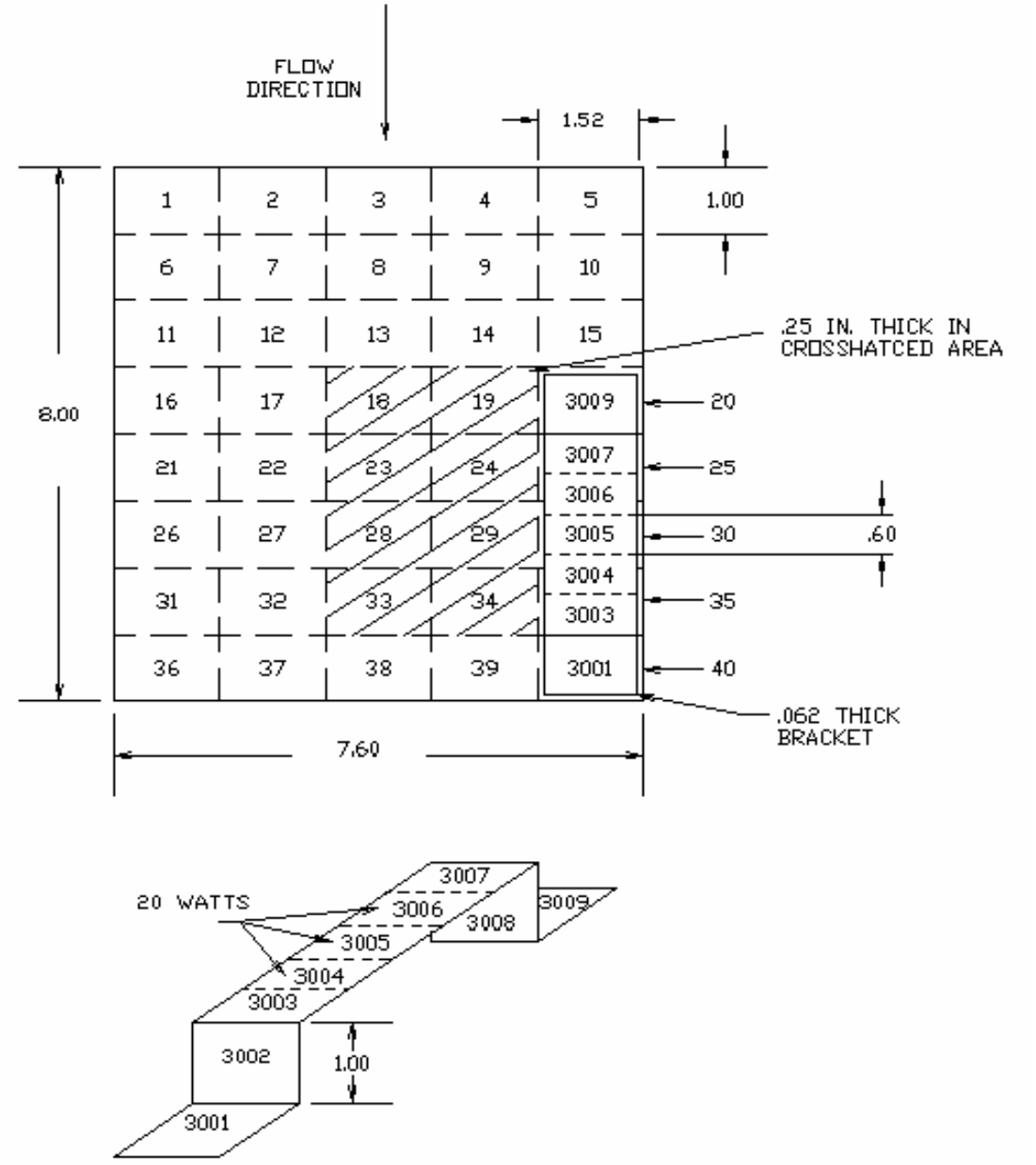
Non-isothermal Analysis Example with a Bracket - Extra Nodes and Conductors

This example builds on the non-isothermal examples with uniform power and non-uniform power. This example will locally thicken the base plate, add a bracket and add 20 Watts on it.

Extra nodes 3001 thru 3009 have to be added to the model. Distribute the 20 Watts on 3 of the nodes on the bracket as shown. Note that there is already 250 Watts that was added from the non-isothermal example with non-uniform power.

