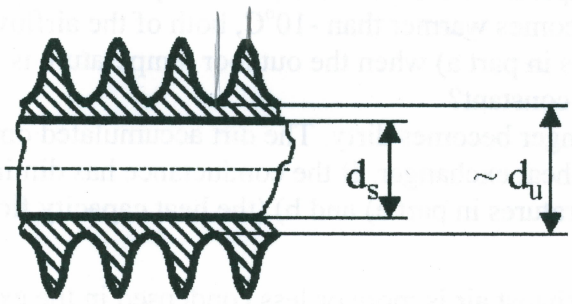
4. Derive, for the finned tube below, the approximate equation

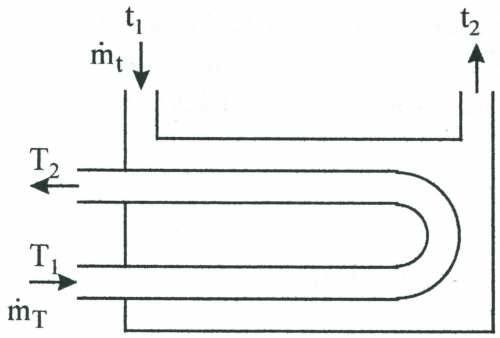
$$\frac{1}{k} = \frac{1}{\alpha_s \pi d_s} + \frac{1}{\eta \alpha_u \pi (A_u/A_s) d_s},$$

where k = conductance per length ($Wm^{-1}K^{-1}$), α_s = inner heat transfer coefficient, d_s = inner diameter, η = fin efficiency, α_u = outer heat transfer coefficient and (A_u/A_s) = ratio of the outer and inner surface areas.



No exact value can be measured for the diameter d_u in the picture.

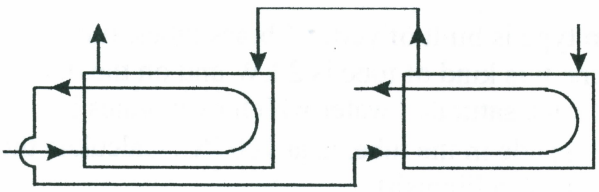
5. Process water heat recovery has been made with the heat exchanger below.



$T_1 = 50°C$, $T_2 = 26°C$, $\dot{m}_T = 2$ kg/s (waterflow)
$t_1 = 10°C$, $\dot{m}_t = 2{,}5$ kg/s (waterflow)

a) Calculate the effectiveness ε and the conductance G of the exchanger.

b) Instead of one exchanger, a series connection below is considered. In the connection, the original exchanger would be replaced with two smaller and identical elements so that the total heat transfer surface would be the same as in the original exchanger.



Calculate the effectiveness of the connection.