Associative modeling (IPM)

In this Webtraining task we will create a mower cover for a children's toy lawn mower. We will learn curve creation, how to create different types of surfaces, what the effects are when we create an associative solid, and filleting a solid instead of surfaces. We will also learn how to use an hybrid modelling by associative curves and surfaces and change them by new IPM concept. The solid modeling and its features will be necessary to complete the model and to permit quick changes.

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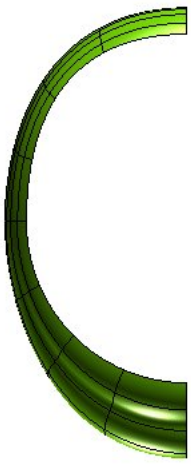
1. Step 1: Creating the Base of the Cover

In this step we will build half of the lower portion of the mower cover. We'll use the **Two D to Three D Curve** command to create the curves, the **Linear Surface** and **Lofted Surface** commands to create the surfaces, and finally the **Connect Surface** command to blend the surfaces together.

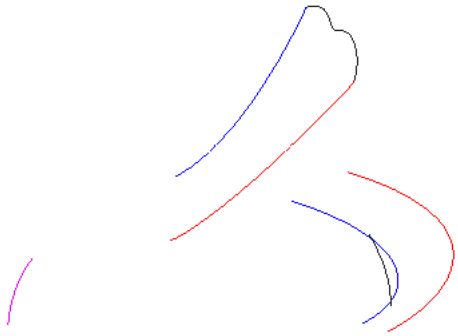


NOTE:

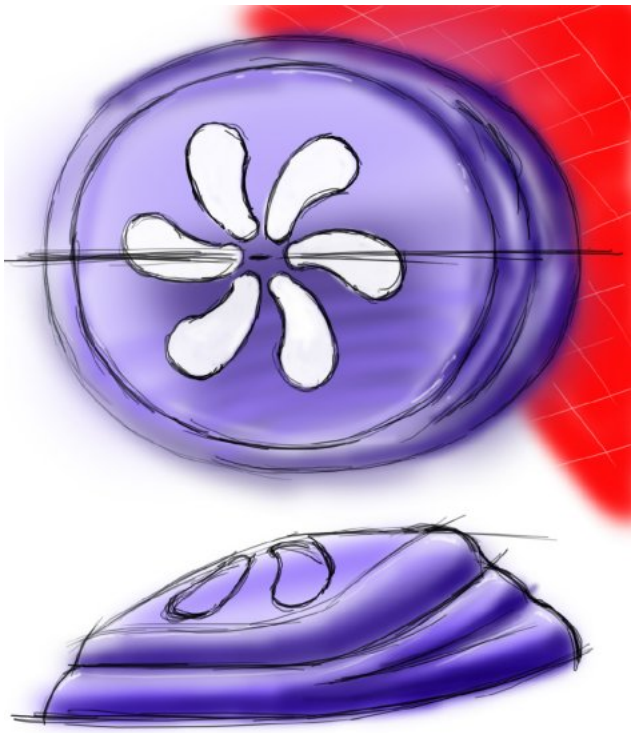
With a double click on the exe file you can run the webtraining session. ThinkDesign will be open with the right model to start.

If request to open a file, you can find it in the C:\MyTraining path.

Let's take a look at what we're starting with first. We have a variety of curves on the screen that represent different things. The purple curve represents a construction curve that we will need later, and the two white curves (shown black in the image below) represent the edges that we will need to construct one of our surfaces.

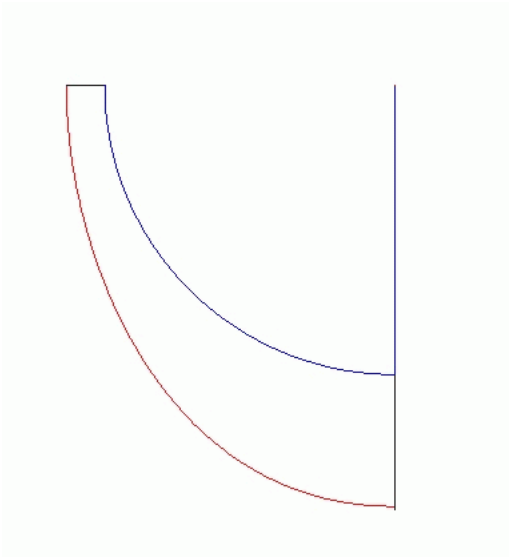


But how did we get the white (black) curves? Like many designers, we started with a sketch and created a set of 2D curves from two different views as represented in the sketch below: the top and side views.



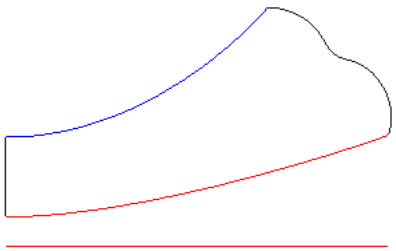
- Change to **Top View** to see the planar (or 2D) curves that represent this view.

The image below was rotated to give a better representation, but as you can see it keeps the same shape as the top view sketch shows above.



- Change to **Left View** to see the planar (or 2D) curves that represent this view.

Once again this view matches the shape shown in the side view sketch above.

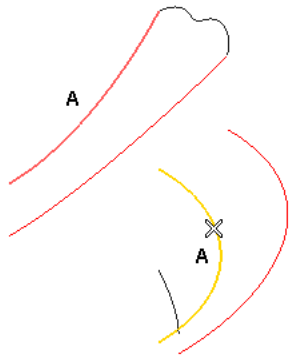


- Change to **Left Back View** to see all the curves.

The white (black) curves were created before hand - meaning that the outcome was known and the curves were created that would represent the final shape. They were placed in the start file to make it easier for the creation of the surfaces to follow.

Now, let's get on with the show! The first thing to do is to use the existing planar curves along with the **Two D to Three D Curve** command to create 3D curves from the 2D data given.

- Start the **Two D to Three D Curve** command.