The conductances are added to the "**Conductor**s" tab of the non-isothermal form. Note that the "Duplicate Conductors" radio button needs to be set to "Over-write" so that in the thickened area of the base plate the internally calculated conductors will be over-written.

Calculations of the extra conductors are shown on the next pages.



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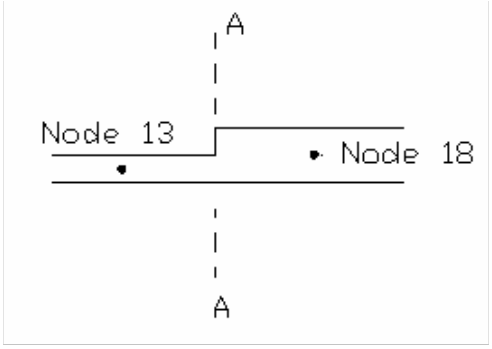
Non-isothermal Analysis Example with Extra Nodes and Conductors Calculations

The conductances for the thickened base plate, bracket and between the base plate and bracket are calculated below.

The calculations for the conductance in the thickened area of the base plate follow.

Nodal hookups: 13-18, 14-19, 33-38, 34-39.



The thermal conductivity of aluminum is 3.92 W/(IN-C)

The resistance from node 13 to A-A is:

$$R_{13} = \frac{L}{KA} = \frac{1.0 / 2}{(3.92)(.062)(1.52)} = 1.5 \text{ C / W}$$

The resistance from A-A to node 18 is:

$$R_{18} = \frac{L}{KA} = \frac{1.0 / 2}{(3.92)(.25)(1.52)} = .336 \text{ C / W}$$

The resistance from node 13 to 18 etc. is :

$$R_{13-18} = R_{13} + R_{18} = 1.35 + .33 = 1.686 \text{ C / W}$$

The conductance from node 13 to 18 etc. is:

$$G_{13-18} = \frac{1}{R_{13-18}} = \frac{1}{1.686} = .59 \text{ W / C}$$

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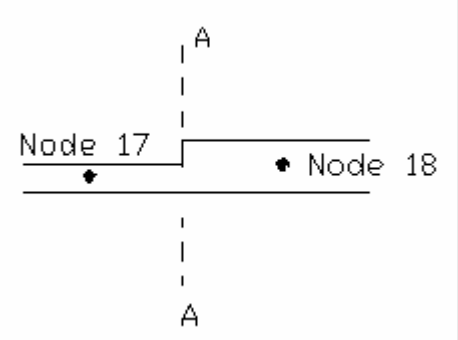
Nodal hookups 17-18, 22-23, 27-28, 32-33, 19-20, 24-25, 29-30, 34-35



$$R_{17} = \frac{L}{KA} = \frac{1.52/2}{(3.92)(1.0)(.062)} = 3.13C/W$$

$$R_{18} = \frac{1.52/2}{(3.92)(1.0)(.25)} = .776C/W$$

$$R_{17\text{-}18} = 3.13 + .776 = 3.906C/W$$

$$G_{17\text{-}18} = \frac{1}{3.906} = .256W/C$$

Nodal hookups: 18-19, 23-24, 28-29, 33-34

$$G_{18-19} = \frac{KA}{L} = \frac{(3.92)(.25)(1.0)}{1.52} = .644W/C$$

Nodal hookups: 18-23, 23-28, 28-33, 19-24, 4-29, 29-34

$$G_{18-23} = \frac{KA}{L} = \frac{(3.92)(.25)(1.52)}{1.0} = 1.49W/C$$

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Calculate the conductance along the bracket.

Nodal hookups: 3001-3002, 3009-3008.

$$G_{3001-3002} = \frac{KA}{L} = \frac{(3.92)(.062)(1.52)}{1.0} = .369 W / C$$

Nodal hookups: 3002-3003, 3007-3008.

$$G_{3002-3003} = \frac{KA}{L} = \frac{(3.92)(.062)(1.52)}{\frac{1.0}{2} + \frac{.6}{2}} = .46 W / C$$

Nodal hookups: 3003-3004, 3004-3005, 3005-3006, 3006-3007.

$$G_{3003-3004} = \frac{KA}{L} = \frac{3.92)(.062)(1.52)}{.6} = .616 W / C$$

Calculate the conductance between the bracket and the cold plate.

Nodal hookups: 20-3009, 40-3001.

