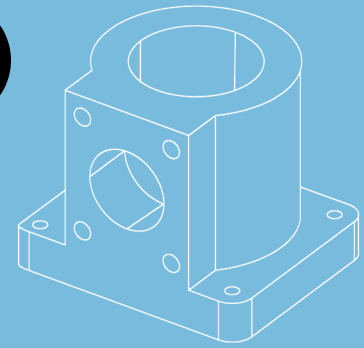


13

Surfacing Wireframe Models

This chapter introduces wireframe surface modeling, one of the key uses for surface modeling. You learn an approach to a surfacing project and techniques for achieving the designer's intent. The tutorial provides instructions for surfacing a wireframe model of a pump housing. The wireframe is the outline of a pump housing, the only data you have to work with.

You should already know how to create surfaces before you begin this lesson. If you do not, complete the exercises in chapter 12, "Creating and Editing Surfaces."



In this chapter

- Studying the design intent and developing a strategy
- Identifying logical surface areas
- Identifying base surface areas
- Using creative techniques to surface a wireframe model
- Verifying surfacing results

Key Terms

Term	Definition
base surface	A basic underlying surface that carries a shape across a larger area. May be trimmed to precise shapes as needed but the base surface remains intact and may be displayed.
logical surface area	An area that can be described by a single surface.
projected wire	A 2D line that represents an opening on a surface and trims a hole in the surface. May also be a 3D polyline that represents the extents of the opening in the wireframe.
watertight	Surfaces conform to the wireframe model and gaps between surfaces are within allowable tolerances.

Key Concepts

A completely surfaced model is a single electronic master suitable for engineering and manufacturing activities, such as

- Generating accurate sections for engineering and packaging studies.
- Providing input for finite element modeling and analysis.
- Producing shaded renderings for marketing.
- Providing input for rapid prototyping equipment.
- Supplying rotated surfaces for tool, mold, and die design.
- Supplying surfaces for numerical control machining of models and tools.

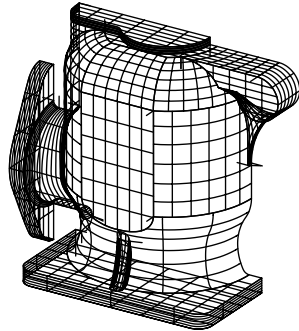
Building on your knowledge of surface types, you examine the wireframe to be surfaced and determine which surface will produce the best results.

Discerning Design Intent

Because wireframe models have complex shapes, they are almost always made up of many surfaces joined together. For a model like the pump housing, you will use many different individual surfaces to completely define it. When you surface a wireframe model, you are really completing its design.

Before you begin, you analyze the design and make some decisions so that you can achieve your design goals. Although it is tempting to simply begin modeling, this process can help avoid errors. In general:

- Study the data to understand the design intent.
- Identify the location and extent of each surface area.
- Identify the base surface area(s) that may be later trimmed to adjacent surfaces and wires.
- Determine where you can use trimmed planar (flat) surfaces.
- Decide on the best surface types and approach for combining them.
- Create additional geometry as needed to resolve problem areas.
- Verify your surfacing results.
- Add the finishing touches to a watertight model.



Review the wireframe in detail, to discern where you will have design challenges. Consider the following:

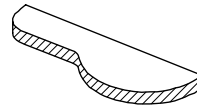
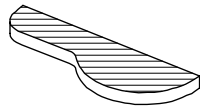
- The complexity of the surfaces you need to create. For example, what curvature is required of surfaces? Is it sufficient to have surfaces with no curvature (such as ruled surfaces), or will you need surfaces with multiple curvatures?
- How you can simplify shapes. Surfaces created from polylines or splines with a large number of points are unnecessarily complex and greatly increase computation time.
- Which surfaces are continuous. Continuous surfaces are smoother and take less time to compute. You can set preferences to prevent lines with breaks or changes in curvature from being converted to splines.
- Whether default preference settings are appropriate for the model. Allow as much tolerance as is practical to avoid converting polylines to splines. Splines take longer to compute than polylines, a factor that becomes more important with complex models.

Identifying Logical Surface Areas

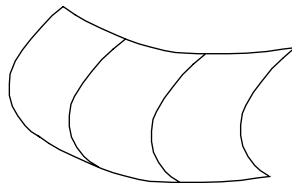
Now that you know the intent of the pump design, you have an idea of the requirements that affect its shape and how you can construct it. Try to identify the location and extent of each logical surface area, an area that can be described by a single surface.

A surface must be smooth and free from sharp breaks. Often, an individual surface area is clearly defined because it is surrounded by sharp break lines on all sides. The pump top is clearly a surface because it is surrounded by sharp edges on three sides, and the fourth edge is the end of the part.

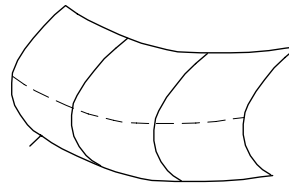
Likewise, the side of the top part of the pump constitutes a single surface. Each of these two surface areas requires a surface because no single surface could cover both.



Surfaces may contain multiple wires.



wireframe

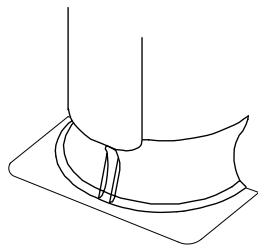


surface

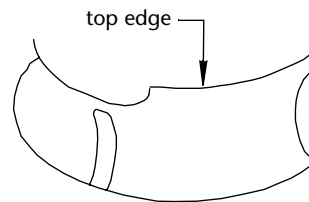
All lines inside the four boundaries share the same smooth curvature as the boundary edges. There are no abrupt curvature changes, so the goal should be to surface the entire area with a single surface, using the additional wires to constrain the surface shape.

Identifying Base Surface Areas

The bottom of the pump housing appears to be a smoothly curved area. However, at the top edge, there is an almost 90-degree bend. Also, a flanged area is formed by a slot opening in the otherwise smooth area.



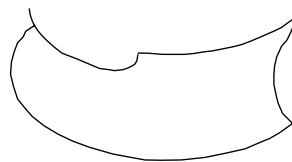
pump housing



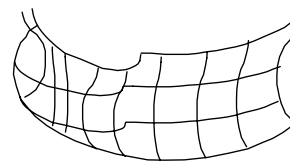
close-up

TIP The primary guideline in wireframe surfacing is to create an acceptable surface first. Later, add a hole by trimming the surface with the shape of the hole.

In general, use only smooth wires to create surfaces. When you use a wire with sharp corners, those sharp areas do not produce an acceptable surface.

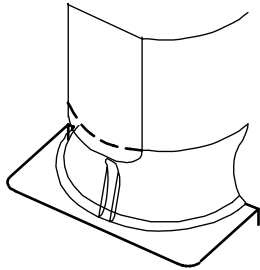


wireframe

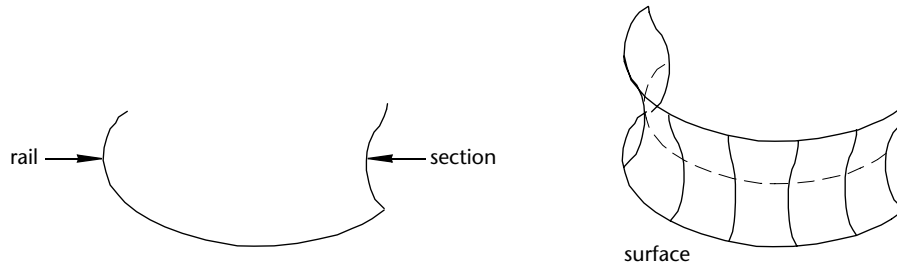


unacceptable surface

Therefore, you need to find some other way to surface the area. Consider the area again, looking for the design intent. A second look reveals a flat surface on the front of the pump housing that intersects a smoothly curved surface at the bottom.

