ARL

Expander

By ARL - Albacore Research Ltd.

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31. Amendment. Any amendment of this Agreement must be in writing and signed by duly authorized representatives of the parties.

32. Waiver. The waiver by any party of a breach by the other party of this Agreement shall not be construed as a waiver by such party of any succeeding breach by the other party of the same or another provision.

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38. Language. It is the express will of the parties that this Agreement and related documents have been prepared in English. C'est la volonté expresse des parties que la présente Convention ainsi que les documents qui s'y rattachent soient rédiges en anglais.

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Contents

Expander

Overview

Expander is a **Rhinoceros 3 Plug-In**, to expand surfaces for production of many types of industrial products, from ship hulls to airplanes, shoes, upholstery, clothing, and more.

Expander's technology has been developed from **ShipCAM**'s plate expansion routine, which has proven its power and reliability in successfully expanding thousands of ship plates over the past twelve years worldwide!

Expander is capable of expanding even the most complex compound-curvature as well as developable surfaces; trimmed and untrimmed.

What is Expansion?

Expansion is the key step in the solution to the question: "Now that I have designed a 3D model, how do I make it?"

It is the conversion of a 3D surface into a 2D shape required for the production of many industrial items made from flat material such as sheet metal, fabric, leather, or re-enforced fibers. There are two distinct types of surfaces developable: surfaces, which can be expanded without stretching the material; and compound curvature surfaces, which require stretching within limits allowable to material and the forming process that is used.

This Manual consists of a Tutorial, and a Reference section.

The Tutorial is a step-by-step marine example to Expand a Bow Wrapper (a steel plate from the bow of a ship hull) and explore Expander's functionalities.

The Reference Manual describes all Expander functions in detail.

Each function can be accessed three ways:

By clicking the appropriate toolbar button.

By entering the function name on the command line.

By clicking the appropriate function in the **Expander** drop down menu.

For the purposes of this manual, a denotation of all three calls to a given function will be used. This denotation is described in the Expand function description of the reference manual. Apply this to the rest of this manual.

Tutorial

Overview

This tutorial will guide you through Expander Functionalities. It includes a Rhino file, which consists of one marked ship hull plate. This plate is a Bow Wrapper (the plate at the bow of a ship hull which has a large degree of curvature). You will open this file, and Expand the 3D surface. The result is a 2D surface. It is what you would use to cut from plate stock and form to manufacture the Bow Wrapper.

Strain color mapping and a table of deformation will be used to analyze the suitability for production.

Furthermore, mapping of curves between 3D and 2D surfaces is demonstrated, and all curves will be labeled.

Lastly, functionality to export surface trimming toolpaths, marking toolpaths, and labeling toolpaths is explored.

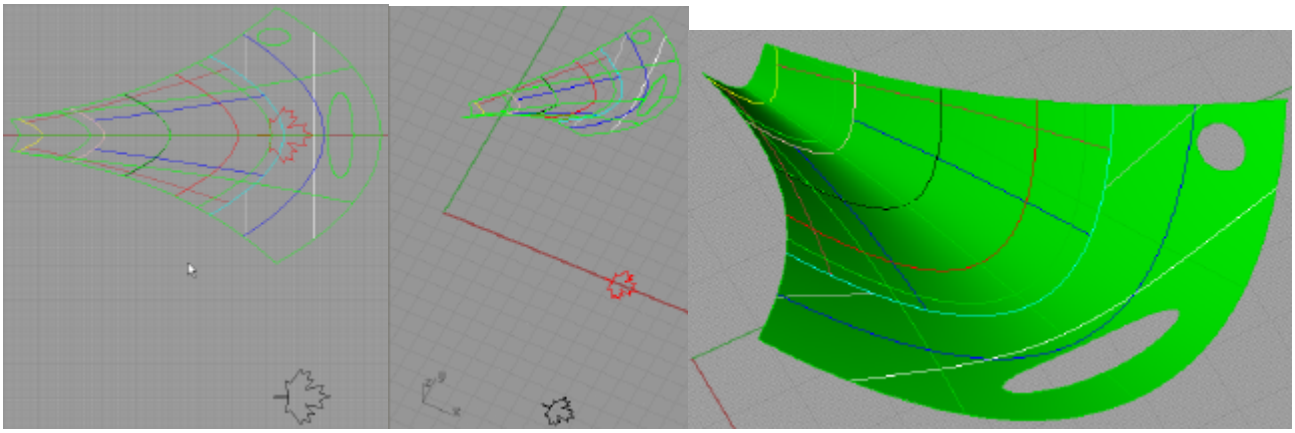
Open the Tutorial File

In this section we will open the supplied tutorial file **Expander_Tutorial.3dm** and investigate it.

1. Startup Rhino 3.0 with **Expander**.
2. Select **File / Open…** and open the file**, Expander_Tutorial.3dm**, included with Expander. Its default location is C:\Program Files\Expander\Tutorial\Exander_Tutorial.3dm.
3. Save the surface under a new name, so you can come back to the original later if you have to.

This file contains a “bow-wrapper” surface of a ship hull. Use the standard Rhino rotate and shade functions to get a feeling for the shape of the surface. Observe that it is a saddle-shaped surface, in contrast to a bowl-shaped surface.

4. When done select the wire frame mode again and set the top view. If in doubt, reload the surface from the original file.



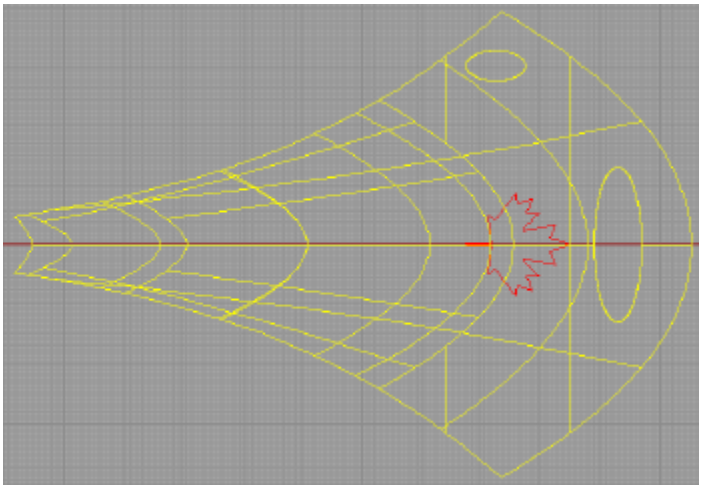
Expansion

Standard Expansion

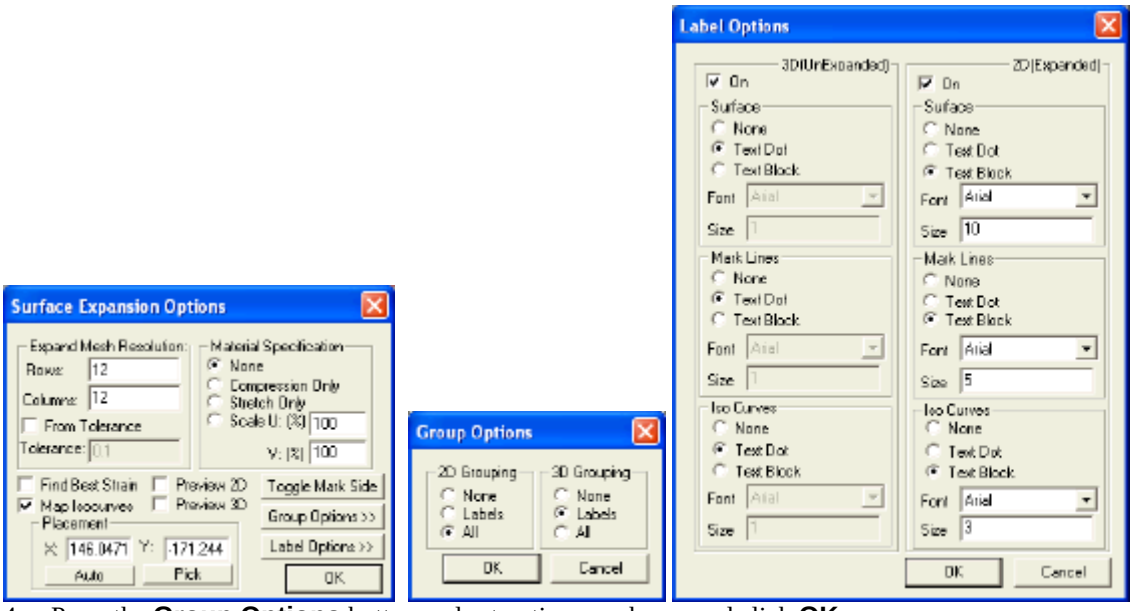
The surface to expand is internally approximated by a mesh consisting of many small quadrilaterals (approximately rectangular shaped elements). These will be laid out flat one-by-one starting near the center of the surface. As most surfaces have compound curvature the mesh elements have to be deformed to be able to stay connected in the flat 2D shape. Try to make a bowl shape from a flat piece of paper. It will crumble. In reverse, if you had a bowl-shape made from paper and you would try to expand it, it would rip at the edges (disconnecting the small mesh elements). During the expansion process the Expander has to adjust individual mesh elements so they remain connected. Using standard expansion, Expander will use stretching for bowl-shaped surfaces areas and compression for saddle-shaped areas. As this sample surface is saddle-shaped throughout, compression in the expanded plate is to be expected.

1. Select **Expander/ Expand Surface**, or click  or type **Expand**.
2. Select the surface by clicking on the any edge or isocurve.

Note: Pre-selection of the surface and marking curves before running the Expand command is also possible. Do not select the red Maple Leaf as it is not on the surface.