$K_{contact}$=.20 IN^2-C/W

$$G_{20-3009} = \frac{A_c}{K_c} = \frac{(1.52)(1.0)}{.2} = 7.6 W / C$$

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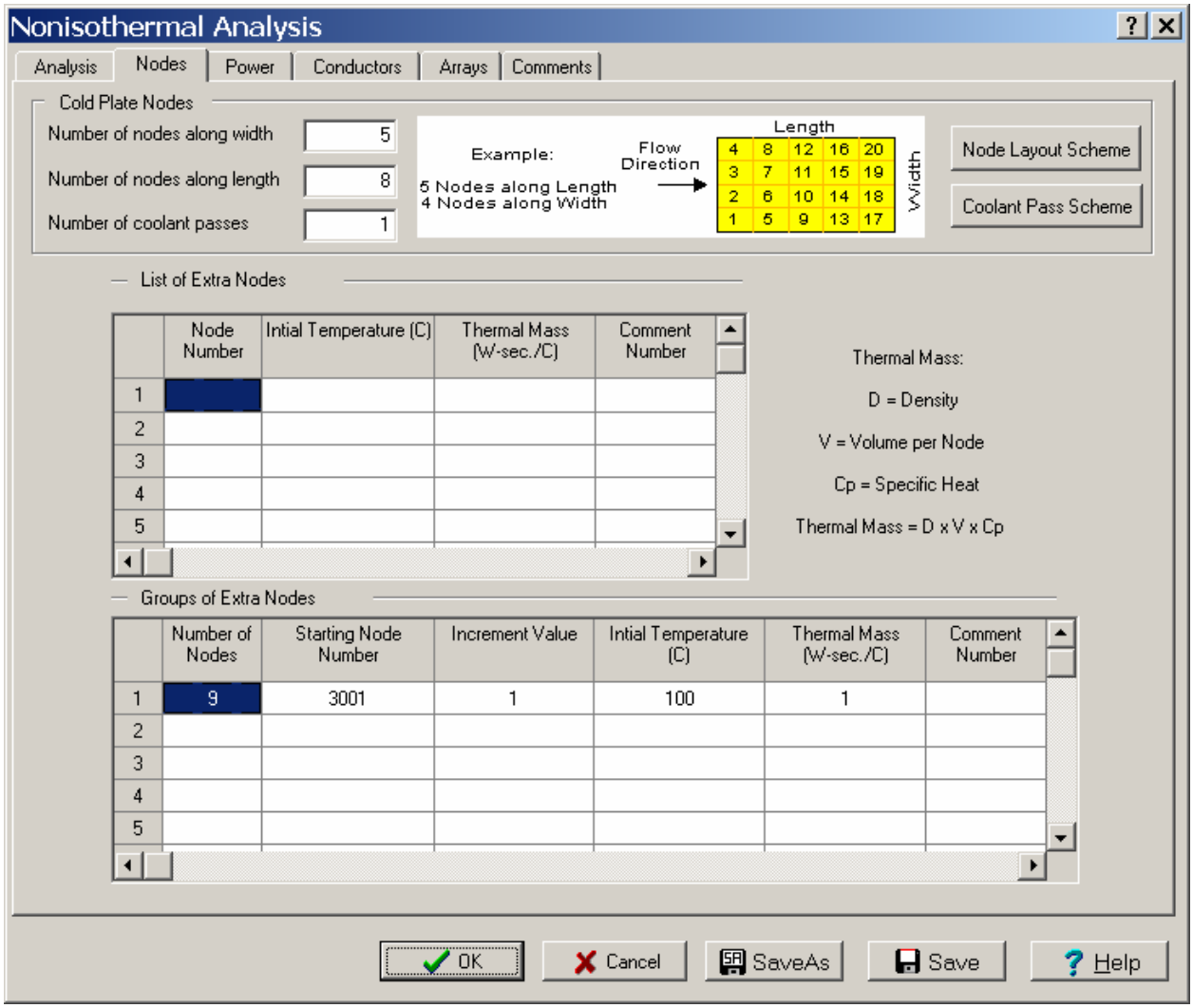
Nodes which represent the bracket are added on the "**Nodes**" tab