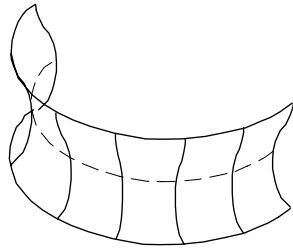


How do you know that the front surface is flat? One way to check is to look at the top line in another view to confirm it. Thus, the approach to surfacing that area is to create the smooth bottom surface and the flat surface. Then intersect one with the other and create a wire at their intersection. If the new wire that the intersection creates is the same as the existing wire in the wire-frame model, you have confirmed that you were correct in your observation and surfacing approach.

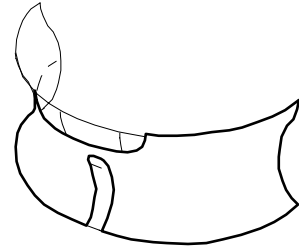


Next, consider the bottom surface. You already know that you cannot use the top wire because it has an abrupt corner. A good approach would be to use only the bottom wire as a rail, and the far edge as a cross section.

A surface like this one is a basic, underlying surface that carries a shape across larger areas. In the Mechanical Desktop, this surface is referred to as a *base surface*. Even after many areas of the surface are trimmed away, the underlying base surface remains intact and may be displayed at any time with the Surface Display dialog box.



base surface



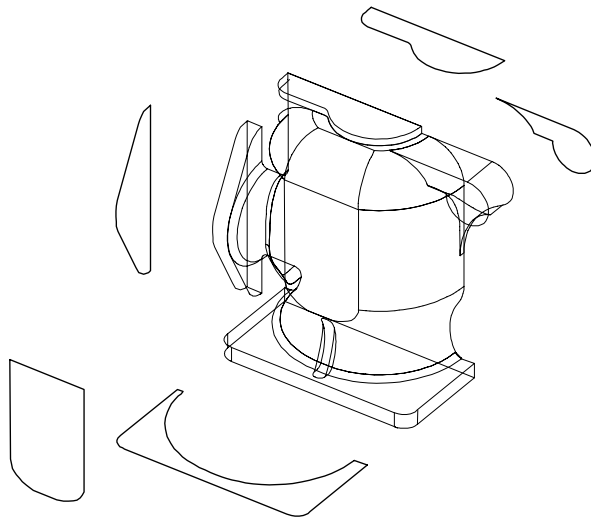
trimmed surface

The ability to identify base surfaces quickly is an important part of wireframe surfacing. Another good approach is to quickly categorize surfaces by type and eliminate unsuitable ones from further consideration.

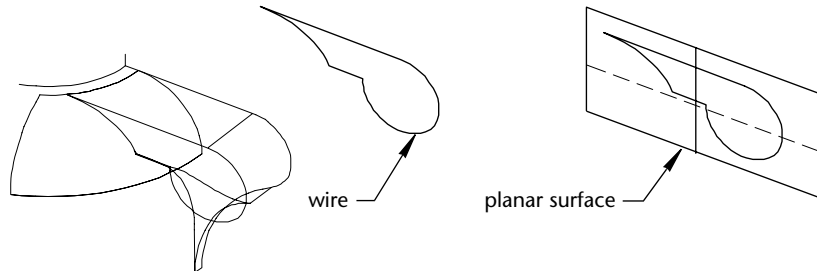
TIP To get shapes you can use for creating surfaces, you may need to break polylines into segments. Then, combine selected segments to form boundaries for individual surfaces.

Using Trimmed Planar Surfaces

Use a trimmed planar surface for an area that you know is a flat plane. By glancing at the pump model you can see areas that appear to be flat and can be surfaced with trimmed flat planes.



If you are in doubt about whether a given area is flat, try to make a planar surface. A planar surface requires a single closed wire as its boundary.



If the wire is *not* a closed single loop, when you select it you can see the breaks in the wire.



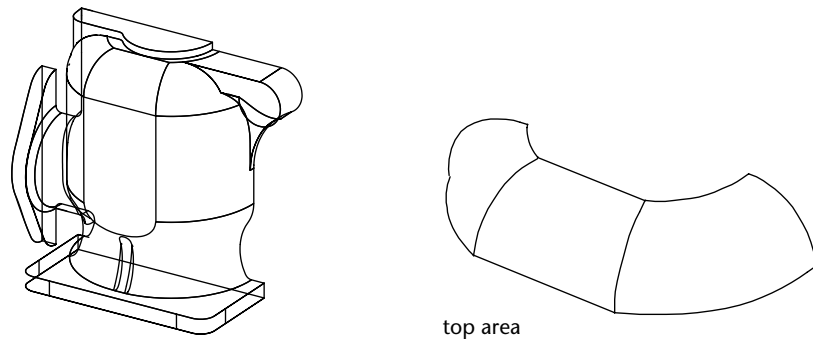
You can join line segments into a closed wire that forms the boundary of a planar surface. The surface is trimmed to the boundary shape.

NOTE When joining line segments, set tolerances to compensate for imperfect wireframe data that would otherwise cause the surface to fail.

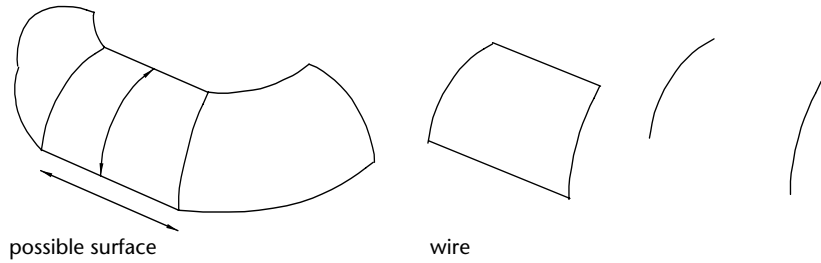
You must judge if a given area was meant to be flat. If it is flat within the tolerance, create a perfectly flat surface and adjust the edges accordingly.

Choosing a Surfacing Method

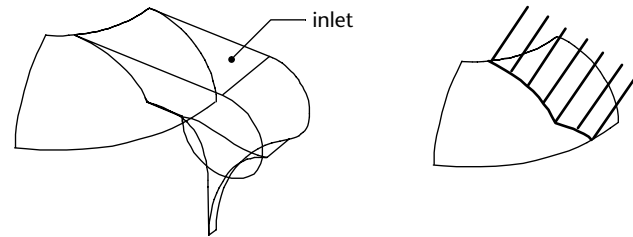
It may not be clear which type of surface is best suited for a given area.



In this example, the top area of the pump is not suitable for a single surface because there are abrupt changes in its smoothness. The center area is curved in one direction but straight in the other. When you have a surface area that can be defined by a straight line between two curves, you can create a ruled surface between the two curves.



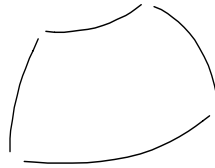
Look beyond the obvious visible surface to find a workable solution. Because the inlet at the right top area of the pump extends from the surface, consider making the base surface first and then trimming it to the correct shape.



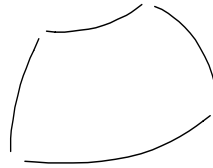
With the inlet shape removed, you can see possibilities for surfaces. The shape created by the four wires contains a sharp corner. Avoid creating a surface from these four wires because they might produce a surface that is not smooth.



You can see that each end of the area beneath the inlet is described by lines with curvatures in both directions. This offers you a choice of surfacing methods, such as a swept surface or a lofted UV surface.



swept surface

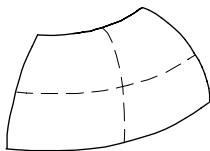


lofted UV surface

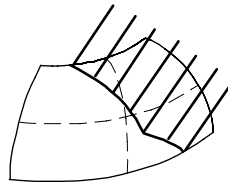
In most cases, there is more than one way to surface an area. Try both methods here, compare the results, and choose the one that produces the better result.

- Swept surfaces give you more control over the shape of the mid-portion of the surface.
- Lofted UV surfaces have fewer controls but risk is minimized.

Once you create a base surface to cover an area, trim the surface back to the wire with the abrupt edge.



