Enrico Nobile
Dipartimento di Ingegneria e Architettura
Università degli Studi di Trieste

Corso di Termofluidodinamica Computazionale

Homework No. 2
AA 2025/2026

March 2020

Problem statement

Following *Homework 1 - AA. 2025-26*, consider a longitudinal, plain fin of rectangular profile, as shown in figure 1, which is cooled only by convection. It has a thermal conductivity value of $k = 50$ W/(m K), a thickness t, a length L and it extends indefinitely along the third direction. The convective heat transfer coefficient is h =200 W/(m^2 K) and the temperature of the surrounding fluid is $T_\infty = 25$ °C. The base of the fin is maintained at a temperature $T_b = 200$ [°C], while the tip of the fin is assumed perfectly insulated.
The fin is also subject to internal heat generation, equal to $\dot{q}_g = 1 \times 10^7$ [W/m^3].

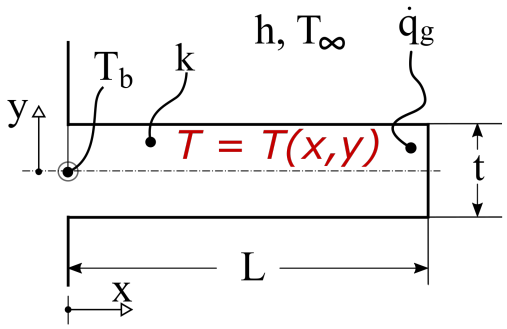

Figure 1: Two-dimensional longitudinal fin of rectangular profile with internal heat generation.

In this case, disregard the usual assumption of 1D temperature distribution (see [1]), i.e.

$$T \approx T(x)$$

and consider a full 2D temperature distribution [2]:

$$T = T(x, y)$$

Assigned tasks

- Using the Finite Volume method, develop a 2D steady numerical model for the fin and, using an *adequate* number of cells, compute the heat transfer for unit width of the fin q'_{num2D} [W/m] for both cases 1 and 2 of *Homework 1*:
  1. $L = 20$ mm and $t = 1$ mm.
  2. $L = 20$ mm and $t = 5$ mm.
- Compare both results with those obtained with the 1D model of *Homework 1*. What is the % error using the 1D assumption for the two cases? In this case, the error is defined as the difference between the numerical value of the computed heat flux per unit width q'_{num2D} assuming a two-dimensional temperature field, and its one-dimensional analytical solution q'_{teor}, reported in [2, 3] and given in *Homework 1*.
- Comment the difference in the error for the two cases.
- Plot a contour map of the temperature field.

References

[1] F. P. Incropera, D. P. Dewitt, T. L. Bergman, A. S. Lavine, *FUNDAMENTALS OF HEAT AND MASS TRANSFER*, 6th Ed., Wiley, (2007).

[2] A. D. Kraus, A. Aziz, J. Welty, EXTENDED SURFACE HEAT TRANSFER, J. Wiley & Sons, (2001).

[3] W.S. Minkler, W.T. Rouleau, The Effects of Internal Heat generation on Heat Transfer in Thin Fins, *Nuclear Science Eng.*, **7**, pp. 400-406, (1960).