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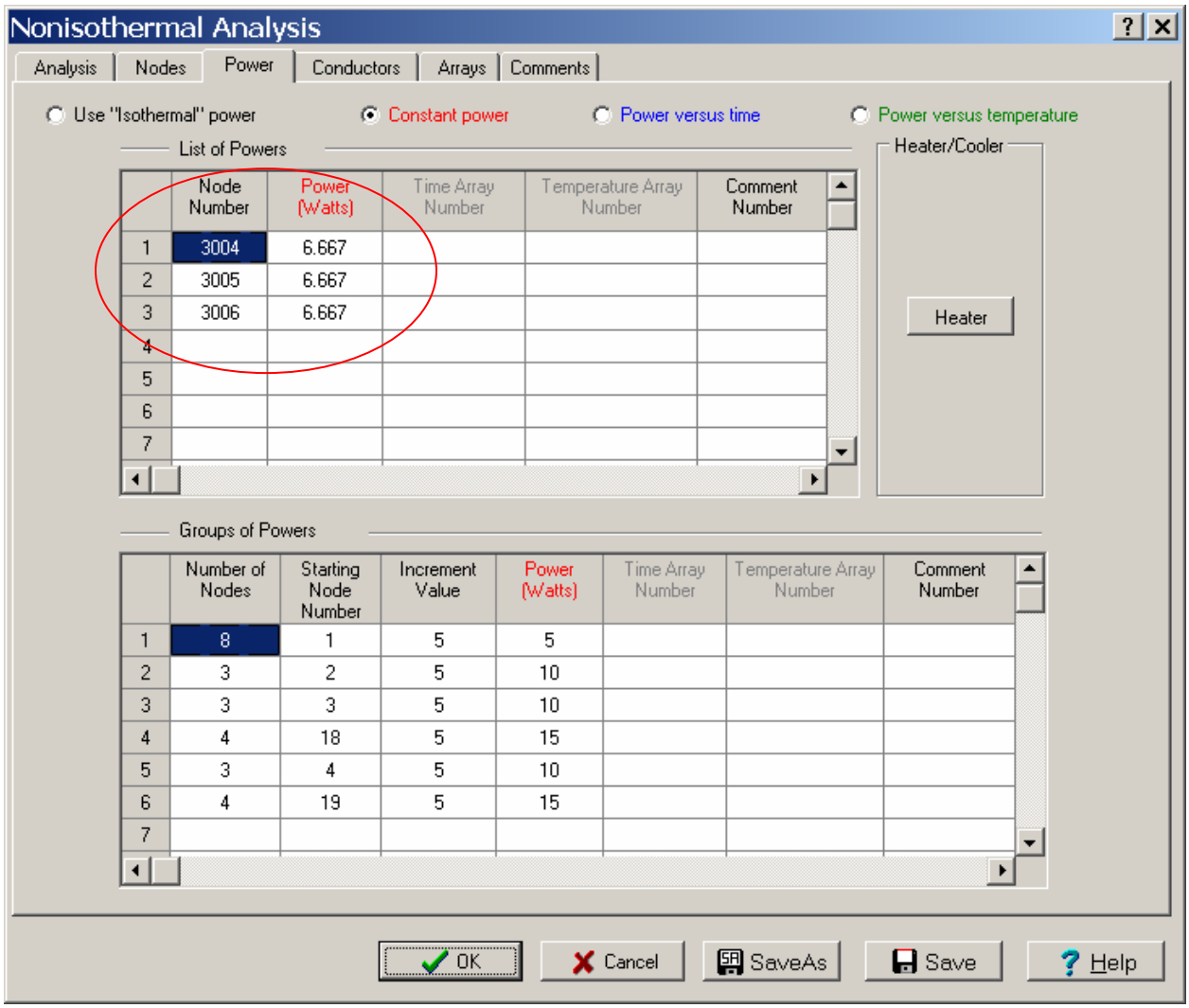
