1.9 Dynamic SINDA Example

What will be learned:

- Using symbols and expressions
- Using symbol-based Articulators to reposition objects
- Setting up a Dynamic SINDA solution

This example uses Thermal Desktop's Dynamic Solver interface to optimize the component (cylinder and box) locations and the thickness of the doubler plate such that the mass of the plate is minimized. Constraints will also be placed on the components such that their individual temperatures limits are not violated. The components are connected to the plate via contact conductance.

Please reference Section 5 of the SINDA/FLUINT manual for a detailed documentation of the Advanced Design Modules such as the SINDA Solver.

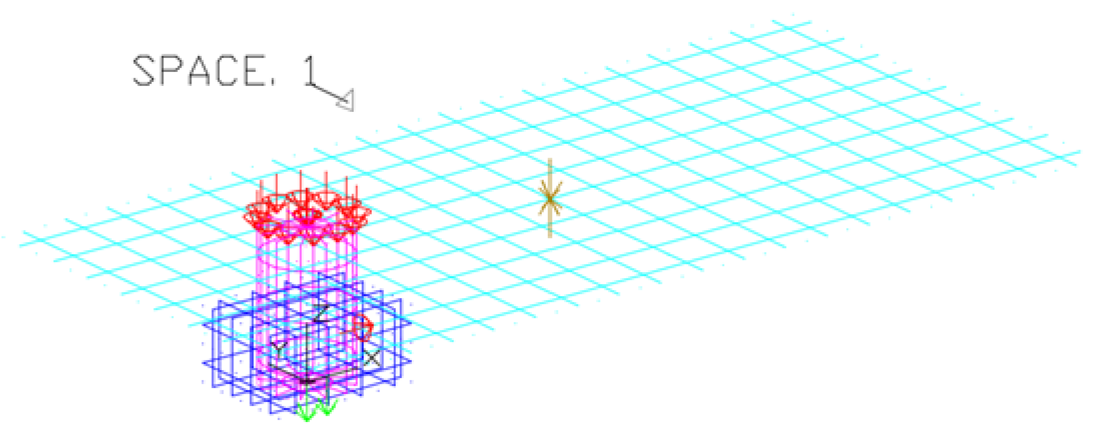
The exercise consists of three parts:

- Step 1: Parameterize the locations of the box and the cylinder, so that their best location can be found by the Solver interface.
- Step 2: Set up the problem in the **Case Set Manager**.
- Step 3: Solve the problem.

Dynamic SINDA Example

1. Double click on the file `dynamic.dwg` located in the `Tutorials\Thermal Desktop - legacy\DynamicSINDA_RadCAD` folder.

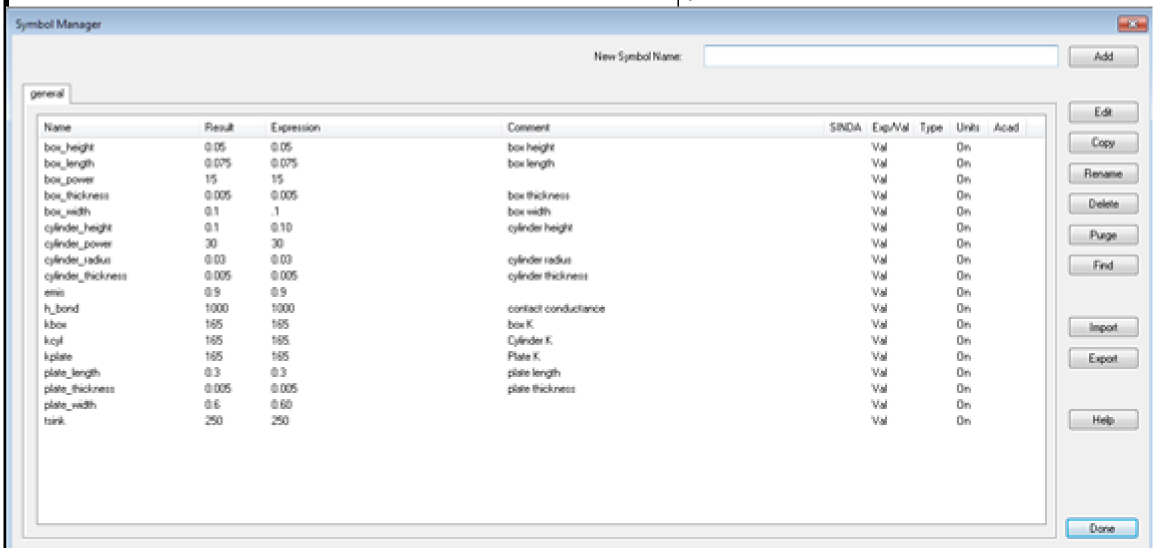
   Thermal Desktop opens with the `dynamic` drawing on the screen.



Take a few moments to examine the model.
There are several layers. Notice that the cylinder and the box are currently coincident at the origin. Also notice the heat loads on the top of the cylinder and on a node on the box. Finally, notice that a space node has been created for radiation to the environment.

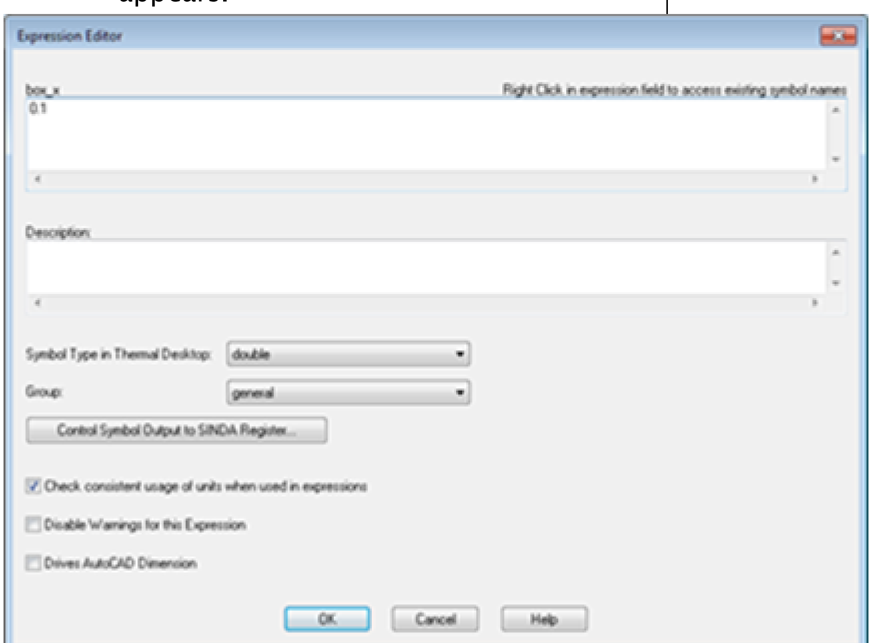
Dynamic SINDA Example (Continued)

2. Select **Thermal > Symbol Manager.** The **Symbol Manager** dialog box appears.	Create symbols for the box and the cylin-der to parameterize the location of the box and cylinder. Notice that much of the model is already parameterized.



3. Type **box_x** in the **New Symbol Name** field and select **Add**.

   The **Expression Editor** dialog box appears.



Dynamic SINDA Example (Continued)

4. Type **0.1** in the **main input** field and select **OK** to close the dialog box.

   The **New Symbol Manager** dialog box updates to display box_x in the main general list area.

5. Repeat the process to create symbols for the following:
   - BOX_Y = 0.1
   - CYL_X = 0.45
   - CYL_Y = 0.15

6. Select **Done** to close the dialog box.

7.  or type LAYER in the Command line.

Note: The menu selection **Format** > **Layer** may also be used.

   The **Layer Properties Manager** dialog box appears.

