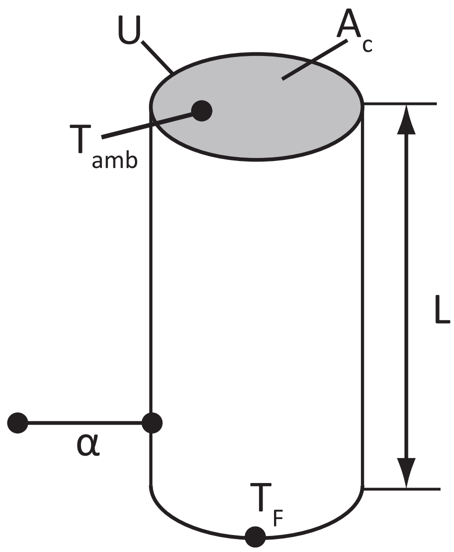
1.7 Pin-fin cooling on gas turbine blades ★★

A rod fin is being used for pin-fin cooling on gas turbine blades. The rod-fin of length L, with a tip temperature equal to the ambient T_{amb}, is given. What is the total heat flux carried away from the fin?

- Fin geometry, U, A_c, L
- Fin material properties, λ
- Surface heat transfer coefficient, α
- Fin base temperature and environment temperature, T_F, T_{amb}



Tasks:

a) Derive the heat conduction equation for the given problem.

b) Derive the function of the temperature profile inside the fin.

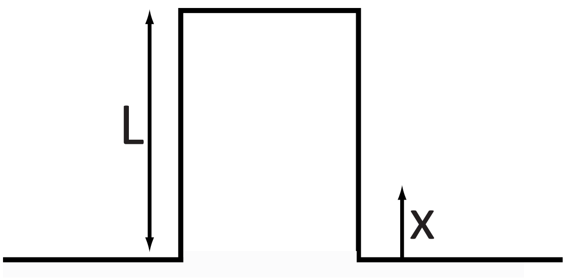
c) Give the expression for the heat flux as a function of the given variables.

1.8 New fin material ★★

An electric motor manufacturer is using fins for cooling purposes. He is considering changing the material used for the fins from copper to aluminium. Because the length L of the fin is also modified, the temperature at the fin head remains identical for both materials. Determine the ratio between the heat flow of the aluminium and the copper fin.

Hints

- The cross section and the thickness remain unchanged.
- There is no change in the convective heat transfer coefficient.
- The temperature at the fin base does not change.
- For both fins, the heat flow through the head is negligible.

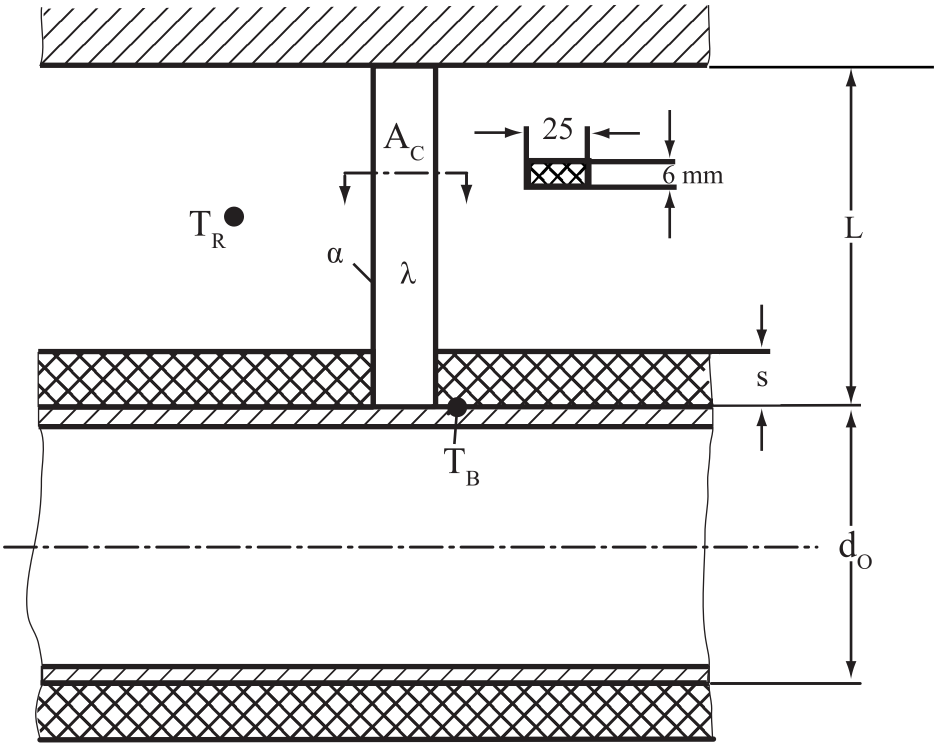


Given parameter

- Thermal conductivity of copper λ_{C}
- thermal conductivity aluminium λ_{A}

1.9 Pipe fastening ★ ★ ★

A pipe containing brine is insulated with cork and fastened to the ceiling with steel bands welded to the pipe. The outer wall temperature of the brine pipe is $T_{\mathrm{B}} = -23,5\,°\mathrm{C}$, the room has a temperature of $T_{\mathrm{R}} = 20\,°\mathrm{C}$.



Known quantities:

d_{o}	50	mm	outer diameter of the pipe
s	40	mm	insulation thickness
A_{Q}	25×6	mm	cross-section of the steel band
L	290	mm	length of the steel band
α	6	$\mathrm{W}/\mathrm{m}^2\,\mathrm{K}$	heat transfer coefficient at the steel band's surface
λ	58	$\mathrm{W}/\mathrm{m\,K}$	thermal conductivity of the steel band

Tasks:

a) Calculate the heat $\dot{Q}$ from one steel band absorbed by the brine.

b) Up to which height h_0 does frost form on the steel ban (h_0 is the distance from the surface of the pipe's insulation layer), if the steam content of the air in the surrounding room is above the saturation vapor pressure for the maximum steel band temperature?

Assumptions:

- The temperature distribution in the steel band's cross-section is homogeneous.

- The heat fluxes from the steel bands into both the ceiling and the insulation are negligible.