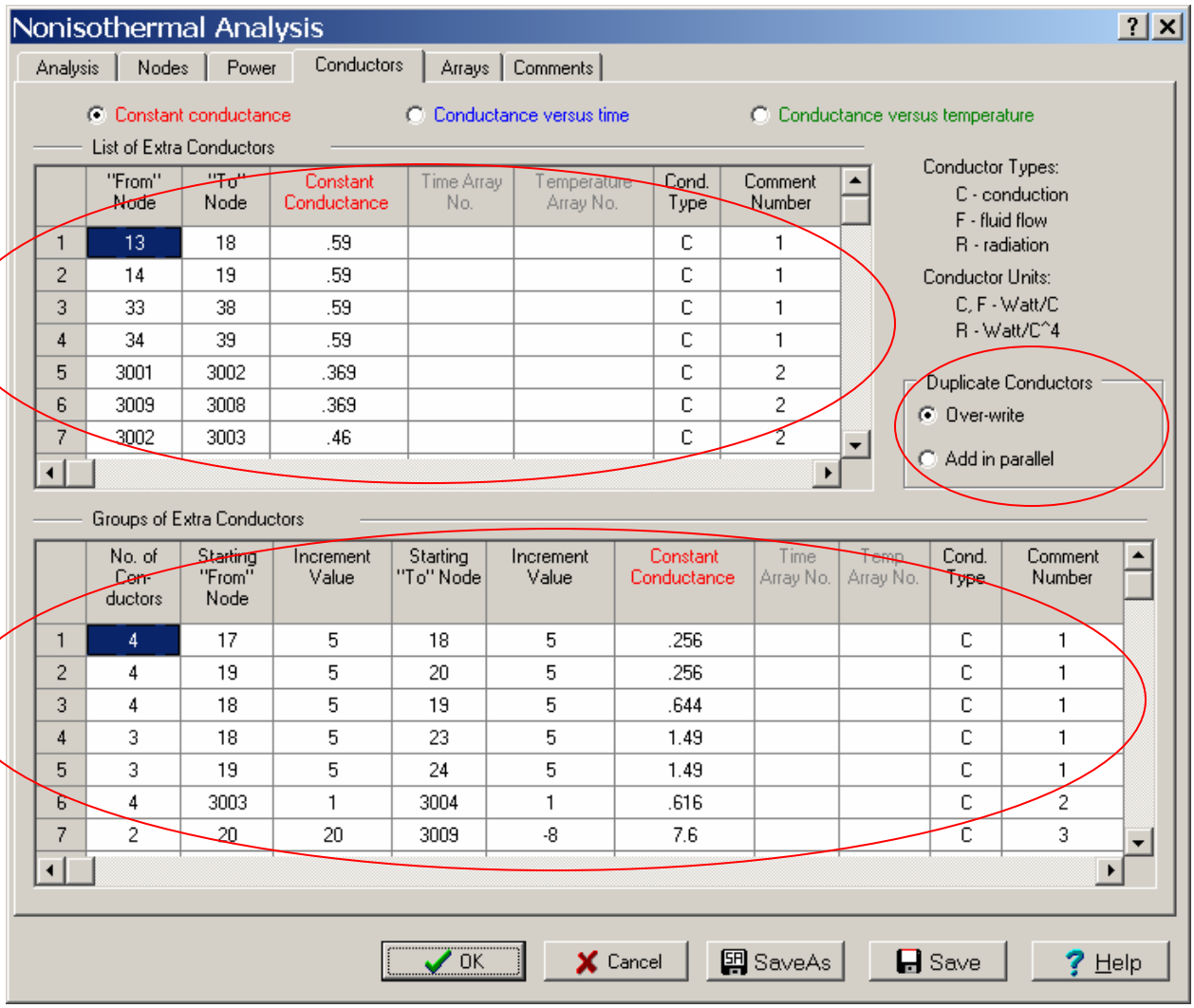
The power on the bracket is added below.