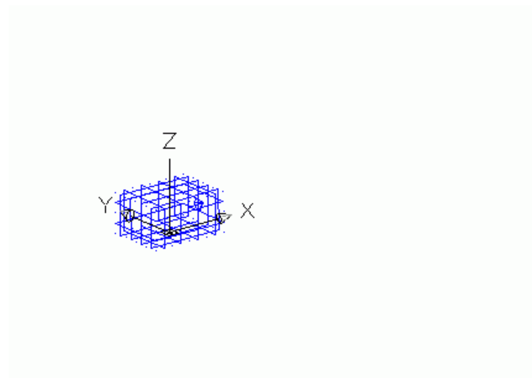
8. Double-click the box layer to make it the current layer.

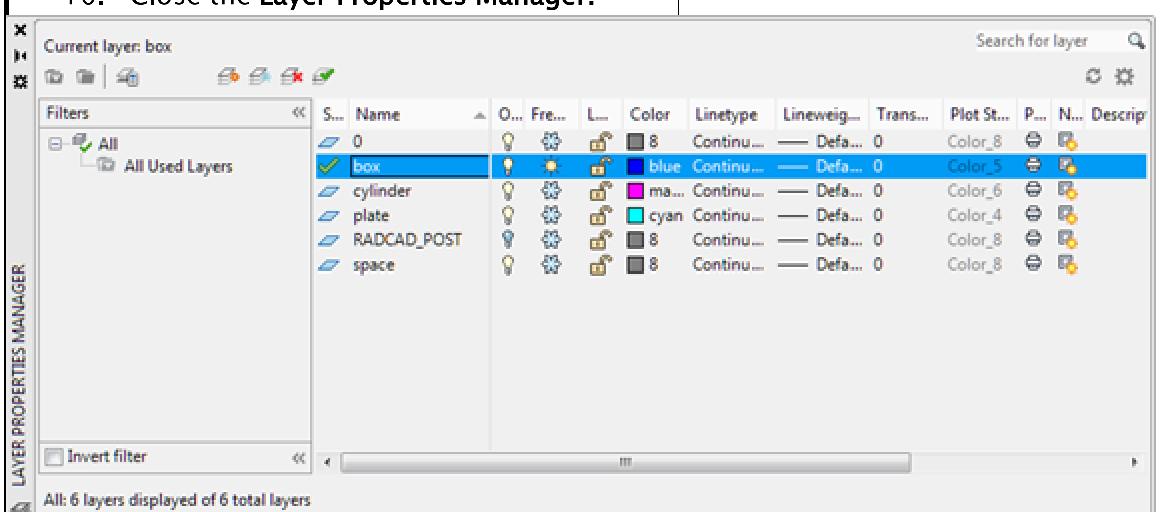
   A green check mark appears next to the layer box and Current Layer changes from **0** to **box**.

9. Click the **Freeze (sun) icons** for all of the layers except the box layer to freeze them (change to a snowflake).

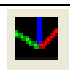
10. Close the **Layer Properties Manager**.

Use Thermal Desktop's Layer functionality by making the box layer the current layer and turn off all other layers.





Dynamic SINDA Example (Continued)

11.  or select **Thermal** > **Articulators** > **Create Assembly.**

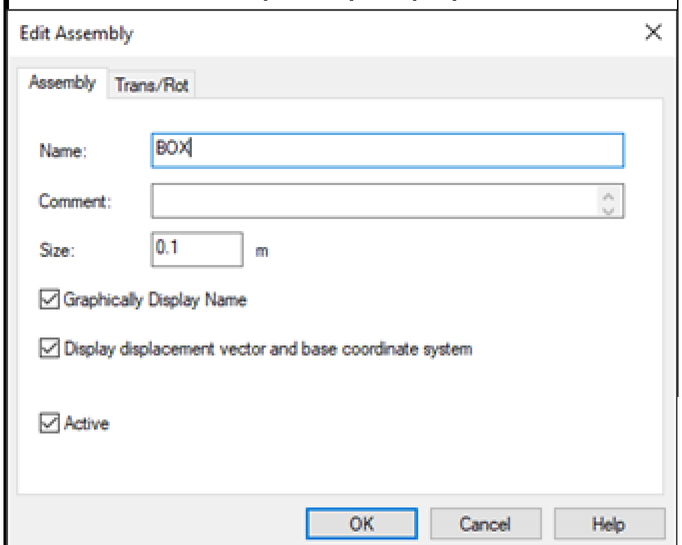
    The Command line should now read:

```
Enter origin of articulator:
```

12. Type **0,0,0** in the Command line.

    The **Edit Assembly** dialog box appears.

13. Highlight the current value in the **Name** field and type **BOX.**
14. Highlight the current value in the **Size** field and type **0.1**
15. Check **Graphically Display Name**

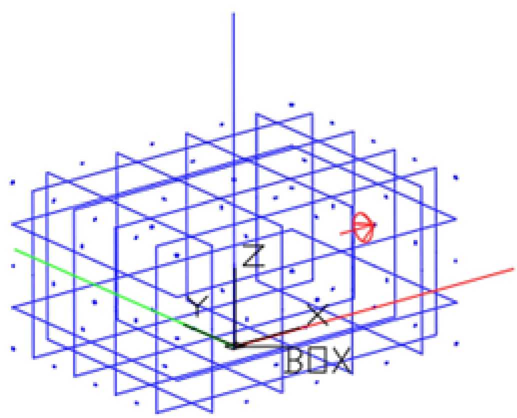


16. Select **OK.**

    Red, green and blue lines along the X, Y and Z axes appear on the screen representing the box assembly. Assembly axes may be partly obscured by the coordinate system. The name **BOX** is also visible.

This part of the exercise creates an assembly—a collection of surfaces associated with a single coordinate system—for the box. The assembly coordinate system is displayed in the graphics area on the screen.

The translations will be edited after the geometry is attached to the assembly. **The order of this is very important.**



Dynamic SINDA Example (Continued)

17.  or select **Thermal** > **Articulators** > **Attach Geometry**.

    The Command line should now read:

```
Select an articulator:
```

18. Click on the articulator coordinate from or the name **BOX**.

    The Command line should now read:

```
Select objects to attach to articulator
or [MB]:
```

19. Create a selection box around the box. It's OK if the articulator is also selected since it cannot be attached to itself.

    The Command line should now read:

```
Select objects to attach to articulator
or [MB]:
```

20. Press <**Enter**>.

    The geometry is attached and the command line should display:

```
7 objects attached to articulator
```

Note: You may need to press <**F2**> to view the command line text window.

Geometry is attached to the assembly. When the assembly is modified, via a rotate or a move, the location of the surfaces attached to that assembly will also be modified. An assembly can be attached to another assembly, and the nesting can be infinitely deep.

Once this occurs, when the assembly is moved, the geometry will move with it.

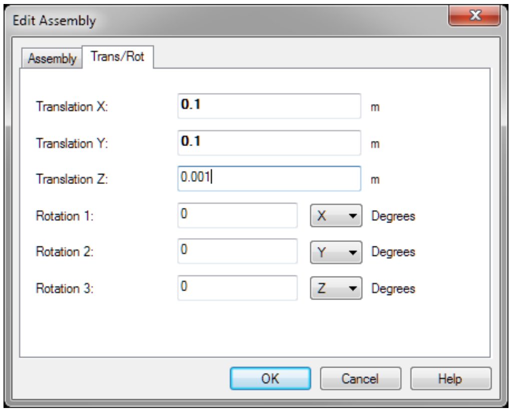
The Assembly coordinate system (red, green and blue axes) may not be visible because of the UCS icon. Zoom extents may help visualization.

Dynamic SINDA Example (Continued)

21. Double-click the articulator axes or the name.

    The **Edit Assembly** dialog box for BOX appears.