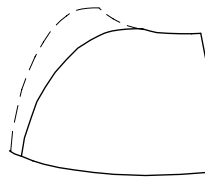
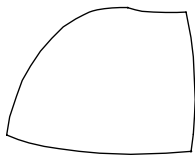
base surface



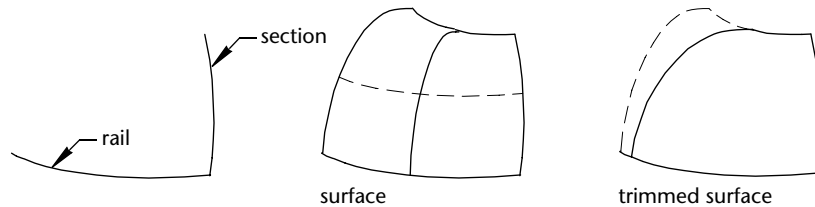
trimmed surface

Use trimmed surfaces to create smooth underlying base surfaces that remain a permanent part of a surface definition. Trim to constrain the edges and you achieve smoothness in a base surface that contains no abrupt corners in its boundary wires, yet creates a logical surface bounded by different edges. The logical surface can contain any number of sharp corners, which have no effect on the smoothness of the base surface.

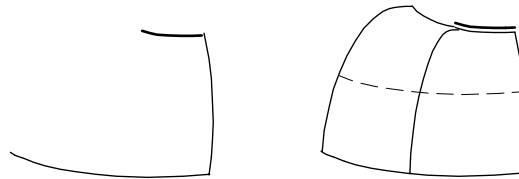
The opposite side of the pump top area may also be surfaced several ways. Again, the surface is really a larger surface cut short by an intersecting area of the pump. This time, the wire that terminates the surface has no abrupt corners, so it could be used as one of four sides of a swept or lofted UV surface.



The easier method in this tutorial uses a single rail and a single section to surface the entire area and then trims the base surface to the intersecting part of the pump.



This choice might not always be correct. As you gain experience, you can predict which approach would yield the most accurate results. In the previous example, you should verify that the surface created without the top line matches the top line within a reasonable tolerance.



Always check the fit between a newly created surface and existing wires to be sure that you are not deviating too far from the wireframe data. If the new surface is not within tolerance to the existing top line, the surface does not accurately reflect the wireframe. You can re-create it using all four wire edges.

Verifying Surfacing Results

As you gain experience, you will see the importance of learned skill and judgment. Your challenge is always to produce smooth surfaces that fit the wireframe closely and are not unnecessarily complex.

There are a number of ways to judge the smoothness of surfaces:

- Create and review flow lines in different rotated views.
- Cut sections through a complete set of surfaces, and then examine the ends to see how closely they match at the edges.
- Shade or render a surface. However small deviations in surface smoothness may go undetected because the rendering software is designed to smooth the rendered model.
- Create augmented flow lines with long vectors on the surface and examine the smoothness of the vector ends. The ends of the vectors greatly exaggerate the smoothness of the surface, and areas where it is not smooth will become apparent.

Surfacing a Wireframe Model

Now that you have analyzed approaches to surfacing the pump housing and practiced surfacing techniques, you are ready to surface the pump in sections.

A surface modeling project may begin with a wireframe, whether it is a DXF or an IGES file from a client or a 2D or 3D CAD design you created yourself. In order to describe the 3D object, most designers begin with a 2D drawing.

In this lesson, you create surfaces for an actual part, a wireframe model of a hydraulic pump. The surfaced model provides the manufacturer with information used to create prototypes or to NC-machine the actual patterns, molds, and tooling.

To set up your file

- 1 Copy the *t_pump.dwg* file.

TIP It is good practice to copy tutorial files so that you can always open the original drawings. That way, any mistakes you make while you are learning will not replace the master tutorial files. For more information about how to copy tutorial drawing files, see “Copying Tutorial Drawing Files” on page 34.

- 2 Choose Surface ► Preferences.
- 3 In the Desktop Preferences dialog box, select the Surfaces tab. Specify:

Surface Properties:

U Display Wires: *Enter 5*

V Display Wires: *Enter 5*

Surface/Spline Options:

Polyline Fit Length: *Enter 1*

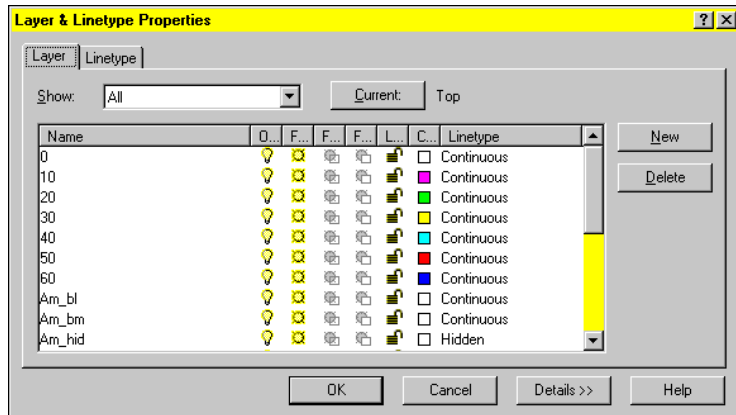
Polyline Fit Angle: *Enter 150*

- 4 Choose Model Size, then Measure Model.

The size 4.7223 inches is displayed. Choose OK twice to exit the dialog boxes.

These settings affect the visual representation of the surfaces and the size of the surface normal.

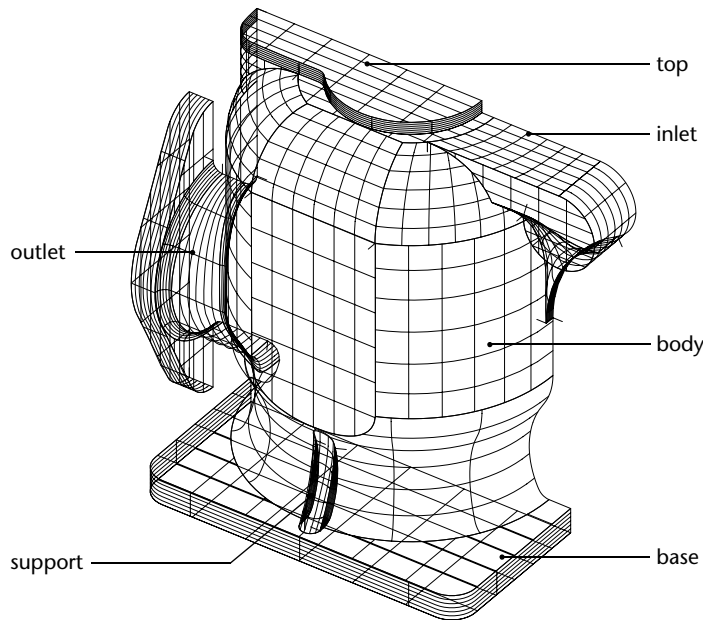
Choose Assist ► Layers and Lines.



- 5 In the Layer and Linetype Properties dialog box, select the Layer tab. Select layer 10, and click Current.
- 6 Press SHIFT and select layer 20 and the last layer. In the second column, click F to freeze all selected layers. Then freeze layer 0.

All layers except Layer 10 should be frozen (snowflake icon). Only Layer 10 is thawed (sun icon).

Choose OK to close the dialog box.

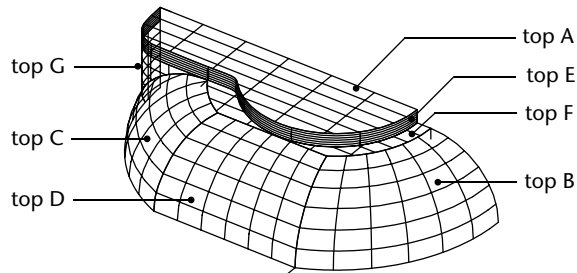


The labeled parts of the pump are on separate layers. As you work on each one, you make its layer current and freeze other layers to make them inactive.