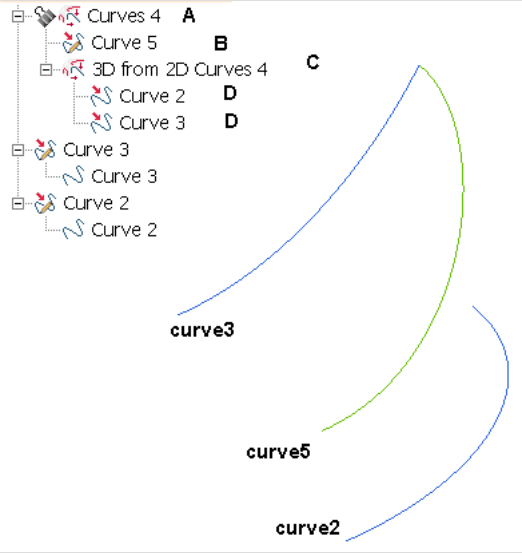


- Check ☑ Associative in the Selection List. Remember to check it in all other commands to make all associative entities.
- Select the two blue planar curves (A).
- Click OK

NOTE: Associative Curve

When you create associative events, you'll find in the history tree second a particular sequence.

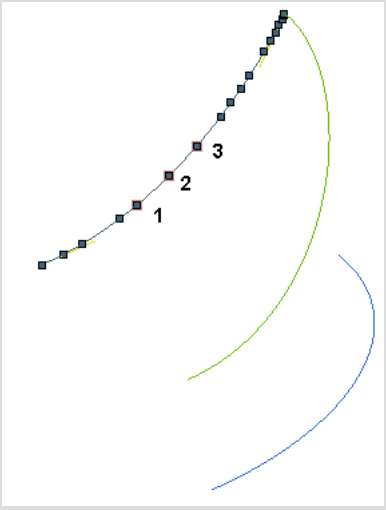
Using the associative option means that if we change the curves later the surface will update.



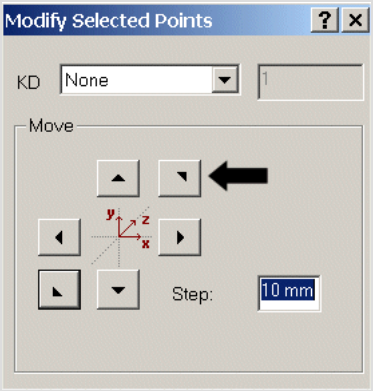
A represent the event that contains the result B made through the C command using the D curves.

Curve D, curve 2 and 3, will be automatically linked in form associative.

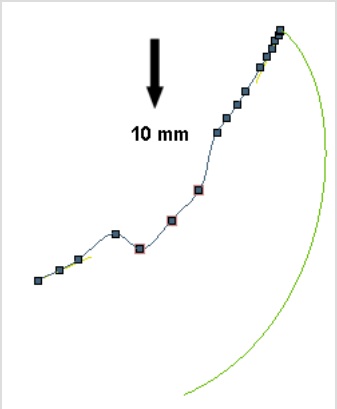
Run **Modify Curve through Interpolation Points** to change the shape of one of D. Select some interpolation points by Ctrl button.



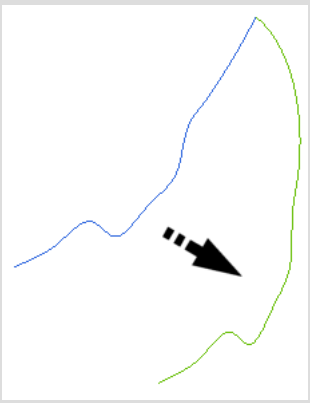
Under Tools - Step move them of 10 mm by Z direction.



This is the temporary result..

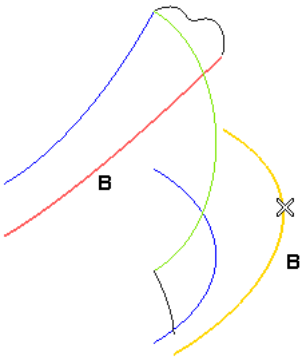


Confirm the command and hits **Rebuild Model** to recompute your changes.

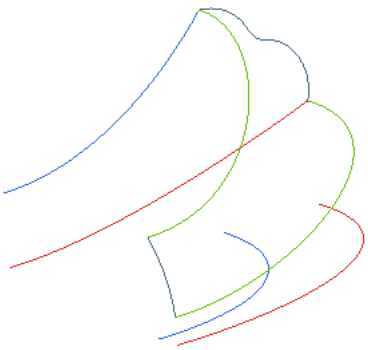


- Select the two red B planar curves.
- Start the **Two D to Three D Curve** command.
- Check ☑ Associative in the Selection List. Remember to check it in all other commands to make all associative entities.
- Select the two red planar curves (B).
- Click OK

This creates 3D curves from the top and side planar curves.



Here the result.

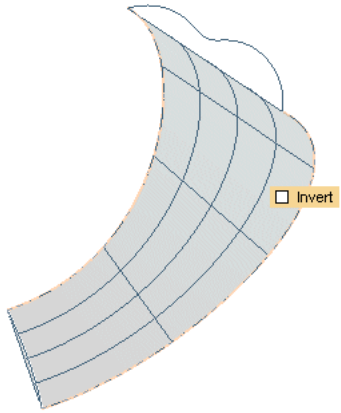


- Use the **Hide Entities** command to hide the four planar curves we just used.

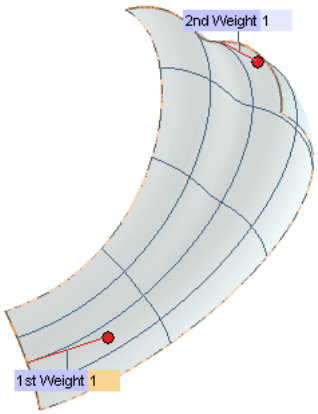
Now we will create a proportional surface from the 3D curves we created using the **Lofted Surface** command.

- Start the **Lofted Surface** command.
- Check Associative in the Selection List.
- Select the two green new curves as the Boundary Set A in the Selection list.

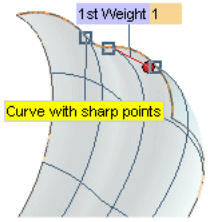
If the surface looks twisted check Invert (see image below).



- Select the two black curves as the Boundary Set B in the Selection list.
- The automatic mode will show a grid surface; change it in proportional.