22. Select the **Trans/Rot** tab.

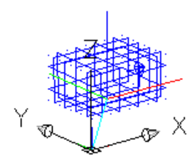


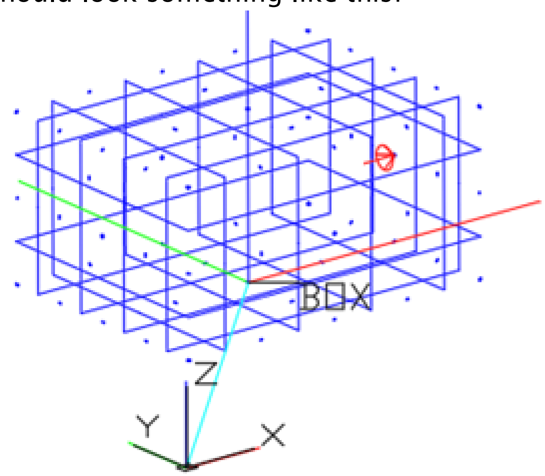
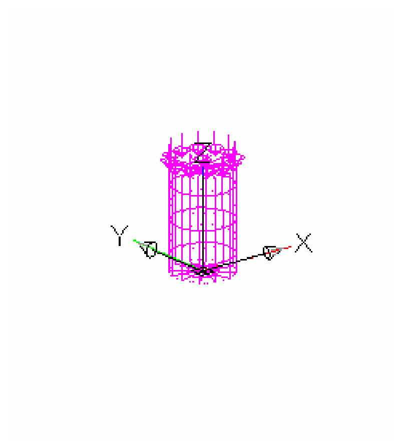
23. Double click in the **Translation X** field to display the **Expression Editor** dialog box.

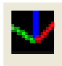
Edit the box assembly.

Z translation is entered so that the contact conductance works properly.

When the editing is complete, the graphic is updated in the drawing area to show 2 axes connected by a blue line. The original assembly is at 0,0,0 while the evaluated assembly is at 0.1, 0.1, 0.005.



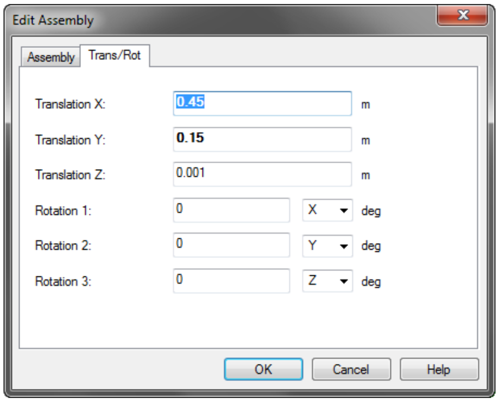
Dynamic SINDA Example (Continued)	
24. Right-click in the **Expression** field and select **general** > **box_x.** 25. Close the **Expression Editor** by clicking **OK.** The **Edit Assembly** dialog box updates to show **0.1** in bold type in the **Translation X** field. 26. Double click in the **Translation Y** field to display the **Expression Editor** dialog box. 27. Type **box_y** in the **Expression** field and click **OK** to close the dialog box. The **Edit Assembly** dialog box updates to show 0.1 in bold type in the **Translation Y** field. 28. Type **0.001** in the **Translation Z** field. 29. Click **OK** to close the dialog box.	When an expression is used to define an input field, the resulting value of the expression is shown in bold type in the input field. If the expression has an error, the field will be highlighted in red. When these steps are completed the model should look something like this:  The Z translation provides separation between the box and the plate for radiation calculations and the contactor calculations.
30.  or type LAYER in the Command line. The **Layer Properties Manager** dialog box appears. 31. Click on the **Freeze (snow flake) icon** for the cylinder layer to thaw the layer. 32. Right-click the cylinder layer and select **Set Current.** A green check mark appears next to the layer and Current Layer changes from box to cylinder. 33. Click on the **Freeze (sun) icon** for the box layer to freeze the layer. 34. Close the **Layer Properties Manager**.	Turn visibility for the cylinder layer on and visibility for the box layer off. Display only the cylinder by making that layer the current layer. 

Dynamic SINDA Example (Continued)	
35.  or select **Thermal** > **Articulators** > **Create Assembly.** The Command line should now read: `Enter origin of articulator:` 36. Type **0,0,0** in the Command line. The **Edit Assembly** dialog box appears with the last selected tab (Trans/Rot) displayed. 37. Select the **Assembly** tab. 38. Highlight the current value in the **Name** field and type **CYLINDER.** 39. Highlight the current value in the **Size** field and type **0.1** 40. Check **Graphically Display Name.** 41. Select **OK.** Red, green, and blue lines along the X, Y, and Z axes appear on the screen representing the cylinder assembly. These axes may be obscured by the coordinate system. The name CYLINDER also appears.	Create an assembly at the origin for the cylinder. The order of attaching the items before putting in the translations is very important.

Dynamic SINDA Example (Continued)	
42.  or select **Thermal** > **Articulators** > **Attach Geometry**. The Command line should now read: `Select an articulator:`	Attach the cylinder to the assembly.
43. Click on the assembly coordinates or the name. The Command line should now read: `Select objects to attach to articulator or [MB]:`	Selecting the articulator coordinates or the name selects the articulator.
44. Create a selection box around the cylin-der. The Command line should now read: `Select objects to attach to articulator or [MB]:`	It's OK to include the assembly in the selection box: it will be filtered out.
45. Press <**Enter**>. The geometry is attached. Confirm with the following in the command line: `4 objects attached to articulator`	

Dynamic SINDA Example (Continued)	
46. Double-click on the assembly axes or name The **Edit Assembly** dialog box for CYLINDER appears. 47. Select the **Trans/Rot** tab. 48. Double click in the **Translation X** field to display the **Expression Editor** dialog box. 49. Type **cyl_x** in the **Expression** field and select **OK** to close the dialog box. **Note**: Expressions are not case-sensitive.	Edit the cylinder assembly.
The **Edit Assembly** dialog box updates to show **0.45** in bold type in the **Translation X** field. 50. Double click in the **Translation Y** field to display the **Expression Editor** dialog box. 51. Type **cyl_y** in the **Expression** field and select **OK** to close the dialog box. The **Edit Assembly** dialog box updates to show 0.15 in bold type in the `Translation Y` field. 52. Type **0.001** in the **Translation Z** field.	As with the box, the Z translation is entered so that the contactor works properly. When an expression is used to define an input field, the resulting value of the expression is shown in bold type in the input field.

Dynamic SINDA Example (Continued)



53. Click **OK** to close the **Edit Assembly** dialog box.

    The drawing area is updated and the cylinder moved out of the current viewing area.

54.  or **Zoom** > **Extents**.

When the editing is complete, the graphic is updated in the drawing area to show 2 axes connected by a blue line. The original assembly is at 0, 0, 0 while the evaluated assembly is at 0.45, 0.15, 0.001. When complete, the view should look similar to the example below.

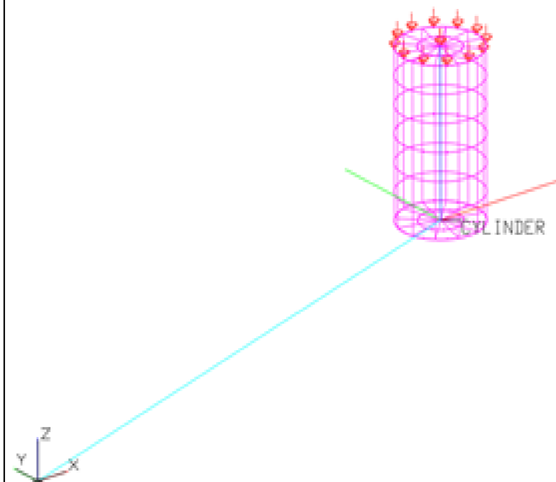


Figure 1-13: Cylinder Assembly

55.  or type **layer** in the Command line.

    The **Layer Properties Manager** dialog box appears.

56. Click on the **Freeze icons** for the **box**, **plate**, and **space** layers to thaw them.
57. Close the **Layer Properties Manager**.

