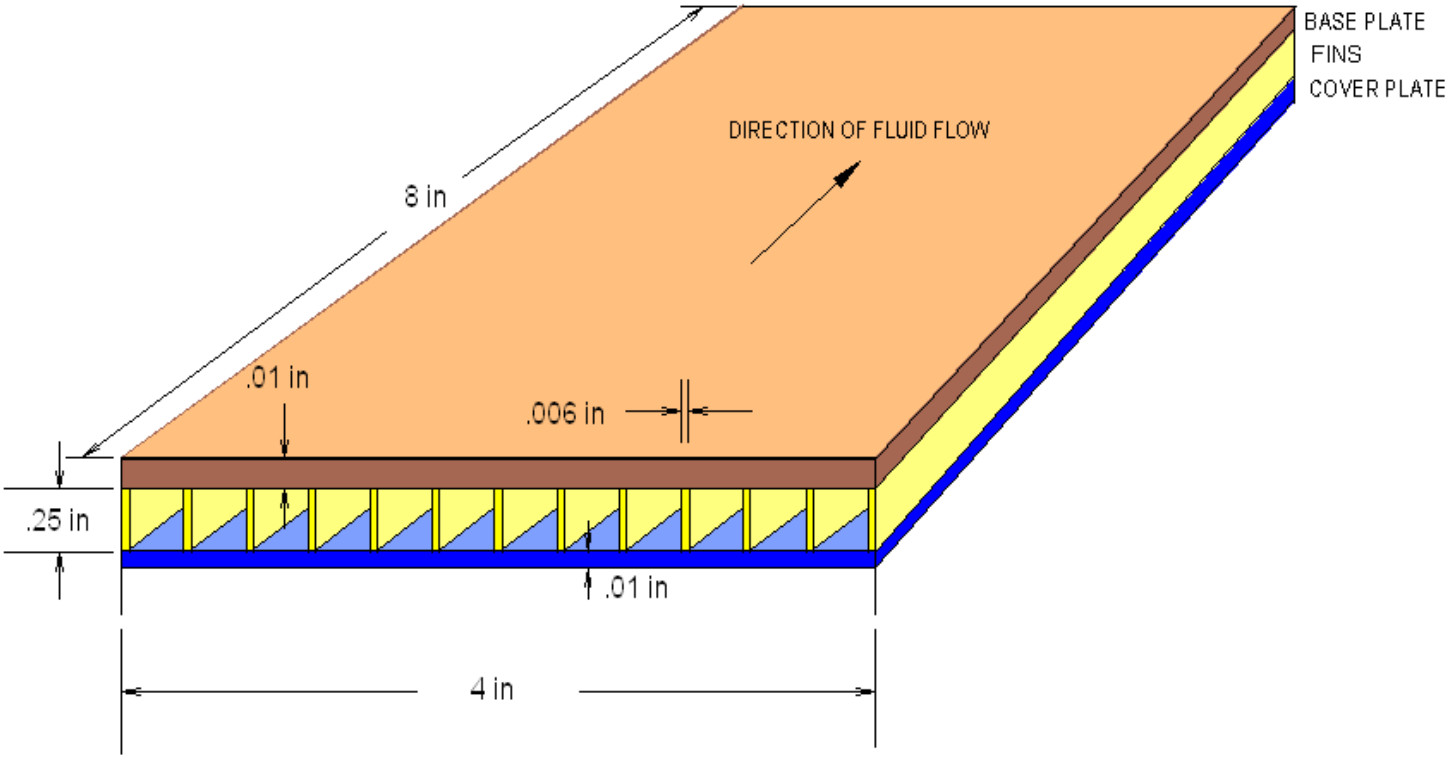
Kraus and Bar-Cohen Sample Problem 15.7 Comparison

Compare the results of sample problem 15.7 of Allan Kraus and Avram Bar-Cohen book "Thermal Analysis and Control of Electronic Equipment" to COLDPLATE results.

Below is a list of input parameters for their sample problem.