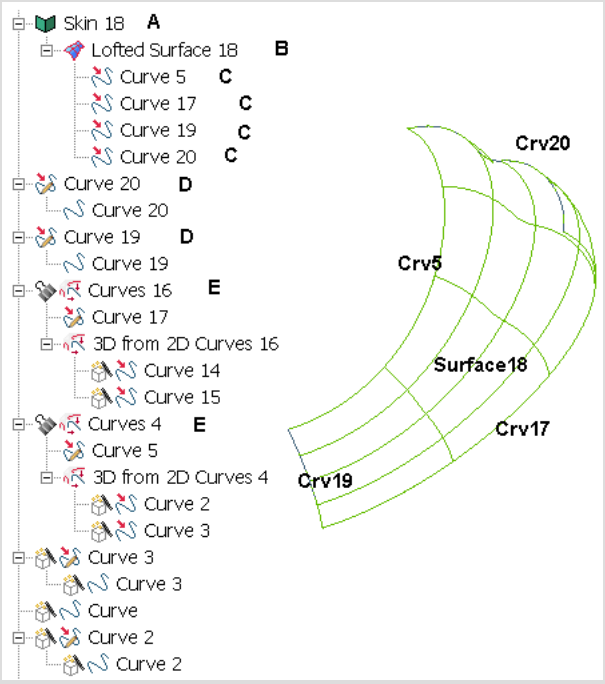
You may receive a warning message about "Curve with sharp points" displayed when the Warning icon is clicked. This warning will be show only if you use an Intrinsic mode. To eliminate this warning select the Clean Curves or the Curvilinear option from the Parameterization drop-down list in the Selection List under More Options.



- Click OK.

NOTE: Associative Surface

When you create associative events, you'll find in the history tree second a particular sequence.



A represent the main event that contains the result B made through the itself command using the C curves.

Some C curves, Curve5 and Curve17, were made previously by other associative commands (events E).

Others, will be automatically linked by D associative events. It means that these curves will have childrelobal relations.

The next step is to start creating other surfaces. We'll create one using the **Linear Surface** command. This surface will be a temporary construction surface that will be used later for blending. It will not be part of the finished model.

- Start the **Linear Surface** command.
- Check Associative in the Selection List.
- Set the Draft None, Direction X and Extent Length in the Selection List.
- Select the purple curve as the Curves in the Selection List.

- Change the Length60
- Click OK

Now we will connect (blend) these two surfaces together using the **Connect Surface** command but this command isn't associative. So will use the **Connect Lofted Surface** that permits it. This command makes the connect surface tangent to the two other surfaces. By using the construction surface to aid in tangency creation, the model will remain tangent when it is mirrored later.

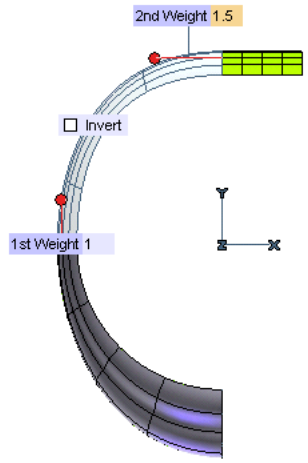
- Start the **Connect Lofted Surface** command.
- Check Associative in the Selection List.
- Select the construction surface edge and then select the proportional surface edge as the Boundaries in the Selection List.

The surface boundaries highlight as the cursor gets closer to them.

This is the reason we hid the curves. We want to make sure we pick the surface edges and not the curves!!

- Change to **Top View**.
- Change the 1st Weight1.5

This weight change modifies the blend of the connected surface relative to the surface to which it is connecting.



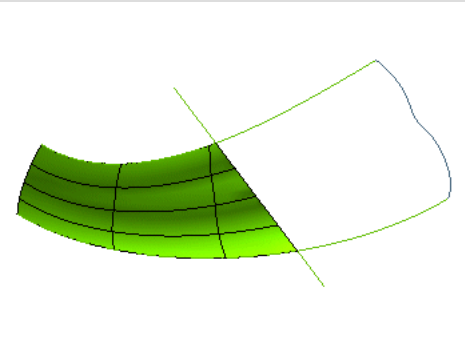
Try inputting different numbers in either weight until you get the desired shape. But don't use 0 since it will take away any tangency that may exist.

- Click OK
- Use **Hide Entities** for the linear surface.
- Hit Esc

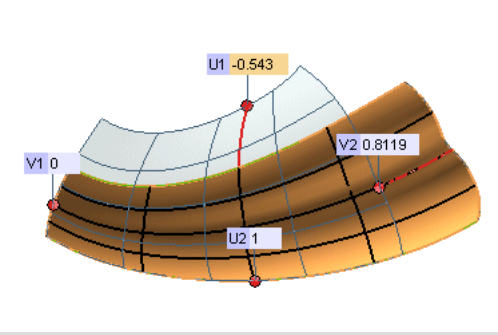
To recap: We used the linear surface purely as a construction surface so when we blended to it, it automatically made the connect surface tangent to it.

NOTE: Change Associative Surfaces

Now is possible change quickly the associative surfaces by a series commands like **Trim Surface with Limits**, changing the main entity, ...



or **Trim Extend Surface**, but....

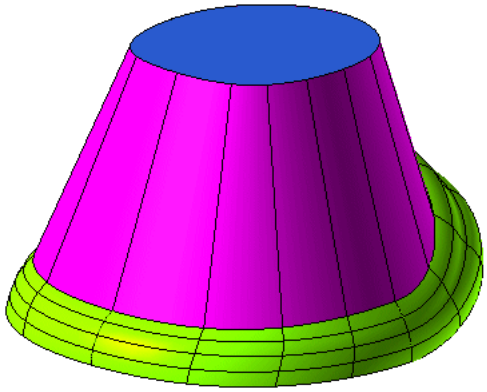


if you try to change the surfaces by **Modify Surface through Control Points** you'll obtain always a duplicated entity as result.

Next we need to add a top to the base of the cover.

2. Step 2: Adding the Top to the Cover

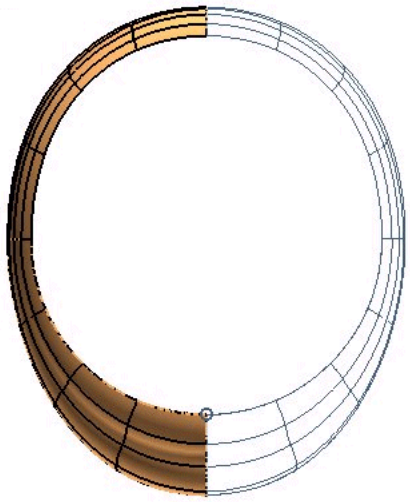
In this step we'll mirror the bottom half of the cover using the **Mirror Entities**command and create the top portion of the Toy Mower Cover using the **Linear Surface** and **Plane Surface** commands.