Reactivate visibility for the box, plate and space layers so all three models and the ambient node are visible.

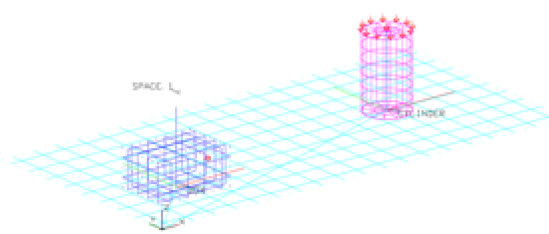
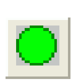


Figure 1-14: Layer Visibility Changes

58. Select **View** > **3D Views** > **SE Isometric**
59.  or **Thermal** > **Case Set Manager**.

    The **Case Set Information** dialog box appears.

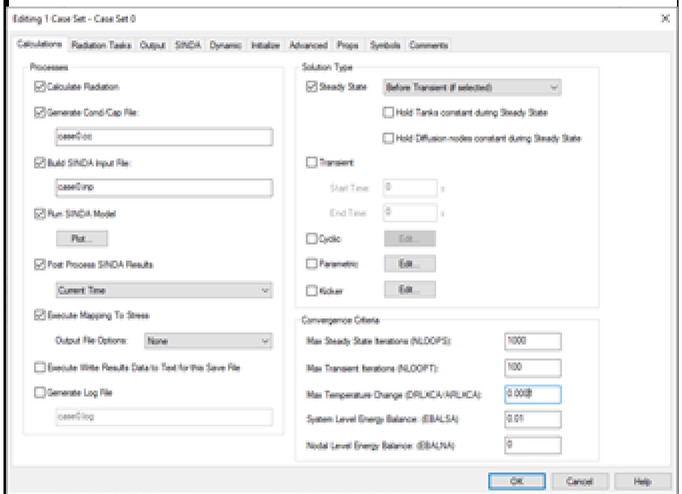
60. Select **Edit**.

Change the orientation of the model view and edit the default Case Set.

Dynamic SINDA Example (Continued)

61. Select the **Calculations** tab in the **Editing Case Set** dialog box.

Tightening up the convergence criteria will help the Solver converge on a solution.

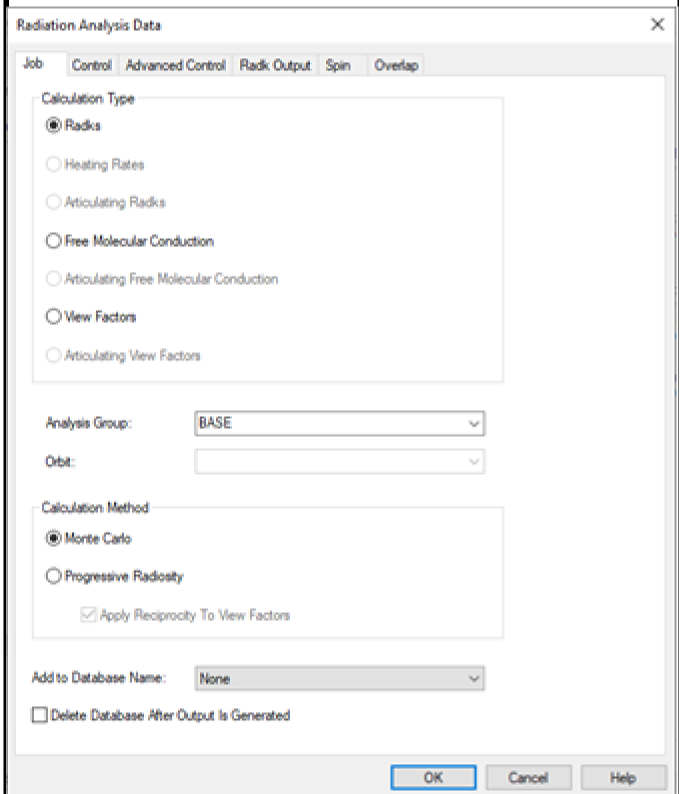


62. Type **0.0001** in the **Max Temperature Change** field

Dynamic SINDA Example (Continued)

63. Select the **Radiation Tasks** tab.
64. Select **Add**.

    The **Radiation Analysis Data** dialog box appears.

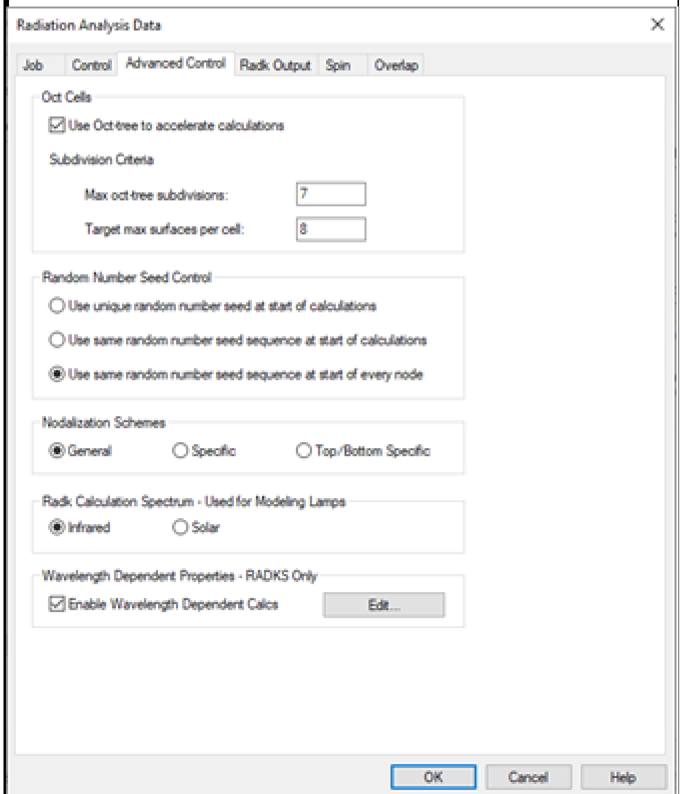


Add a radk job and edit the properties to use the same random number seed. This will help the program give consistent results from radk run to radk run.

More importantly, in a real-world analysis, the analyst should ensure that enough rays are shot to provide consistent results.