Creating Trimmed Planar Surfaces

Begin by surfacing the top section of the pump model, creating the individual surfaces. Top A is a planar surface because it is flat with sharp edges. Tops B and C are swept surfaces, bounded by curved wires. Top B uses two curves and two rails, and top C uses only one curve and one rail. Later you trim top C surface where it extends beyond the wireframe boundary.

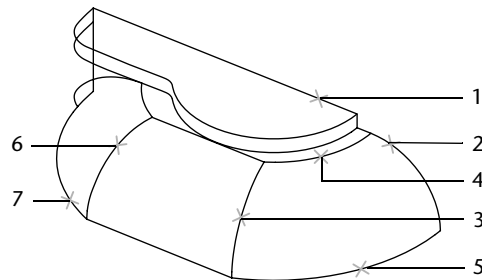
TIP As you gain experience using the menu selections that correspond to commands in this lesson, you begin to use shortcuts. For a list of shortcuts that automate selection of menu options and commands, see “Using Accelerator Keys” on page 28.



TIP For a trimmed planar surface, the surface must be a single polyline that lies in a single plane. If the wireframe is composed of multiple polylines, you must join them into a single polyline before you create the surface.

To create the top A, B, and C surfaces

- 1 Use ZOOM to enlarge the view.
- 2 Choose Surface ► Create Surface ► Planar Trim.
Select wires: *Select wire (1) and press ENTER*



A planar surface, trimmed to the boundary of wire (1), is created on the top of the model. Next, create the top B surface.

3 Choose Surface ► Create Surface ► Sweep.

Select cross sections: *Select wires (2) and (3) and press ENTER*

Select rails: *Select wires (4) and (5)*

In the Sweep Surface dialog box, specify:

Transition: *Scale, then OK*

4 Choose Surface ► Create Surface ► Sweep.

Select cross sections: *Select wire (6) and press ENTER*

Select rails: *Select wire (7) and press ENTER*

In the Sweep Surface dialog box, specify:

Orientation: *Normal, then OK*

The surface extends beyond the far side of the top. You trim it later.

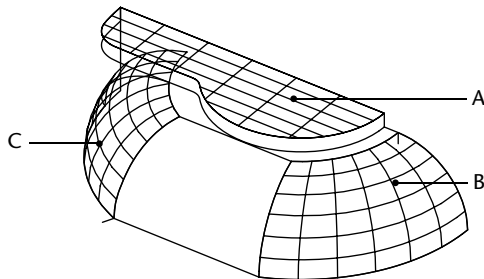
5 Use CHPROP to move surfaces A, B, and C to the TOP layer.

Select objects: *Select surfaces (A), (B), and (C) and press ENTER*

Change what property (Color/LAYER/LType/ltScale/Thickness): *Enter La*

New layer <10>: *Enter top*

Change what property (Color/LAYER/LType/ltScale/Thickness): *Press ENTER*

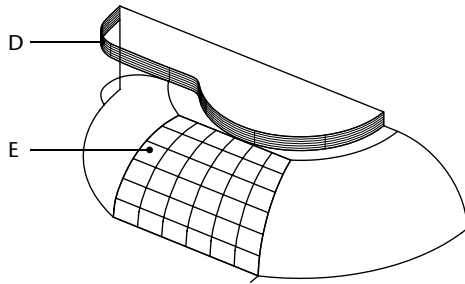


The surfaces are now on the TOP layer. Because the TOP layer is frozen, you cannot see the surfaces, although the wireframe is still visible.

6 Use REDRAW to refresh the display.

7 Save the file.

The D and E surfaces are ruled surfaces.

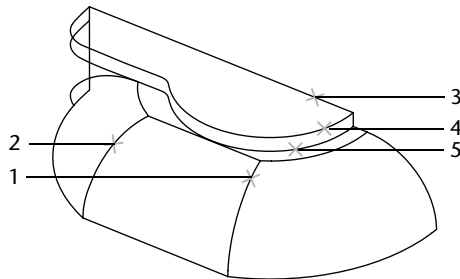


To create the top D surface

1 Choose Surface ► Create Surface ► Rule. Create the top D surface.

Select first wire: *Select wire (1)*

Select second wire: *Select wire (2)*



2 Use BREAK to create a separate line segment for the top polyline, line (4).

Select object: *Enter end*

of: *Select line (3)*

Enter second point (or F for first point): *Enter @*

TIP Unless you enter @, the adjoining portion of the polyline is deleted. The @ symbol breaks the polyline at the specified location and retains both segments.

To create the top E surface

- 1 Choose Surface ► Create Surface ► Rule.

Select first wire: *Select line (4)*

Select second wire: *Select line (5)*

- 2 Use CHPROP to move top D and top E surfaces to the TOP layer.

Select objects: *Select surface (D)*

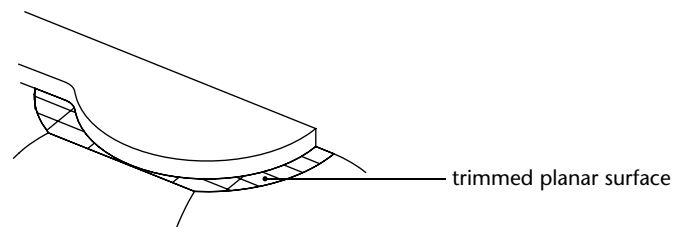
Select objects: *Select surface (E) and press ENTER*

Change what property (Color/Layer/LType/ltScale/xx): *Enter La*

New layer <10>: *Enter top and press ENTER*

Save the file.

Next, break and join lines that are needed to create the top F planar surface.



To create the top F surface

- 1 Use BREAK to break polyline (1) where it intersects polyline (2).

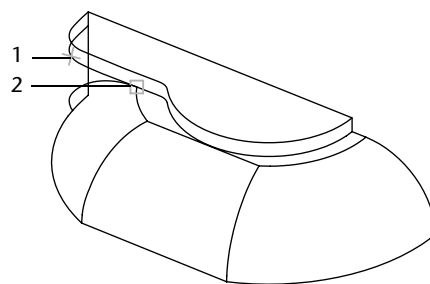
Select object: *Select polyline (1)*

Enter second point (or F for first point): *Enter f*

Enter first point: *Enter int*

of: *Select polyline (2) at the intersection*

Enter second point: *Enter @*



TIP To check whether the polyline is broken properly, select it. Grip points should appear only for the line segment you select. Press ESC twice to exit Grip mode.

The break creates a line segment you use as part of the boundary for the next surface. Join the polylines that form the boundary of top F.

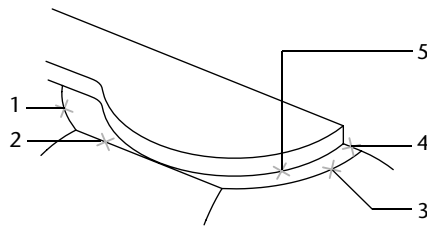
2 Choose Surface ► Edit Wireframe ► Join.

In the Join3D dialog box, specify:

Mode: *Automatic*

Output: *Polyline, then OK*

Select start wire: *Select polyline (1)*



Select all wires you want to join, including the first wire:

Select wires to join: *Select polylines (1) through (5) and press ENTER*

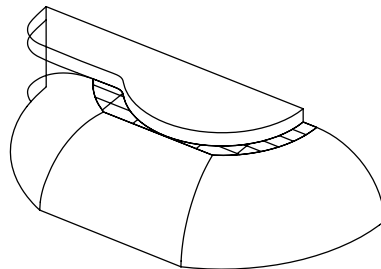
Reverse? Yes/<No>: *Press ENTER to accept the direction of the new wire*

The duplicate wire is removed (polyline 1), and the remaining wires are joined into a polyline.

TIP To confirm that the lines are joined, select the line and check the grip points.

3 Choose Surface ► Create Surface ► Planar Trim.

Select wires: *Select the joined polyline and press ENTER*

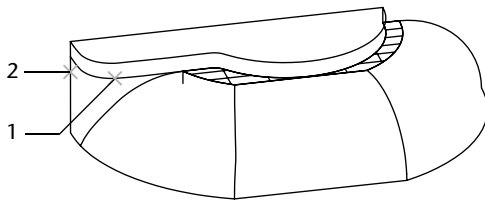


You have created the trimmed planar surface. Save the file.