- Length L is 8 inches
- Width W is 4 inches
- Fin height H is .25 inches
- Fins are to be .006 inches thick
- Fin type is rectangular 11.1
- The fin density is 11.1 fins/inch
- Cover plate is .01 inches
- Base plate is .01 inches thick
- The inlet fluid temperature is 71C
- The inlet fluid pressure is 14.7 PSI
- Cooling fluid is air
- Mass flow rate is 1.35 lb/min
- 400 Watts, 200 Watts on both sides, uniformly distributed
- Base, fins and cover are made of aluminum, K = 5.14 W/(in-C)



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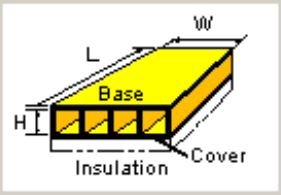
Input the geometry on this tab sheet.

Finned Cold Plate or Heat Sink

Geometry | Material | Fluid Properties | Power Dissipation | Pressure Drop | External Heat Transfer | Generate Plots

Geometry



Length (in.)	8	
Width (in.)	4	
Base Thickness (in.)	0.01	Variable
Insulation Thickness (in.)		Variable
Cover Thickness (in.)	0.01	
Fin Height (in.)	0.25	Variable

Type of Fins

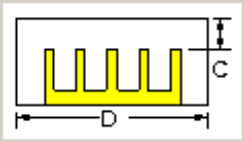
- 10.27T
- 11.44-3/8W
- 11.5-3/8W
- 17.8-3/8W
- 3/32-12.22
- PF4
- PF9
- PLANE FIN 11.1

View fin description

For Plate Fins Only

Fin Thickness (in.)	0.006	Variable
Fin Density (fins/in.)	11.1	Variable

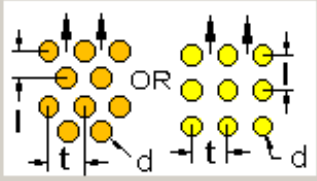
For Bypass Flow Only



Duct Width (in.) — Variable

Cover Clearance (in.) — Variable

For Pins Fins Only



Lateral Spacing (in.)		Variable
Transverse Spacing (in.)		Variable
Pin Diameter (in.)		Variable

Model Description | OK | Cancel | SaveAs | Save | Help

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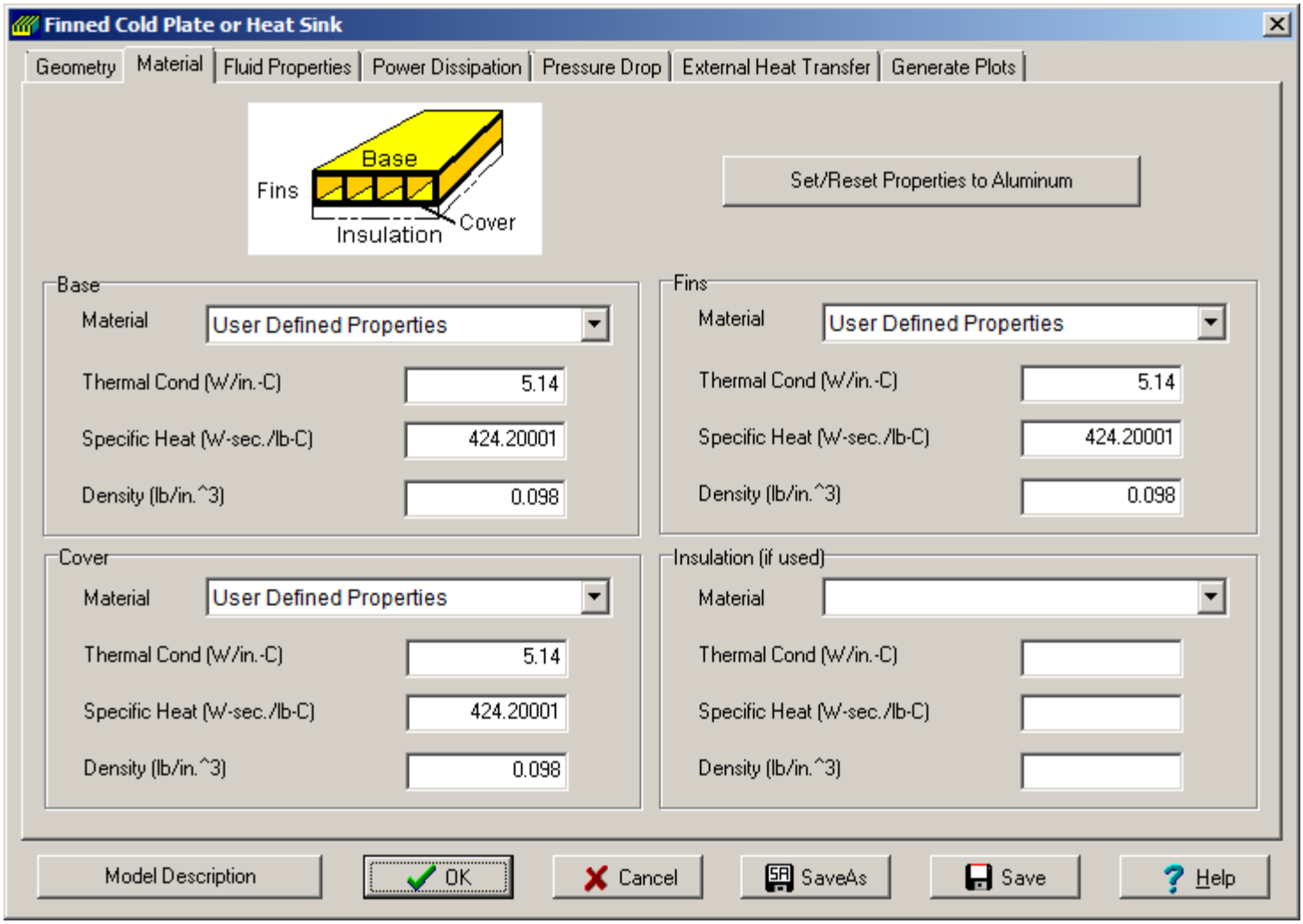
Input the base plate, cover and fin conductivity on this tab sheet.