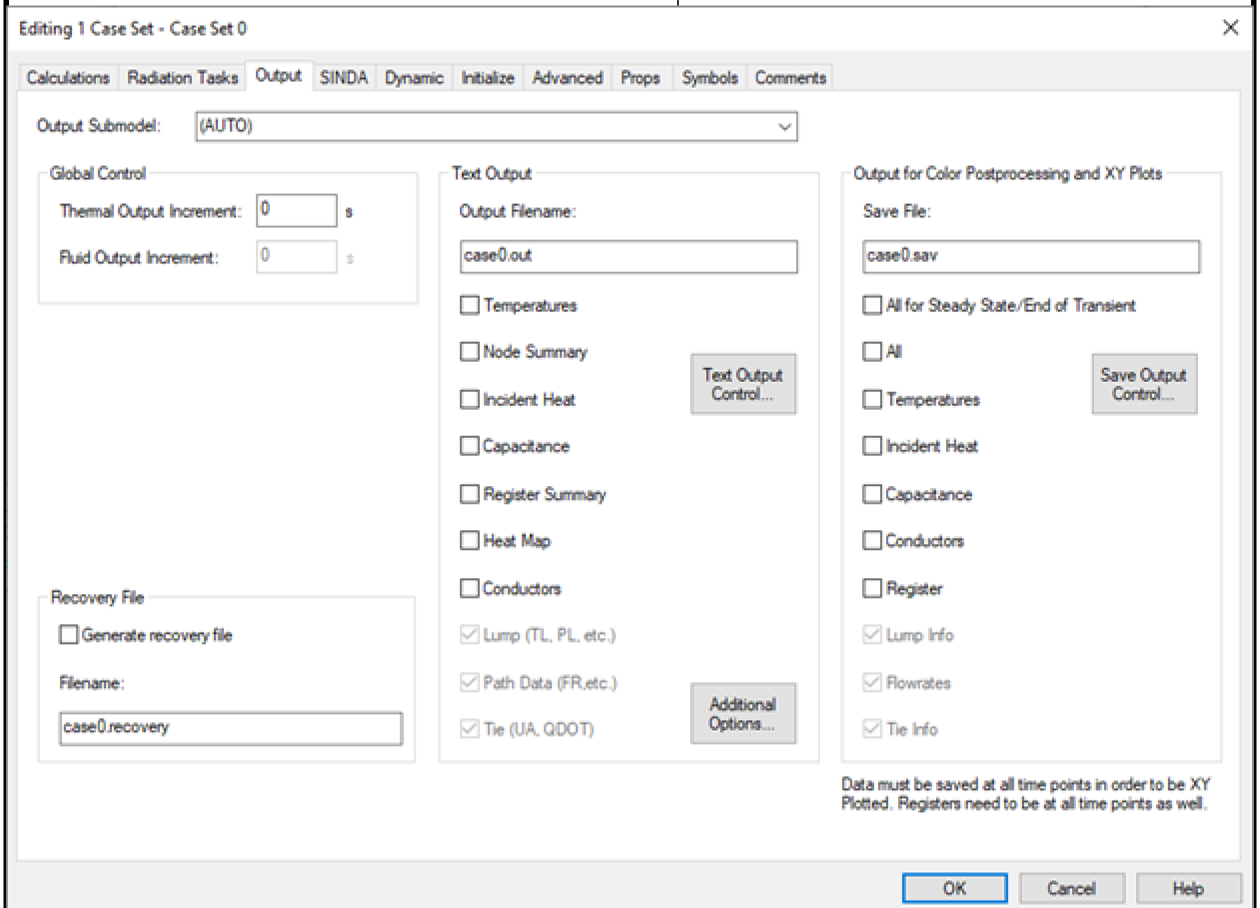
Dynamic SINDA Example (Continued)

65. Select the **Advanced Control** tab.



66. Select **Use same random number seed sequence at start of every node** in the **Random Number Seed Control** field.
67. Click **OK** to close the **Radiation Analysis Data** dialog box.

Dynamic SINDA Example (Continued)	
68. Select the **Output** tab in the **Case Set Information** dialog box. 69. Under `Text Output`, clear **Temperatures**. 70. Under `Output for Color Postprocessing and XY Plots`, uncheck **Temperatures**.	These runs can quickly generate a lot of data if these output options are left on. The temperatures will still be able to be seen while it calculates.



Dynamic SINDA Example (Continued)

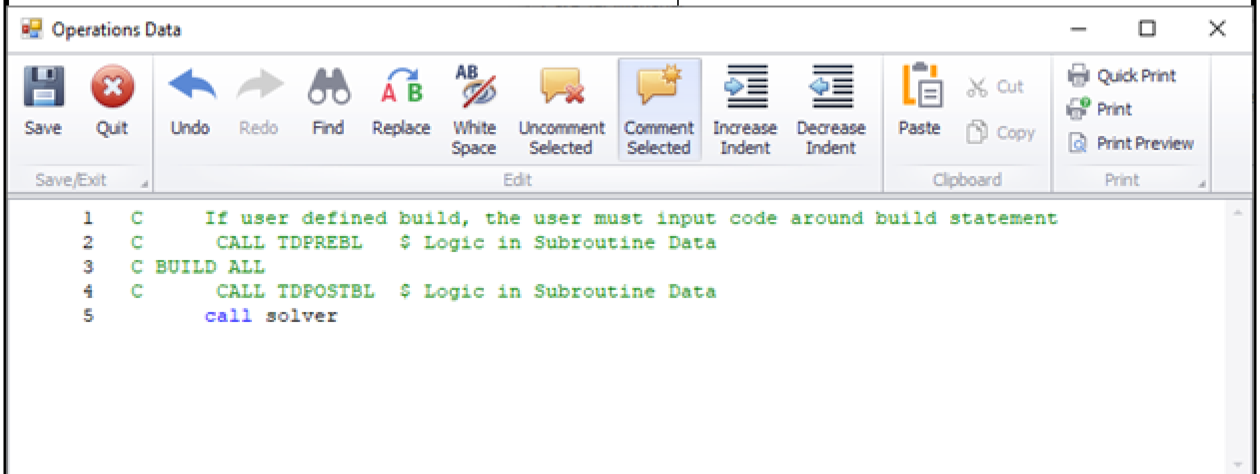
71. Select the **SINDA** tab in the **Case Set Information** dialog box.

72. Double click on **OPERATIONS** in the **Global S/F Input** field.

    The **Operations Data** text editor appears.

Replace the current OPERATIONS input text with CALL SOLVER.

Note: CALL SOLVER is a FORTRAN program and must start in the 7th column.

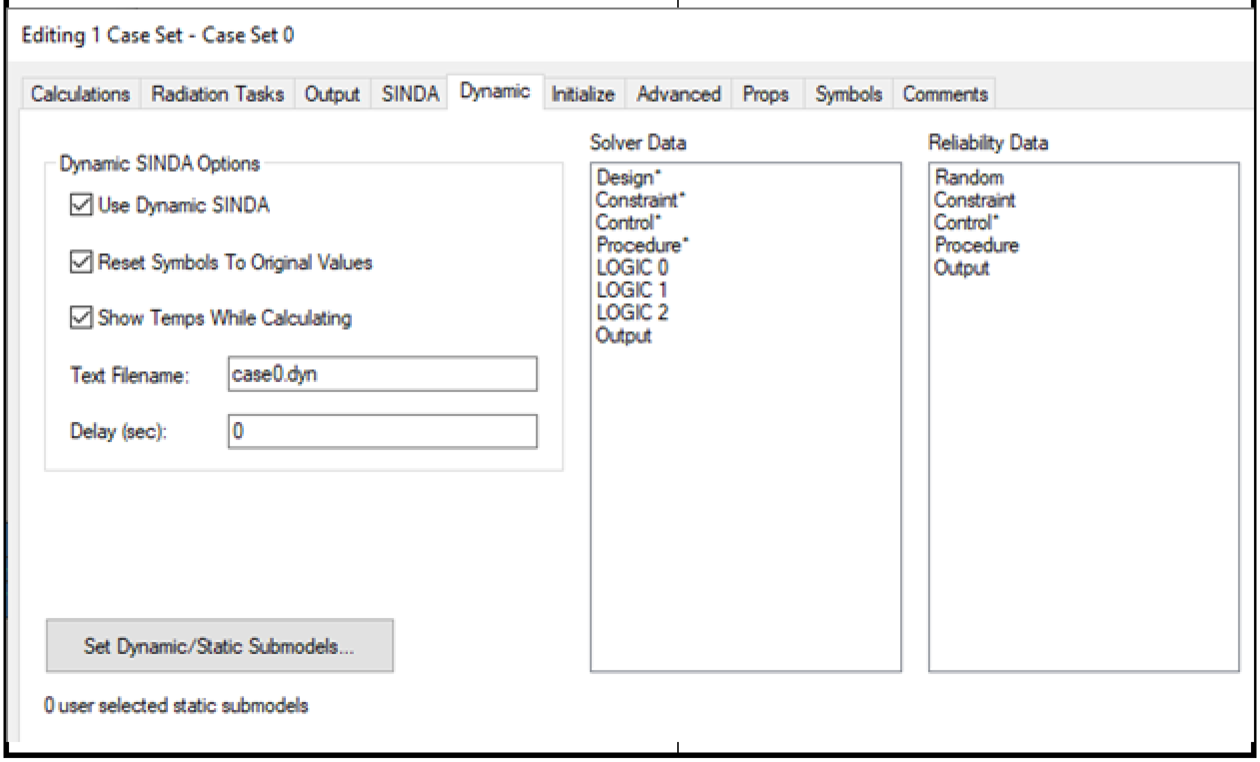


73. Delete the last three lines and type <Tab>**CALL SOLVER**

Note: Formatted FORTRAN requires that the lines of code start after the 6th column, so the <Tab> can be replaced by six or more spaces.