The conductances which were calculated on previous page and represent the brackets are added to the **"Conductor"** tab



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Isothermal results used for input to the non-isothermal predictions are shown below.

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######################################################################
                        HEATING ON ONE SIDE ONLY

************************ VARIABLE INPUTS ***************************
THE TYPE OF FINS SPECIFIED ARE:                        RECTANGULAR
FIN HEIGHT, INCHES                                           0.500
BASE THICKNESS, INCHES                                       0.062
FIN THICKNESS, INCHES                                        0.0060
FIN DENSITY, FINS PER INCH                                   8.0
STATIC INLET FLUID TEMPERATURE, DEG C                       55.0
INLET PRESSURE, LBS/IN2                                     14.70
VOLUME FLOWRATE, FT3/MIN                                    50.00
THE POWER APPLIED TO ONE SIDE ONLY, WATTS                  270.00
THE COOLING FLUID IS:                                 AIR

**************** INTERMEDIATE CALCULATED PARAMETERS ****************
FREE FLOW CROSS SECTIONAL AREA, IN2                          3.62
HYDRAULIC DIAMETER, INCHES                                   0.192
COLDPLATE WEIGHT, LBS                                        0.75
TOTAL MASS FLOWRATE, LBS/MIN                                 3.31
COLD PLATE MASS FLOWRATE, LBS/MIN                            3.31
COLDPLATE VOL FLOWRATE, [GAL/MIN] FT3/MIN [   374.0]        50.00
COLDPLATE VELOCITY, FT/SEC                                  33.17
REYNOLDS NUMBER                                           2639.
EQUIVALENT FRICTION LOSS COEFFICIENT, KFRICTION              1.67
INLET LOSS COEFFICIENT, KINLET                               0.82
EXIT LOSS COEFFICIENT, KEXIT                                -0.73
FILM COEFFICIENT, [BTU/(HR-FT2-F)] W/(IN2-C)  [   8.21]      0.0301
THE FIN EFFICIENCY WITH HEAT ON ONE SIDE ONLY IS             0.796

*************************** PRESSURE *******************************
INLET PRESSURE, [LB/IN2] INCHES-H2O      [ 14.700]         407.077
INLET PRESSURE DROP, INCHES-H2O                              0.196
ACCELERATION PRESSURE DROP, INCHES-H2O                       0.014
FRICTIONAL PRESSURE DROP, INCHES-H2O                         0.363
EXIT PRESSURE DROP, INCHES-H2O                              -0.182
TOTAL PRESSURE DROP, INCHES-H2O                              0.391
EXIT PRESSURE, [LB/IN2] INCHES-H2O       [ 14.686]         406.686
DENSITY RATIO TIME PRESSURE DROP, INCHES-H20                 0.3376

************************ THERMAL RESISTANCE ************************
THERMAL RESISTANCE FROM INLET FLUID TO COLDPLATE, C/W        0.090
THERMAL RESISTANCE FROM LOCAL FLUID TO COLDPLATE, C/W        0.068

************************** TEMPERATURES ****************************
STATIC INLET FLUID TEMPERATURE, DEG C                       55.0
STAGNATION FLUID TEMP RISE ALONG COLDPLATE, DEG C           10.7
TOTAL STAGNATION FLUID TEMP RISE, DEG C                     10.7
STATIC EXIT FLUID TEMPERATURE, DEG C                        65.7
ISOTHERMAL COLDPLATE TEMPERATURE, DEG C                     79.2
MAXIMUM COLDPLATE TEMPERATURE, DEG C                        84.1
```

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The predicted cold plate and fluid temperatures as well as the power at each node are shown below

```
                    INLET FLUID TEMPERATURE=  55.0 C
------------                         V
| CP TEMP  |                         V
| FLD TEMP |                         |
| POWER    |                         |
| NODE NO. |                         |
------------                         V
          ---------------------------------------------------
          |   74.7  |   81.2  |   82.9  |   79.9  |   67.0  |
          | ( 56.3) | ( 56.8) | ( 56.9) | ( 56.7) | ( 55.8) |
          |   5.00W |  10.00W |  10.00W |  10.00W |   0.00W |
          |   N  1  |   N  2  |   N  3  |   N  4  |   N  5  |
          ---------------------------------------------------
          |   75.0  |   81.3  |   84.0  |   81.3  |   68.4  |
          | ( 57.6) | ( 58.5) | ( 58.7) | ( 58.4) | ( 56.7) |
          |   5.00W |  10.00W |  10.00W |  10.00W |   0.00W |
          |   N  6  |   N  7  |   N  8  |   N  9  |   N 10  |
          ---------------------------------------------------
          |   75.1  |   80.5  |   85.9  |   84.1  |   71.7  |
          | ( 58.8) | ( 60.0) | ( 60.6) | ( 60.1) | ( 57.7) |
          |   5.00W |  10.00W |  10.00W |  10.00W |   0.00W |
          |   N 11  |   N 12  |   N 13  |   N 14  |   N 15  |
          ---------------------------------------------------
          |   74.8  |   76.0  |   90.0  |   89.8  |   78.1  |
          | ( 59.9) | ( 61.0) | ( 62.6) | ( 62.2) | ( 59.1) |
          |   5.00W |   0.00W |  15.00W |  15.00W |   0.00W |
          |   N 16  |   N 17  |   N 18  |   N 19  |   N 20  |
          ---------------------------------------------------
          |   74.8  |   74.7  |   90.7  |   90.7  |   75.4  |
          | ( 60.9) | ( 62.0) | ( 64.5) | ( 64.1) | ( 60.2) |
          |   5.00W |   0.00W |  15.00W |  15.00W |   0.00W |
          |   N 21  |   N 22  |   N 23  |   N 24  |   N 25  |
          ---------------------------------------------------
          |   75.0  |   74.4  |   90.6  |   90.8  |   75.3  |
          | ( 61.9) | ( 62.8) | ( 66.3) | ( 65.9) | ( 61.2) |
          |   5.00W |   0.00W |  15.00W |  15.00W |   0.00W |
          |   N 26  |   N 27  |   N 28  |   N 29  |   N 30  |
          ---------------------------------------------------
          |   75.2  |   73.9  |   89.2  |   89.7  |   76.8  |
          | ( 62.8) | ( 63.6) | ( 67.9) | ( 67.5) | ( 62.3) |
          |   5.00W |   0.00W |  15.00W |  15.00W |   0.00W |
          |   N 31  |   N 32  |   N 33  |   N 34  |   N 35  |
          ---------------------------------------------------
          |   75.3  |   72.7  |   79.9  |   81.2  |   81.5  |
          | ( 63.6) | ( 64.2) | ( 68.7) | ( 68.5) | ( 63.6) |
          |   5.00W |   0.00W |   0.00W |   0.00W |   0.00W |
          |   N 36  |   N 37  |   N 38  |   N 39  |   N 40  |
          ---------------------------------------------------
                     FLUID TEMPERATURE OUT=  65.7
                                     V
                                     V
EXTRA NODES POWER=         20.00     |
AVERAGE COLDPLATE TEMP.=    79.7     |
POWER DIRECTLY ON CP=     250.00     |
NO. OF ITERATIONS REQUIRED=   79     |
ALLOW. NO. OF ITERATIONS= 1000       |
TEMP. RELAXATION CRITERIA=.00100     |
PERCENT ENGERY BALANCE= 0.0010       |
                                     V
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The bracket temperatures, conductors and power are shown below.

