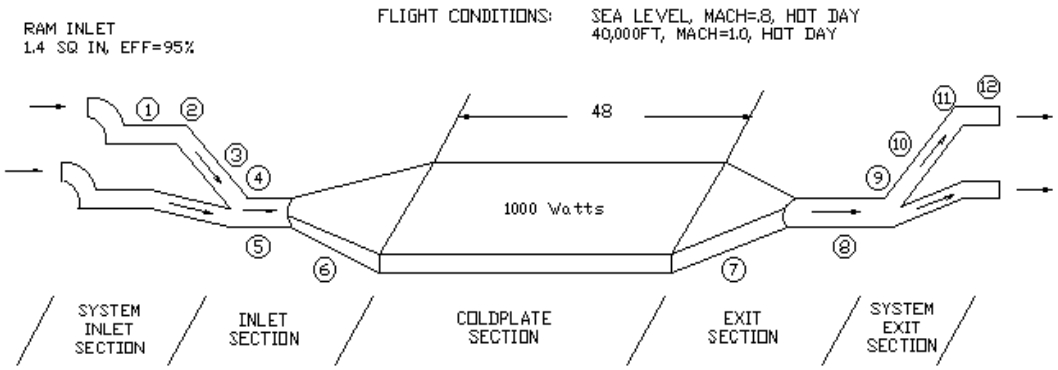
Ram Air Cooling Example

This example demonstrates the Ram cooling/heating capabilities and the use of pressure drop analysis.

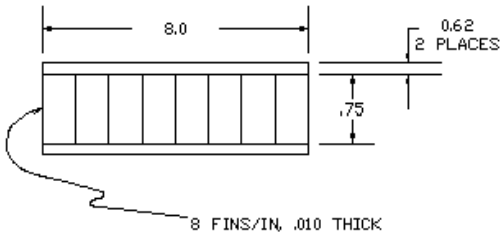
Assume an electronics assembly that dissipates 1000 Watts of power is to be ram air cooled using the geometry of the cooling system shown to the below. Determine the mass flow rate through the system, the pressure drop and Mach number through each duct, the cooling air temperatures, and the cold plate temperatures. Use the flight conditions shown and the pressure loss parameters for each section that are shown in the table.

To keep the model simple for demonstration purposes set the number of nodes along the width to 4 and the number along the length to 12.

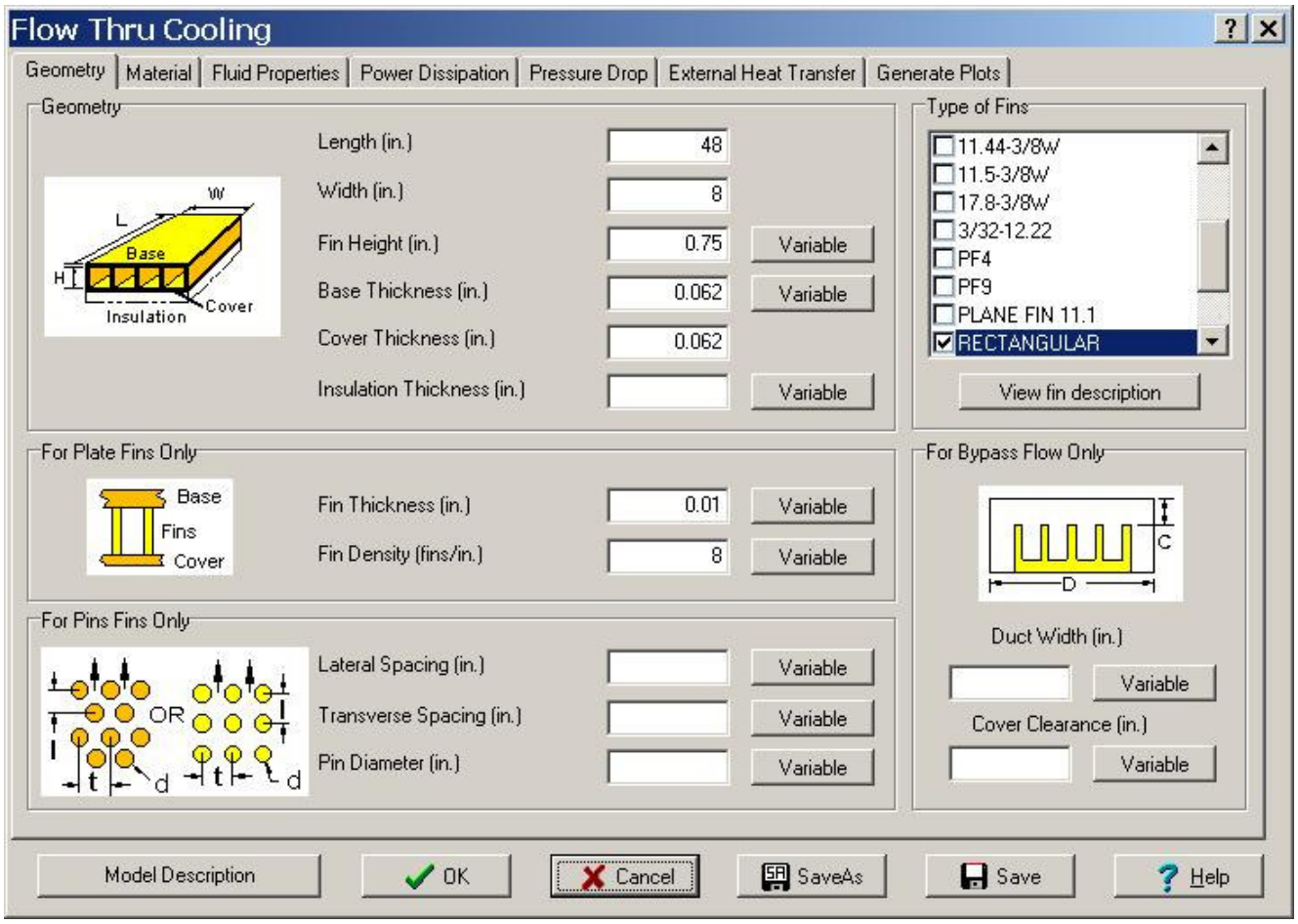
Assume an all aluminum construction.