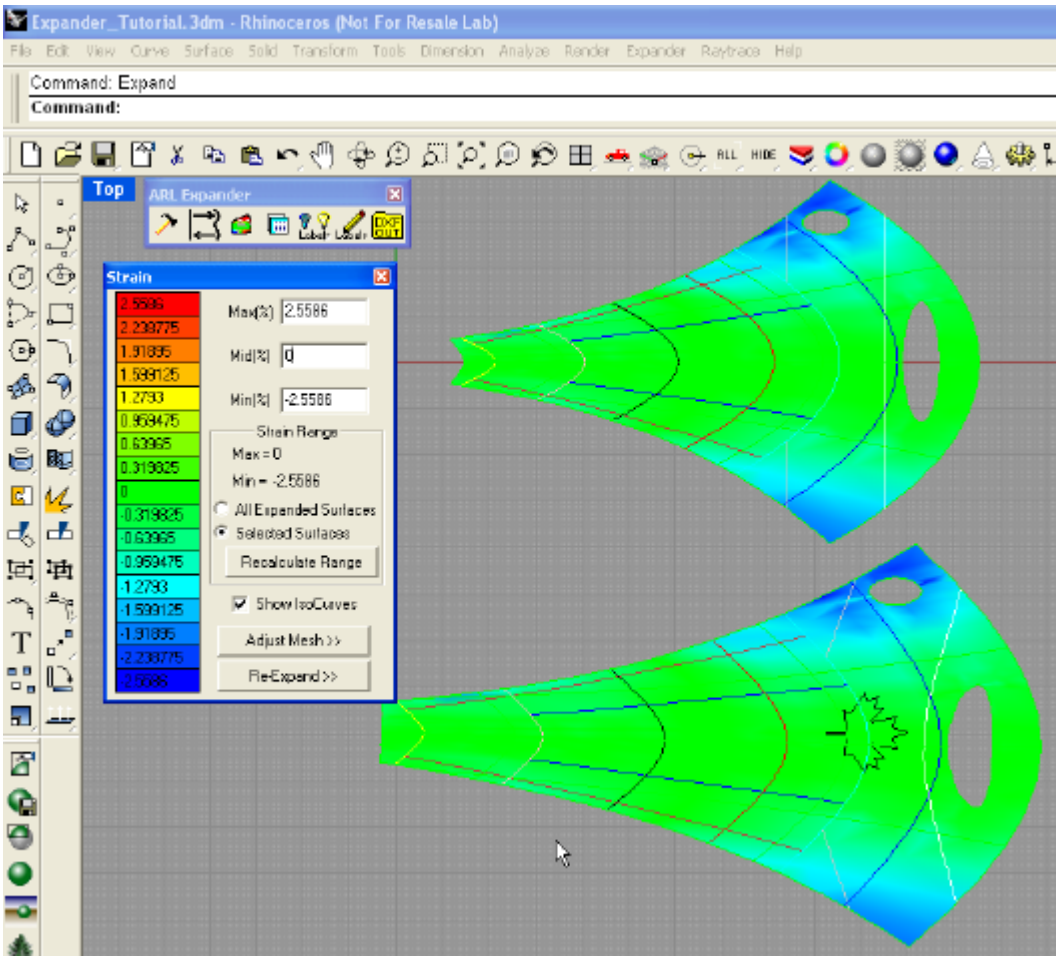
3. Use the settings as shown in the **Surface Expansion Options** dialog.



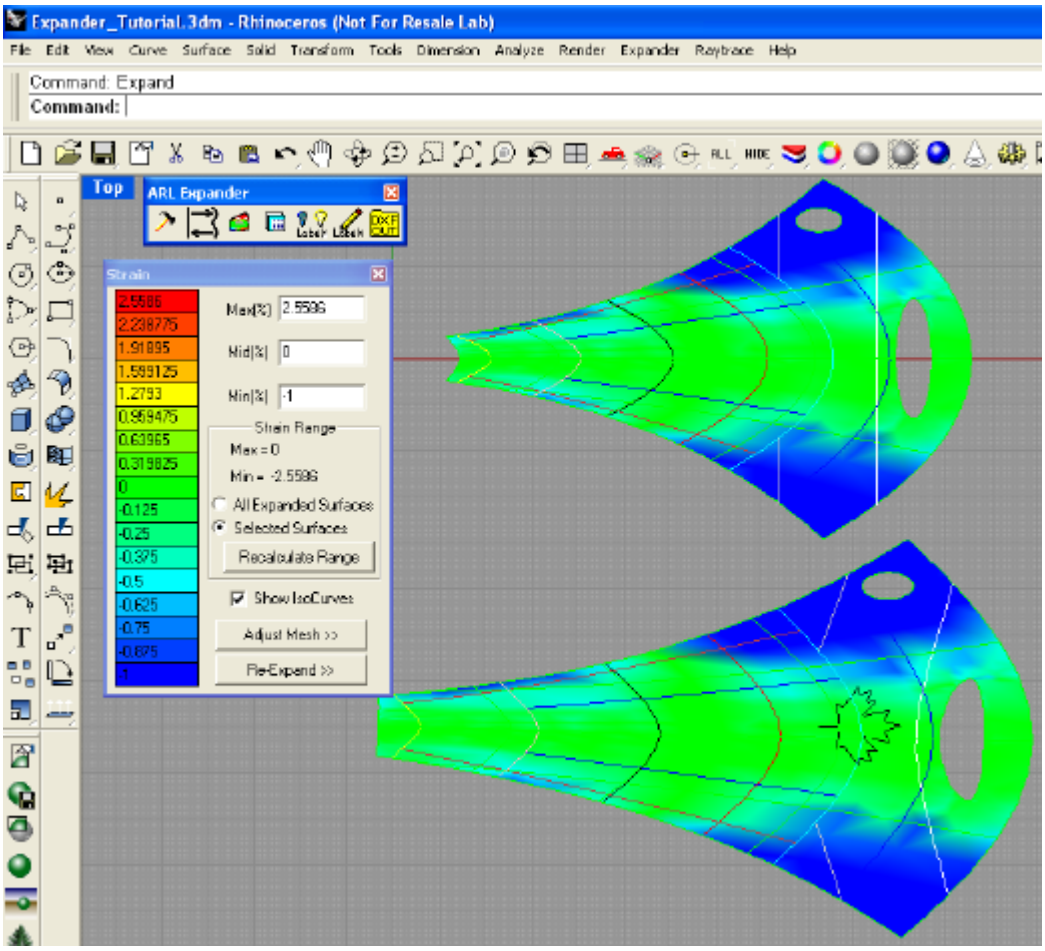
4. Press the **Group Options** button and set options as shown and click **OK**.
5. Press the **Label Options** button and set options as shown and click **OK**.
6. Click **OK** to start the expansion process.
7. Select Curves to expand with the Surface:
   Select all the Marking lines on the 3D surface (NOT THE RED MAPLE LEAF) to map them to the expanded surface.
8. The Expanded Bow Wrapper surface will now be created along with the markings mapped to it. Also labels and grouping will be applied and created according to the settings applied to this expansion. These settings are maintained for this expansion for further mappings (using the MapBack function), label changes, etc…

Note: If the Expand command was not run with pre-selection of the surface **and** the marking curves, there is an intermediate step at this point to select any markings. The command line will prompt for the selection at the appropriate time.

At this time, Strain Analysis mode is automatically initiated for the current expansion. The Strain analysis mode is a shaded color mapping representation of the amount of strain in areas of the surface. While green represents developable areas (areas of little or no strain), Red areas are areas of higher Stretch, and blue areas are of higher Compression.



9. By default the Strain dialog sets the Max and Min Strain Range values to the larger of Stretch or Compression. Change the minimum strain range value to –1.0 and the maximum strain range value to 1.0. Click anywhere outside of the edit box to recalculate the StrainMap. The StrainMap will have smaller green area and larger blue areas. This is a useful tool when limiting the amount of allowable strain for a particular surface due to type of material used to create it, or some other factor or factors. You may know from experience that a certain amount of compression or stretching is too much for your application. Set the minimum and maximum values such that the problem areas are clearly indicated.



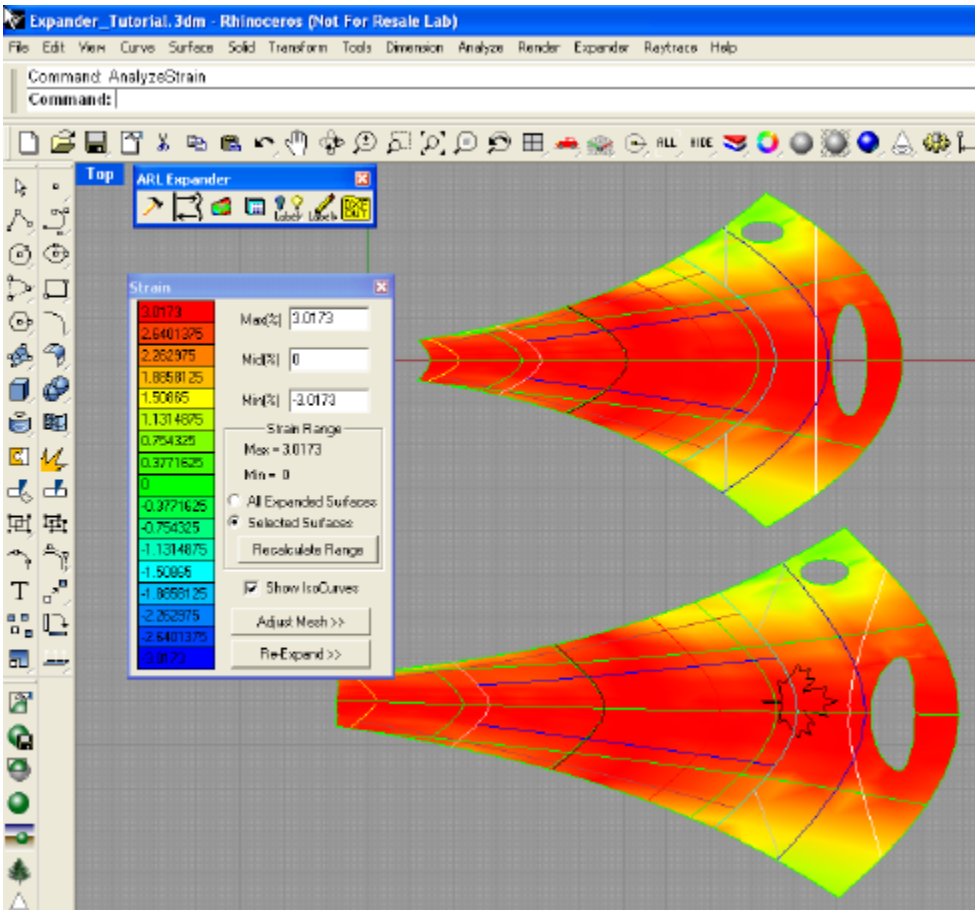
10. Click Recalculate Range. The range will get recalculated to the max and min for this selection (the selection in this case is only the current expansion), and the Strain Map will adjust accordingly.

Stretch Only Expansion

We will now expand the same surface again, but using the **Stretch Only Expansion** option. Normally a saddle shaped surface will result in an expanded surface that is smaller than the 3D surface; the surface is compressed where not developable. Using **Stretch Only Expansion** option we force the expanded surface to consist of stretch where not developable. Use this option when the forming process shrinks the material during forming. Line heating is such a process. Wheeling of aluminum, on the other hand, stretches the material and requires an expanded surface that is smaller than the 3D surface.

1. Press the **Re-Expand** button. All the expansion options will be the same as the last time you expanded this surface. The selection will be the same as well.

2. Select the **Stretch Only** option and then click **OK.** You will notice that the strain is now limited to positive values. The shape of the expanded Bow Wrapper surface is longer and slightly wider.



3. Close the Strain Analysis dialog.

Optimum Mesh Density

The mesh density greatly influences the result of the expanded surfaces. Higher mesh densities generally provide more accurate results, but are also slower. The accuracy of the expanded plate can generally be determined from the smoothness of the edges of the plate in critical areas (maximum strain), and from the smoothness of the marking. Almost flat 3D surface require very few mesh elements, highly curved surfaces require a much denser mesh. The 12 by 12 mesh we have used so far is definitely not fine enough.

We will now expand the bow surface 3 times, each time with different settings.

1. Start the expansion process for the bow wrapper surface. Use a mesh standard mesh density of 12 Rows by 12 Columns.

Hint: Turn the label options off to save time.