74. Click **Save** to save the changes and close the text editor.

Dynamic SINDA Example (Continued)	
75. Select the **Dynamic** tab in the **Case Set Information** dialog box. 76. Check **Use Dynamic SINDA** and **Show Temps While Calculating.** **Note**: Leave **Reset Symbols to Original Values** checked.	When Use Dynamic SINDA is selected, the program opens a connection between SINDA and Thermal Desktop so that they can communicate to change the design variables. The option to reset symbols upon completion prevents undesired Solver results from remaining in the model. The results can be obtained from the Solver output to modify the model if the user chooses.

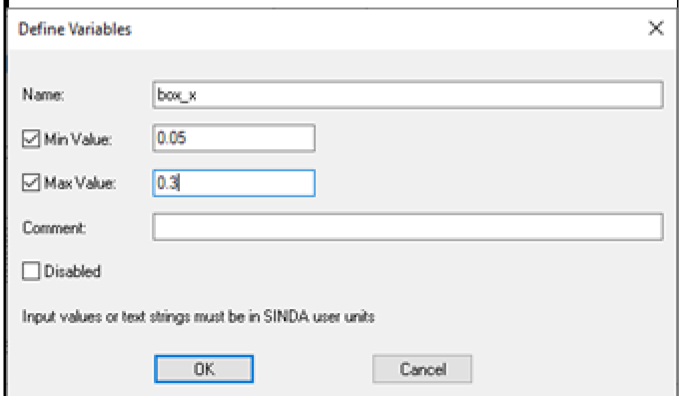


<table>
<tr><th colspan="2">Dynamic SINDA Example (Continued)</th></tr>
<tr><td>
77. Double click on Design in the Solver Data column.

The Solver Design Variables dialog box appears.

78. Double click on box_x in the Global Symbols field.

The Define Variables dialog box appears.



79. Turn on Min Value.
80. Type 0.05 in the Min Value field.
81. Turn on Max Value.
82. Type 0.3 in the Max Value field.
83. Select OK.

The Solver Design Variables dialog box reappears with the value limits for box_x displayed in the Solver Design Variables field.
</td><td>
To achieve the goal of minimizing the doubler plate mass, specify which parameters must be manipulated.

Additional design variables and parameters will be defined, by editing several of the subroutines listed in the Solver Data field.

In this problem, the components will be allowed to move in their XY locations in addition to varying the thickness of the plate. Note the minimum and maximum X and Y values are defined to prevent the components from moving off the plate and from moving past the centerline of the plate. The plate thickness must be at least 1 mil.

Solver design variables for the box, the cylinder and the plate must be defined.
</td></tr>
</table>

Dynamic SINDA Example (Continued)

84. Repeat the process for the **box_y**, **cyl_x**, **cyl_y** and **plate_thickness**. Use the Solver Design Variables table shown to the right as a reference.

Note: *Note that the plate_thickness does not have a maximum value.*

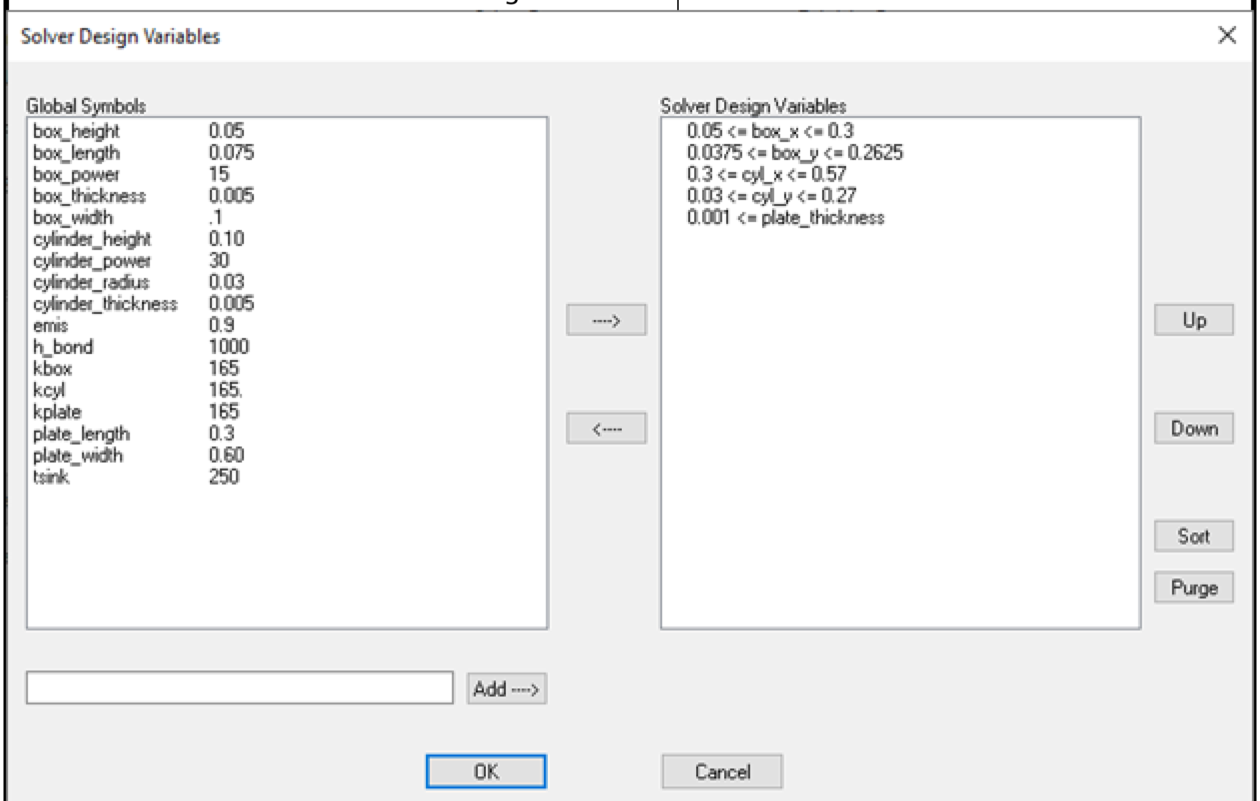
When complete, the **Solver Design Variables** dialog box should look similar to the graphic below:

85. Select **OK** to close the **Solver Design Variables** dialog box.

The **Case Set Information** dialog box is visible. An asterisk (*) is displayed next to **Design** in the **Solver Data** field to show the variables have been changed.

Use the table shown below for variable input values.