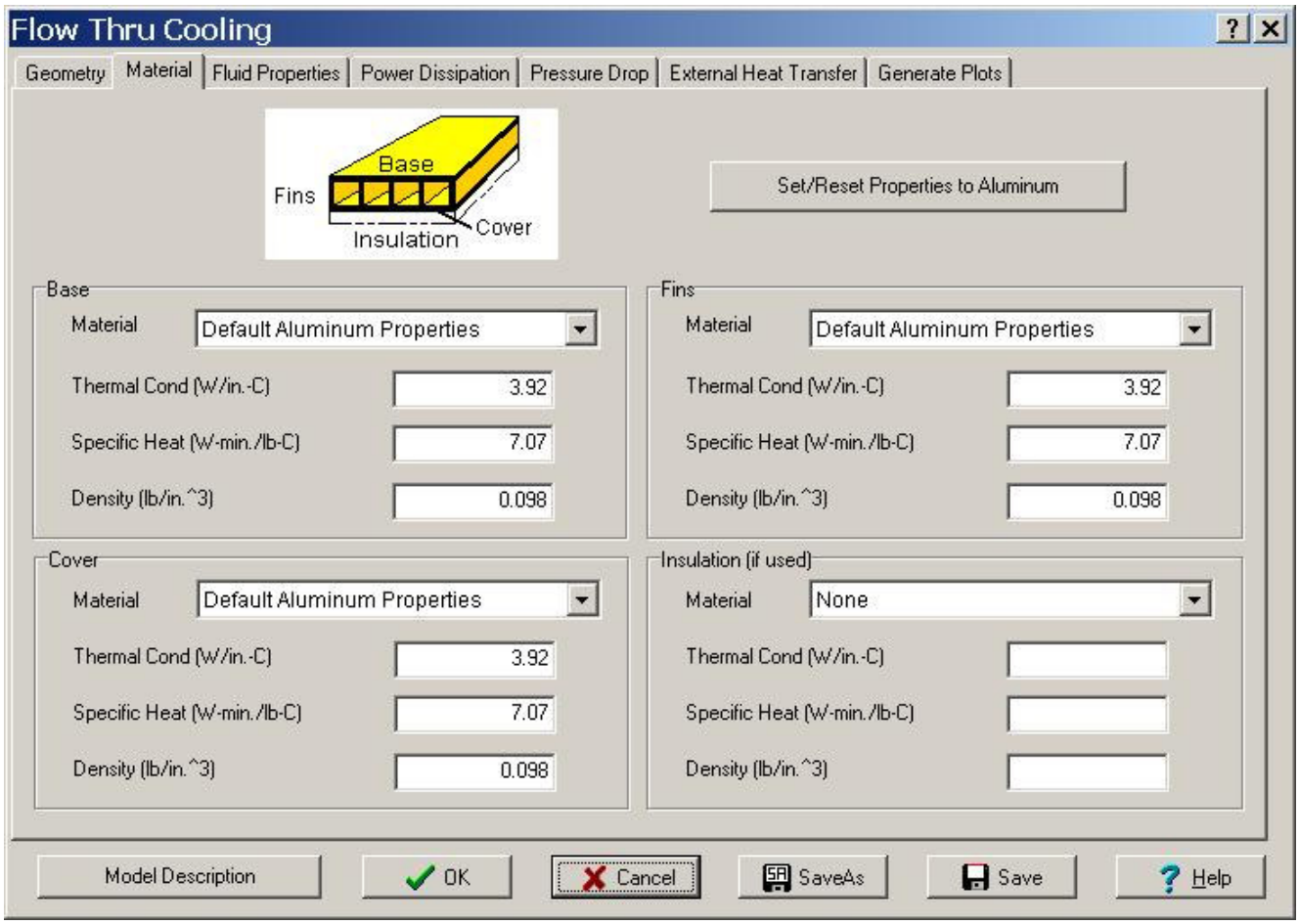
SECTION	DIA OR WIDTH	HEIGHT	LENGTH	K
①	1.3	0.0	2.0	--
②	1.3	0.0	--	1.0
③	1.3	0.0	12.0	--
④	1.3	0.0	--	1.6
⑤	2.0	2.0	4.0	0.5
⑥	2.0	.87	1.5	0.2
⑦	2.0	.87	1.5	0.2
⑧	2.0	2.0	4.0	-0.2
⑨	1.3	0.0	--	1.4
⑩	1.3	0.0	12.0	--
⑪	1.3	0.0	--	1.0
⑫	1.3	0.0	2.0	--



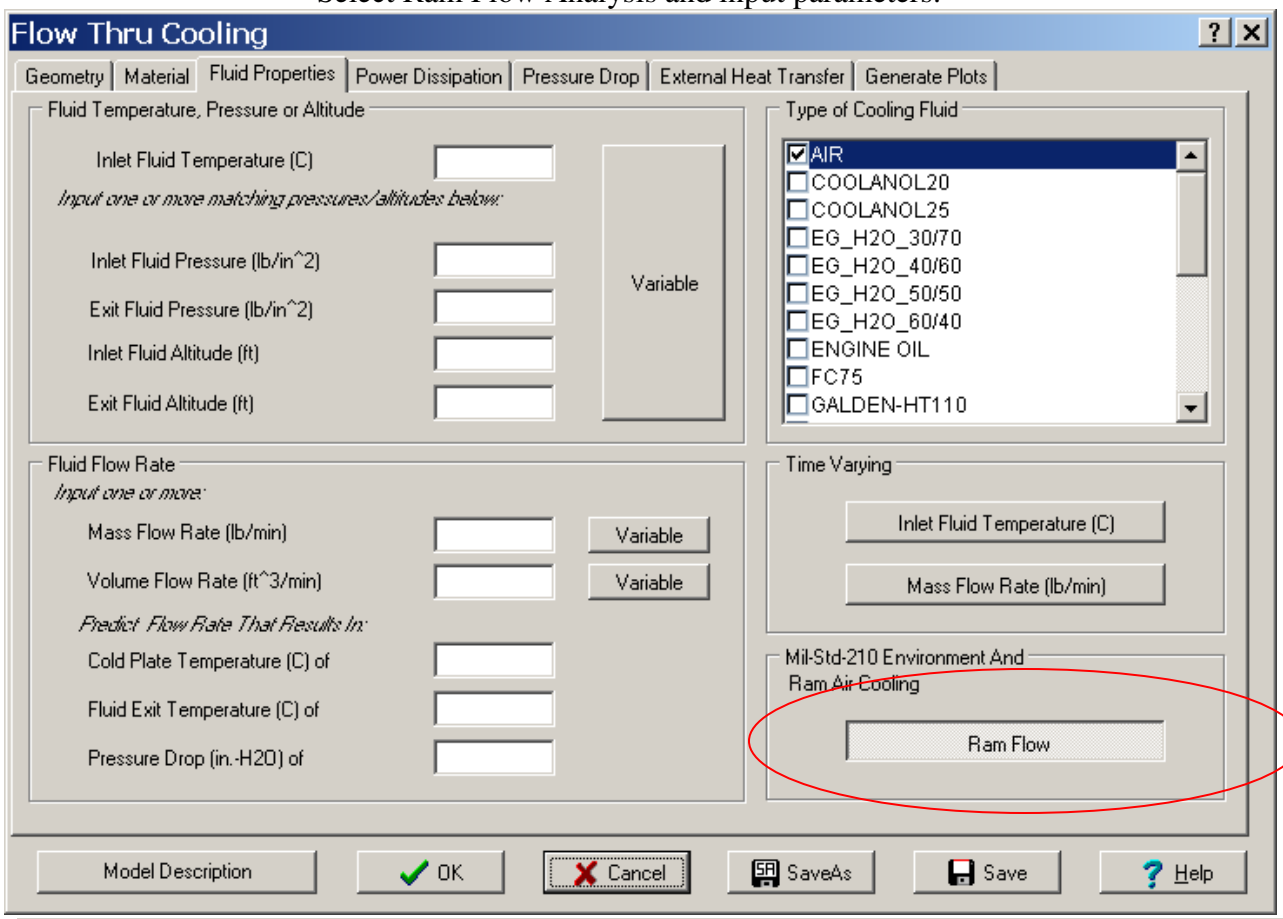
Input the geometry of the cold plate on this tab.