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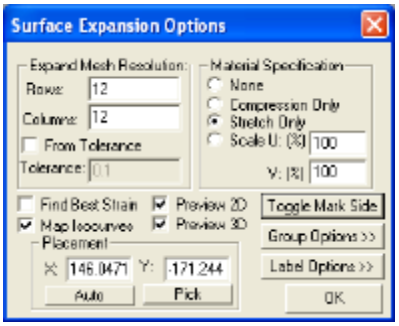
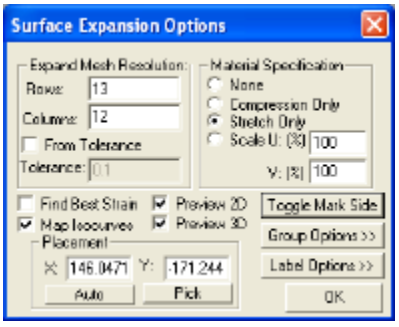
2. Select the Preview 3D option. This display the mesh used for expanding the surface. Click OK to start the expansion. Map the marking curves onto the expanded surface as before.



3. Close the strain map dialog.

4. Move the expanded surface downwards to make space for the next expansion.

5. Start the expansion process for the bow wrapper surface again. Use a mesh standard mesh density of 13 Rows by 12 Columns. Observe that there is no mesh line along the center of the surface now. Instead the middle row straddles the centerline. This is important for symmetrical surfaces as the middle strip is laid down first during the expansion.

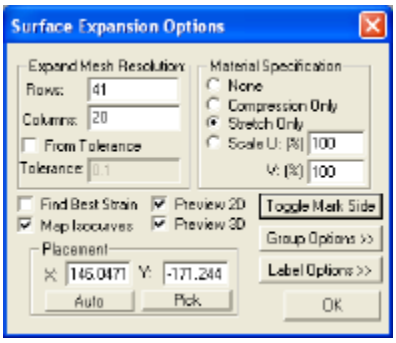


6. Close the strain map dialog.

Compare the two expanded surfaces by drawing a straight line along the centerline of both expanded surfaces. The second expanded surface with an uneven number of rows has an almost straight centerline, while the one with an even number of rows has a curved centerline.

However, the centerline of the second expanded surface shows waviness and close inspection of the marking lines and the edges show waviness as well. We have to increase the mesh density to achieve a smoother result.

7. Move both expanded surface downwards on the screen to make room for the next expansion trial.
8. Start the expansion process for the bow wrapper surface again. Use a mesh standard mesh density of 41 Rows by 20 Columns.

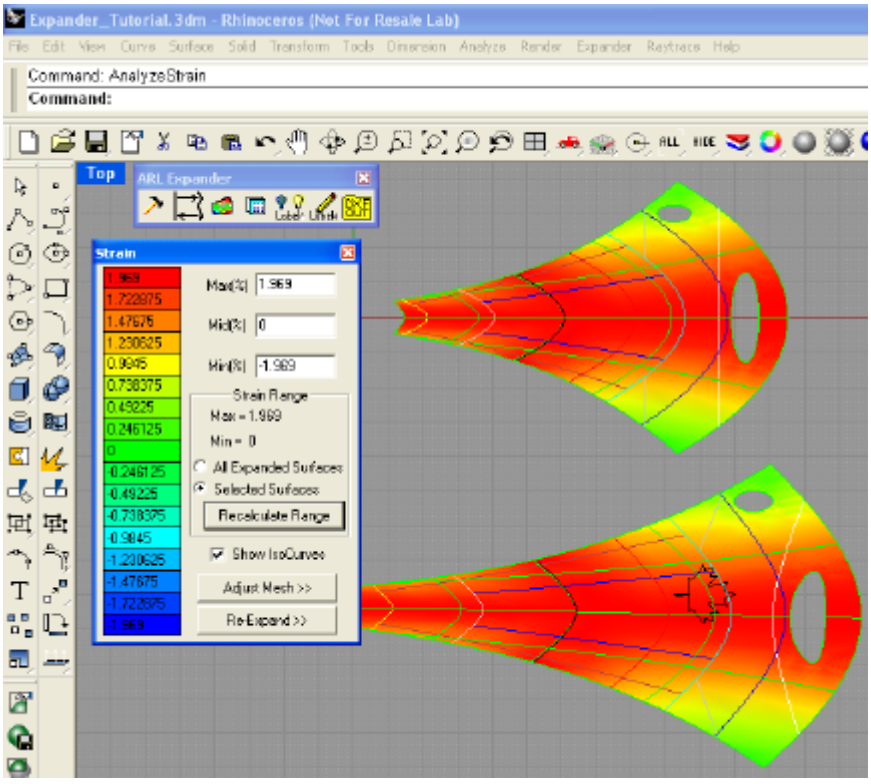


9. Inspect the surface now. It has much smoother edges and smoother markings. Draw a straight line along the centerline as before, and observe the deviation is now minute. We now have a mesh density suitable for production.

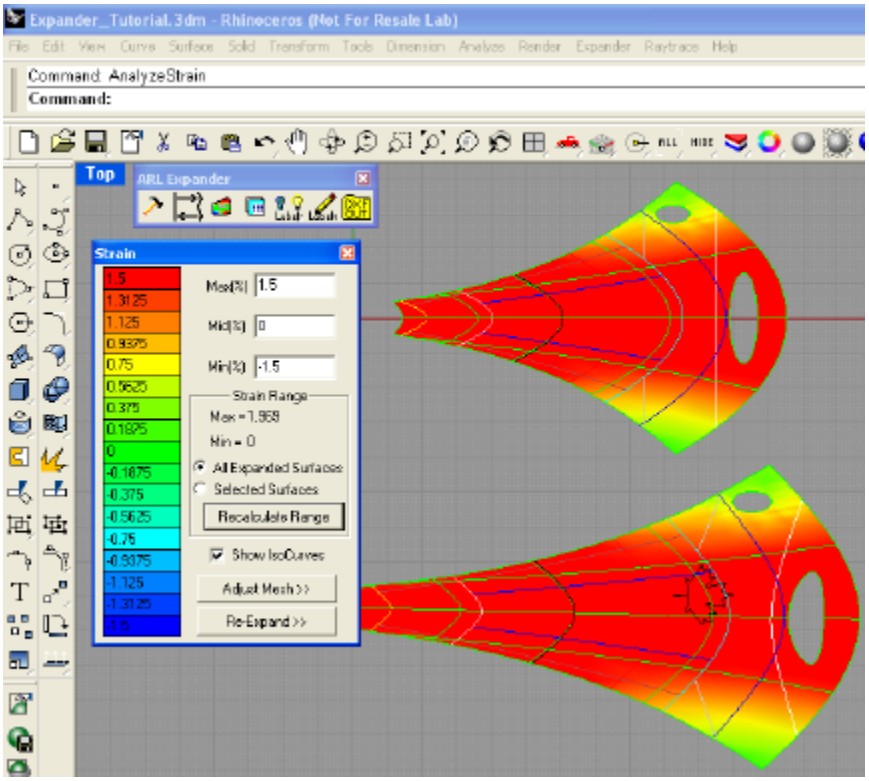
Dividing to Reduce Strain

We will now divide the surface to reduce the strain for easier manufacturing. We will achieve this by drawing a straight line seam on the expanded plate, mapping it back to the 3d surface, dividing the 3D surface into two and expanding the upper portion to see the reduction in strain. We will also use the strain map values to be able the judge the surface by simply looking at it.

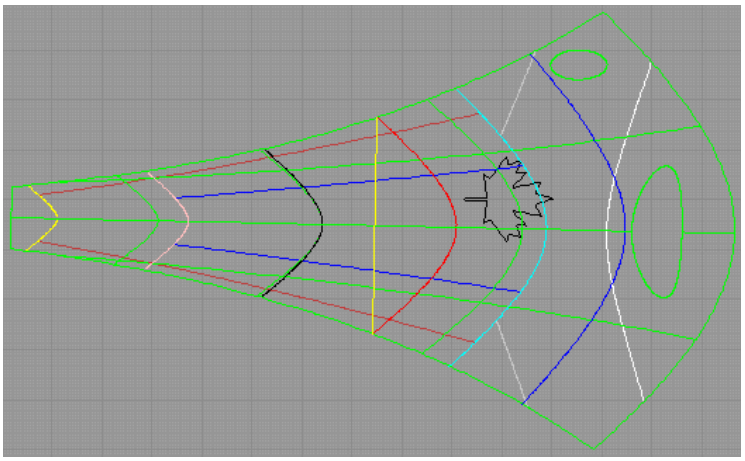
1. To prepare delete all expanded surfaces or open the original document again, and save it under a new name.
2. Expand the surface using 41 by 21 mesh density, and stretching only. Note that the maximum strain is about 2%.



3. Let us assume that we can tolerate 1.5% strain in our forming process.
4. In the Strain dialog select the radio button **All Expanded Surfaces**. This will prevent the strain map to re-adjust after each expansion, but use the document set value for the minimum and maximum strain.
5. Set the maximum strain to +1.5% and the minimum –1.5%; our maximum allowable values, and click anywhere to update the strain map. Observe that most of the plate area is red; above our threshold limit.



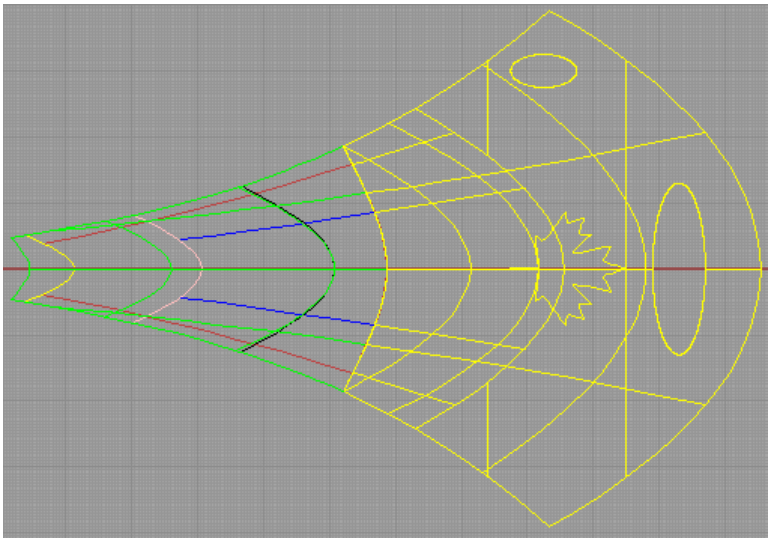
6. Close the Strain Analysis dialog.
7. Draw a straight line on the expanded surface from the end points of the red, BHOOK 1 marking lines (see figure below). Make sure to use the END OSNAP.



8. Select **Expander/ Map Curves Across Expansion, click**  , or type **MapBack.**
9. Select the 2D surface.
10. Select the straight seam line and Press **Enter.**

This Maps the straight-line curve back to the 3D surface.