Now that we have half of the shape we are looking for, let's mirror it using the **Mirror Entities** command.

- Start the **Mirror Entities** command
- Select the two surfaces
- Set the Symmetry plane: Perpendicular to axis through point, change the Axis to X through point, then pick one of the corners.
- Check Copies.
- Check, under More Options, Linked Copies.
- Click OK

Since we mirrored in the X direction the two linear surfaces are tangent to each other, and all we have to do is repair the tangency between the two proportional surfaces.

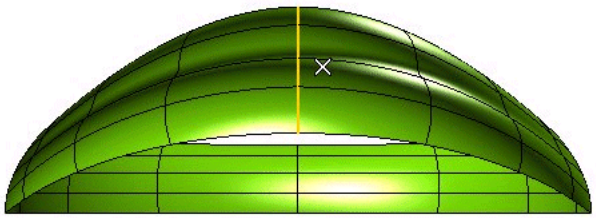


If we take a look at the front view, we can see that the surfaces aren't perfectly tangent; we haven't impose it before. So we'll use the **Surface Continuity** command to fix that.

- Change to **Front View**
- Start the **Surface Continuity** command.
- Check Associative in the Selection List.
- Set the Degree: Tangency and Method: Adjust both in the Selection List.

Using Adjust both will make both surfaces tangent at the same time, but the intersection where they mate will stay the same.

- Now select both of the front surfaces towards the middle as the Surface to be modified in the Selection List.
- Hit Yes to both of the "Convert to NURBS?" pop-ups and then click OK.

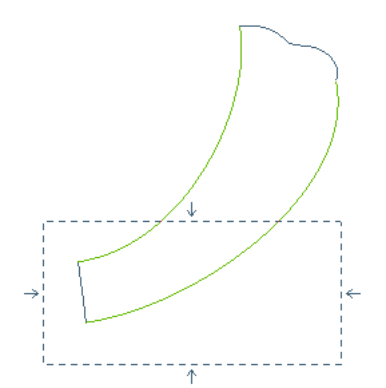


NOTE: An other approach

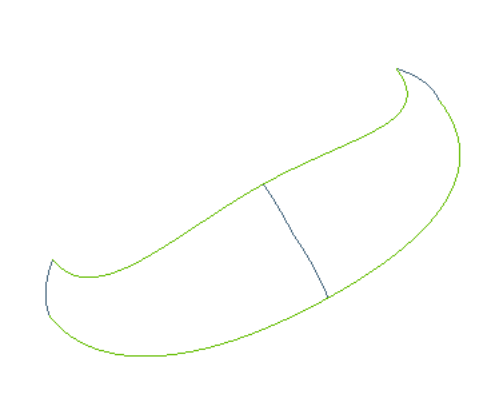
Generally in these object let's made a part and replicate it by Mirror command in the other half sides.

We be carefull especially in the symmetry plane to obtain the better continuity, G1 (tangent) for i.e.

Some times, as shown below, could be interesting an other approach by the new improvement in the Global Sweep command. Follow these steps.

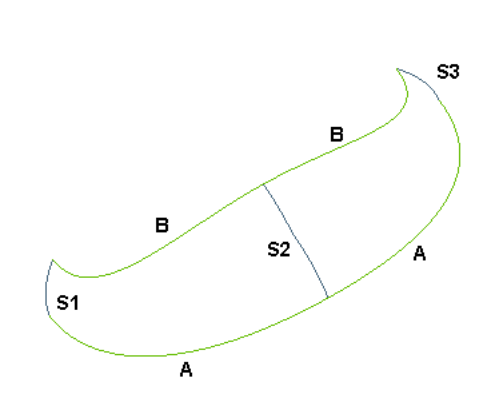


Mirror the 3 curves in the opposite side.

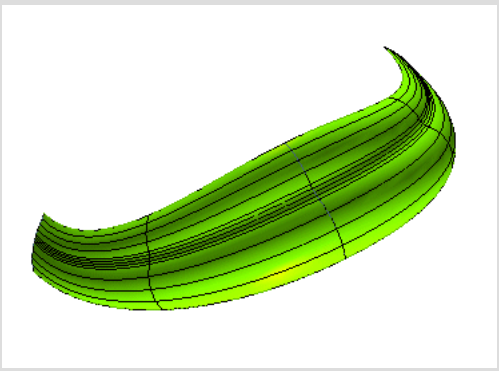


Run Global Sweep.

- Select A curves as the Drive Curves.
- Select S1 curves as the Curves 1 under Section Group(s) 1.
- Select S2 curves as the Curves 2 under Section Group(s) 2.
- Select S3 curves as the Curves 3 under Section Group(s) 3.



- Choose Bi-driven under Motion Mode.
- Select B curves as the Second Drive curves.
- Hit Preview and OK.



The base surfaces are all set. Next we need to create a couple of surfaces for a cover. The first surface we'll create using the **Linear Surface** command.

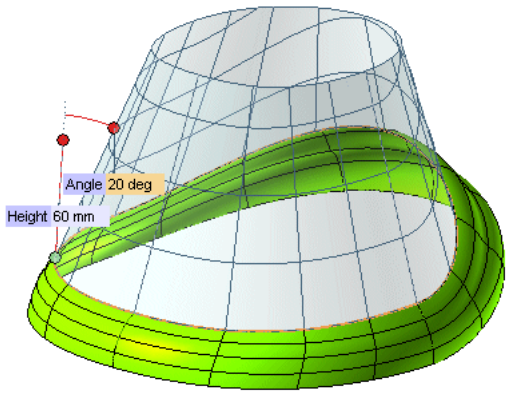
- Change the color to something different.

This is to help distinguish between the different surfaces.

Change to **Left Back View**.

- Start the **Linear Surface** command.
- Check Associative in the Selection List.
- Change these settings in the Selection List: Draft Angle, Direction Z and Extent Height.
- Select the four edges that are located on the edge of our base surfaces as the Curves in the Selection List.
- Change Angle20 and Height60 .
- Click OK.

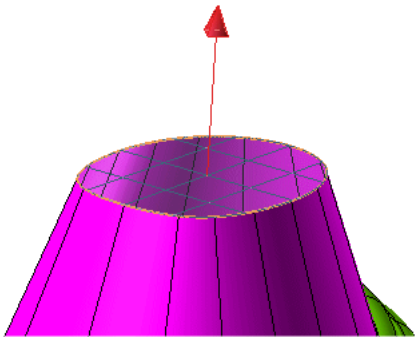
Make sure the angle is going inward and not outward. If it is going out, right click on the Angle mini dialog and select Invert.