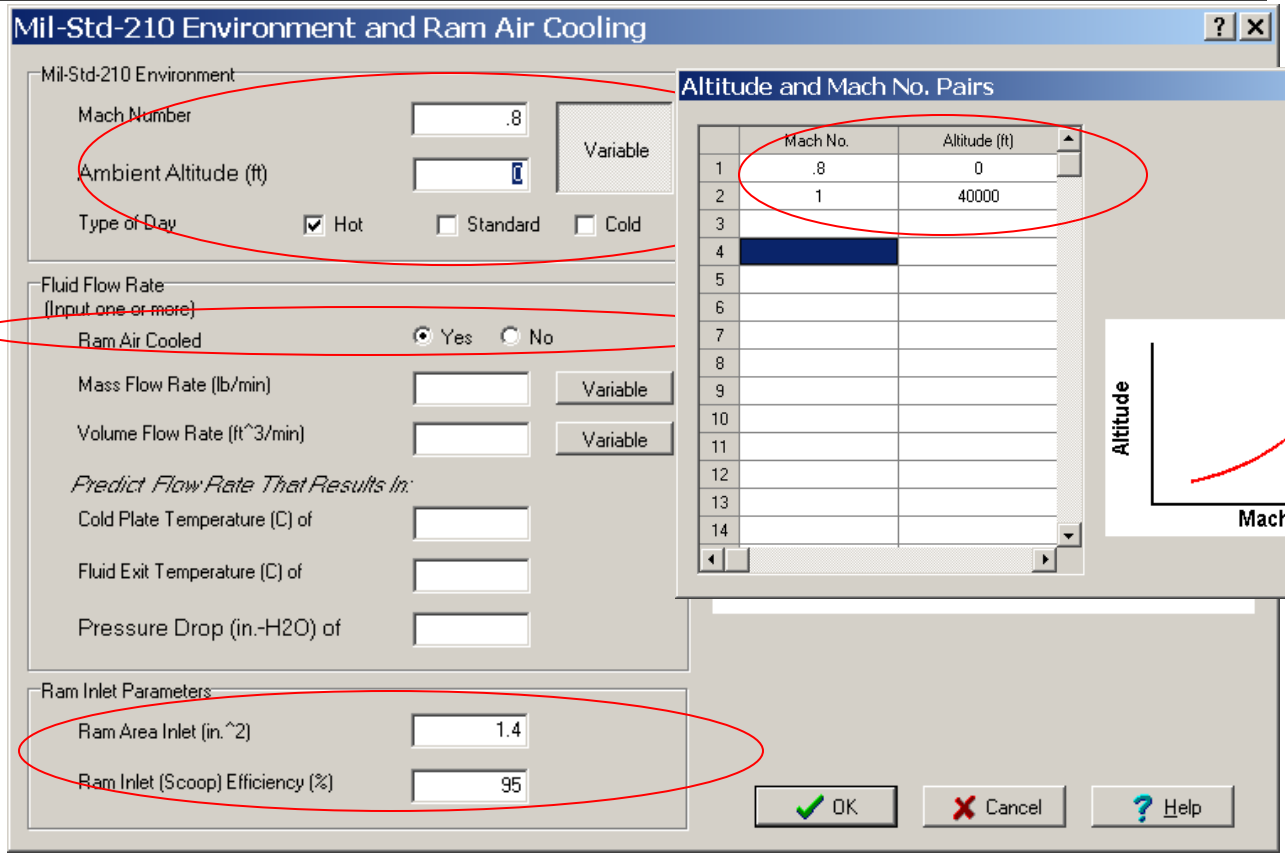


Select Default Aluminum Properties on this tab

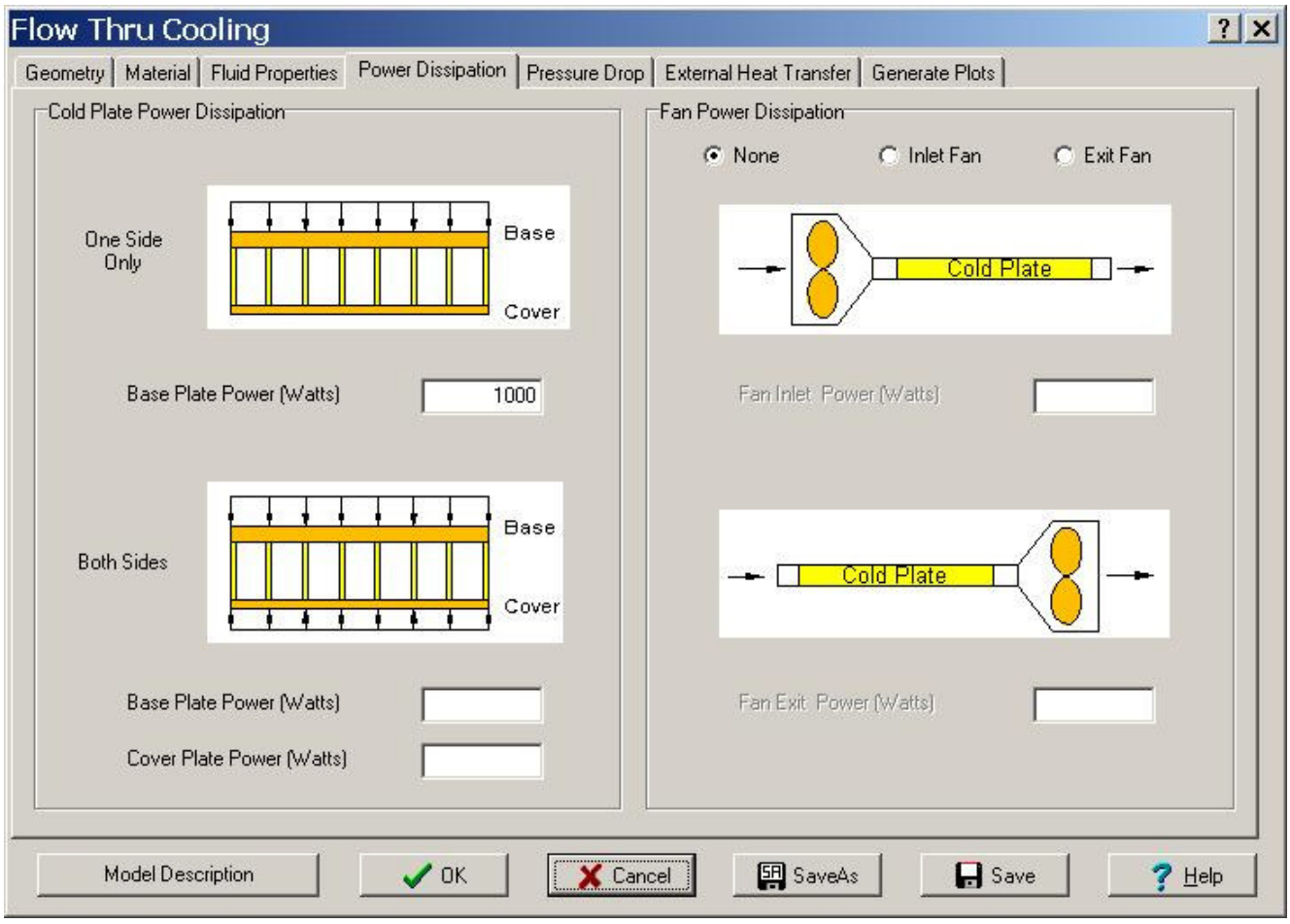


Select Ram Flow Analysis and input parameters.