11. Use the mapped curve to trim the 3D Bow Wrapper into two plates using regular Rhino commands.

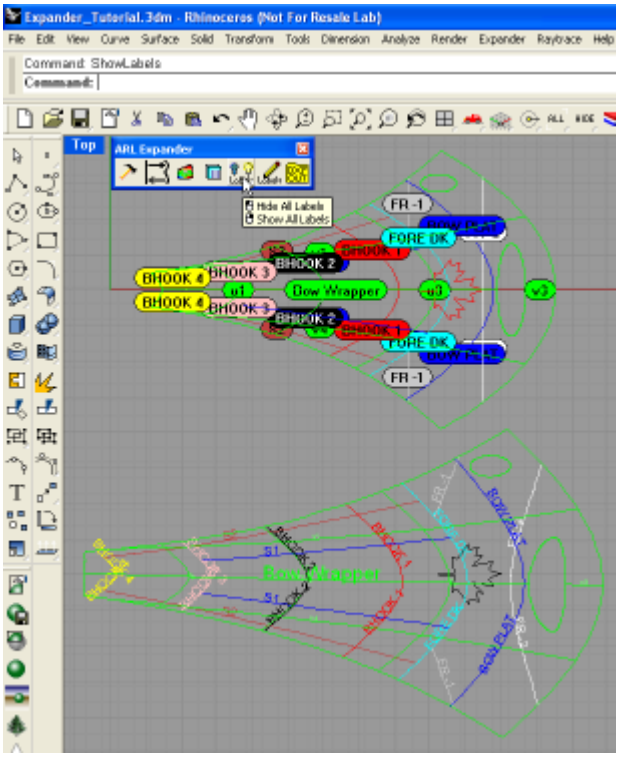


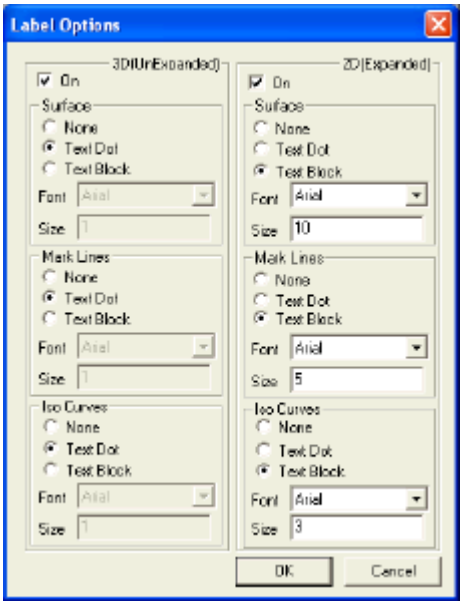
12. Expand the upper surface using a 41 by 10 mesh density. Map the marking lines. Note that the maximum strain is now about 1%, below our maximum value of 1.5%. This is also immediately visible from the lack of red color in the strain map surfaces. We can now safely assume that this plate can be manufactured using our production process.

Dealing with Labels

In this section hiding, showing, and editing labels is explored. Preparation for using the **MapBack** function is done in this section with the added purpose of familiarizing the user with the implications of transforming a surface with hidden labels.

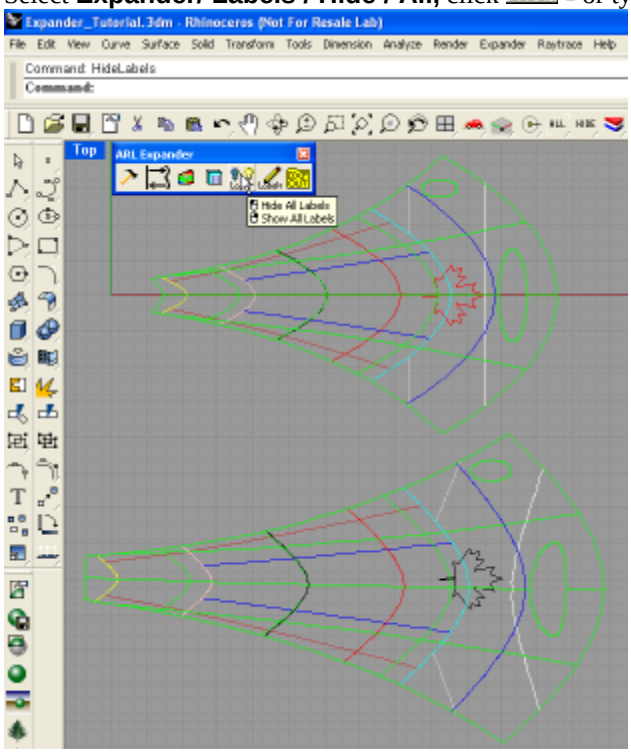
1. Open the original surface file again and save it under a new name.
2. Expand the surface. Make sure to set the label options the same as in the figure below. The expanded surface should look like in the figure below.
3. Close the Strain Analysis dialog.



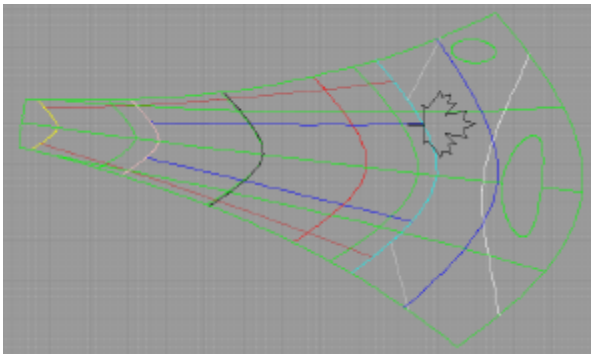


4. Select **Expander/ Labels / Hide / All,** click 

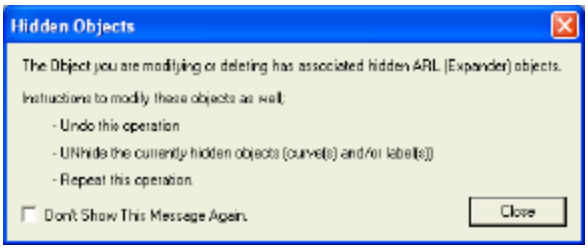
or type **HideLabels.** The Labels are now hidden.



5. Using Standard Rhino commands rotate the expanded group so that the black maple leaf is to one side of centerline.



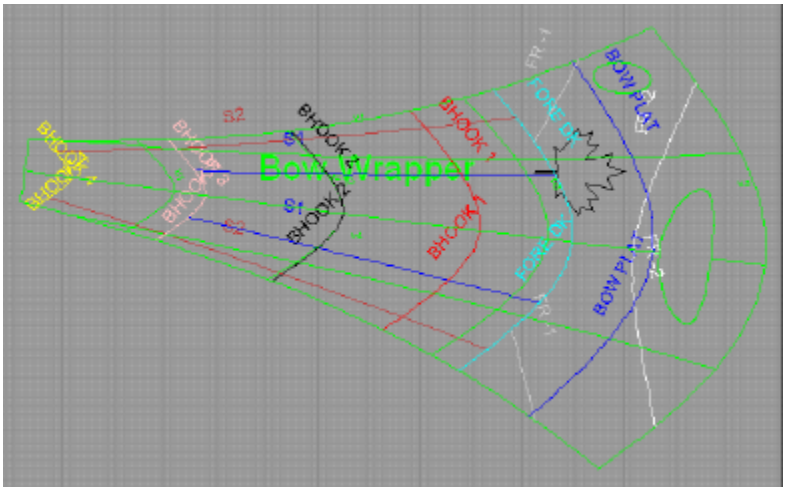
6. A dialog box will appear warning you that the labels will not be moved with the surface.



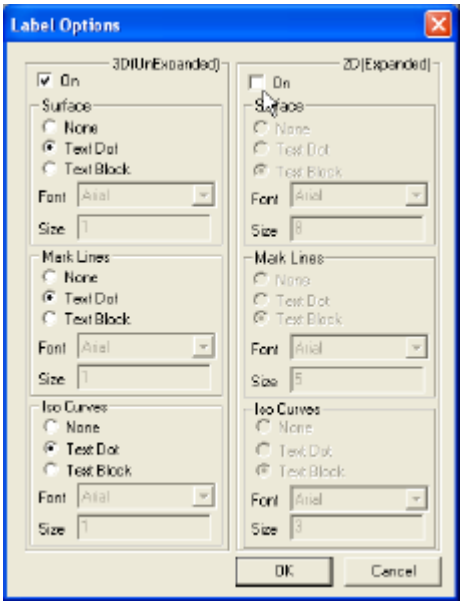
7. This dialog is warning that some labels are hidden, and have not been transformed (rotated) with the surface. There are two ways at this point to rotate the labels as well. One is to **undo** the rotation, show the labels, and re-rotate everything. The other option is described in the steps below.

8. **Expander/ Labels / Show / All,** click 

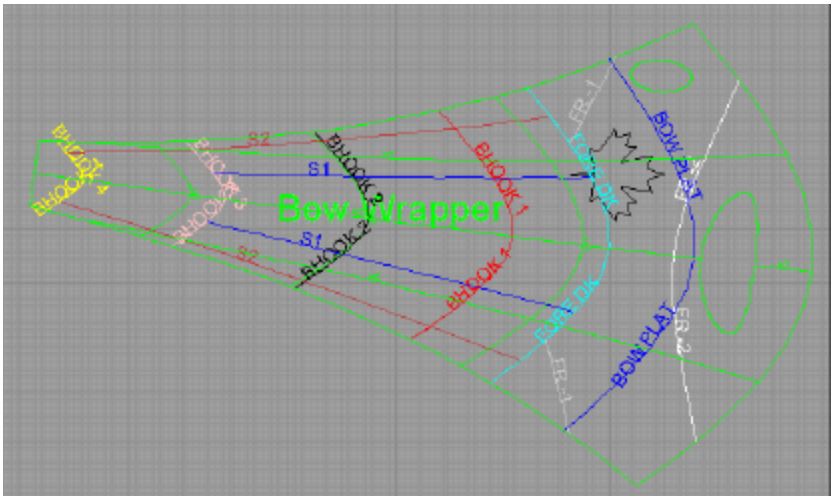
, or type **ShowLabels.** Observe that the labels are not aligned with the surface anymore.



9. **Expander/ Labels / Change Labels**  **LabelChange.** Remove all the labels for the expanded Bow Wrapper surface by turning off all 2D labels, then click **OK**.



10. **Expander/ Labels / Change Labels**  **LabelChange.** Re-generate all the labels for the Expanded Bow Wrapper surface by turning all 2D labels back on and then click **OK**. The labels are now created again in the correct position.

