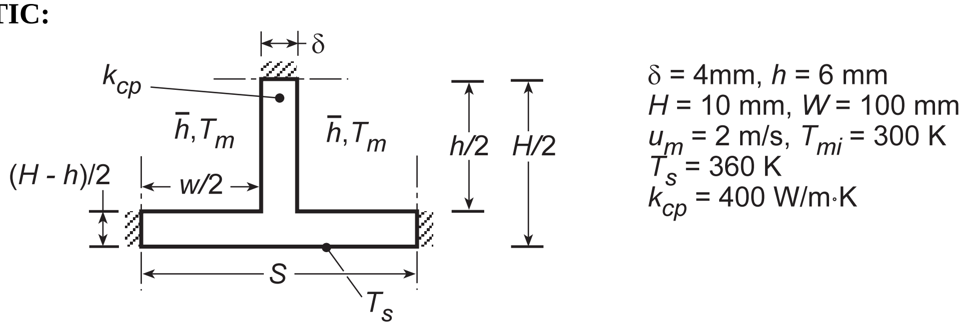
PROBLEM 8.83

KNOWN: Geometry, surface temperature and thermal conductivity of a *cold plate*. Velocity and inlet temperature of coolant.

FIND: Effect of channel width on total heat rate.

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state conditions, (2) Incompressible liquid with negligible viscous dissipation, (3) Constant properties, (4) Symmetry about midplane (horizontal) of the cold plate and the midplane (vertical) of each channel, (5) Negligible heat transfer at sidewalls of cold plate, (6) One-dimensional conduction from outer surface of cold plate to base surface of channel and within the channel side walls, which act as extended surfaces.

PROPERTIES: Water: Evaluated at $\bar{T}_m$ using the *Properties* Toolpad of IHT.

ANALYSIS: The model developed for the preceding problem was entered into the workspace of IHT, with the Dittus-Boelter equation and exponential relation accessed from the *Correlations* Toolpad and modified to account for the hydraulic diameter and the total resistance to heat transfer. Calculations were performed for

Case 1: w = 96 mm, N = 1, S = W = 100 mm
Case 2: w = 46 mm, N = 2, S = 50 mm
Case 3: w = 21 mm, N = 4, S = 25 mm
Case 4: w = 6 mm, N = 10, S = 10 mm
Case 5: w = 1 mm, N = 20, S = 5 mm

and the results are tabulated as follows.

Case	N	D_h (m)	Re_D	$\bar{h}\left(W/m^2 \cdot K\right)$	$T_{m,o}$ (K)	q (W)
1	1	0.01129	26,920	8783	302.1	10,090
2	2	0.01062	25,310	8892	302.3	10,370
3	4	0.00933	22,340	9142	302.6	10,960
4	10	0.00600	14,630	10,070	304.3	12,950
5	20	0.00171	4760	13,740	317.2	17,160

It is clearly beneficial to increase the number of channels, with the total heat rate increasing by approximately a factor of 5 as N increases from 1 to 20. The heat rate may be increased further by increasing u_m, and hence the flowrate per channel, although an upper limit would be associated with the pressure drop, which would increase with decreasing D_h. Could additional heat transfer enhancement be achieved by altering the thickness δ of the channel walls?

COMMENTS: (1) Note that results obtained for Case 4 differ from those of the preceding problem due to different fluid properties. In this case the properties were evaluated at the actual value of $\bar{T}_m$ = 302.2 K, rather than at an assumed (significantly larger) value. (2) Note that the Dittus-Boelter correlation is applied outside its intended range for the Reynolds number of case 5. The Gnielinski correlation would be preferable.