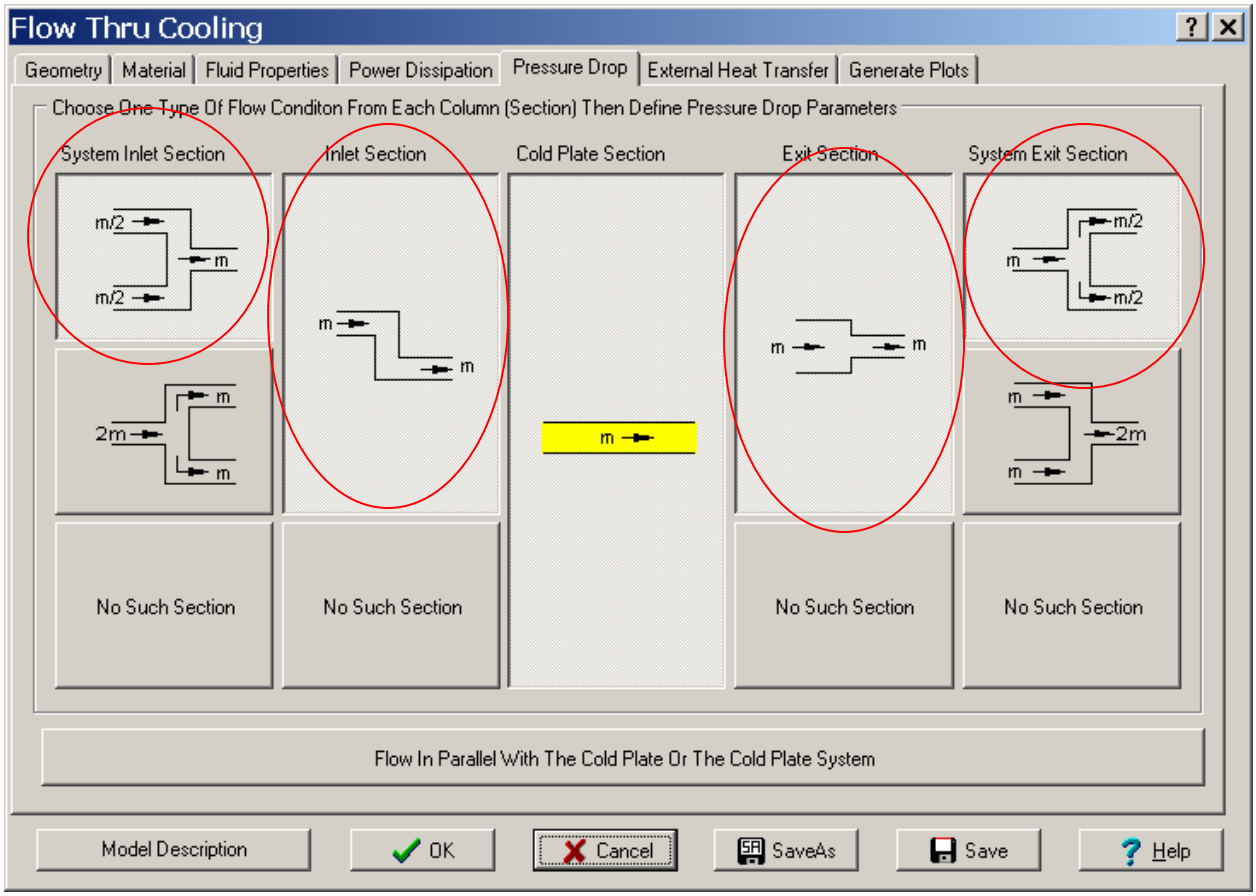




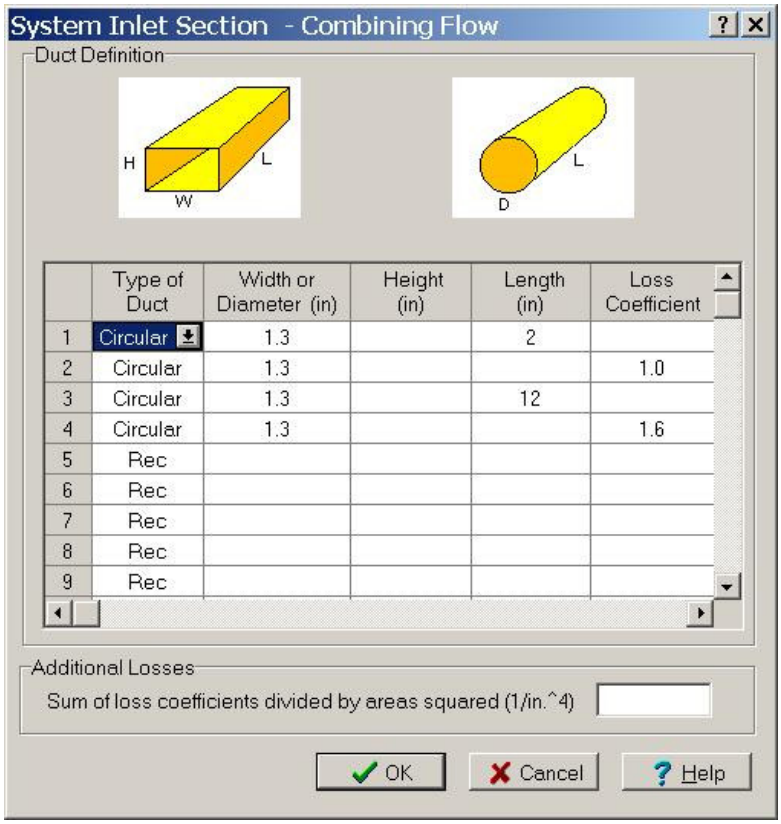
Input the power here.



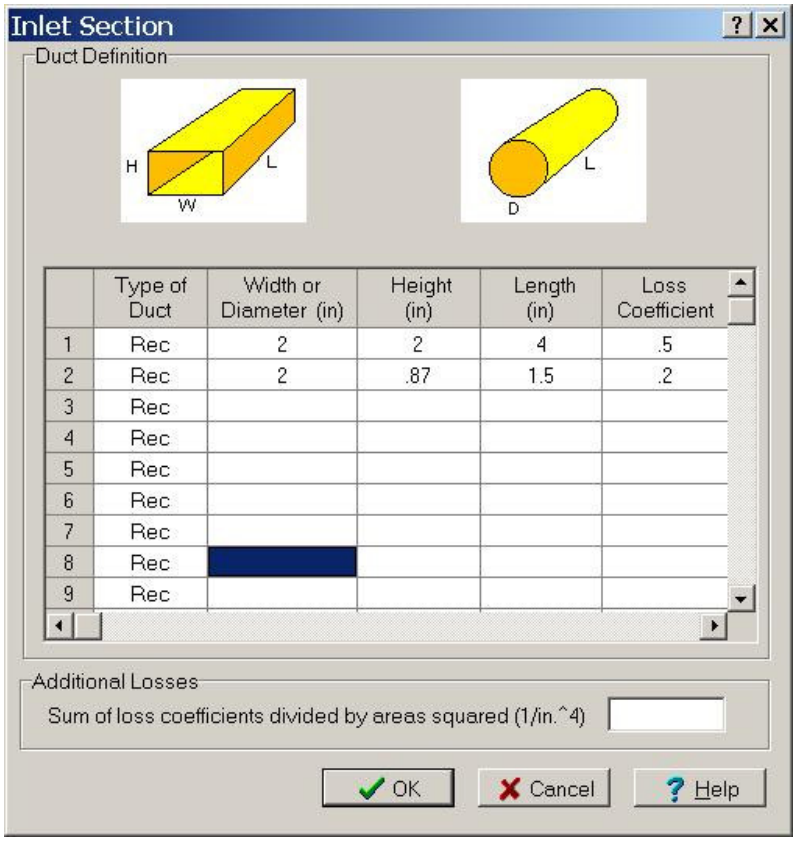
Each of the “Section” buttons is selected to specify the duct dimensions (pressure loss parameters) shown on the table on the first page.



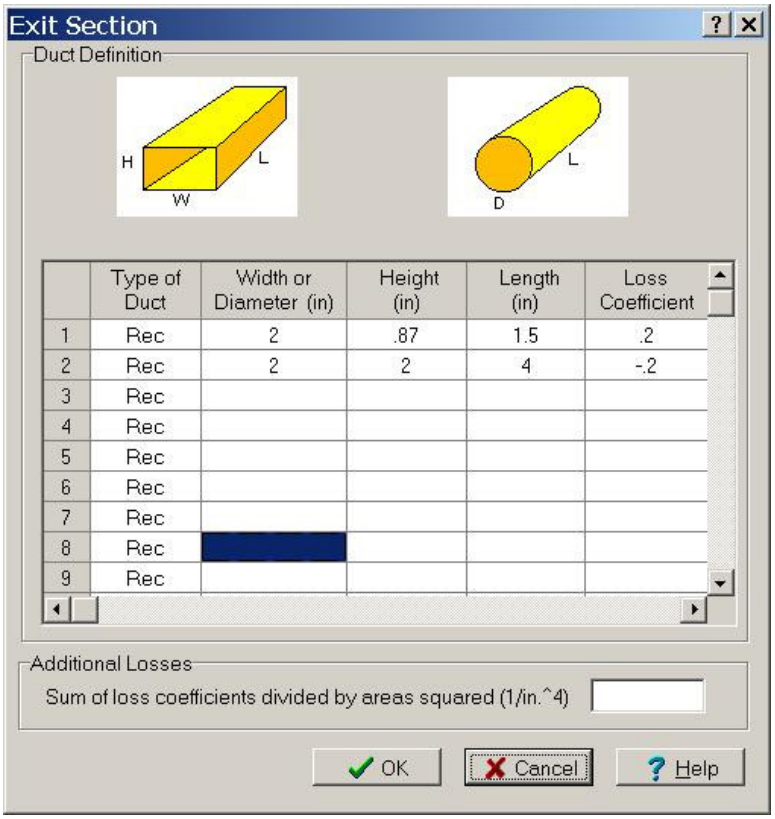
The “System Inlet Section” geometry goes here – Section 1 through 4.



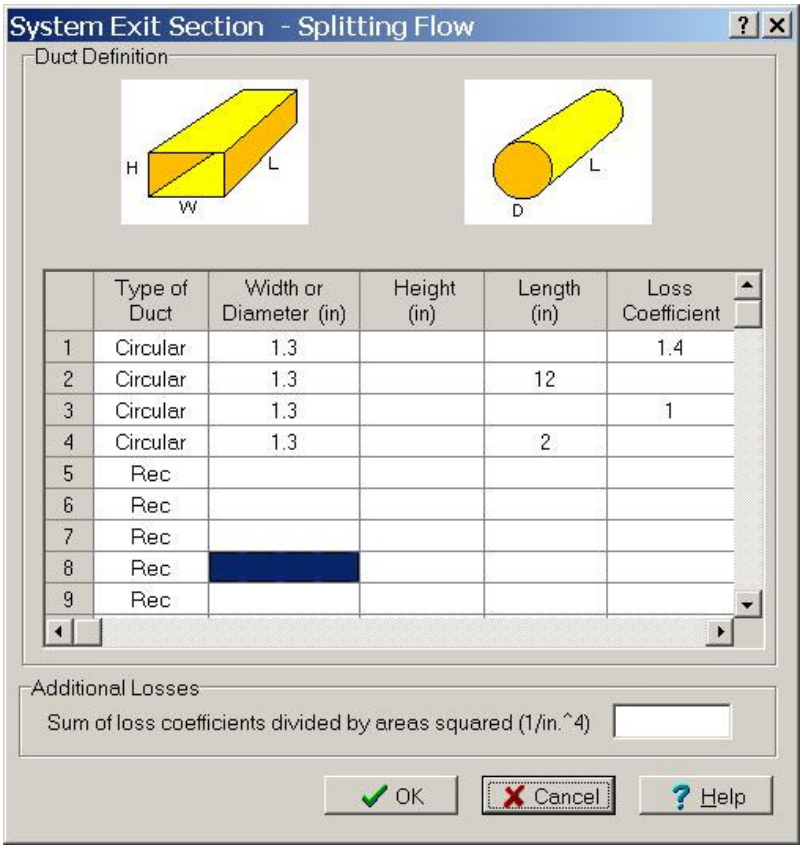
The “Inlet Section” geometry goes here – Section 5 and 6.