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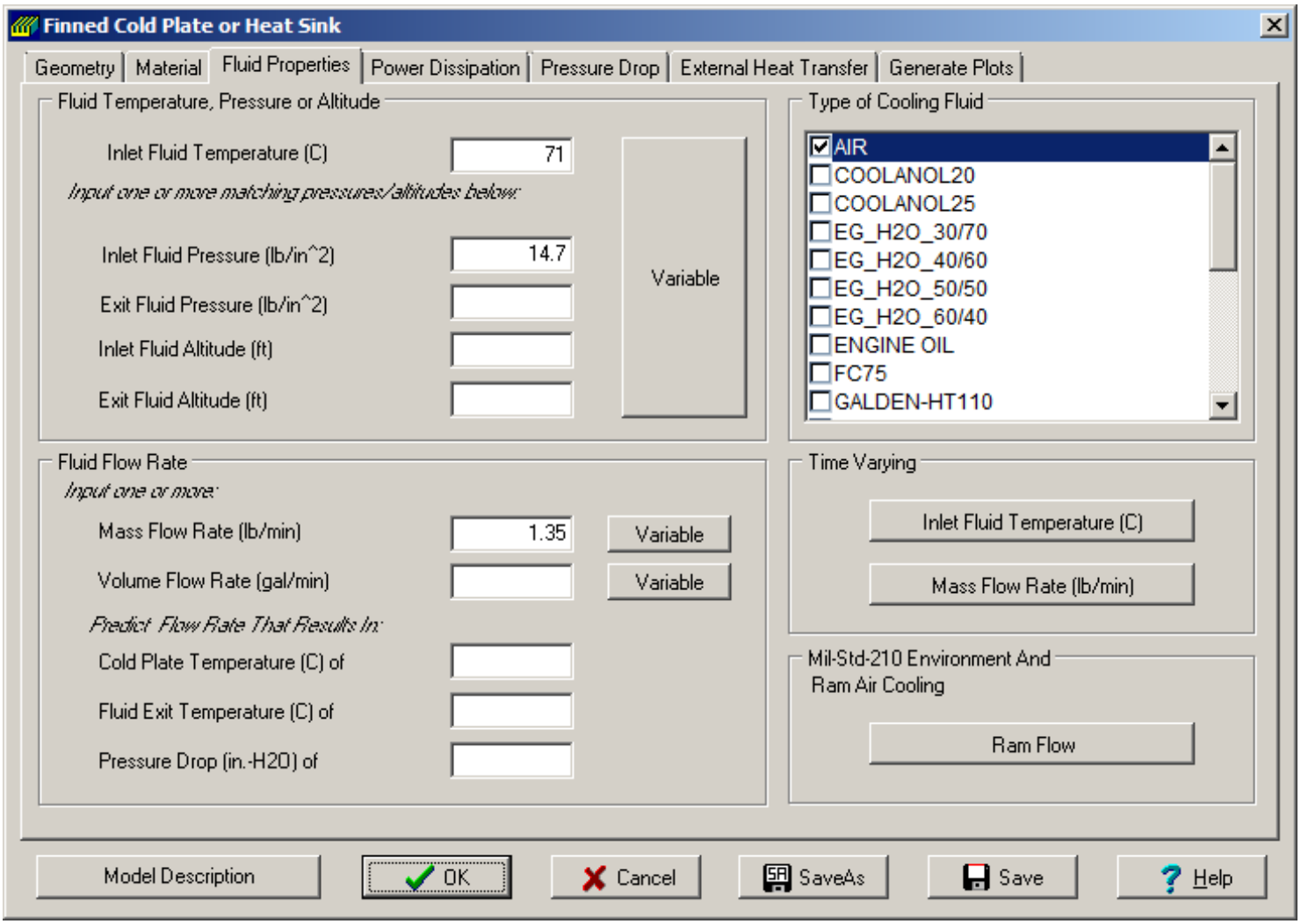
Input the temperature, pressure, flow rate and air as the fluid on this tab sheet.