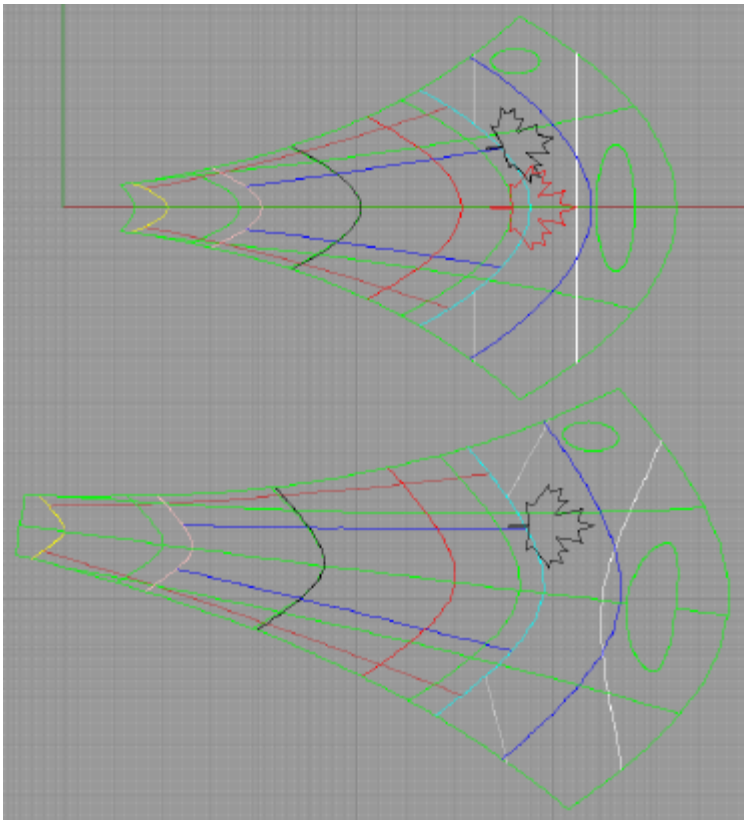

Bow Wrapper
BHOOK 1
BHOOK 2
BHOOK 3
BHOOK 4
S1
S2
BOW PLAT
CORT DK
FR 1
FR 2

2D to 3D MapBack

MapBack is a tool used to Map Markings and curves between the 3D and Expanded surfaces, and vice versa.

1. Select **Expander/ Map Curves Across Expansion, click**  **,** or type **MapBack.**
2. Select the Expanded Bow Wrapper surface and the black maple leaf. The Black Maple leaf will get mapped to the 3D Bow Wrapper surface.

Note: This function may take a few minutes to complete, as it involves complex computations.



The result is a maple leave mapped onto the 3D surface.

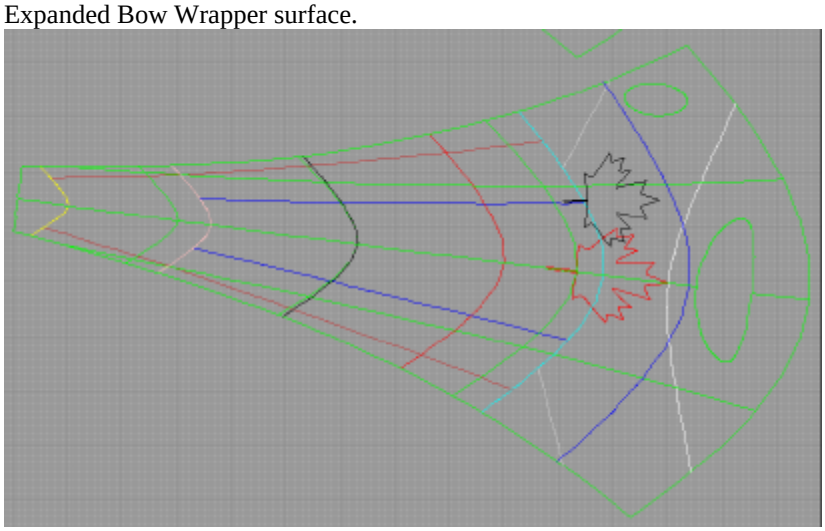
3D to 2D MapBack

We will now project the red maple leave onto the 3D surface and then map is back to the expanded plate. The red maple leaf is a 2D curve, and not on the 3D surface. You may want to rotate your view to verify this.

1. Project the red maple leaf in the "Z" direction onto the 3D Bow Wrapper surface using standard Rhino commands. (Curve / Curve From Objects / Project).

2. Select **Expander/ Map Curves Across Expansion,** click  **,** or type **MapBack.**

3. Select the 3D Bow Wrapper surface and the projected red maple leaf. The red maple leaf will get mapped to the 2D Expanded Bow Wrapper surface.

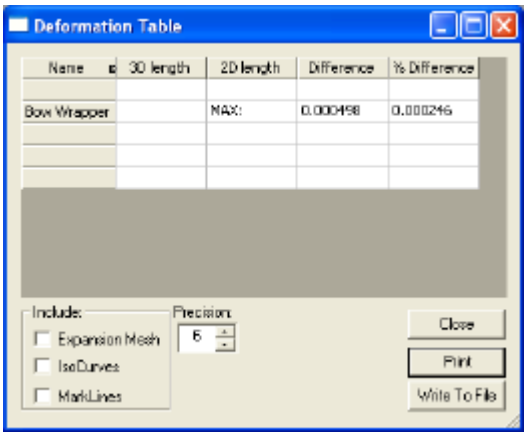


You will notice the 3D to 2D MapBack is much faster than the 2D to 3D MapBack because the computations are simpler.

Deformation Tables

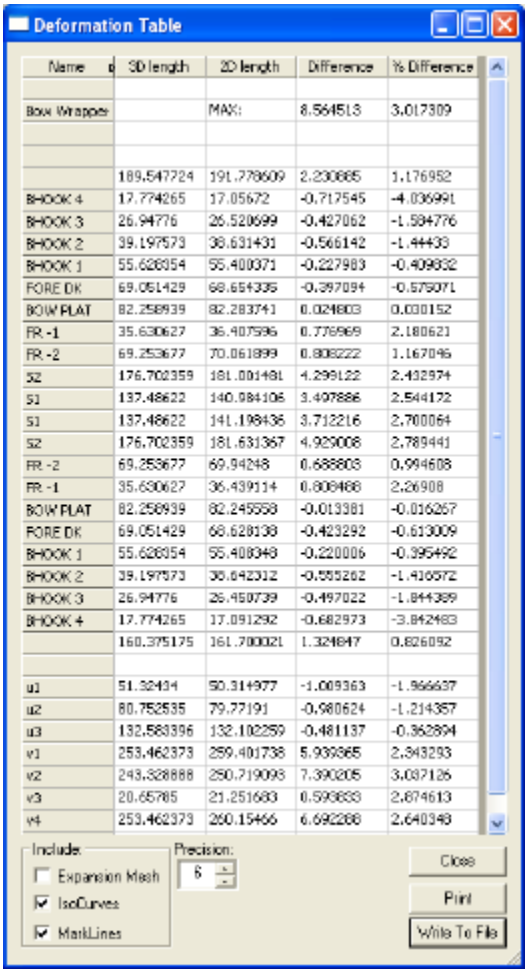
A **Deformation Table** is a table which compares lengths of markings, curves, and Expansion mesh columns and rows from a given Expansion. It is another tool to use for judging if the plate can be produced.

1. Select the Bow Wrapper surface and select **Expander/ Create Deformation Table,** click  , or type **DeformTable.** The following dialog box will appear:

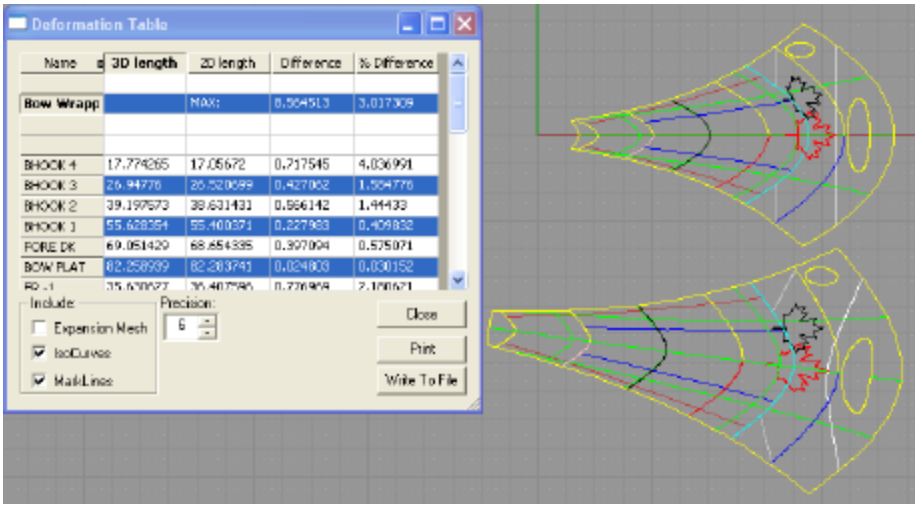


2. The values displayed for the surface itself (Bow Wrapper) are displayed at the top. The value shown is the deformation of the most stretch or compressed mesh line.
3. Reduce the Precision to 2 decimal places. This is accurate enough for our purposes here.
4. Select the options to show deformations of IsoCurves and Marklines. For each line you will find detailed information:
    a. Where on the surface the lines are – U and V maximums and minimums.
    b. The 3D length – on the 3D surface
    c. The 2D length – on the 2D surface
    d. The difference in absolute values
    e. The difference in %

Note: It will take some experience to interpreter these numbers well. In many cases this function is not required to create good results



5. Select a few rows in the Table and notice the selection of the corresponding objects for easy identification.



6. Likewise, selection of objects in the viewport will result in selection of corresponding rows in the Table.

The deformation table may be printed or output to a file for documentation.

Export an Expanded Surface for NC cutting:

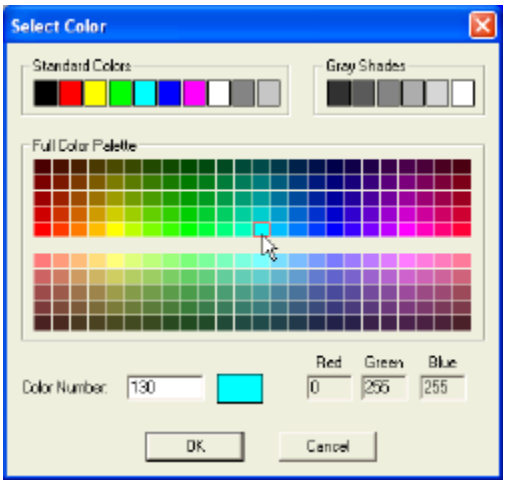
In order to create cutting instructions or perform nesting, the expanded surface curves and markings often have to be transferred to other programs. Expander provides functionality to export many file formats including DXF, which is accepted by most NC processing and nesting, programs.

Important: Make sure to install at least Rhino service pack 2 as it provides fixes with DXF export problem in Rhino.

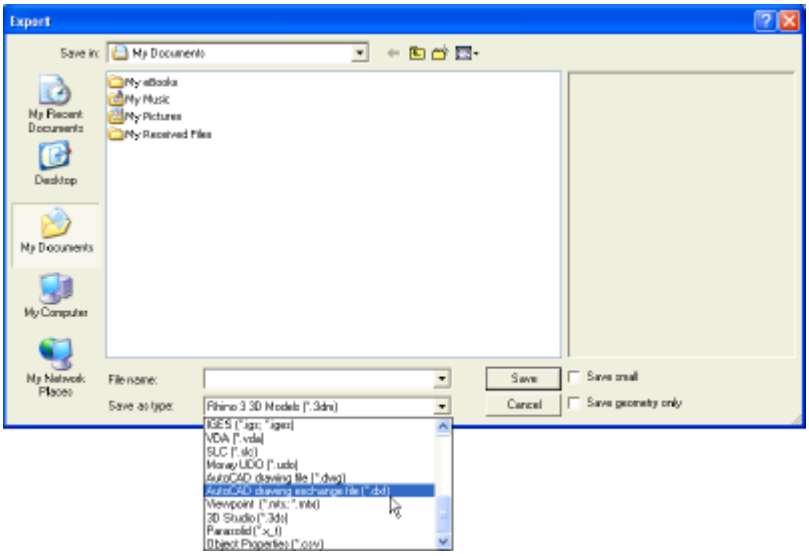
1. Select the expanded surface and select Expander/ Export / DXF (For NC Cutting), click 

or type DXFoutFile
2. The following dialog will appear.