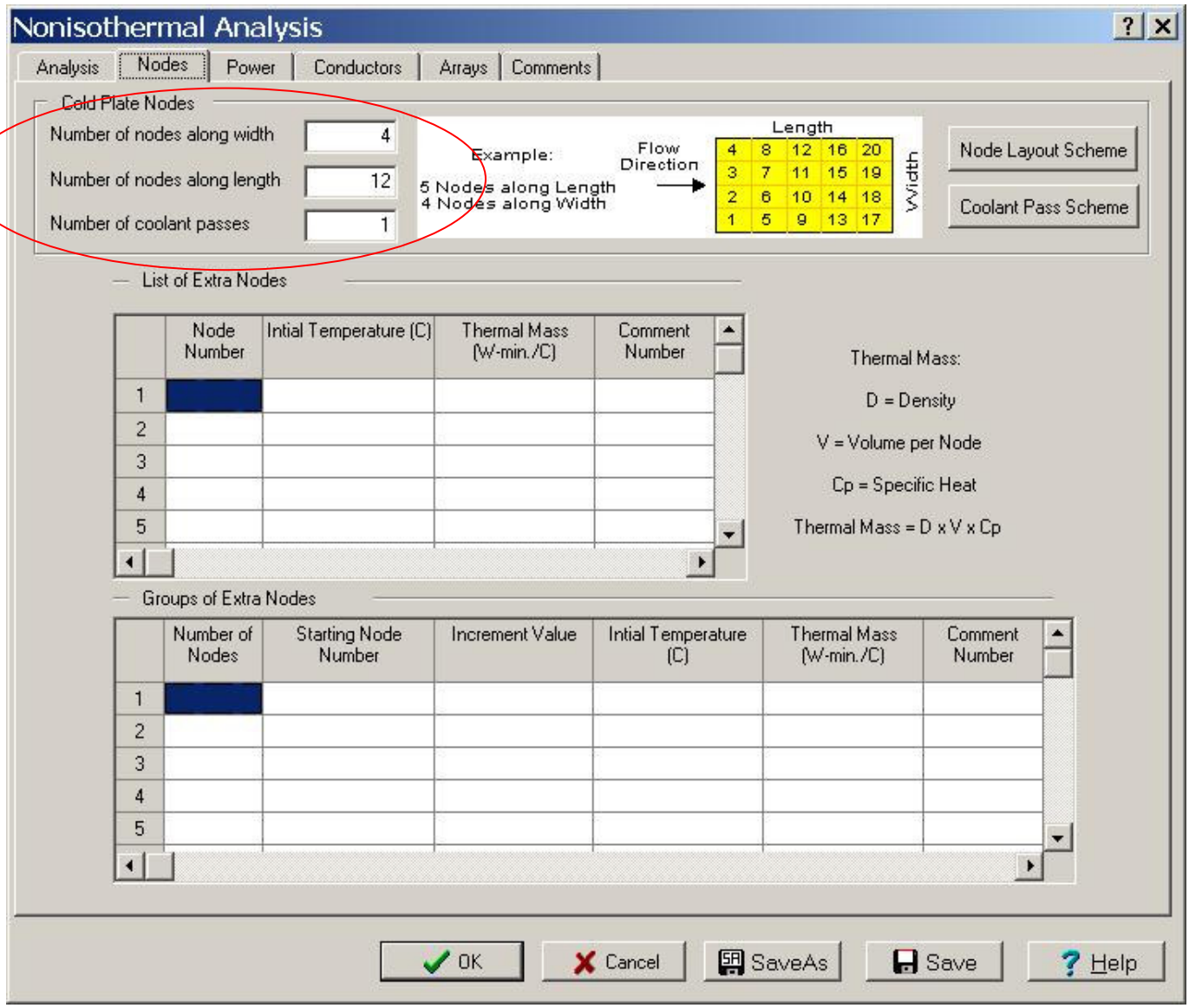
The “Exit Section” geometry goes here – Section 7 and 8.



The “System Exit Section” geometry goes here – Section 9 through 12.



The number of nodes along the length and width are defined below. The model is now ready to be run.



The isothermal results are shown below; they are always calculated prior to calculating of non-isothermal results. These results are for Sea Level and Mach =.8.

```
************************ VARIABLE INPUTS ************************
THE TYPE OF FINS SPECIFIED ARE:                      RECTANGULAR
FIN HEIGHT, INCHES                                         0.750
BASE THICKNESS, INCHES                                     0.062
FIN THICKNESS, INCHES                                      0.0100
FIN DENSITY, FINS PER INCH                                 8.0
THE OUTSIDE MACH NO. IS                                    0.80
ATMOSPHERE:HOT      DAY        0. FEET    39.0 DEG C   14.70 LBS/IN2
RAM INLET STAGNATION TEMP AND PRESS IN DEG C AND PSI  79.0  22.02
RAM INLET STATIC TEMP. AND PRESS. IN DEG C AND PSI    76.3  21.44
ADIABATIC COMPRESSION EFFICIENCY IN PERCENT             95.
                     RAM AIR FLOWRATE CALCULATIONS ARE TURNED ON
THE POWER APPLIED TO ONE SIDE ONLY, WATTS             1000.00
THE COOLING FLUID IS:                              AIR

**************** INTERMEDIATE CALCULATED PARAMETERS ****************
FREE FLOW CROSS SECTIONAL AREA, IN2                        5.52
HYDRAULIC DIAMETER, INCHES                                 0.199
COLDPLATE WEIGHT, LBS                                      6.94
TOTAL MASS FLOWRATE, LBS/MIN                              25.82
COLD PLATE MASS FLOWRATE, LBS/MIN                         25.82
TOTAL VOL FLOWRATE,     [GAL/MIN] FT3/MIN [  2486.7]     332.43
COLDPLATE VOL FLOWRATE, [GAL/MIN] FT3/MIN [  2486.7]     332.43
COLDPLATE VELOCITY, FT/SEC                                144.53
REYNOLDS NUMBER                                         13416.
EQUIVALENT FRICTION LOSS COEFFICIENT, KFRICTION            6.38
INLET LOSS COEFFICIENT, KINLET                             0.84
EXIT LOSS COEFFICIENT, KEXIT                              -0.70
FILM COEFFICIENT, [BTU/(HR-FT2-F)] W/(IN2-C)  [  35.16]    0.1288
THE FIN EFFICIENCY WITH HEAT ON ONE SIDE ONLY IS           0.465

************************** PRESSURE ******************************
INLET PRESSURE, [LB/IN2] INCHES-H2O      [ 21.438]       593.669
INLET PRESSURE DROP, INCHES-H2O                            4.650
ACCELERATION PRESSURE DROP, INCHES-H2O                     0.749
FRICTIONAL PRESSURE DROP, INCHES-H2O                      30.960
EXIT PRESSURE DROP, INCHES-H2O                            -4.306
FLOWLOSS SYSTEM INLET PRESSURE DROPS, INCHES-H2O          54.165
FLOWLOSS INLET PRESSURE DROPS, INCHES-H2O                 19.036
FLOWLOSS EXIT PRESSURE DROPS, INCHES-H2O                  15.033
FLOWLOSS SYSTEM EXIT PRESSURE DROPS, INCHES-H2O           66.303
TOTAL PRESSURE DROP, INCHES-H2O                          186.590
EXIT PRESSURE, [LB/IN2] INCHES-H2O       [ 14.700]       407.079
DENSITY RATIO TIME PRESSURE DROP, INCHES-H20             189.4384

*********************** THERMAL RESISTANCE ***********************
THERMAL RESISTANCE FROM INLET FLUID TO COLDPLATE, C/W      0.007
THERMAL RESISTANCE FROM LOCAL FLUID TO COLDPLATE, C/W      0.003

************************** TEMPERATURES ******************************
STATIC INLET FLUID TEMPERATURE, DEG C                     76.3
STAGNATION FLUID TEMP RISE ALONG COLDPLATE, DEG C          5.1
TOTAL STAGNATION FLUID TEMP RISE, DEG C                    5.1
STATIC EXIT FLUID TEMPERATURE, DEG C                      81.2
ISOTHERMAL COLDPLATE TEMPERATURE, DEG C                   83.2
MAXIMUM COLDPLATE TEMPERATURE, DEG C                      85.1
```


