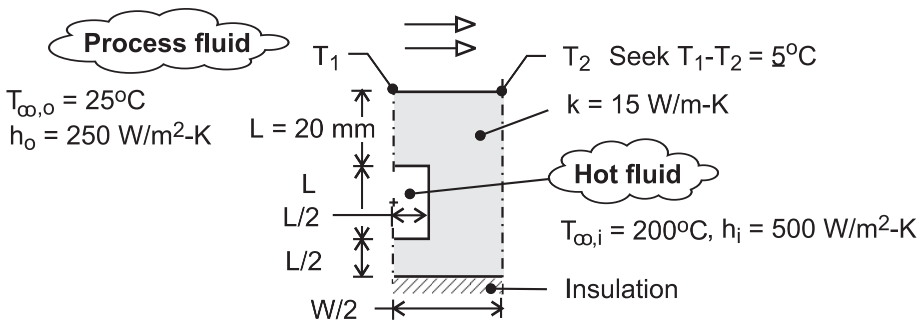
PROBLEM 4.95

KNOWN: Upper surface of a platen heated by hot fluid through the flow channels is used to heat a process fluid.

FIND: (a) The maximum allowable spacing, W, between channel centerlines that will provide a uniform temperature requirement of 5°C on the upper surface of the platen, and (b) Heat rate per unit length from the flow channel for this condition.

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state, two-dimensional conduction with constant properties, and (2) Lower surface of platen is adiabatic.

ANALYSIS: As shown in the schematic above for a symmetrical section of the platen-flow channel arrangement, the temperature uniformity requirement will be met when $T_1 - T_2 = 5$°C. The maximum temperature, T_1, will occur directly over the flow channel centerline, while the minimum surface temperature, T_2, will occur at the mid-span between channel centerlines.

We chose to use FEHT to obtain the temperature distribution and heat rate for guessed values of the channel centerline spacing, W. The following method of solution was used: (1) Make an initial guess value for W; try W = 100 mm, (2) Draw an outline of the symmetrical section, and assign properties and boundary conditions, (3) Make a copy of this file so that in your second trial, you can use the *Draw | Move Node* option to modify the section width, W/2, larger or smaller, (4) Draw element lines within the outline to create triangular elements, (5) Use the *Draw | Reduce Mesh* command to generate a suitably fine mesh, then solve for the temperature distribution, (6) Use the *View | Temperatures* command to determine the temperatures T_1 and T_2, (7) If, $T_1 - T_2 \approx 5$°C, use the *View | Heat Flows* command to find the heat rate, otherwise, change the width of the section outline and repeat the analysis. The results of our three trials are tabulated below.

Trial	W (mm)	T_1 (°C)	T_2 (°C)	$T_1 - T_2$ (°C)	q' (W/m)
1	100	108	98	10	--
2	60	119	118	1	--
3	80	113	108	5	1706

COMMENTS: (1) In addition to the tutorial example in the FEHT User's Manual, the solved models for Examples 4.3 and 4.4 of the Text are useful for developing skills in using this problem-solving tool.

(2) An alternative numerical method of solution would be to create a nodal network, generate the finite-difference equations and solve for the temperature distribution and the heat rate. The FDEs should allow for a non-square grid, $\Delta x \neq \Delta y$, so that different values for W/2 can be accommodated by changing the value of Δx. Even using the IHT tool for building FDEs (*Tools | Finite-Difference Equations | Steady-State*) this method of solution is very labor intensive because of the large number of nodes required for obtaining good estimates.