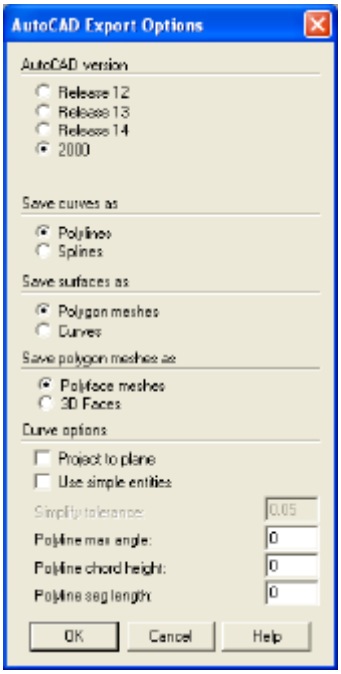
3. Label the Layers as preferred, and press the **Color** buttons to edit the layer colors. The following dialog will appear:



4. Click **OK** in the **Layer Options** dialog to continue.



5. Name your file and make sure to select the **DXF Format Type** (File Extension):
6. Enter a file name and click **Save** to continue

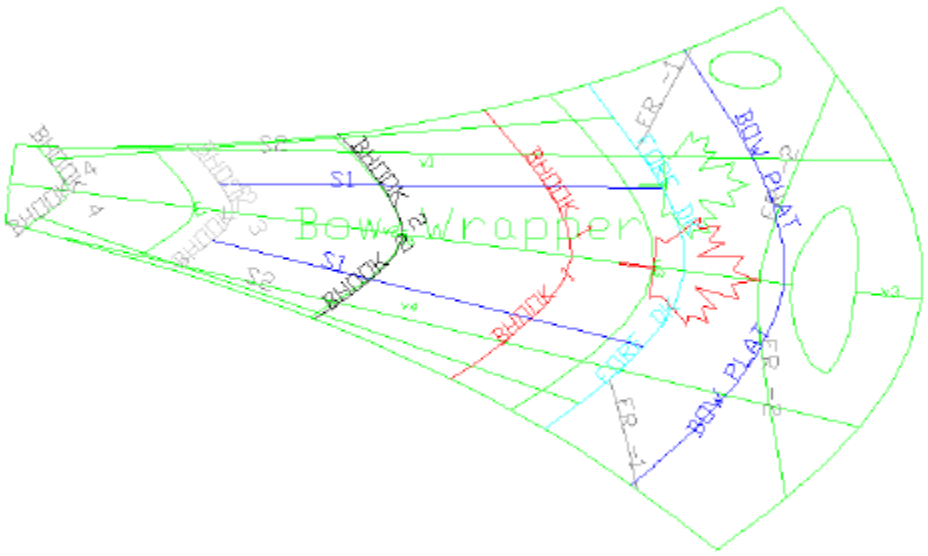


Note: This export function extracts trim curves from surfaces, so all exported objects are polyline/arc estimates of these curves, and text Blocks (Text dots do not get exported). This means that only the Curve options are applicable in the above dialog when running the DXF OutFile command ("Save surfaces as", and "Save polygon meshes as" options have no meaning). The above settings are recommended for outputting accurate results (no thinning or simplifying is done). If your NC cutting machine requires a minimum spacing between points check the "Use simple entities" box and enter the value in the Simplify tolerance box.

7. The options in the AutoCAD Export dialog should be set to:
    a. Polyline max angle = 0
    b. Polyline chord height = 0

c. Polyline seg length = 0.

IMPORTANT: The settings above export all curve points to the DXF file. This may in some cases overload the NC-cutting machine. None of the Rhino values above affect the DXF export in a way you would need to prevent a data overload. ARL expects to post a new Expander release with an updated export function before 11 July, 2003.



A view of the DXF File in AutoCAD.

Notice that the objects with color properties set to be By Layer will still have this setting, so the objects color will change to the color of the export layer.

Reference Manual

Overview

The Following is a detailed description of each Expander function.

These functions include:

- Expand
- Hide Label functions
- Show Label functions
- Change Labels
- MapBack
- Analyze Strain
- Deformation Tables
- Export

To become familiar with Rhinoceros functionality, refer to the Rhinoceros user manual.

Expand Function

Overview

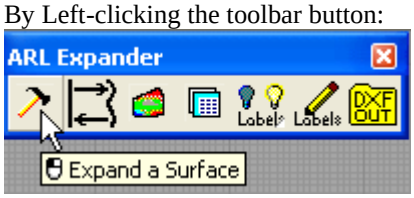
This function is the heart of Expander. To expand a surface, select the surface and curves to be mapped with the expansion, and run the command. (Note: you can also select the surface and/or markings after the command is run. You will be prompted at the appropriate times)

If some curves are forgotten in the selection, you can use the MapBack command later.

The Expand command may be run one of three ways:

1. By using the drop-down menu:

2. By Left-clicking the toolbar button:



3. By using the command prompt ("**Expand**")

For the purposes of this document, accessing a function as above will be described as following:

Expander/ Expand Surface, click  , or type **Expand**

Expanding a Surface

Once the function is run, and a surface is selected (note: to expand a polysurface you must explode the surface, and expand one surface at a time) an option dialog will appear.

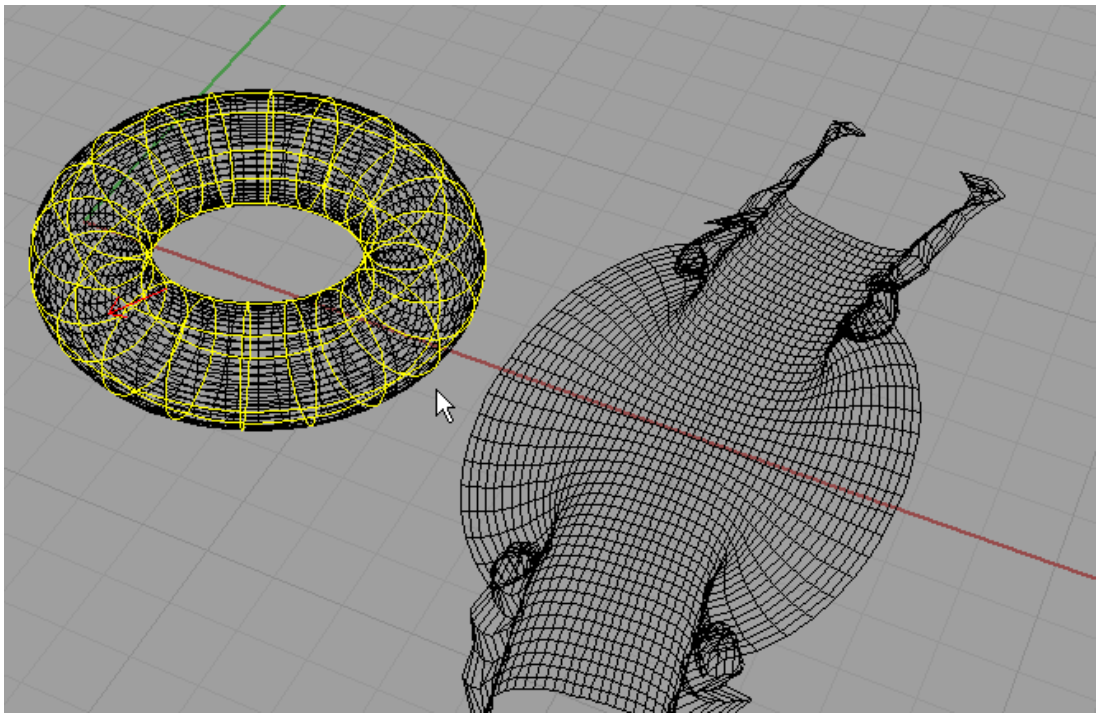
Expand Mesh Resolution

The Expansion calculation is based off of this mesh. It is a quad-mesh approximation to the NURBS surface.

To view the mesh, check the Preview 3D box. Check the Preview 2D box to preview the expanded Mesh, which is the counterpart of the 3D mesh, and is what the expanded surface is based off of. The Resolution of the Expand Mesh may be specified directly (Rows and Columns), or by a tolerance. Tolerance specifies how much the mesh is allowed to deviate from the true NURBS surface.

Important: For complex surfaces it may happen that the large strains during expansion cause the expanded mesh to fold back onto itself. See the torus example below. You are ok, if your expanded section falls clearly within the area where no folding-back occurs. Make sure that **Find Best Strain** box is checked. Try better tolerances. If nothing helps, then you

have to split the surface into smaller patches, before expanding. In any case, the folding means that the stretch has gone way past what regular materials, except for rubber or latex, can take in deformation before breaking.



If the resulting curves and trims of the expansion calculation are not considered smooth enough, the most accurate way to remedy this is to re-expand with an increased the Mesh Resolution.

Advanced Users: The calculation for the mesh Resolution based on a tolerance is interpolated three times as a default. To change this, right-click on the "**Tolerance**:" area..

Material Specification

Use Material Specification to control the size of the expanded surface with regards to the 3D surface. The procedure to use depends on how the forming process will treat the material.

For example, stretching will be used to form a leather shoe. Forming is the opposite process to expanding, thus the **Compression Only** radio button should be selected for expansion. Thus the expanded surface is smaller than the 3D surface. Stretching the leather during forming should result in a 3D shape that will very closely match the computer 3D surface shape.

Likewise, shrinking it with line heating may be used to form a steel plate. In this case, the **Strech Only** radio button should be selected.

Advanced Users: The Scale options for Material Specification may be used to estimate a smaller degree of stretch than compression, or vice versa. Use mesh previews as a reference when doing this. Some aluminum ship builders in Europe use this technique successfully.

Find Best Strain

Expander limits to the parametric U or V direction. The expanded surface is either stretched or compressed along the V or the U direction, but never along both directions. This option finds the U or V expansion direction with the least strain.

Surfaces with singularities (coming to a point) may require this option to achieve an acceptable result at all. It is recommended that you enable this option.