The predicted cold plate and fluid temperatures as well as the power at each node are shown below for Sea Level and Mach =.8

```
INLET FLUID TEMPERATURE=  76.3 C
                                        V
     ------------                       V
     | CP TEMP  |                       |
     | FLD TEMP |                       |
     | POWER    |                       |
     | NODE NO. |                       |
     ------------                       |
                                        V
                    ---------------------------------------
                    |   79.6  |   79.6  |   79.6  |   79.6  |
                    | ( 76.7) | ( 76.7) | ( 76.7) | ( 76.7) |
                    |  20.83W |  20.83W |  20.83W |  20.83W |
                    |   N  1  |   N  2  |   N  3  |   N  4  |
                    ---------------------------------------
                    |   80.0  |   80.0  |   80.0  |   80.0  |
                    | ( 77.1) | ( 77.1) | ( 77.1) | ( 77.1) |
                    |  20.83W |  20.83W |  20.83W |  20.83W |
                    |   N  5  |   N  6  |   N  7  |   N  8  |
                    ---------------------------------------
                    |   80.5  |   80.5  |   80.5  |   80.5  |
                    | ( 77.5) | ( 77.5) | ( 77.5) | ( 77.5) |
                    |  20.83W |  20.83W |  20.83W |  20.83W |
                    |   N  9  |   N 10  |   N 11  |   N 12  |
                    ---------------------------------------
                    |   80.9  |   80.9  |   80.9  |   80.9  |
                    | ( 78.0) | ( 78.0) | ( 78.0) | ( 78.0) |
                    |  20.83W |  20.83W |  20.83W |  20.83W |
                    |   N 13  |   N 14  |   N 15  |   N 16  |
                    ---------------------------------------
                    |   81.3  |   81.3  |   81.3  |   81.3  |
                    | ( 78.4) | ( 78.4) | ( 78.4) | ( 78.4) |
                    |  20.83W |  20.83W |  20.83W |  20.83W |
                    |   N 17  |   N 18  |   N 19  |   N 20  |
                    ---------------------------------------
                    |   81.7  |   81.7  |   81.7  |   81.7  |
                    | ( 78.8) | ( 78.8) | ( 78.8) | ( 78.8) |
                    |  20.83W |  20.83W |  20.83W |  20.83W |
                    |   N 21  |   N 22  |   N 23  |   N 24  |
                    ---------------------------------------
                    |   82.2  |   82.2  |   82.2  |   82.2  |
                    | ( 79.2) | ( 79.2) | ( 79.2) | ( 79.2) |
                    |  20.83W |  20.83W |  20.83W |  20.83W |
                    |   N 25  |   N 26  |   N 27  |   N 28  |
                    ---------------------------------------
                    |   82.6  |   82.6  |   82.6  |   82.6  |
                    | ( 79.6) | ( 79.6) | ( 79.6) | ( 79.6) |
                    |  20.83W |  20.83W |  20.83W |  20.83W |
                    |   N 29  |   N 30  |   N 31  |   N 32  |
                    ---------------------------------------
                    |   83.0  |   83.0  |   83.0  |   83.0  |
                    | ( 80.1) | ( 80.1) | ( 80.1) | ( 80.1) |
                    |  20.83W |  20.83W |  20.83W |  20.83W |
                    |   N 33  |   N 34  |   N 35  |   N 36  |
                    ---------------------------------------
                    |   83.4  |   83.4  |   83.4  |   83.4  |
                    | ( 80.5) | ( 80.5) | ( 80.5) | ( 80.5) |
                    |  20.83W |  20.83W |  20.83W |  20.83W |
                    |   N 37  |   N 38  |   N 39  |   N 40  |
                    ---------------------------------------
                    |   83.9  |   83.9  |   83.9  |   83.9  |
                    | ( 80.9) | ( 80.9) | ( 80.9) | ( 80.9) |
                    |  20.83W |  20.83W |  20.83W |  20.83W |
                    |   N 41  |   N 42  |   N 43  |   N 44  |
                    ---------------------------------------
                    |   84.3  |   84.3  |   84.3  |   84.3  |
                    | ( 81.3) | ( 81.3) | ( 81.3) | ( 81.3) |
                    |  20.83W |  20.83W |  20.83W |  20.83W |
                    |   N 45  |   N 46  |   N 47  |   N 48  |
                    ---------------------------------------
                             FLUID TEMPERATURE OUT=  81.3
                                        V
                                        V
     AVERAGE COLDPLATE TEMP.=   81.9     |
     POWER DIRECTLY ON CP=   1000.00     |
     NO. OF ITERATIONS REQUIRED=   11    |
     ALLOW. NO. OF ITERATIONS= 1000      |
     TEMP. RELAXATION CRITERIA=.00100    |
     PERCENT ENGERY BALANCE= 0.0002      |
                                        V
```

The isothermal results are again shown below; they are always calculated prior to non-isothermal analysis. These results are for 40KFT and Mach =1.

```
************************ VARIABLE INPUTS ************************
THE TYPE OF FINS SPECIFIED ARE:                      RECTANGULAR
FIN HEIGHT, INCHES                                         0.750
BASE THICKNESS, INCHES                                     0.062
FIN THICKNESS, INCHES                                      0.0100
FIN DENSITY, FINS PER INCH                                 8.0
THE OUTSIDE MACH NO. IS                                    1.00
ATMOSPHERE:HOT      DAY    40000. FEET   -42.0 DEG C     2.72 LBS/IN2
RAM INLET STAGNATION TEMP AND PRESS IN DEG C AND PSI    4.2    5.03
RAM INLET STATIC TEMP. AND PRESS. IN DEG C AND PSI      1.8    4.87
ADIABATIC COMPRESSION EFFICIENCY IN PERCENT              95.
                    RAM AIR FLOWRATE CALCULATIONS ARE TURNED ON
THE POWER APPLIED TO ONE SIDE ONLY, WATTS             1000.00
THE COOLING FLUID IS:                                  AIR

*************** INTERMEDIATE CALCULATED PARAMETERS ***************
FREE FLOW CROSS SECTIONAL AREA, IN2                        5.52
HYDRAULIC DIAMETER, INCHES                                 0.199
COLDPLATE WEIGHT, LBS                                      6.93
TOTAL MASS FLOWRATE, LBS/MIN                               7.08
COLD PLATE MASS FLOWRATE, LBS/MIN                          7.08
TOTAL VOL FLOWRATE,     [GAL/MIN] FT3/MIN [  2545.0]    340.21
COLDPLATE VOL FLOWRATE, [GAL/MIN] FT3/MIN [  2545.0]    340.21
COLDPLATE VELOCITY, FT/SEC                               147.92
REYNOLDS NUMBER                                         4302.
EQUIVALENT FRICTION LOSS COEFFICIENT, KFRICTION            7.80
INLET LOSS COEFFICIENT, KINLET                             0.84
EXIT LOSS COEFFICIENT, KEXIT                              -0.70
FILM COEFFICIENT, [BTU/(HR-FT2-F)] W/(IN2-C)  [  10.20]   0.0374
THE FIN EFFICIENCY WITH HEAT ON ONE SIDE ONLY IS           0.720

************************** PRESSURE ******************************
INLET PRESSURE, [LB/IN2] INCHES-H2O      [  4.874]      134.975
INLET PRESSURE DROP, INCHES-H2O                            1.252
ACCELERATION PRESSURE DROP, INCHES-H2O                     0.452
FRICTIONAL PRESSURE DROP, INCHES-H2O                      10.623
EXIT PRESSURE DROP, INCHES-H2O                            -1.267
FLOWLOSS SYSTEM INLET PRESSURE DROPS, INCHES-H2O          14.903
FLOWLOSS INLET PRESSURE DROPS, INCHES-H2O                  5.659
FLOWLOSS EXIT PRESSURE DROPS, INCHES-H2O                   5.640
FLOWLOSS SYSTEM EXIT PRESSURE DROPS, INCHES-H2O           22.389
TOTAL PRESSURE DROP, INCHES-H2O                           59.651
EXIT PRESSURE, [LB/IN2] INCHES-H2O       [  2.720]        75.324
DENSITY RATIO TIME PRESSURE DROP, INCHES-H20              16.2324

*********************** THERMAL RESISTANCE ***********************
THERMAL RESISTANCE FROM INLET FLUID TO COLDPLATE, C/W      0.021
THERMAL RESISTANCE FROM LOCAL FLUID TO COLDPLATE, C/W      0.007

************************** TEMPERATURES ****************************
STATIC INLET FLUID TEMPERATURE, DEG C                      1.8
STAGNATION FLUID TEMP RISE ALONG COLDPLATE, DEG C         18.6
TOTAL STAGNATION FLUID TEMP RISE, DEG C                   18.6
STATIC EXIT FLUID TEMPERATURE, DEG C                      20.0
ISOTHERMAL COLDPLATE TEMPERATURE, DEG C                   22.4
MAXIMUM COLDPLATE TEMPERATURE, DEG C                      27.9
```