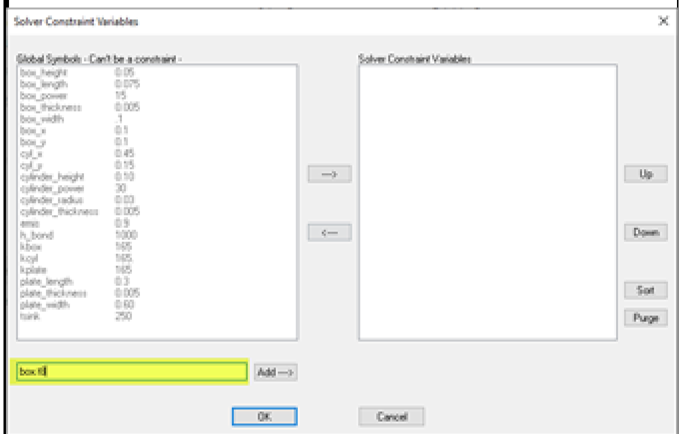
OBJECT	MIN VALUE	MAX VALUE
box_x	0.05	0.3
box_y	0.0375	0.2625
cyl_x	0.3	0.57
cyl_y	0.03	0.27
plate_thickness	0.001	



Dynamic SINDA Example (Continued)

86. Double click on **Constraint** in the Solver Data column.

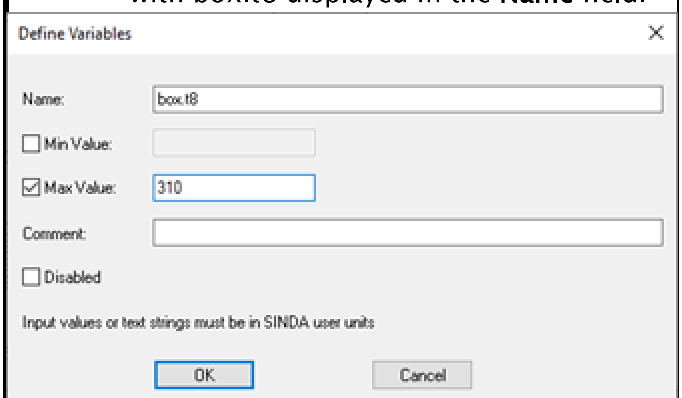
    The **Solver Constraint Variables** dialog box appears.



The **Global Symbols** field is greyed out and cannot be accessed.

87. Type **BOX.T8** in the **text input** field at the bottom of the dialog box and select **Add-->**.

    The **Define Variables** dialog box appears with box.t8 displayed in the **Name** field.



88. Turn on **Max Value**.
89. Type **310** in the **Max Value** field.
90. Select **OK** to close the dialog box and return to the **Solver Constraint Variables** dialog box.

What distinguishes a viable design from a bad design must be defined for Solver.

For this problem, if the box or cylinder exceed their maximum allowable temperature, the design is invalid. This type of information must be defined as constraint data.

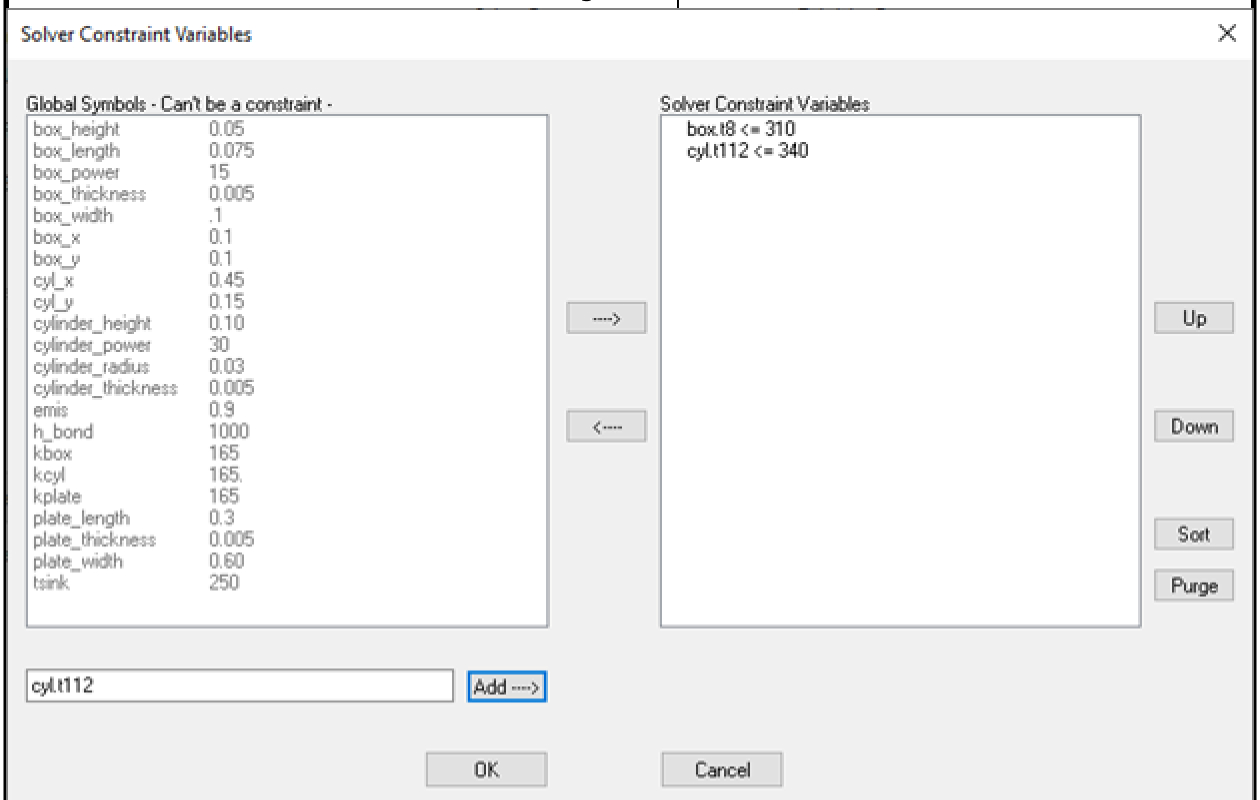
Dynamic SINDA Example (Continued)

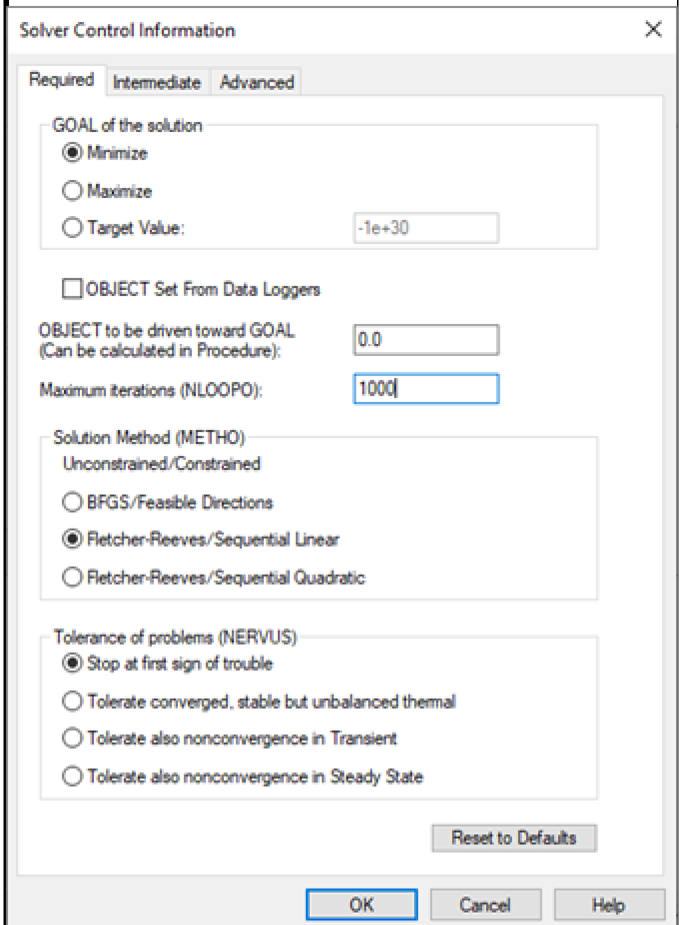
91. Repeat the process for **CYL.T112.** Type **340** for the **Max Value**.

    When complete, the **Solver Constraint Variables** dialog box should look similar to the graphic below.