For the top G surface, extrude a polyline along a straight line and then trim the surface to the desired shape.

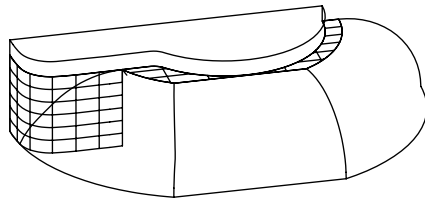
To create the top G surface

- 1 Choose View ► Model Views ► Left Isometric.
- 2 Choose Surface ► Create Surface ► Extrude. Extrude polyline (1) down wire (2).
Select wires: *Select polyline (1) and press ENTER*
Direction: Viewdir/Wire/X/Y/Z/<Start point>: *Enter w*
Select wires: *Select polyline (2)*
Flip/<Accept>:
Flip the direction arrow to extrude the surface toward the part and press ENTER
Taper angle <0>: *Press ENTER to accept the default*



NOTE Your selection point determines the extrusion direction. The illustration shows the direction when you select polyline (2) close to polyline (1). If you selected below the midpoint of the wire, the direction of the extrusion is reversed.

Your illustration should now look like this.

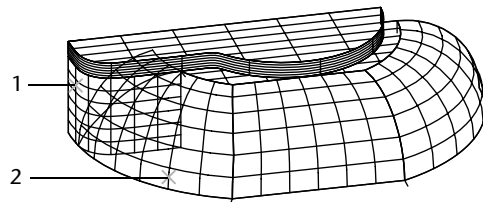


- 3 Use CHPROP to move top F and top G to the TOP layer. See the diagram at “Creating Trimmed Planar Surfaces” on page 364.
Select objects: *Select surface (F)*
Select objects: *Select surface (G) and press ENTER*
Change what property (Color/Layer/LType/lType/ltScale/xx): *Enter La*
New layer <10>: *Enter top and press ENTER*
- 4 Choose Layers.
Thaw the TOP layer to see all the surfaces you have created.

5 Choose Surface ► Edit Surface ► Intersect Trim. Trim top G and top C at their intersection.

Select first surface: *Select surface (1)*

Select second surface: *Select surface (2)*

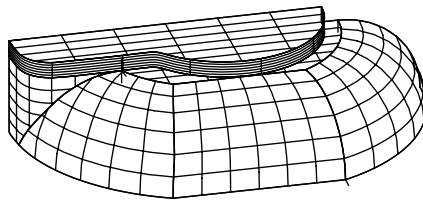


In the Surface Intersection dialog box, specify:

Intersection: *Clear Polyline*

Trim: *First Surface and Second Surface, then OK*

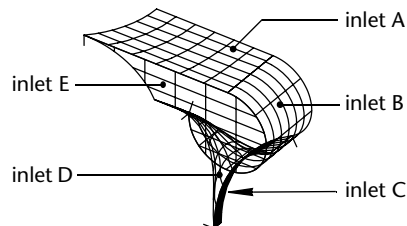
The surfaces are trimmed where they intersect. Save the file.



Joining Surfaces on a Complex Shape

Next, surface the inlet portion of the pump. Because the inlet has a complex shape, you will need five surfaces to represent its shape.

- Inlets A and C are ruled surfaces because they follow two polylines.
- Inlet B is an extruded surface that is trimmed to its final shape.
- Inlet D is a surface blended to surfaces B, C and E.
- Inlet E is a trimmed planar surface created from joined lines that form its boundary.



TIP Be sure to select surfaces and lines where indicated on the illustrations. To make it easier to select precisely, zoom in as needed.

To create the inlet A surface

- 1 Choose Assist ► Layers and Lines.

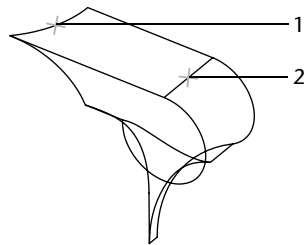
In the Layers dialog box, thaw layer 20 and make it the current layer. Then freeze layer 10 and TOP.

- 2 Choose View ► Model Views ► Right Isometric. You have restored the isometric view. Next, you create the inlet A surface.

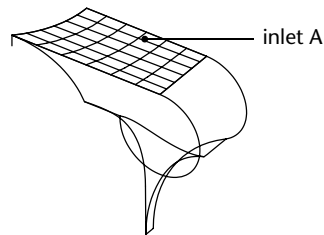
- 3 Choose Surface ► Create Surface ► Rule.

Select first wire: *Select wire (1)*

Select second wire: *Select wire (2)*



The ruled surface is created on the top of the inlet.



- 4 Use CHPROP to move the inlet A surface to the INLET layer.

Select objects: *Select inlet A surface and press ENTER*

Change what property (Color/Layer/LType/ltScale/Thickness): *Enter La*

New layer <20>: *Enter inlet*

Change what property (Color/Layer/LType/ltScale/Thickness): *Press ENTER*

Inlet B is an extruded partial cylinder, trimmed to its final shape by a closed wire. The surface is extruded across the inlet wireframe.

The direction of the extrusion is determined by where you select the wire. If you need to, you can flip the direction of the extrusion.

You create a ruled surface for inlet C.

TIP To select the wires, you might need to rotate the view. Use icons on the Desktop View toolbar to reposition the view or use VPOINT to specify a viewpoint.

To create the inlet B surface

- 1 Choose Surface ► Create Surface ► Extrude.

You extrude polyline (1) along line (2).

Select wires: *Select polyline (1) and press ENTER*

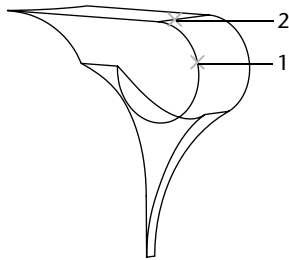
Direction: Viewdir/Wire/X/Y/Z/<Start Point>: *Enter w*

Select wire: *Select polyline (2) near (1)*

Flip/<Accept>:

Flip the direction arrow as necessary to extrude the surface and press ENTER

Taper angle <0>: *Press ENTER*



A close look at the inlet reveals that the extruded surface extends beyond the wireframe. You trim the inlet B surface to the boundary of surface D.

- 2 Reset the DELOBJ variable so that the projected wire is not deleted.

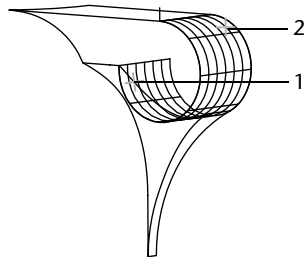
New value for delobj <1>: *Enter 0*

Next, project the edge of inlet D to trim the inlet A surface.

- 3 Choose Surface ► Edit Surface ► Project Trim.

Select wires to project: *Select line (1) and press ENTER*

Select target surfaces: *Select surface (2) and press ENTER*



In the Project to Surface dialog box, specify:

Direction: *Normal to Surface*

Output type: *Trim Surface, then OK*

TIP If you want to delete the wire or line you use to create a surface, reset the DELOBJ variable to the default setting of 1 (delete the object).

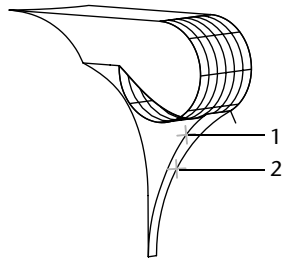
You have trimmed inlet B by projection. Next you create inlet C, a ruled surface between two wires.

To create the inlet C surface

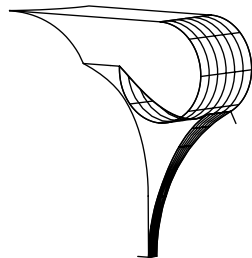
- 1 Choose Surface ► Create Surface ► Rule.