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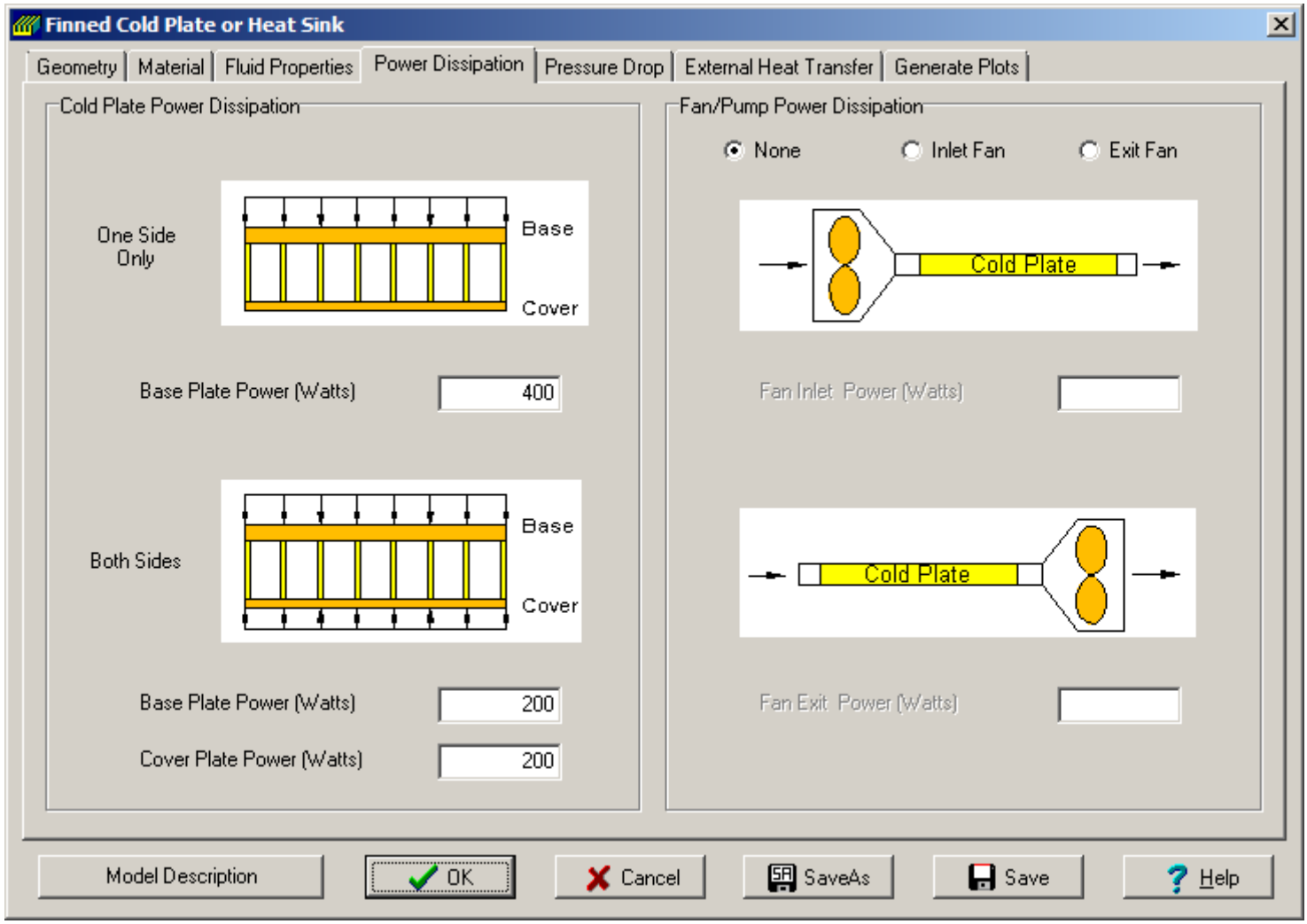
Input the power dissipation on this tab sheet.

