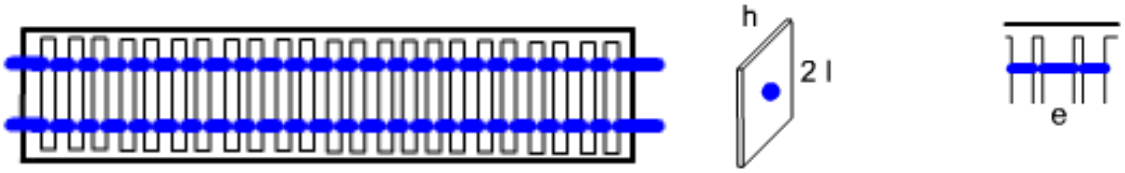
Setting the exchanger

The air-water heat exchanger we are trying to set corresponds to the one presented in Chapter 5 of Part 5 of the book Energy Systems. This is a tube and fins heat exchanger, of effectiveness epsilon equal to 0.84.

This exchanger is designed to cool 0.011738 kg/s of air leaving a compressor to 5 bar and 275 °C with a flow rate of 0.02 kg/s of cold water passing through a coil of two parallel tubes, arranged in several layers.



The tube diameter is 15 mm, its thickness 1.5 mm. The spacing between the fins is 3 mm.

Inside the tubes, dh is given, and the calculation of Ac is very simple: it is equal to product of the number of tubes by the section of one of them. With an outside diameter tubes of 15 mm and a thickness of 1.5 mm, inner diameter is 12 mm. A simple calculation shows that for two tubes, Ac is 0.000226195 m2.

Outside the tubes, the calculations are a bit more complicated. The diagrams above show the arrangement of fins around the tubes in blue water: it is rectangular fins half-length l = 1 cm and depth h = 2 cm, spacing e = 3 mm, pressed perpendicular to the tubes. Their number has to be determined. We begin by taking 100.

The determination of different sizes poses no particular problem and can be done in a spreadsheet:

spacing e	0.0030	
half-height h	0.01	
depth l	0.02	
nb of fins	100	
unit Ac	0.000015	(2 h - d) e
Ac total	0.003	
fin thicknesse a	0.0003	
exchanger length	0.33	nb (e + a
extended surface	0.00057381	2 (2 l h - pi d2/4) + pi d (e - a)
initial surface	0.00014137	pi d e
surface factor	4.05884242	
wetted perimeter	0.046	2 (2 h +e)
dh	0.00130435	4 Ac/p

We made the hypothesis that the free flow area devoted to the fluid was the minimum at the center of the tubes, arranged supposedly in the same plane, and the thickness of the fins is equal to 1/10th of the spacing, 0.3 mm.

By entering this setting in the exchanger, the calculated area is 0.0695 m2, leading to a need for two layers of 2.8 tubes.

By reducing the number of fins 100 to 90, the size of the spreadsheet is changed slightly, the free flow area devoted to the air passing 0.0027 m2.

After entering this value in the technological design screen, the calculated area is 0.0671 m2, and the number of layers is equal to 3.

So there are six tubes of 0.297 m, about 1.80 m tube, with a total of 540 fins.

The length of the heat exchanger air side is 3 cm x 2 = 6 cm, and that of water tubes 3 times 0.297 cm = 0.9 m. They are used to calculate the losses, negligible here.