Select first wire: *Select wire (1)*

Select second wire: *Select wire (2)*



Your model should look like this.



- 2 Use CHPROP to move inlet B and C surfaces to the INLET layer.

- 3 Save the file.

Next, you create inlet D, a surface blended from the edges of inlet B and C surfaces and the polyline that defines the edge of inlet E.

NOTE You may need to rotate the model to show the intersection clearly.

To create the inlet D surface

- 1 Break the polyline into two line segments.

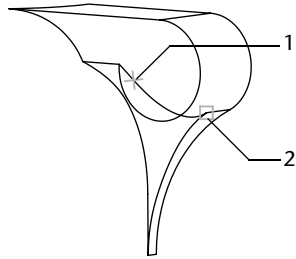
Select object: *Select polyline (1)*

Enter second point (or F for first point): *Enter f*

Enter first point: *Enter int*

of: *Select polyline (2)*

Enter second point: *Enter @*



TIP Check grip points of the line segments after you break it.

- 2 Choose Surface ► Create Surface ► Blend.

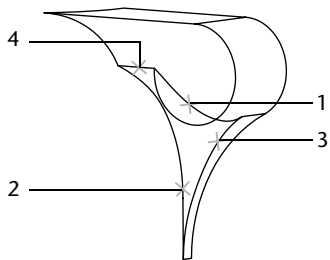
TIP Be sure to make selections in order. When you make selections for blending a surface, do *not* make the selections consecutively in a ring.

Select first wire: *Select wire (1)*

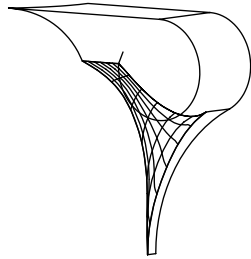
Select second wire: *Select wire (2)*

Select third wire: *Select wire (3)*

Select fourth wire: *Select wire (4)*



The blended surface should look like this.



- 3 Use CHPROP to move the surface to the INLET layer.

Join the lines to form the boundary of inlet E and then create a trimmed planar surface from the joined lines. Zoom in as needed to make line selection easier.

To create the inlet E surface

- 1 Choose Surface ► Edit Wireframe ► Join.

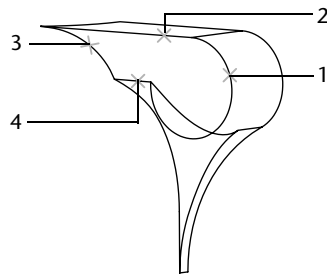
In the Join3D dialog box, specify:

Mode: *Automatic*

Output: *Polyline*

Gap Tolerance: *.01, then OK*

Select start wire: *Select polyline (1)*



Select all wires you want to join, including the first wire.

Select wires to join: *Select wires (1) through (4) and press ENTER*

Reverse? Yes/<No>: *Press ENTER*

The duplicate wire (wire 1) is removed and all line segments are joined.

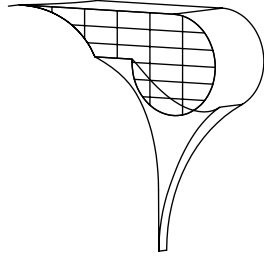
NOTE This procedure joins lines regardless of their original direction and explodes arcs and splines into polylines.

- 2 Choose Surface ► Create Surface ► Planar Trim. Create a trimmed planar surface from the joined lines.

Select wires: *Select polyline (1)*

Select wires: *Press ENTER*

Your surface should look like this.



- 3 Use CHPROP to move inlet E to the INLET layer.

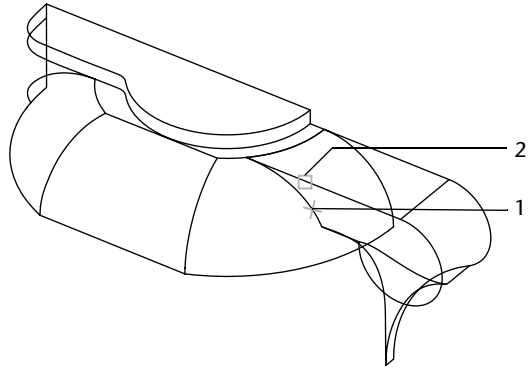
Now you can trim top D by projecting the edge of the inlet. Thaw layers to show the inlet and top sections of the pump. Then break a polyline into segments. Select segments to join; the joined polylines form the shape of the projection that cuts material where the two surfaces intersect.

To make selection easier, zoom and rotate the view as needed.

TIP When you want to create an opening or a hole, project a wire onto a surface to remove the portion of the surface bounded by the wire. Choose Surface ► Edit Surface ► Project Trim.

To trim surfaces by projection

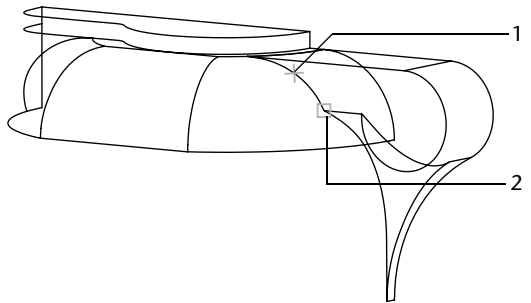
- 1 Thaw layers 10 and 20.
- 2 Choose View ► Model Views ► Right Isometric.
- 3 Break the polyline.
Select object: *Select polyline (1)*
Enter second point (or F for first point): *Enter f*
Enter first point: *Enter end*
of: *Select polyline (2)*
Enter second point: *Enter @*



TIP Use icons on the Desktop View toolbar to rotate the view and zoom in to show the lines clearly. If you prefer, use VPOINT to set a precise viewpoint. In this case, set the coordinates **4,-6,1** to show the lines you need for the next step.

- 4 Use BREAK to break the upper part of the polyline into segments.

Select object: *Select polyline (1)*
 Enter second point (or F for first point): *Enter f*
 Enter first point: *Enter int*
 of: *Select polyline (2)*
 Enter second point: *Enter @*



Next, you combine three polyline segments.

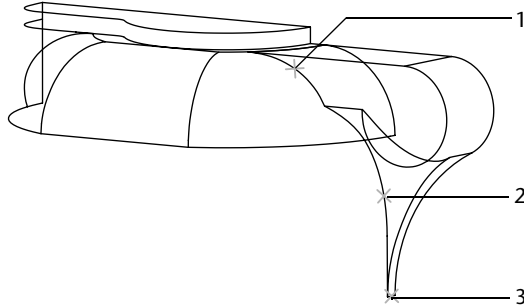
- 5 Choose Surface ► Edit Wireframe ► Join. In the Join3D dialog box, specify:

Mode: *Automatic*

Output: *Polyline*

Gap Tolerance: *Enter .004 and choose OK*

Select start wire: *Select polyline (1)*



Select all wires you want to join, including the first wire:

Select wires to join: *Select wire (1)*

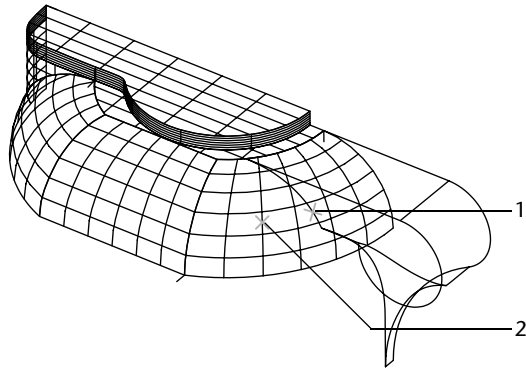
Select wires to join: *Select wire (2)*

Select wires to join: *Select wire (3) and press ENTER*

Reverse? Yes/<No>: *Press ENTER*

The duplicate wire (wire 1) is removed and the segments are joined together. Later, you will project the joined line onto the top surface.