Now we'll use the **Plane Surface** command to cap off the top of the model.

- Change the color to something different, to distinguish between the surfaces.

- Start the **Plane Surface** command
- Check Associative in the Selection List.
- Select the top four edges of the linear sweep surface we just created as the Boundaries in the Selection List.
- Click OK

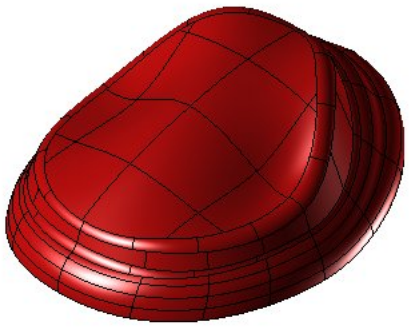


Changing the parameters on the Linear surfaces, redefining the feature, will have an automatic update of planar linked surface.

Since we have all the surfaces we need, the next step is to make this model an actual solid in thinkdes.

3. Step 3: Converting to a Solid

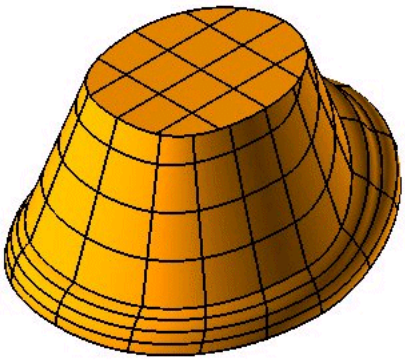
In this step we are going to convert the surfaces into an associative open solid and create a surface for the top shape of the cover using the **Make Solid** command. By making the outer shape and the top shape of the cover solids, we will be able to use **Trim Surface with Limits** to create the final shape we want. Finally, we will add thickness to the solid using the **Solid Shell** command.



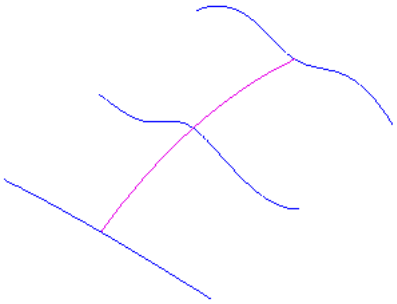
In this step we'll use the completed surfaces and turn them into an open solid using the **Make Solid** command.

- Start the **Make Solid** command.
- Select all the Skin surfaces as the Surfaces or Solids in the Selection list.
- Check Associative in the Selection List and click OK.
- Select Continue when the warning dialog appears.

This "open solid" warning was expected due to the fact that the part has no bottom -- these edges are highlighted when the error occurs.

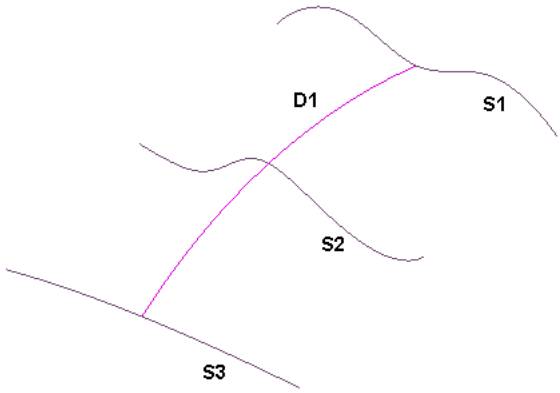


- Change the color to something different.
- Use **Hide Entities** to hide the main solid we just created
- Make Layer 1 Visible.

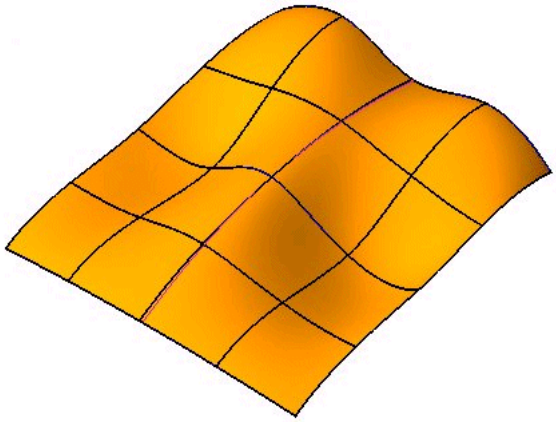


The base surfaces are all set. Next we need to create some surfaces for a cover. We will create the first surface using the **Lofted Surface**, **Spined Surface** or Global Sweep command. Let's prefer now Global Sweep because will be the better mode if you need, next time, to change completly the inner sections.

- Start Global Sweep command.
- Select D1curves as the Drive Curves.
- Select S1 curves as the Curves 1 under Section Group(s) 1.
- Select S2 curves as the Curves 2 under Section Group(s) 2.
- Select S3 curves as the Curves 3 under Section Group(s) 3.



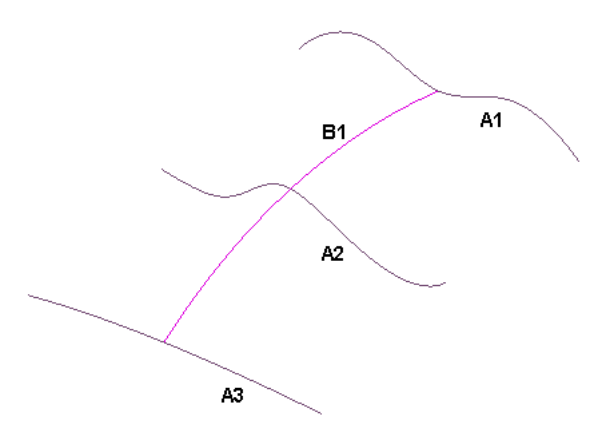
- Choose Along one planeunder Motion Mode.
- Check Associative.
- Hit Preview and OK.