Map Isocurves

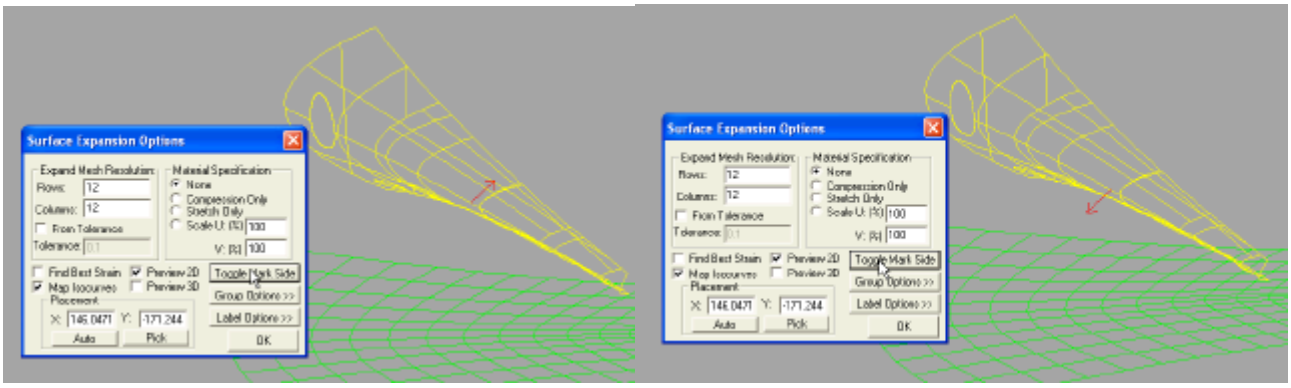
Select this option to map the visible iso-parametric curves onto the Expanded surface.

Position

By default the expanded surface is positioned at the lower Y-coordinate side of the Original 3D surface. To specify the placement, press the **Pick** button, and then select a point on the z=0 plane. To re-calculate the auto-generated position, press the **Auto** button.

Toggle Mark Side

To change which side of the expansion is up (the side to be marked, and cut from), press the **Toggle Mark Side** button. A red mark side direction indicator is located perpendicular on the center of 3D surface. It points in the direction on which you want the markings. The mark side direction indicator of the expanded plate will be aligned with the positive Z-axis (point up) in the expanded plate.



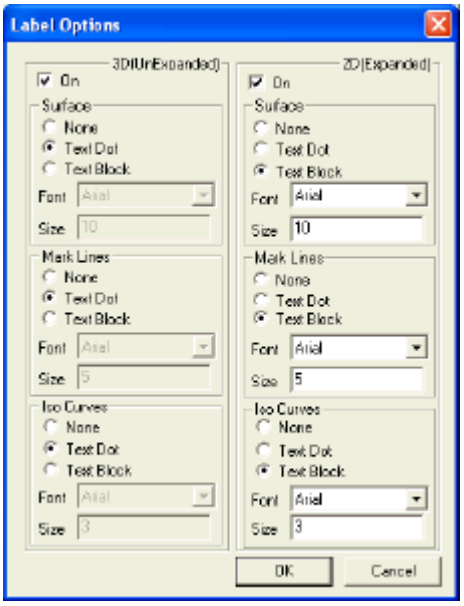
Group Options

Pressing the **Group Options** button will pop up a dialog to specify how you wish to group the surfaces with their mapped curves, and labels.

- The **None** option will not group anything together.
- The **All** option will group the surface, all curves including isocurves, and all labels together in one group.
- The **Labels** option will group labels to their appropriate objects (surface label to the surface, isocurve labels to their isocurves in the Expanded surface, but to the surface in the 3D as they are not separate objects, and marking labels to their appropriate marking curves.

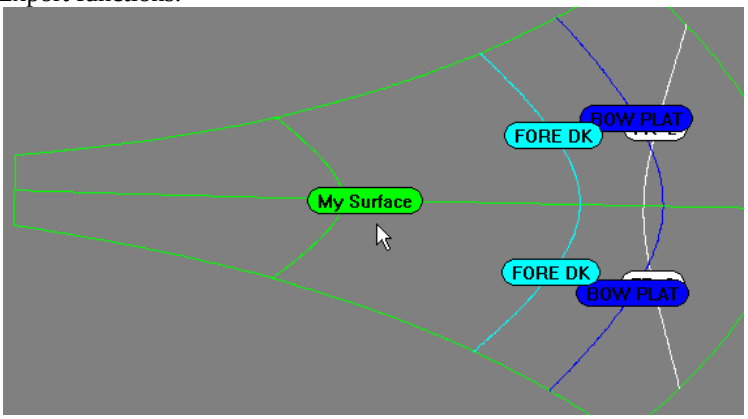
Label Options

Pressing the **Label Options** button will pop up a dialog to specify how you wish to Label curves, isocurves, and surfaces involved in this expansion.

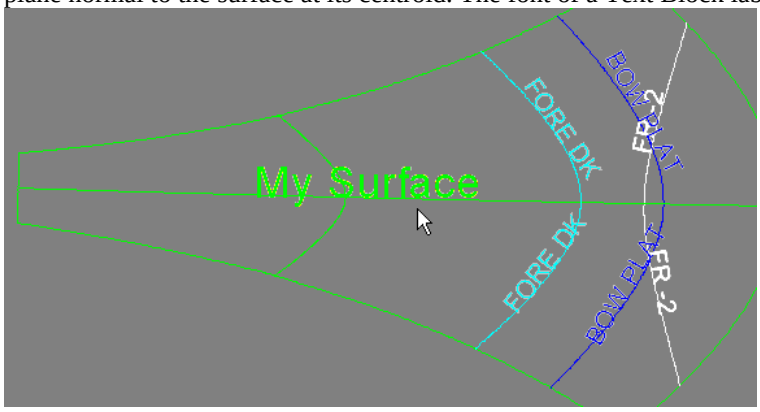


There are two text labeling primitives used in Expander:

1. **Text Dots**, which are viewport dependent, and useful to identify objects, but are not exported with Expander Export functions.



2. **Text Blocks** which are exported, and are not viewport dependent. They are sizeable, and are calculated to be in a plane normal to the surface at its centroid. The font of a Text Block label may also be changed.



Once the Expand function is complete, the “Analyze Strain” function is automatically launched, and Strain analysis mode will be initialized for the current expansion only.

Labels

There are three different types of labels, which Expander creates.

1. **Surface Labels** (one per surface, and takes on the surface's name)
2. **Isocurve labels** (one per mapped iso-parametric curve, and it's name is auto-generated by it's direction and constant parametric value)
3. **Marking curve labels** (one per mapped marking curve, and it takes on the name of the marking curve)

Hiding and Showing Labels

Pre or Post select surfaces you wish to hide or show labels, and run the appropriate command:

Expander/ Labels / Hide / All, click  , or type **HideLabels**

Hides all labels associated with the selected surface(s).

Expander/ Labels / Show / All, click  , or type **ShowLabels**

Shows all labels associated with the selected surface(s).

Expander/ Labels / Hide / Surface, click  , or type **HideSrfLabels**

Hides the surface label(s) associated with the selected surface(s).

Expander/ Labels / Show / Surface, click  , or type **ShowSrfLabels**

Shows the surface label(s) associated with the selected surface(s).

Expander/ Labels / Hide / Curves, click  , or type **HideCrvLabels**

Hides all curve labels associated with the selected surface(s).

Expander/ Labels / Show / Curves, click  , or type **ShowCrvLabels**

Shows all curve labels associated with the selected surface(s).

Expander/ Labels / Hide / Iso Curves, click  , or type **HideIsoLabels**

Hides all isocurve labels associated with the selected surface(s).

Expander/ Labels / Show / Iso Curves, click  , or type **ShowIsoLabels**

Shows all isocurve labels associated with the selected surface(s).

Changing Labels

Pre or Post select a surface you wish to change associated labels (with itself, and it's counterpart [Original 3D surface if 2Dexpanded surface was selected, and vice versa if 3D surface was selected]), and run the following command:

Expander/ Labels / Change Labels, click  , or type **LabelChange**

The Label options Dialog will pop up, and you can change the labeling size, font, and type.

If there were no existing labels where there could be, the labels are recalculated from curve and surface properties. This may be found to be useful when you wish to trim or modify a curve or surface in other minor ways, which would affect the position and plane of a label.

MapBack

Expander/ Map Curves Across Expansion, click  , or type **MapBack**

Overview

The MapBack function maps curves across the expansion exactly like the mapping done in the original expansion (if curves were originally selected). You can pre-select the surface and curve you wish to map to the Expanded surface. The labeling and grouping rules apply in the same way they were set up during the expansion.

You can also Map a curve which is on the Expanded surface back to the original 3D surface. Run the command like normal; just select the planar (Expanded surface) and the curve you wish to map to the 3D surface

.

Analyze Strain

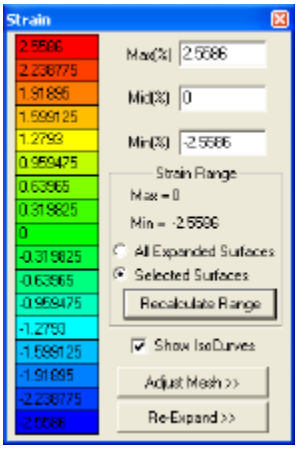
Pre or Post select surfaces you wish to display Strain Maps for, and run the command:

Expander/ Analyze Strain, click  , or type **AnalyzeStrain**

Overview

Strain Analysis Mode shades the viewports, and displays a colored Strain Map on selected surfaces. This Analysis mode was designed to work similar to other analysis modes in Rhino such as Surface Curvature, Draft Angle, Environment Map, and Zebra. There is a one-to-one relationship between the Strain Maps on corresponding surfaces. The Strain Map can be displayed on a 3D surface and/or the resultant 2D (Expanded) surface.

The following Dialog appears when in Strain Analysis mode:



Strain Range

The contrast in colors is dependent on the Strain Range.

Three range options can be used:

1. Document Range. This setting uses the accumulated range of all expansions done in this document.
2. Current Selection. This setting uses the accumulated range of the current set of selected Expansions.
3. Per-Surface Range. This setting is used to display maximum contrast in color for every surface in the selection. The range is specific to the Strain Map (surface).

Positive values of Strain represent Stretch while negative values represent Compression.

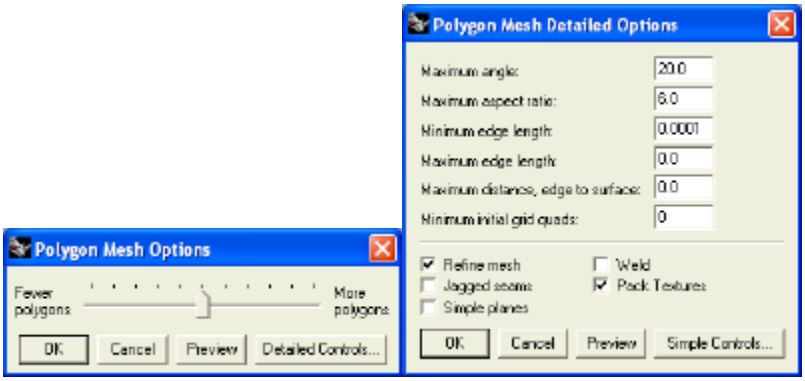
Note: The Max and Min fields are only displayed when the Strain mode is initialized for one expansion (the 2D and/or 3D surfaces of a given expansion are selected for strain analysis mode only.).

Show IsoCurves

This option turns on and off the display of iso-parametric curves in the selection.

Adjust Mesh

Press the **Adjust Mesh** button to adjust the Strain Map Mesh. The Preview is displayed on the 3D surfaces only. You can toggle between simple mesh definition controls, and detailed mesh definition controls.