(Note that we are inputting power on both "One Side Only" and "Both Sides" which will result in 2 runs to show the difference in results)



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Here are the results with power on both sides

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************************* VARIABLE INPUTS **************************
THE TYPE OF FINS SPECIFIED ARE:                        PLANE FIN 11.1
FIN HEIGHT, INCHES                                           0.250
BASE THICKNESS, INCHES                                       0.010
FIN THICKNESS, INCHES                                        0.0060
FIN DENSITY, FINS PER INCH                                  11.1
STATIC INLET FLUID TEMPERATURE, DEG C                       71.0
INLET PRESSURE, LBS/IN2                                     14.70
MASS FLOWRATE, LBS/MIN                                       1.35
THE POWER APPLIED TO BOTH SIDES, WATTS               TOP   200.00
                                                  BOTTOM   200.00
THE COOLING FLUID IS:                                        AIR

**************** INTERMEDIATE CALCULATED PARAMETERS ****************
FREE FLOW CROSS SECTIONAL AREA, IN2                          0.933
HYDRAULIC DIAMETER, INCHES                                   0.126
COLDPLATE WEIGHT, LBS                                        0.12
TOTAL VOL FLOWRATE,     [GAL/MIN] FT3/MIN [  166.39]    22.243
COLDPLATE VOL FLOWRATE, [GAL/MIN] FT3/MIN [  166.39]    22.243
COLDPLATE VELOCITY, FT/SEC                                  57.19
AVERAGE DENSITY, LB/FT3                                      0.061
AVERAGE CONDUCTIVITY, W/(IN-C)                               0.00079
AVERAGE SPECIFIC HEAT, W-MIN/(LB-C)                          7.640
AVERAGE DYNAMIC VISCOSITY, LB/(MIN-IN)                       0.000072
PRANDTL NUMBER                                               0.694
REYNOLDS NUMBER                                          2543.
EQUIVALENT FRICTION LOSS COEFFICIENT, KFRICTION              3.01
INLET LOSS COEFFICIENT, KINLET                               0.26
EXIT LOSS COEFFICIENT, KEXIT                                -0.12
FILM COEFFICIENT, [BTU/(HR-FT2-F)] W/(IN2-C)  [  16.28]  0.0596

*************************** PRESSURE *******************************
INLET PRESSURE, [LB/IN2] INCHES-H2O      [ 14.700]     407.077
INLET PRESSURE DROP, INCHES-H2O                              0.289
ACCELERATION PRESSURE DROP, INCHES-H2O                       0.132
FRICTIONAL PRESSURE DROP, INCHES-H2O                         1.785
EXIT PRESSURE DROP, INCHES-H2O                              -0.232
TOTAL PRESSURE DROP, INCHES-H2O                              1.974
EXIT PRESSURE, [LB/IN2] INCHES-H2O       [ 14.629]     405.103
DENSITY RATIO TIMES PRESSURE DROP, INCHES-H20                1.5660

*********************** THERMAL RESISTANCE ***********************
THERMAL RESISTANCE FROM INLET FLUID TO COLDPLATE, C/W
                                                     TOP     0.261
                                                  BOTTOM     0.261
THERMAL RESISTANCE FROM LOCAL FLUID TO COLDPLATE, C/W
                                                     TOP     0.142
                                                  BOTTOM     0.142

************************* TEMPERATURES ***************************
STATIC INLET FLUID TEMPERATURE, DEG C                       71.0
STAGNATION FLUID TEMP RISE ALONG COLDPLATE, DEG C           38.8
TOTAL STAGNATION FLUID TEMP RISE, DEG C                     38.8
STATIC EXIT FLUID TEMPERATURE, DEG C                       109.7
ISOTHERMAL COLDPLATE TEMPERATURE, DEG C            TOP     123.1
                                                BOTTOM     123.1
MAXIMUM COLDPLATE TEMPERATURE, DEG C               TOP     138.2
                                                BOTTOM     138.2
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Here are the results with power on the base plate only

