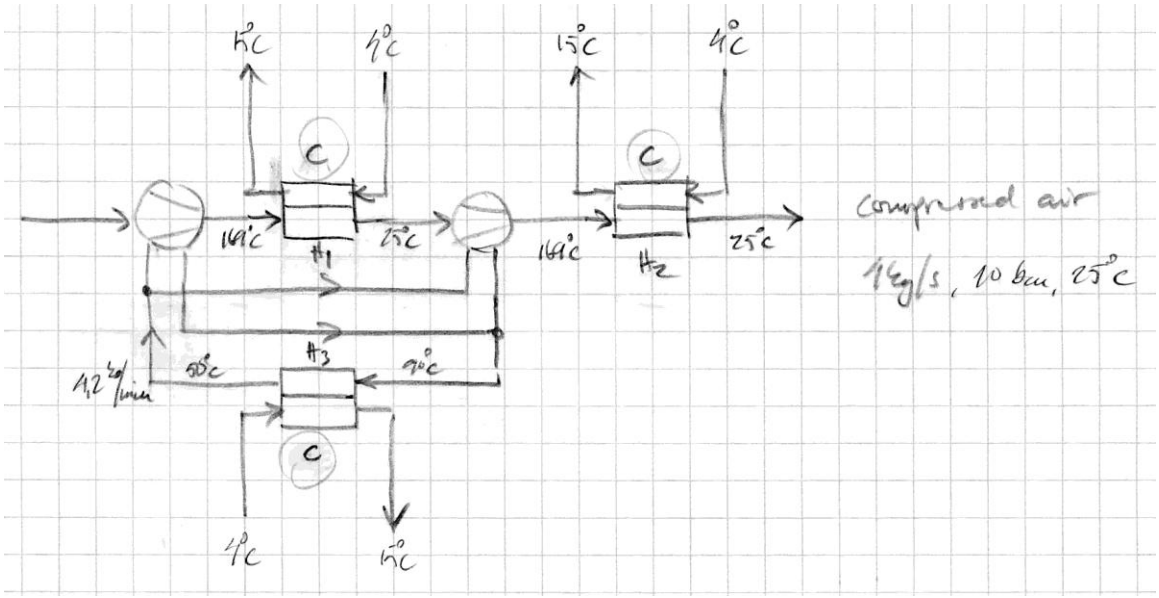
Example – Heat exchangers

A compressor produces 4 kg/min compressed air of 10 bar using 25 C air. The compressor is a two stage compressor with and intercooler and aftercooler that cool the air to 25 C after each compression step. The air temperature after each compression step is 169 C.

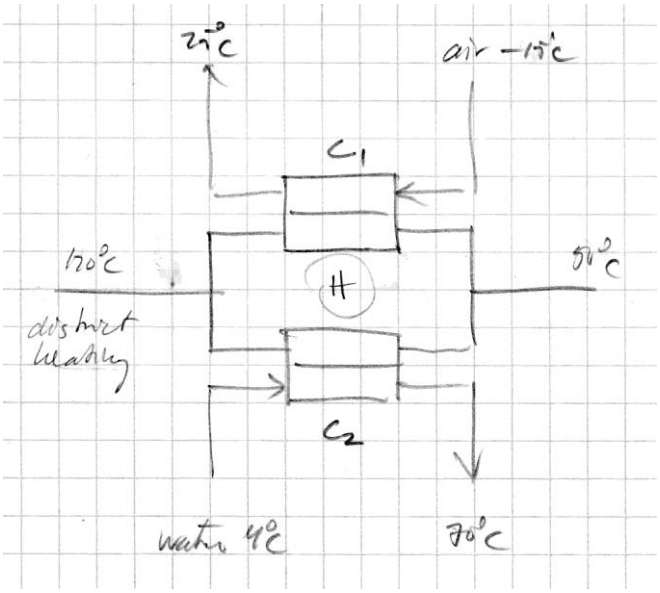


The compressor also has a separate oil cooler which cools the lubrication oil in the compressor. When the oil flow is 4.2 kg/min and 50 C when it enters the compressor then it will be 90 C when it is returned to the cooler. The specific heat capacity of the oil is about 2 kJ/kgC.

Cold tap water (4 C) has been used for cooling in all three coolers. The flow is set so that the water temperature out is no higher than 15 C.



The heat from the coolers could be used to heat the air that comes into the building at -15 C to 25 C. The necessary air flow is about 15 kg/s. Another possible use for the heat is for making hot tap water. The water comes in at 4 C and should be heated to 70 C. The hot water usage is about 8 kg/min.



So there are three hot flows that have to be cooled: air in intercooler, air in aftercooler and lubrication oil in the oil cooler. The heat in these flows could possibly be used to heat the two cold flows: house air, and tap water.

It is of course also possible to use additional heating from the district heating system and additional cooling with cold tap water using the existing systems.

Calculate the need for additional heating and/or cooling. Draw a graph with heating and cooling curves to see if it possible to realize this heat recovery using a heat exchanger network.

H1	air in intercooler	4 kg/min	1.2 kJ/kgK	169 C	25 C
H2	air in aftercooler	4 kg/min	1.2 kJ/kgK	169 C	25 C
H3	oil in oil cooler	4.2 kg/min	2.0 kJ/kgK	90 C	50 C
H	district heating	x kg/min	4.2 kJ/kgK	120 C	50 C
C1	house air	15 kg/min	1.2 kJ/kgK	-15 C	25 C
C2	hot tap water	8 kg/min	4.2 kJ/kgK	4 C	70 C
C	cold tap water	x kg/min	4.2 kJ/kgK	4 C	15 C