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**************************************************************************
                NONISOTHERMAL EXTRA NODES AND CONDUCTORS OUTPUT DATA

**************************************************************************


       T3001=  82.79 T3002= 109.34 T3003= 130.64 T3004= 146.54 T3005= 151.63
       T3006= 145.89 T3007= 129.32 T3008= 107.14 T3009=  79.49

       G(  13,  18)= 0.590 G(  18,  13)= 0.590 G(  14,  19)= 0.590 G(  19,  14)= 0.590
       G(  33,  38)= 0.590 G(  38,  33)= 0.590 G(  34,  39)= 0.590 G(  39,  34)= 0.590
       G(3001,3002)= 0.369 G(3002,3001)= 0.369 G(3009,3008)= 0.369 G(3008,3009)= 0.369
       G(3002,3003)= 0.460 G(3003,3002)= 0.460 G(3007,3008)= 0.460 G(3008,3007)= 0.460
       G(  17,  18)= 0.256 G(  18,  17)= 0.256 G(  22,  23)= 0.256 G(  23,  22)= 0.256
       G(  27,  28)= 0.256 G(  28,  27)= 0.256 G(  32,  33)= 0.256 G(  33,  32)= 0.256
       G(  19,  20)= 0.256 G(  20,  19)= 0.256 G(  24,  25)= 0.256 G(  25,  24)= 0.256
       G(  29,  30)= 0.256 G(  30,  29)= 0.256 G(  34,  35)= 0.256 G(  35,  34)= 0.256
       G(  18,  19)= 0.644 G(  19,  18)= 0.644 G(  23,  24)= 0.644 G(  24,  23)= 0.644
       G(  28,  29)= 0.644 G(  29,  28)= 0.644 G(  33,  34)= 0.644 G(  34,  33)= 0.644
       G(  18,  23)= 1.490 G(  23,  18)= 1.490 G(  23,  28)= 1.490 G(  28,  23)= 1.490
       G(  28,  33)= 1.490 G(  33,  28)= 1.490 G(  19,  24)= 1.490 G(  24,  19)= 1.490
       G(  24,  29)= 1.490 G(  29,  24)= 1.490 G(  29,  34)= 1.490 G(  34,  29)= 1.490
       G(3003,3004)= 0.616 G(3004,3003)= 0.616 G(3004,3005)= 0.616 G(3005,3004)= 0.616
       G(3005,3006)= 0.616 G(3006,3005)= 0.616 G(3006,3007)= 0.616 G(3007,3006)= 0.616
       G(  20,3009)= 7.600 G(3009,  20)= 7.600 G(  40,3001)= 7.600 G(3001,  40)= 7.600