The predicted cold plate and fluid temperatures as well as the power at each node are shown below for 40KFT and Mach =1.

```
INLET FLUID TEMPERATURE=   1.8 C
                                   V
     ------------                  V
     | CP TEMP  |                  |
     | FLD TEMP |                  |
     | POWER    |                  |
     | NODE NO. |                  |
     ------------                  |
                                   V
                     ---------------------------------------
                     |   10.4  |   10.4  |   10.4  |   10.4  |
                     | (  3.4) | (  3.4) | (  3.4) | (  3.4) |
                     |  20.83W |  20.83W |  20.83W |  20.83W |
                     |   N  1  |   N  2  |   N  3  |   N  4  |
                     ---------------------------------------
                     |   11.8  |   11.8  |   11.8  |   11.8  |
                     | (  4.9) | (  4.9) | (  4.9) | (  4.9) |
                     |  20.83W |  20.83W |  20.83W |  20.83W |
                     |   N  5  |   N  6  |   N  7  |   N  8  |
                     ---------------------------------------
                     |   13.3  |   13.3  |   13.3  |   13.3  |
                     | (  6.5) | (  6.5) | (  6.5) | (  6.5) |
                     |  20.83W |  20.83W |  20.83W |  20.83W |
                     |   N  9  |   N 10  |   N 11  |   N 12  |
                     ---------------------------------------
                     |   14.9  |   14.9  |   14.9  |   14.9  |
                     | (  8.0) | (  8.0) | (  8.0) | (  8.0) |
                     |  20.83W |  20.83W |  20.83W |  20.83W |
                     |   N 13  |   N 14  |   N 15  |   N 16  |
                     ---------------------------------------
                     |   16.4  |   16.4  |   16.4  |   16.4  |
                     | (  9.6) | (  9.6) | (  9.6) | (  9.6) |
                     |  20.83W |  20.83W |  20.83W |  20.83W |
                     |   N 17  |   N 18  |   N 19  |   N 20  |
                     ---------------------------------------
                     |   18.0  |   18.0  |   18.0  |   18.0  |
                     | ( 11.1) | ( 11.1) | ( 11.1) | ( 11.1) |
                     |  20.83W |  20.83W |  20.83W |  20.83W |
                     |   N 21  |   N 22  |   N 23  |   N 24  |
                     ---------------------------------------
                     |   19.5  |   19.5  |   19.5  |   19.5  |
                     | ( 12.7) | ( 12.7) | ( 12.7) | ( 12.7) |
                     |  20.83W |  20.83W |  20.83W |  20.83W |
                     |   N 25  |   N 26  |   N 27  |   N 28  |
                     ---------------------------------------
                     |   21.1  |   21.1  |   21.1  |   21.1  |
                     | ( 14.2) | ( 14.2) | ( 14.2) | ( 14.2) |
                     |  20.83W |  20.83W |  20.83W |  20.83W |
                     |   N 29  |   N 30  |   N 31  |   N 32  |
                     ---------------------------------------
                     |   22.6  |   22.6  |   22.6  |   22.6  |
                     | ( 15.7) | ( 15.7) | ( 15.7) | ( 15.7) |
                     |  20.83W |  20.83W |  20.83W |  20.83W |
                     |   N 33  |   N 34  |   N 35  |   N 36  |
                     ---------------------------------------
                     |   24.1  |   24.1  |   24.1  |   24.1  |
                     | ( 17.3) | ( 17.3) | ( 17.3) | ( 17.3) |
                     |  20.83W |  20.83W |  20.83W |  20.83W |
                     |   N 37  |   N 38  |   N 39  |   N 40  |
                     ---------------------------------------
                     |   25.7  |   25.7  |   25.7  |   25.7  |
                     | ( 18.8) | ( 18.8) | ( 18.8) | ( 18.8) |
                     |  20.83W |  20.83W |  20.83W |  20.83W |
                     |   N 41  |   N 42  |   N 43  |   N 44  |
                     ---------------------------------------
                     |   27.1  |   27.1  |   27.1  |   27.1  |
                     | ( 20.4) | ( 20.4) | ( 20.4) | ( 20.4) |
                     |  20.83W |  20.83W |  20.83W |  20.83W |
                     |   N 45  |   N 46  |   N 47  |   N 48  |
                     ---------------------------------------
                              FLUID TEMPERATURE OUT=  20.4
                                   V
                                   V
     AVERAGE COLDPLATE TEMP.=   18.7       |
     POWER DIRECTLY ON CP=   1000.00       |
     NO. OF ITERATIONS REQUIRED=   18      |
     ALLOW. NO. OF ITERATIONS= 1000        |
     TEMP. RELAXATION CRITERIA=.00100      |
     PERCENT ENGERY BALANCE= 0.0000        |
                                           v
```


Detailed Pressure Drop Results at each Section for the two different conditions– Sea Level, Mach =.8, and 40KFT, Mach = 1 – are listed on the next page. They are contained in the .dlp file.

RAM AIR COOLING INPUT AND RESULTS DATA

DAY	MACH-A/C	ALT	T-AMB	P-AMB	EFF	ARAMI	T-STAG	P-STAG	T-STAT	P-STAT	RHO-S	MACH-RAM	M-DOT
HOT	0.80	0.	39.0	14.70	95.	1.4000	79.0	22.02	76.3	21.44	0.0921	0.196	12.911

********** INPUT **********

********** RESULTS **********

SYSTEM INLET FLOWLOSS INPUT AND RESULTS DATA

WIDTH OR DIA	HEIGHT	LENGTH	K	M-DOT	f	RHO-IN	RHO-EX	MACH-IN	MACH-EX	DP-ACC	DP-f	DP-K	DP-TOT	PRESS-I	PRESS-E
1.300	0.000	2.00	0.000	12.911	0.0098	0.0920	0.0918	0.206	0.207	0.068	1.074	0.000	1.142	593.67	592.53
1.300	0.000	0.00	1.000	12.911	0.0000	0.0918	0.0890	0.207	0.213	0.000	0.000	18.011	18.011	592.53	574.52
1.300	0.000	12.00	0.000	12.911	0.0065	0.0890	0.0883	0.213	0.215	0.301	4.394	0.000	4.695	574.52	569.82
1.300	0.000	0.00	1.600	12.911	0.0000	0.0883	0.0836	0.215	0.227	0.000	0.000	30.317	30.317	569.82	539.50
									SUB-TOTALS	0.370	5.467	48.328	54.165		

THE TOTAL PRESSURE DROP ACROSS THE INLET SYSTEM IS 54.165

INLET FLOWLOSS INPUT AND RESULTS DATA

WIDTH OR DIA	HEIGHT	LENGTH	K	M-DOT	f	RHO-IN	RHO-EX	MACH-IN	MACH-EX	DP-ACC	DP-f	DP-K	DP-TOT	PRESS-I	PRESS-E
2.000	2.000	4.00	0.500	25.822	0.0089	0.0836	0.0828	0.151	0.152	0.163	0.617	4.310	5.091	539.50	534.41
2.000	0.870	1.50	0.200	25.822	0.0097	0.0828	0.0807	0.350	0.359	2.453	2.217	9.276	13.946	534.41	520.47
									SUB-TOTALS	2.617	2.833	13.586	19.036		