(NOTE: The Strain Map Mesh is not used for expansion calculation. It is not at all similar to the Expansion Mesh, and is only used for generation of the Strain Map while in Strain Analysis mode)

Re-Expand

Press the **Re-Expand** button to delete the Expanded Surface, all related Labels and Mapped curves, and pop up the Expansion Options Dialog with the previous expansion options set. The selection and options will all be the same.

Deformation Tables

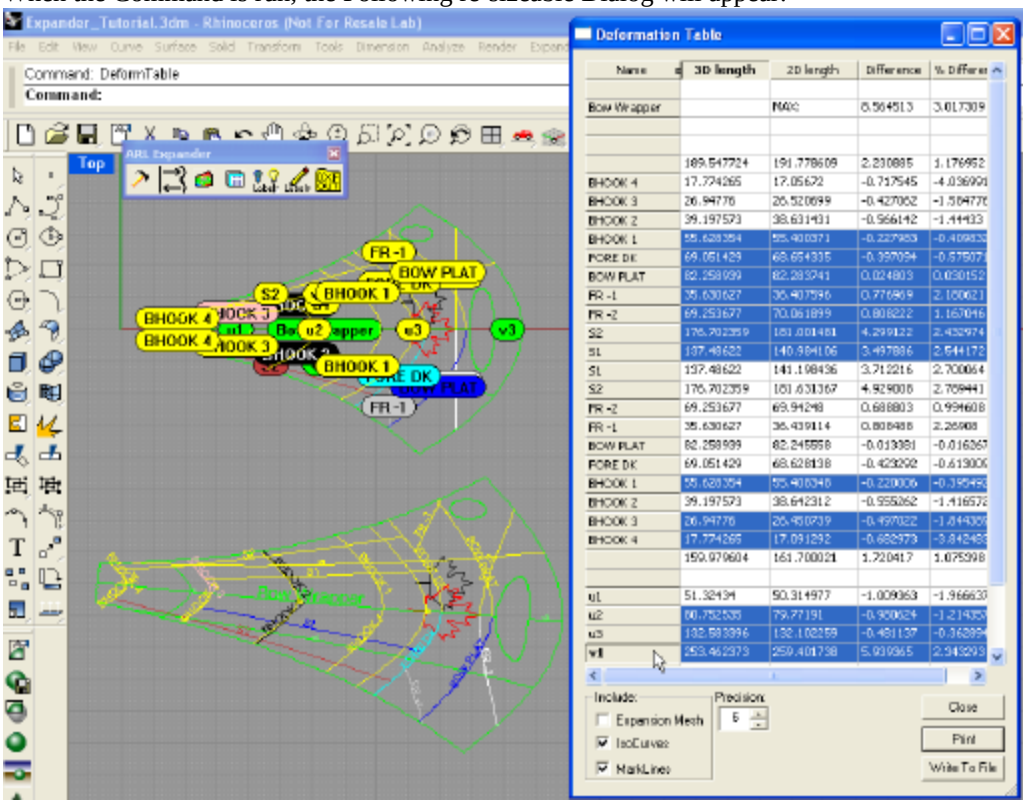
Pre or Post select surfaces you wish to display Tables of Deformation for, and run the command:

Expander/ Create Deformation Table, click  , or type **DeformTable**

Overview

This tool is intended to analyze areas on a surface for levels of deformation. Comparing length differences between corresponding curves, and Expansion Mesh Rows/Columns does this.

When the Command is run, the Following re-sizeable Dialog will appear:



(NOTE: The selected rows select the represented objects in the viewport. Likewise, selecting objects in the viewport will highlight the corresponding rows.)

The Surface's Difference and %Difference is the maximum value calculated from the Expansion Mesh.

Include Expansion Mesh

If this option is selected, the Expansion Mesh Deformations are listed in the Table for every Row and Column (be careful, this could take a long time to build the list if your Expansion Mesh is of high resolution).

Include IsoCurves

If this option is selected, the Table is rebuilt with the deformations of Isocurves included.

Include Marklines

If this option is selected, the Table is rebuilt with the deformations of Marklines included.

Precision

The precision of values displayed in the table can be changed to within the Document Tolerance.

Copying Selected Rows

Pressing **Ctrl+C** will copy the contents of the selected rows to the clipboard so you can paste into a text file, or a spreadsheet.

If a particular column width is zero, that column information will not be included in the copy.

The Table actually contains fifteen columns:

1. Name
2. U minimum
3. U maximum
4. V minimum
5. V maximum
6. X minimum
7. X maximum
8. Y minimum
9. Y maximum
10. Z minimum
11. Z maximum
12. 3D length
13. 2D length
14. Difference (of lengths)
15. % Difference

As default columns 2 to 11 have a zero width. If this information is desired, the Columns should be resized.

Print

Pressing the **Print** button will allow you to print the entire contents of the Table as you see it (same columns widths etc.)

Write To File

Pressing the **Write To File** button will allow you to write the selected rows out to a text file. If no rows are selected, all the rows are written out.

Export

Export DXF

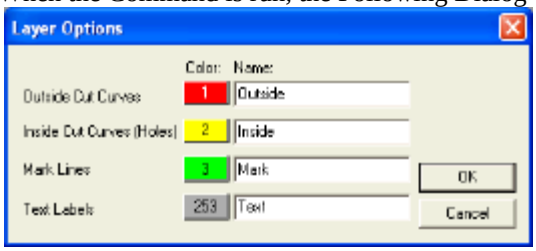
Pre or Post select surfaces and curves you wish to Export, and run the command:

Expander/ Export / DXF (For NC Cutting), click  , or type **DXFoutFile**

Overview

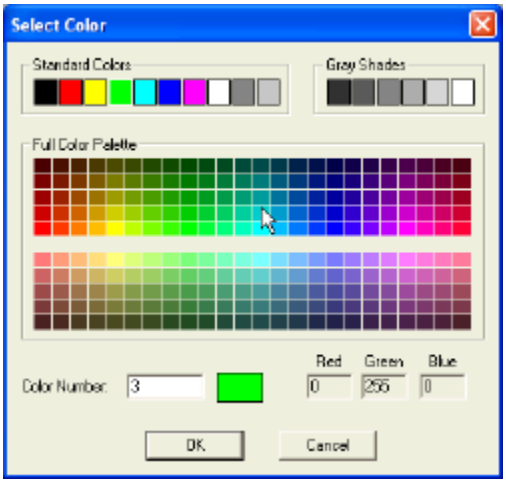
For production purposes (such as NC cutting code generation) the expanded surfaces will need to be exported in a format such as DXF, and the Trim tool paths, Marklines, and Text Block Labels will need to be placed on appropriate layers.

When the Command is run, the Following Dialog will appear:



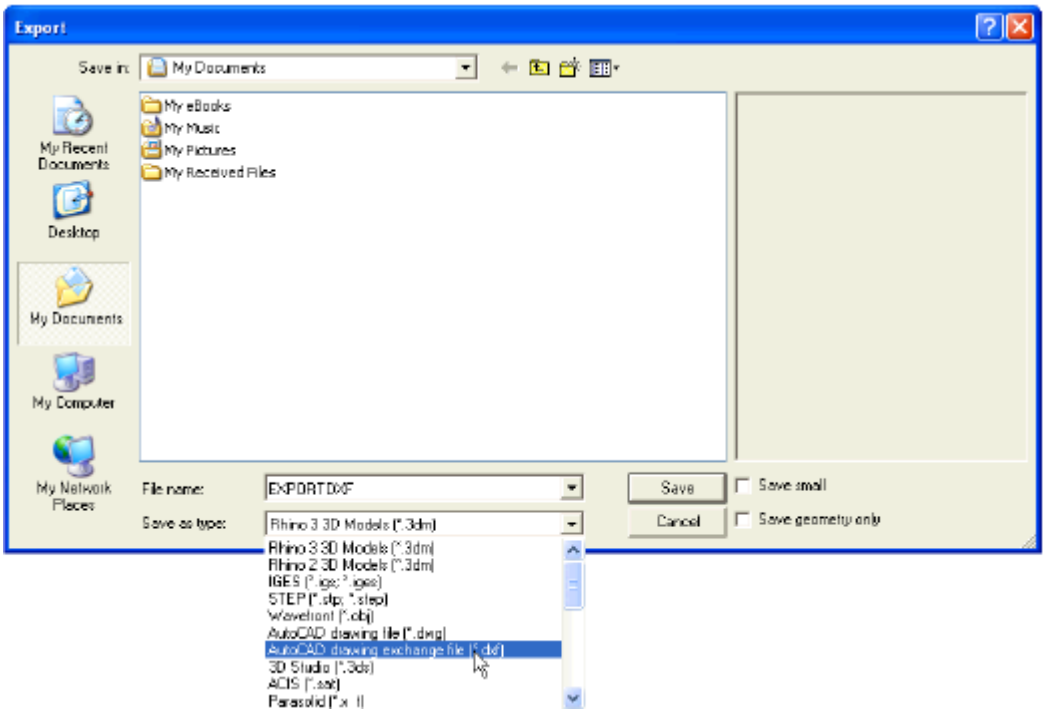
You can modify the exported file Layer names at this time by editing the Names in the appropriate edit box.

You can modify the exported file Layer colors at this time by clicking the appropriate color box. A color selection dialog will pop up:

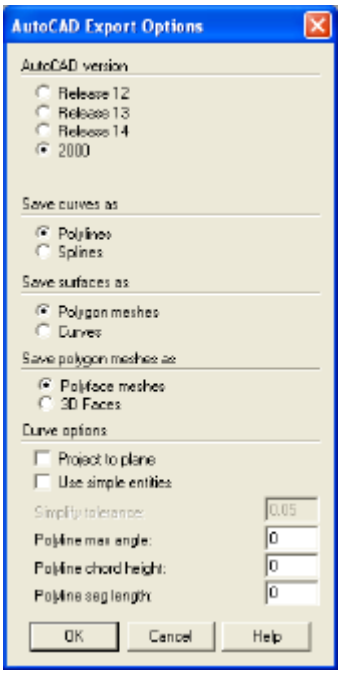


Once all the colors and Names are set, press the **OK** button.

The following dialog will pop up:



Select a filename, and desired export format (such as DXF).



Note: This export function extracts trim curves from surfaces, so all exported objects are polyline/arc estimates of these curves, and text Blocks (Text dots do not get exported). This means that only the Curve options are applicable in the above dialog when running the DXF OutFile command (“Save surfaces as”, and “Save polygon meshes as” options have no meaning). The above settings are recommended for outputting accurate results (no thinning or simplifying is done). If your NC cutting machine requires a minimum spacing between points check the “Use simple entities” box and enter the value in the Simplify tolerance box.

8. The options in the AutoCAD Export dialog should be set to:
    a. Polyline max angle = 0
    b. Polyline chord height = 0
    c. Polyline seg length = 0.

IMPORTANT: The settings above export all curve points to the DXF file. This may in some cases overload the NC-cutting machine. None of the Rhino values above affect the DXF export in a way you would need to prevent a data overload. ARL expects to post a new Expander release with an updated export function before 11 July, 2003.

Index