FINNED MODEL WITH HEATING ON ONE SIDE ONLY

********** VARIABLE INPUTS **********	
THE TYPE OF FINS SPECIFIED ARE:	PLANE FIN 11.1
FIN HEIGHT, INCHES	0.250
BASE THICKNESS, INCHES	0.010
FIN THICKNESS, INCHES	0.0060
FIN DENSITY, FINS PER INCH	11.1
STATIC INLET FLUID TEMPERATURE, DEG C	71.0
INLET PRESSURE, LBS/IN2	14.70
MASS FLOWRATE, LBS/MIN	1.35
THE POWER APPLIED TO ONE SIDE ONLY, WATTS	400.00
THE COOLING FLUID IS:	AIR

********** INTERMEDIATE CALCULATED PARAMETERS **********		
FREE FLOW CROSS SECTIONAL AREA, IN2		0.933
HYDRAULIC DIAMETER, INCHES		0.126
COLDPLATE WEIGHT, LBS		0.12
TOTAL VOL FLOWRATE, [GAL/MIN] FT3/MIN	[166.39]	22.243
COLDPLATE VOL FLOWRATE, [GAL/MIN] FT3/MIN	[166.39]	22.243
COLDPLATE VELOCITY, FT/SEC		57.19
AVERAGE DENSITY, LB/FT3		0.061
AVERAGE CONDUCTIVITY, W/(IN-C)		0.00079
AVERAGE SPECIFIC HEAT, W-MIN/(LB-C)		7.640
AVERAGE DYNAMIC VISCOSITY, LB/(MIN-IN)		0.000072
PRANDTL NUMBER		0.694
REYNOLDS NUMBER		2543.
EQUIVALENT FRICTION LOSS COEFFICIENT, KFRICTION		3.01
INLET LOSS COEFFICIENT, KINLET		0.26
EXIT LOSS COEFFICIENT, KEXIT		-0.12
FILM COEFFICIENT, [BTU/(HR-FT2-F)] W/(IN2-C)	[16.28]	0.0596
THE FIN EFFICIENCY WITH HEAT ON ONE SIDE ONLY IS		0.901

********** PRESSURE **********		
INLET PRESSURE, [LB/IN2] INCHES-H2O	[14.700]	407.077
INLET PRESSURE DROP, INCHES-H2O		0.289
ACCELERATION PRESSURE DROP, INCHES-H2O		0.132
FRICTIONAL PRESSURE DROP, INCHES-H2O		1.785
EXIT PRESSURE DROP, INCHES-H2O		-0.232
TOTAL PRESSURE DROP, INCHES-H2O		1.974
EXIT PRESSURE, [LB/IN2] INCHES-H2O	[14.629]	405.103
DENSITY RATIO TIMES PRESSURE DROP, INCHES-H20		1.5660

********** THERMAL RESISTANCE **********	
THERMAL RESISTANCE FROM INLET FLUID TO COLDPLATE, C/W	0.136
THERMAL RESISTANCE FROM LOCAL FLUID TO COLDPLATE, C/W	0.078

********** TEMPERATURES **********	
STATIC INLET FLUID TEMPERATURE, DEG C	71.0
STAGNATION FLUID TEMP RISE ALONG COLDPLATE, DEG C	38.8
TOTAL STAGNATION FLUID TEMP RISE, DEG C	38.8
STATIC EXIT FLUID TEMPERATURE, DEG C	109.7
ISOTHERMAL COLDPLATE TEMPERATURE, DEG C	125.5
MAXIMUM COLDPLATE TEMPERATURE, DEG C	140.9

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Comparison of results between Kraus and Bar-Cohen, and COLDPLATE:

	Kraus and Bar-Cohen	COLDPLATE: Both Side Heating	COLDPLATE: Single Side Heating
Isothermal Temp C	122.8	123.1	125.5
Pressure Drop in H2O	2.09*	1.97	1.97

* Note that Kraus and Bar-Cohen used their Entrance and exit loss coefficient Figure 10.8 which is for triangular fins rather than the correct Figure 10.9 which is for rectangular fins. This accounts for the difference in their results versus COLDPLATE.

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