NOTE: Other approaches

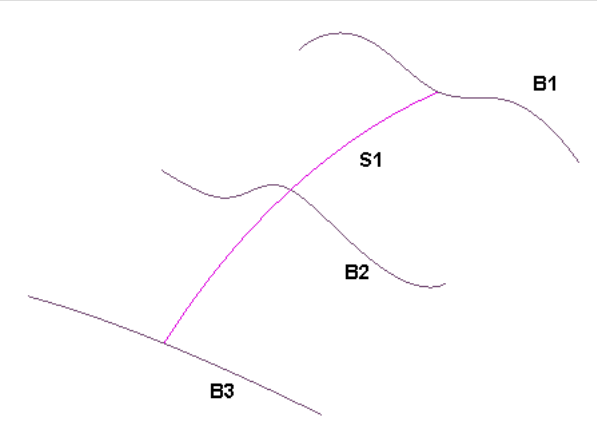
Generally we create the basic surfaces to obtain the first shape. Using Associative mode we need to understand better which commands to use. What is the better command in our geometries? Let's try ors.

- Start the **Lofted Surface** command.
- Check Associative in the Selection List.
- Select in order the A1 - A2 - A3 curves as the Boundary Set A in the Selection list.
- Select the B1 curve as the Boundary Set B in the Selection list.
- The automatic mode will show a Grid surface.
- Click OK

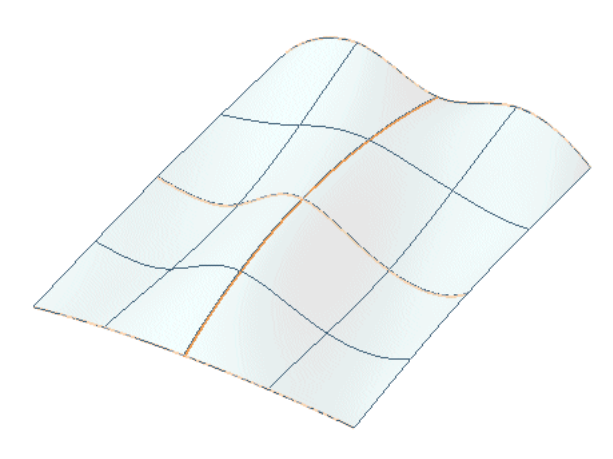


Other mode.

- Start the **Spined Surface** command.
- Check Associative in the Selection List.
- Select the S1 curve as the Spine in the Selection List.
- Select in order the B1 - B2 - B3 curves as the Boundary in the Selection List.
- Hit the More Options and select Blending: Hermite in the Selection List.
- Click OK



The result could be same if you use a traditional surface modeling. Now with Associative entities you can have different parameters to obtain other behaviours in the inner shape.



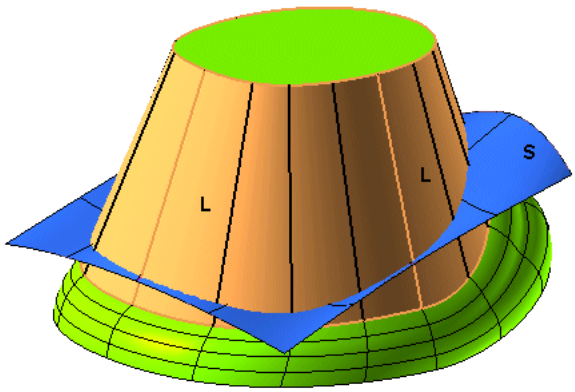
By Spined Surface, be careful while modifying the control point not to snap to the existing model geometry. The curve MUST stay parallel to the work plane!! By snapping to other geometry the curve will no longer be on the same work plane and the original command that created the shape will no longer work.

Image that need to replace one or more sections with news. With these two commands you must always unselect and redefine the sections starting from the chaged to forward.

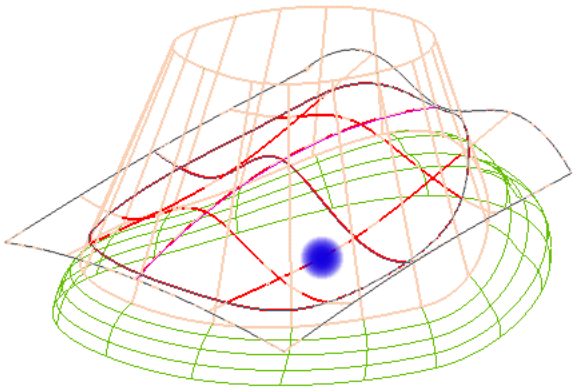
By Global Sweep instead you have only to redefine the changed sections.

With new improvments is possible trim skins without using the Boolean Operation between open solids.Let's use **Trim Surface with Limits** imaging we have to trim simple surfaces.

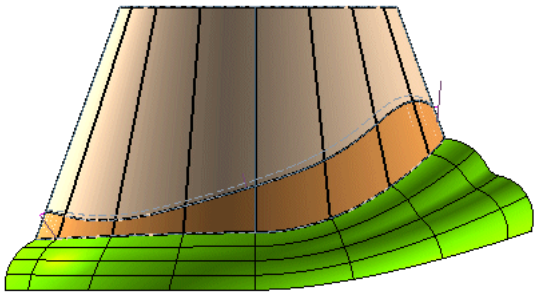
- Run **Trim Surface with Limits** command.
- Check ☑ Associative.
- Select the L skins, linear surfaces, as the Limits in the Selection list.
- Select the S skin, sweep surfaces, as the Surfaces in the Selection list.



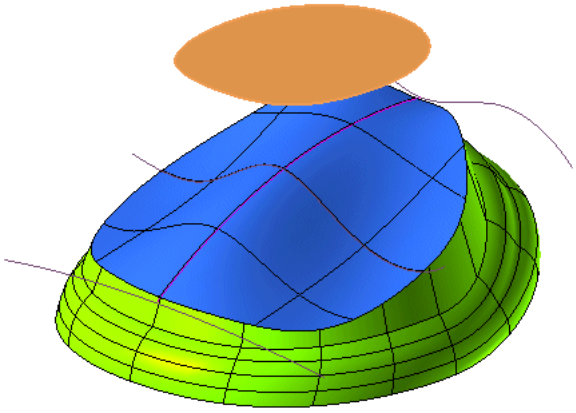
- Pick the inner side of the S skin as the Regions to Keep.
- Click OK



Use again **Trim Surface with Limits** where as Limits is the splitted Skin and the Surfaces are the four draft linear Skins. Keep the bottom sides.



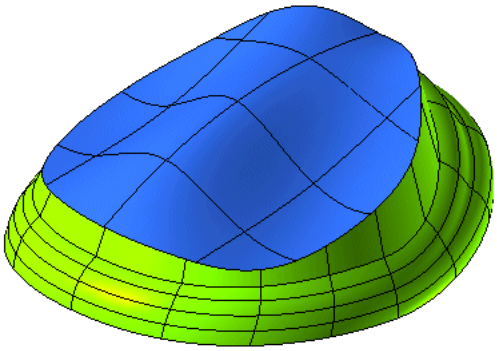
After having cut the skins, now let's remove the plane from solid by **Break Solid** in Local mode. Also in this case is important to active ☑ Associative option to keep this feature in the hybrid modeling. Use **Hide Entities** to deactive it.