- 6 Freeze layer 10 and thaw the TOP layer.
- 7 Choose View ► Model View ► Right Isometric. Reset the DELOBJ system variable to **0** so that the wires are not deleted.
- 8 Choose Surface ► Edit Surface ► Project Trim. Cut top B where the inlet fits.
- Select wires to project: *Select wire (1) and press ENTER*
- Select target surfaces: *Select surface (2) and press ENTER*

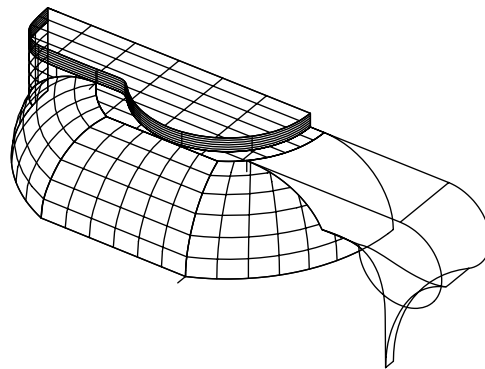


In the Project to Surface dialog box, specify:

Direction: *Normal to Surface*

Output Type: *Trim Surface, then OK*

Top B is cut open for the inlet. The top and inlet are complete.

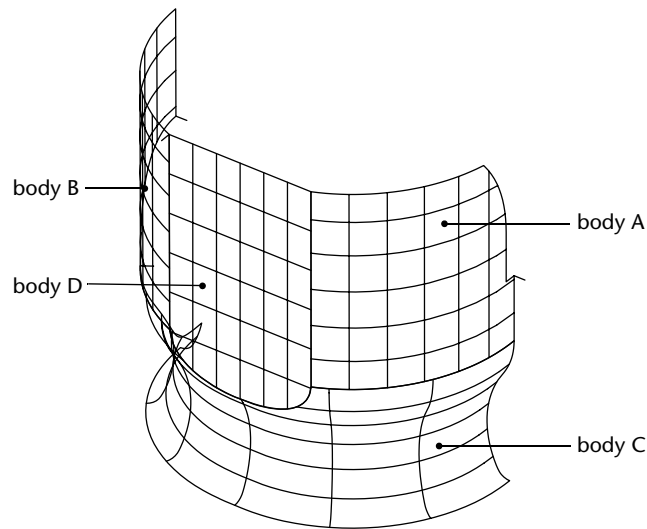


9 Reset the DELOBJ system variable to **1** and save the file.

Creating Swept and Projected Surfaces

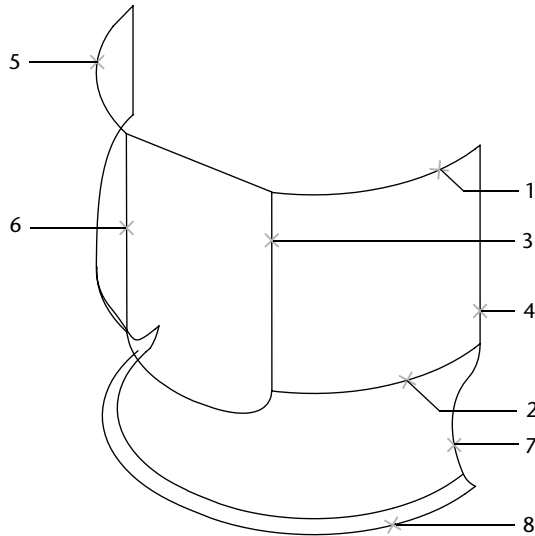
For the main body of the pump, you continue building and trimming surfaces to their correct shapes.

- Body A, B, and C are swept surfaces created from curves and rails.
- Body D is a surface created from the boundaries of Body A, B, and C surfaces.



To create the body A, B, and C surfaces

- 1 Thaw layer 30 and make it current. Freeze layers 10, 20 and TOP.
- 2 Choose Surface ► Create Surface ► Sweep. Create the body A surface on the right side of the model.
Select cross sections: *Select wire (1)*
Select cross sections: *Select wire (2) and press ENTER*
Select rails: *Select wire (3)*
Select rails: *Select wire (4)*



In the Sweep Surface dialog box, specify:

Transition: *Scale, then OK*

- 3 Choose Surface ► Create Surface ► Sweep. Create the body B surface on the left side of the model.

TIP To repeat the previous command, press ENTER or the spacebar.

Select cross sections: *Select wire (5) and press ENTER*

Select rails: *Select wire (6) and press ENTER*

In the Sweep Surface dialog box, specify:

Orientation: *Normal, then OK*

- 4 Choose Surface ► Create Surface ► Sweep. Create the body C surface near the bottom of the model.

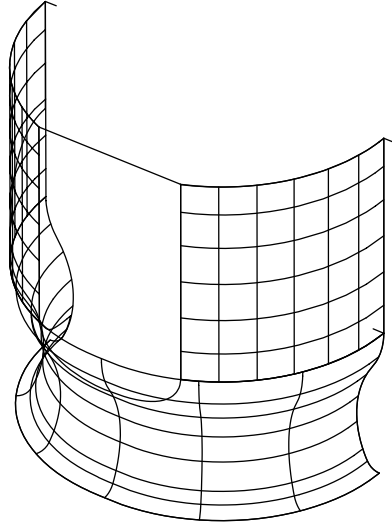
Select cross sections: *Select wire (7) and press ENTER*

Select rails: *Select the wire (8) and press ENTER*

In the Sweep Surface dialog box, specify:

Orientation: *Normal, then OK*

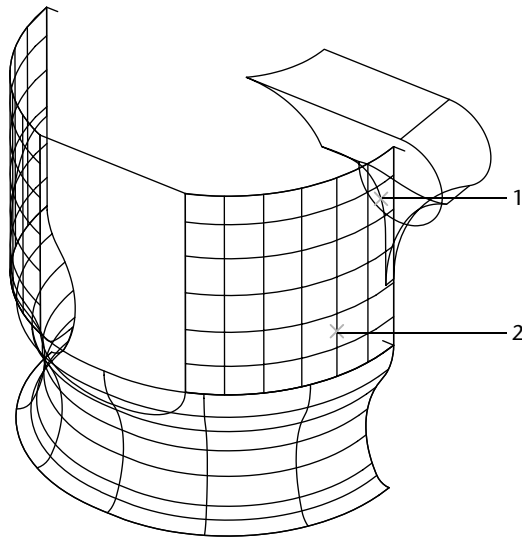
Your model should look like this.



- 5 Thaw layer 20 to reveal the inlet.
- 6 Reset the DELOBJ system variable to **0** so that the projected wire is not deleted.
- 7 Choose Surface ► Edit Surface ► Project Trim. Trim the body surface with the inlet edge.

Select wires to project: *Select wire (1) and press ENTER*

Select target surfaces: *Select surface (2) and press ENTER*



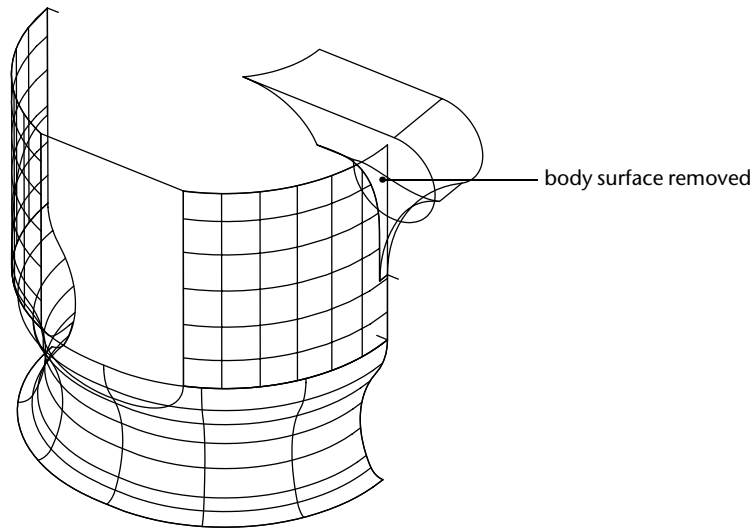
In the Project to Surface dialog box, specify:

Direction: *Normal to Surface*

Output Type: *Trim Surface, then OK*

NOTE Do not reset the DELOBJ variable because you will need to retain projected wires in the following steps.