THE TOTAL PRESSURE DROP ACROSS THE INLET IS 19.036

COLDPLATE FLOWLOSS INPUT AND RESULTS DATA

WIDTH OR DIA	HEIGHT	LENGTH	K IN/EX	M-DOT	f	RHO-IN	RHO-EX	MACH-IN	MACH-EX	DP-ACC	DP-f	DP-KI/KE	DP-TOT	PRESS-I	PRESS-E
8.000	0.750	48.00	0.996	25.822	0.0066	0.0807	0.0747	0.113	0.121	0.749	30.960	4.650	32.053	520.47	488.41
			-0.854									-4.306			

EXIT FLOWLOSS INPUT AND RESULTS DATA

WIDTH OR DIA	HEIGHT	LENGTH	K	M-DOT	f	RHO-IN	RHO-EX	MACH-IN	MACH-EX	DP-ACC	DP-f	DP-K	DP-TOT	PRESS-I	PRESS-E
2.000	0.870	1.50	0.200	25.822	0.0097	0.0747	0.0722	0.385	0.399	3.568	2.468	10.329	16.365	488.41	472.05
2.000	2.000	4.00	-0.200	25.822	0.0089	0.0722	0.0724	0.174	0.173	-0.056	0.710	-1.986	-1.332	472.05	473.38
									SUB-TOTALS	3.512	3.179	8.343	15.033		

THE TOTAL PRESSURE DROP ACROSS THE EXIT IS 15.033

SYSTEM EXIT FLOWLOSS INPUT AND RESULTS DATA

WIDTH OR DIA	HEIGHT	LENGTH	K	M-DOT	f	RHO-IN	RHO-EX	MACH-IN	MACH-EX	DP-ACC	DP-f	DP-K	DP-TOT	PRESS-I	PRESS-E
1.300	0.000	0.00	1.400	12.911	0.0000	0.0724	0.0674	0.261	0.280	0.000	0.000	32.646	32.646	473.38	440.74
1.300	0.000	12.00	0.000	12.911	0.0065	0.0674	0.0664	0.280	0.284	0.731	5.828	0.000	6.558	440.74	434.18
1.300	0.000	0.00	1.000	12.911	0.0000	0.0664	0.0625	0.284	0.302	0.000	0.000	25.283	25.283	434.18	408.89
1.300	0.000	2.00	0.000	12.911	0.0098	0.0625	0.0622	0.302	0.303	0.232	1.583	0.000	1.815	408.89	407.08
									SUB-TOTALS	0.963	7.411	57.929	66.303		

THE TOTAL PRESSURE DROP ACROSS THE SYSTEM EXIT IS 66.303

ACCELERATION TOTAL	8.209
FRICTIONAL TOTAL	49.851
FITTING OR TURN TOTAL	128.530
THE TOTAL PRESSURE DROP ACROSS THE WHOLE SYSTEM IS	186.590
DENSITY RATIO TIMES PRESSURE DROP	189.4383

RAM AIR COOLING INPUT AND RESULTS DATA

DAY	MACH-A/C	ALT	T-AMB	P-AMB	EFF	ARAMI	T-STAG	P-STAG	T-STAT	P-STAT	RHO-S	MACH-RAM	M-DOT
HOT	1.00	40000.	-42.0	2.72	95.	1.4000	4.2	5.03	1.8	4.87	0.0266	0.209	3.542

********** INPUT ********** ********** RESULTS **********

SYSTEM INLET FLOWLOSS INPUT AND RESULTS DATA

WIDTH OR DIA	HEIGHT	LENGTH	K	M-DOT	f	RHO-IN	RHO-EX	MACH-IN	MACH-EX	DP-ACC	DP-f	DP-K	DP-TOT	PRESS-I	PRESS-E
1.300	0.000	2.00	0.000	3.542	0.0139	0.0266	0.0265	0.221	0.222	0.029	0.394	0.000	0.423	134.97	134.55
1.300	0.000	0.00	1.000	3.542	0.0000	0.0265	0.0256	0.222	0.230	0.000	0.000	4.707	4.707	134.55	129.85
1.300	0.000	12.00	0.000	3.542	0.0091	0.0256	0.0252	0.230	0.233	0.131	1.618	0.000	1.749	129.85	128.10
1.300	0.000	0.00	1.600	3.542	0.0000	0.0252	0.0237	0.233	0.248	0.000	0.000	8.024	8.024	128.10	120.07
									SUB-TOTALS	0.160	2.012	12.731	14.903		

THE TOTAL PRESSURE DROP ACROSS THE INLET SYSTEM IS 14.903

INLET FLOWLOSS INPUT AND RESULTS DATA

WIDTH OR DIA	HEIGHT	LENGTH	K	M-DOT	f	RHO-IN	RHO-EX	MACH-IN	MACH-EX	DP-ACC	DP-f	DP-K	DP-TOT	PRESS-I	PRESS-E
2.000	2.000	4.00	0.500	7.083	0.0126	0.0237	0.0234	0.165	0.167	0.055	0.231	1.148	1.434	120.07	118.64
2.000	0.870	1.50	0.200	7.083	0.0136	0.0234	0.0225	0.384	0.398	0.902	0.837	2.486	4.225	118.64	114.41
									SUB-TOTALS	0.957	1.068	3.634	5.659		

THE TOTAL PRESSURE DROP ACROSS THE INLET IS 5.659

COLDPLATE FLOWLOSS INPUT AND RESULTS DATA

WIDTH OR DIA	HEIGHT	LENGTH	K IN/EX	M-DOT	f	RHO-IN	RHO-EX	MACH-IN	MACH-EX	DP-ACC	DP-f	DP-KI/KE	DP-TOT	PRESS-I	PRESS-E
8.000	0.750	48.00	0.996	7.083	0.0081	0.0225	0.0191	0.125	0.143	0.452	10.623	1.252	11.061	114.41	103.35
			-0.854									-1.267			

EXIT FLOWLOSS INPUT AND RESULTS DATA

WIDTH OR DIA	HEIGHT	LENGTH	K	M-DOT	f	RHO-IN	RHO-EX	MACH-IN	MACH-EX	DP-ACC	DP-f	DP-K	DP-TOT	PRESS-I	PRESS-E
2.000	0.870	1.50	0.200	7.083	0.0136	0.0191	0.0180	0.454	0.482	1.844	1.036	3.076	5.957	103.35	97.40
2.000	2.000	4.00	-0.200	7.083	0.0126	0.0180	0.0181	0.210	0.209	-0.019	0.302	-0.599	-0.317	97.40	97.71
									SUB-TOTALS	1.825	1.338	2.477	5.640		

THE TOTAL PRESSURE DROP ACROSS THE EXIT IS 5.640

SYSTEM EXIT FLOWLOSS INPUT AND RESULTS DATA

WIDTH OR DIA	HEIGHT	LENGTH	K	M-DOT	f	RHO-IN	RHO-EX	MACH-IN	MACH-EX	DP-ACC	DP-f	DP-K	DP-TOT	PRESS-I	PRESS-E
1.300	0.000	0.00	1.400	3.542	0.0000	0.0181	0.0162	0.315	0.351	0.000	0.000	10.020	10.020	97.71	87.69
1.300	0.000	12.00	0.000	3.542	0.0091	0.0162	0.0156	0.351	0.364	0.563	2.584	0.000	3.147	87.69	84.55
1.300	0.000	0.00	1.000	3.542	0.0000	0.0156	0.0141	0.364	0.404	0.000	0.000	8.251	8.251	84.55	76.29
1.300	0.000	2.00	0.000	3.542	0.0139	0.0141	0.0139	0.404	0.409	0.224	0.747	0.000	0.971	76.29	75.32
									SUB-TOTALS	0.788	3.331	18.271	22.389		

THE TOTAL PRESSURE DROP ACROSS THE SYSTEM EXIT IS 22.389

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ACCELERATION TOTAL	4.181
FRICTIONAL TOTAL	18.371
FITTING OR TURN TOTAL	37.099
THE TOTAL PRESSURE DROP ACROSS THE WHOLE SYSTEM IS	59.651
DENSITY RATIO TIMES PRESSURE DROP	16.2324

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