This was expected due to the fact that the bottom is still open and that there is no thickness to the model.

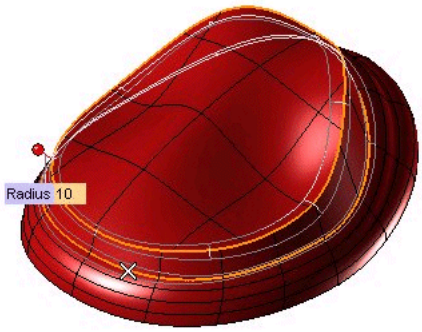
- Start the **Make Solid** command.
- Select all skins as the ◉ Surfaces or Solids in the Selection list.
- Check ☑ Associative in the Selection List and click ✔ OK.

- Select Continue when the warning dialog appears.



Time to add a little bit more flavor to the model by using the **Fillet Edges** command.

- Start the **Fillet Edges** command and select the two edges shown below.
- Change the Radius8
- Click OK

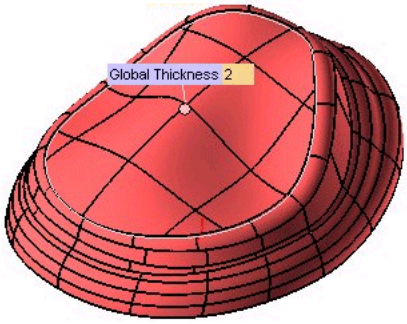


The model is shaping up, but what is a solid without thickness? Let's use the **Solid Shell** command to fix that.

- Start the **Solid Shell** command.
- Change the Mode to Add Thickness and select the model as the Solid in the Selection List.
- Make the Global Thickness2

We want to create thickness inside of the model -- that was the purpose of checking the normals earlier.

- Click OK
- Use **Hide Entities** to hide all of the dimensions



We've created a nice looking solid. Now lets add some additional features to it and see what happens if we need to modify it.

4. Step 4: Modifying the Solid

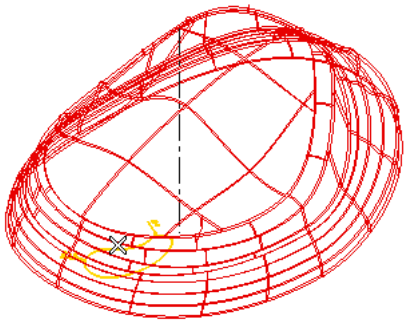
In this step we will add a hole as a vent in the cover using the **Linear Slot** command. We will then use the **Pattern Solid** command to create multiple vents in the cover. Finally, we will modify one of the original curves using the **Modify Curve Control Points** command and see how the solid automatically updates.

We will add some vent holes in the cover. We'll use a profile from another layer and then use the **Linear Slot** command to create the vent.

- Make Layer 2 Visible.
- Start the **Linear Slot** command and select the profile as the Profile in the Selection List.

New paragraph. Replace this text.

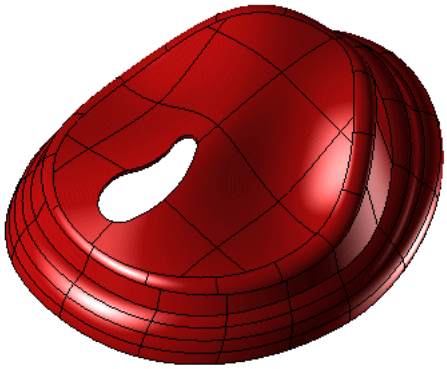
It might be easier to temporarily switch to a **Wireframe View** to select the profile.



- Make sure the Extension Thru all is set and select the top face as the Face in the Selection List.
- Right Click in the Graphics area and select Both Sides in the Context menu.

This is done to make sure the slot goes thru the solid.

- Click OK



One vent just won't do, so let's use the **Pattern Solid** command to create more vent holes.

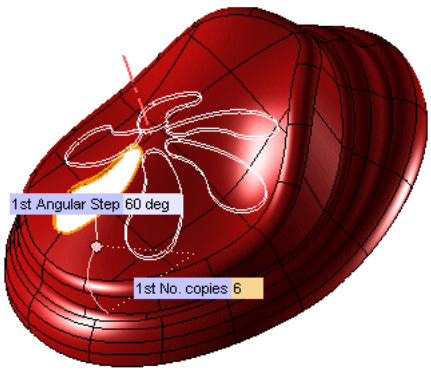
- Start the **Pattern Solid** command.
- Select Type: Angular and Placement: Fixed in the Selection List.

We are using Placement: Fixed since we are assigning a fixed number of vents.

- Select the vent face we just created as the Base Entities from the Selection List.

Select the vent face, the vent edge or directly the feature in the history tree, better to get an accurate selection.

- Select the reference line from Layer 2 as the 1st Axis Line in the Selection List.
- Set 1st Angular step60 and 1st No. copies6 , and then click OK

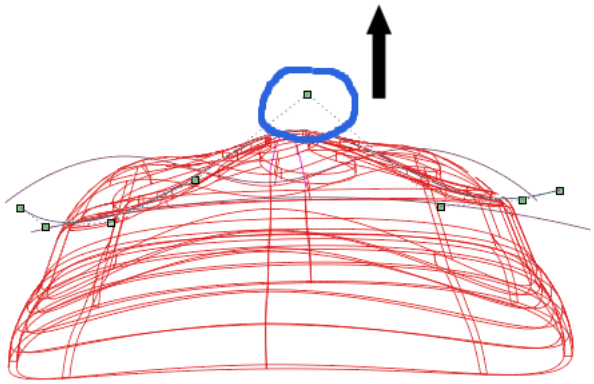


What would happen if you have to change the shapes? Let's prepare.

- Use **Hide Entities** to hide everything but the solid.
- Make Layer 1 Visible

- Change to **Wireframe View**.
- Right click on the middle blue curve and select Modify Curve through control points.

- Change to the **Back View** to get a better perspective of the changes.
- Modify any one of the control points by clicking and dragging it. Moving control point keeping pressed X, Y or W, let's move them in X, Y or Z direction or press more times X, Y or W.