       Q3004=   6.667 Q3005=   6.667 Q3006=   6.667

  ***** THE TOTAL EXTRA NODES POWER APPLIED IS=   20.00 *****

  ***** THE SUM OF THE COLDPLATE POWER AND THE EXTRA NODES POWER IS=  270.00  WATTS *****
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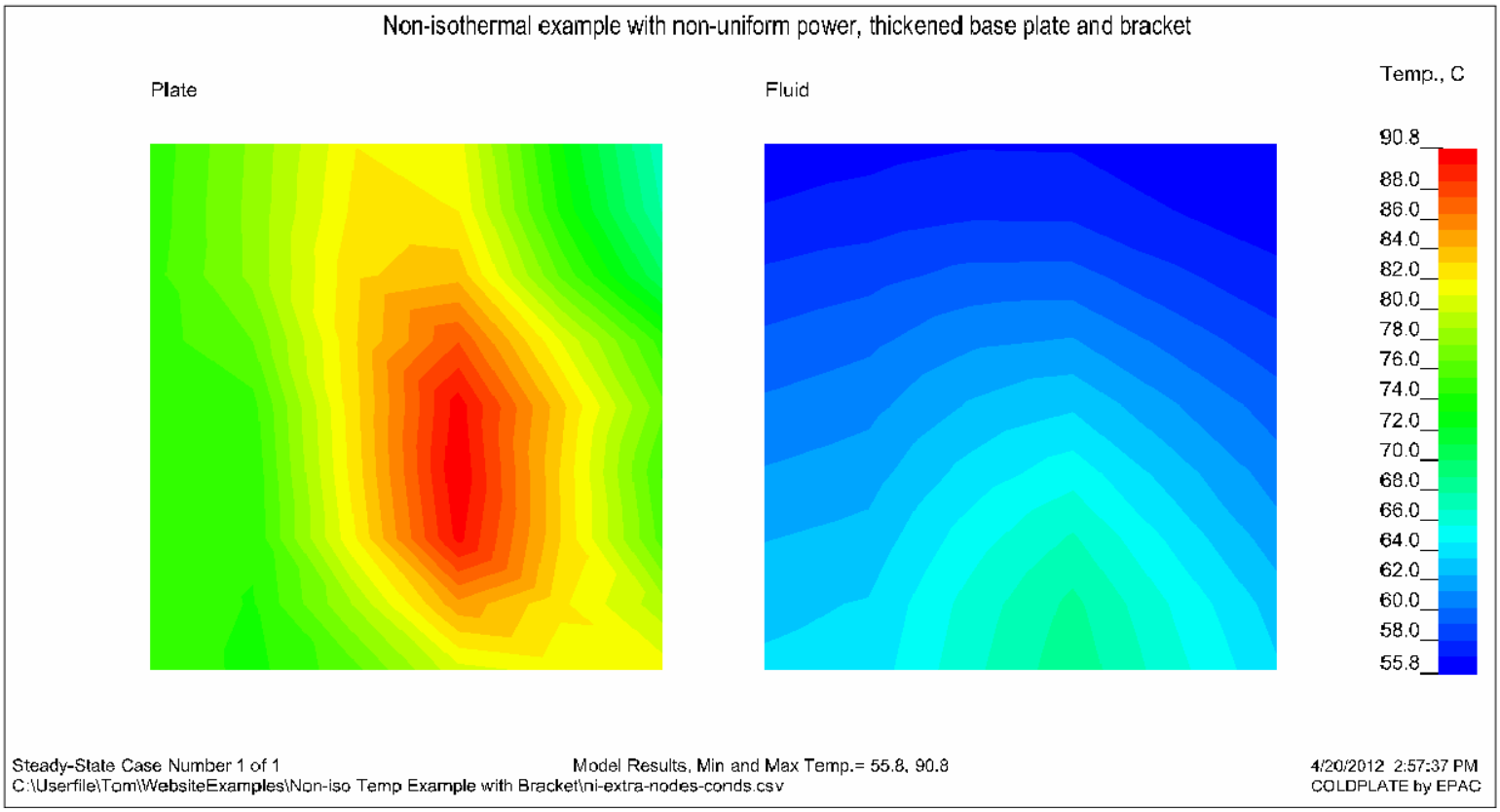
A color contour plot of the cold plate temperatures is shown below.



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