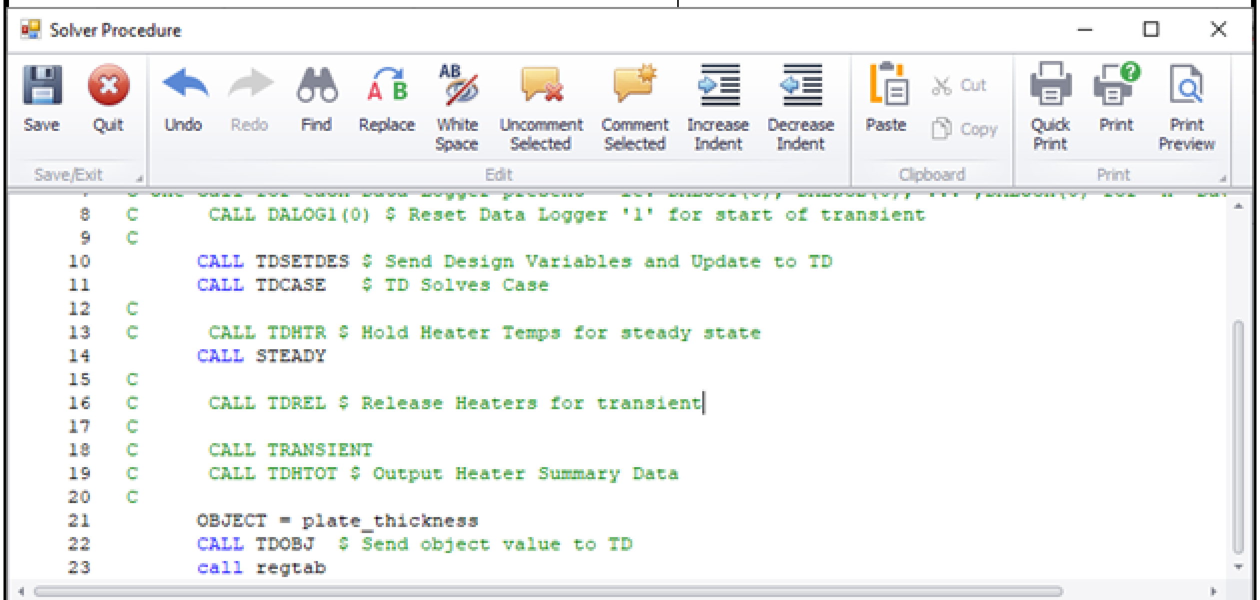
92. Select **OK** to close the **Solver Constraint Variables** dialog box.

    The **Case Set Information** dialog box is visible. An asterisk (*) is displayed next to **Constraint** in the **Solver Data** field to show the variables have been changed.



Dynamic SINDA Example (Continued)	
93. Double click on **Control** in the Solver Data column. The **Solver Control Information** dialog box appears.  94. Highlight the current value in the **Maximum iterations** field and type **1000**. 95. Select **OK** to close the dialog box. The **Case Set Information** dialog box is visible. An asterisk (*) is displayed next to **Control** in the **Solver Data** field to show the variables have been changed.	For Solver Control, change the Maximum iterations from 100 to 500. The Solver will minimize the OBJECT which will be defined in the next few steps.

Dynamic SINDA Example (Continued)	
96. Double click on **Procedure** in the Solver Data column. The **Solver Procedure** dialog box appears. 97. Delete the **C** in the first column to activate lines **10**, **11**, **14**, **21**, and **22**. 98. Modify line **21** and add line **23** as shown below.	This is FORTRAN code, so all the text must begin in Column 7. Press **Tab** or add six spaces.



99. Click **Save** to close the dialog box.	
The **Case Set Information** dialog box is visible. An asterisk (*) is displayed next to **Procedure** in the **Solver Data** field to show the variables have been changed. 100. Select **OK** to close the **Case Set Information** dialog box and return to the **Case Set Manager** dialog box. 101. Turn on **Save drawing before running.** 102. Click **Run 1 Selected Case.**	Save the drawing and the run the case. As the model runs, notice the box and cylinder move around the drawing area. Once postprocessed, the commands will quickly follow to move the box and cylinder, thus making a hot spot on the board when the object is no longer in that location. The Dynamic SINDA status window can be expanded to show all design variables and the object stepping through the iterations.

Dynamic SINDA Example (Continued)

Look at the output file, `case0.out`, in the current directory. The best solution is found at the end of the file. The temperatures may be slightly greater than the maximum constraint input, but they are within the constraint violation control parameter.(**Solver Control** > **Advanced tab**).

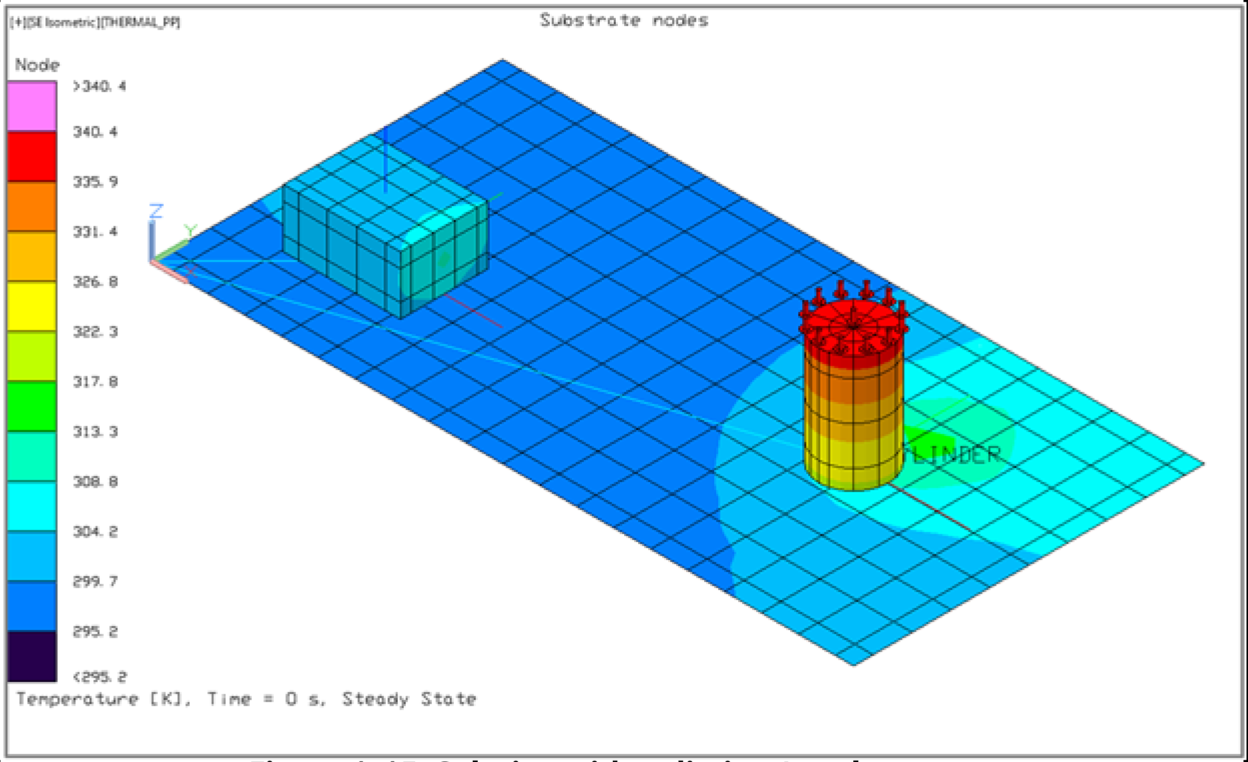


Figure 1-15: Solution with radiation (results may vary with default ray tracing settings)

Since the symbols were reset to the original values, the results will look somewhat odd. To see the geometry as it was at the end of the solution, the user must open the Symbol Manager and import `dynamicSymbols.sym`. Replace any or all of the symbols. You can revert back to the original symbol values by importing `originalSymbols.sym`.

103. Select **File** > **Exit**. A **Thermal Desktop**/**AutoCAD** dialog box appears asking to save the drawing changes. 104. Select **Yes**.	Exit Thermal Desktop and save as prompted.