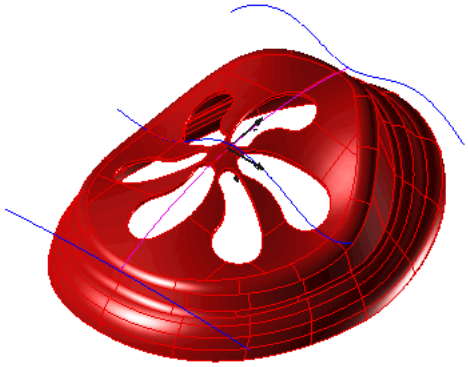
- When you click OK a message could appear informing that the curve will be duplicated. Need to use **Redefine Feature** to replace it. Instead..
- ... if in the command will be checked Update Dependencies, instead, the main curve will be changed automatically.

Using Update Dependencies means that you'll lost the orginal shape that will be replaced by a new.

Now let's see the effect this modification had on the model.

- Change back to the **Shaded View and Boundaries**.
- Rotate the model to get a better perspective.
- Click **Rebuild Model**.

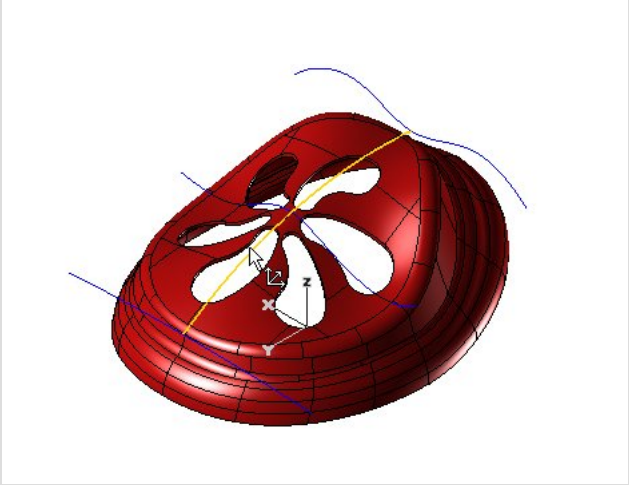
Place the mouse over the image below to see it update.



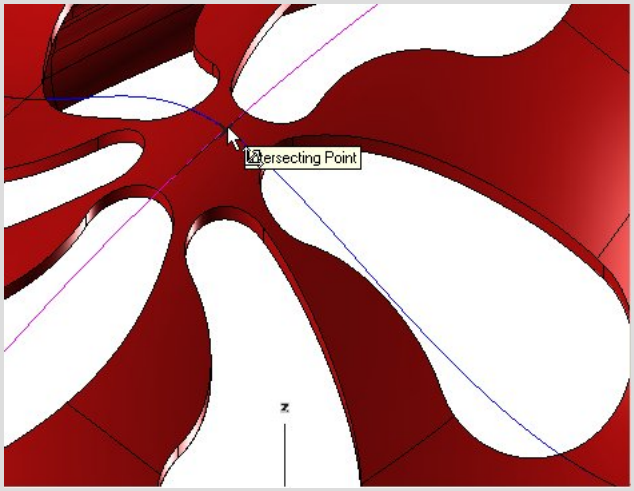
NOTE: If Spined Surfaces?

A series of steps if you chosen the Spined Surface.

- Select **Edit→Work Plane→Edit**
- Select the purple long curve as Set On Entity and drag the handle to 0.5.



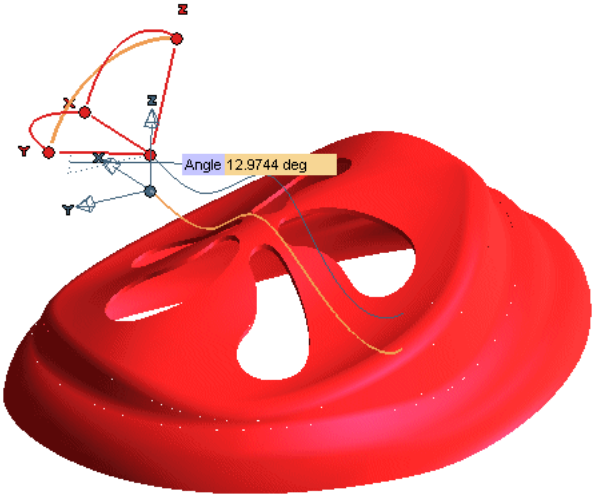
We changed the work plane location because the curve editing process has to be parallel to the plane where lies the curve.



With the setup out of the way, we can move on to the editing.

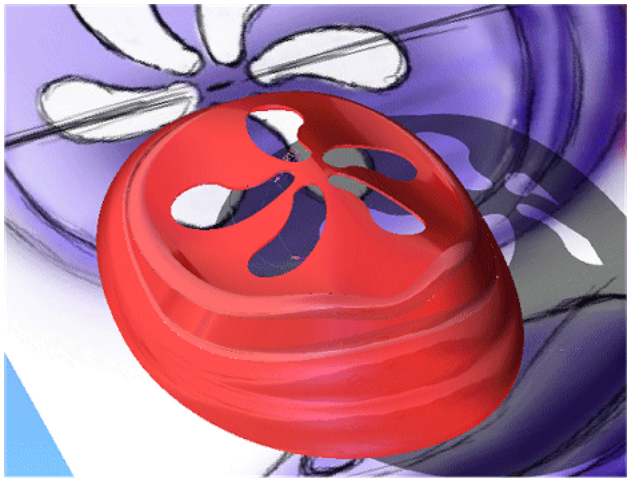
- Change to **Wireframe View**.
- Right click on the middle blue curve and select Modify Curve through control points.
- Change to the **Back View** to get a better perspective of the changes.
- Modify any one of the control points by clicking and dragging it. Moving control point keeping pressed X or Y, let's move them in X or Y. Not move on Z direction because isn't possible to manage it in Spined Surfaces.
- Click OK and **Rebuild Model**.

Other possibility to modify associative entities could be moving the linked curves in the space. Be carefull, when change these entities, to keep the right rules to valide the command used.



- Use **Hide Entities** to hide everything but keeping the solid.

Actually, we would have liked to use the **Save** or Save As command to save the model before the changes were made, but for this example it is OK.



All Done! We have an original looking motor cover and we are able to make additional changes at the drop of a hat due to the associativity of the curves to the surfaces and solids used to create this part.