The projected wire cut away a portion of body A surface, but the wire was not deleted.



8 Freeze layer 20.

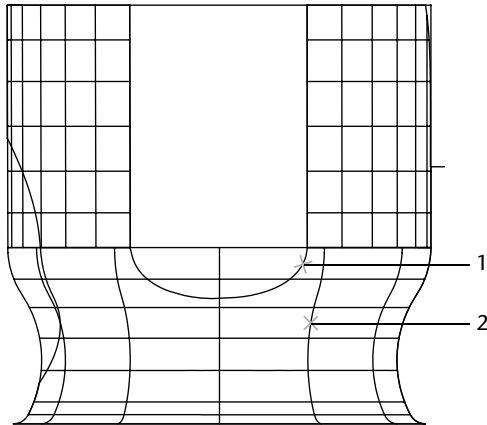
Cut out the surface areas on body C where body D and the outlet (to be surfaced later) extend onto body C.

To project onto the body C surface

- 1 Choose View ► Model Views ► Front. Change the display so that you can project wires onto the surface.
- 2 Choose Surface ► Edit Surface ► Project Trim. Trim body C with the lower curve of the flat surface (1).

Select wires to project: *Select wire (1) and press ENTER*

Select target surfaces: *Select surface (2) and press ENTER*



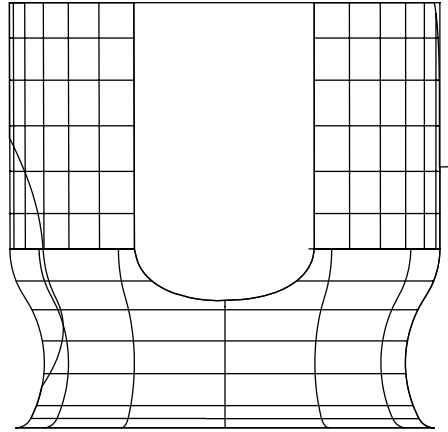
In the Project to Surface dialog box, specify:

Direction: *Normal to Surface*

Output Type: *Trim Surface, then OK*

TIP You may have noticed that the Project to Surface dialog box is displayed when you select either Surface ► Create Wireframe ► Project Wire or Surface ► Edit Surface ► Project Trim. Although all dialog box options are available with either menu option, the default settings depend on the menu selection. For example, for Create Wireframe, the output type defaults to Polyline. In this case, you selected Edit Surface, so the default output option is Trim Surface.

Your model should look like this.



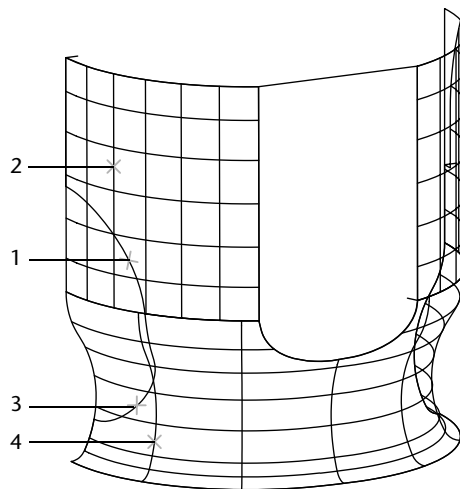
- 3 Use View ► Model Views ► Right Isometric.

TIP If you prefer to set the viewpoint precisely, use VPOINT to specify coordinates. For example, this viewpoint is -5,-10,3.

- 4 Choose Surface ► Edit Surface ► Project Trim. Trim the body B surface with the curve that defines the upper edge of the outlet.

Select wires to project: *Select wire (1) and press ENTER*

Select target surfaces: *Select surface (2) and press ENTER*



In the Project to Surface dialog box, specify:

Direction: *Normal to Surface*

Output Type: *Trim Surface, then OK*

- 5 Choose Surface ► Edit Surface ► Project Trim. Trim body C with the curve that defines the lower edge of the outlet.

Select wires to project: *Select wire (3) and press ENTER*

Select target surfaces: *Select surface (4) and press ENTER*

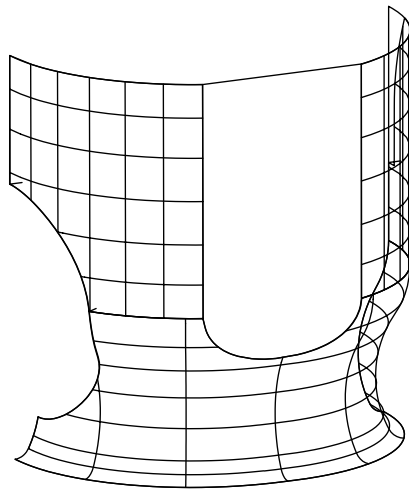
In the Project to Surface dialog box, specify:

Direction: *Normal to Surface*

Output Type: *Trim Surface, then OK*

- 6 Set the DELOBJ variable back to **1** so that it is in the default state (to delete objects).

Your model should look like this.



- 7 Use CHPROP to move surfaces A, B, and C to the BODY layer.

Next, you edit the wireframe to join the lines that form the boundary of body D. You use the polyline to create a planar surface.

To create the body D surface

- 1 Choose Surface ► Edit Wireframe ► Join. Combine line segments.

In the Join 3D dialog box, specify:

Mode: *Automatic*

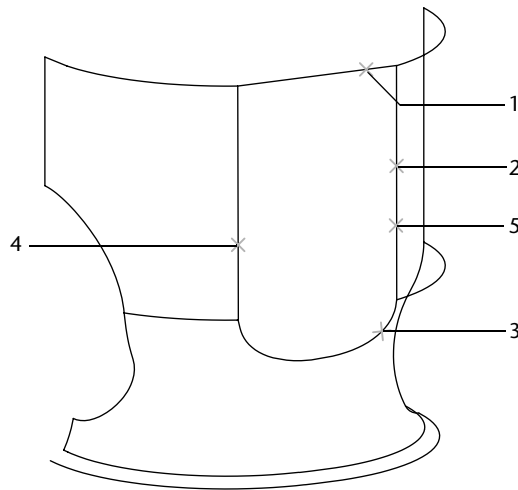
Output: *Polyline, then OK*

Select start wire: *Select the wire (1)*

Select wires to join: *Select wires (2), (3), and (4)*

Select wires to join: *Press ENTER*

Reverse? Yes/<No>: *Press ENTER*

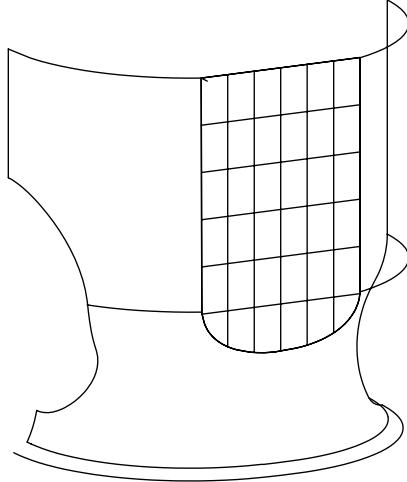


- 2 Choose Surface ► Create Surface ► Planar. Create a planar surface from the joined line.

Plane/Wires/<First corner>: *Enter w*

Select wires: *Select wire (5) and press ENTER*

Your model should look like this.

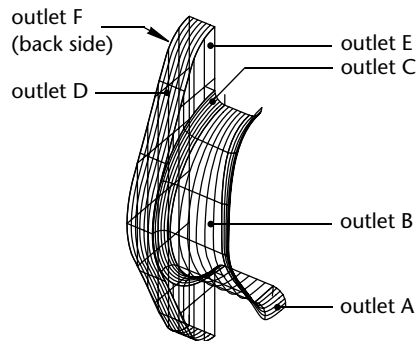


- 3 Use CHPROP to move body D to the BODY layer. Save the file.

The pump body surfaces are complete.

Creating Complex Swept Surfaces

Next, you create the surfaces for the outlet on the side of the pump.



Outlet A is a swept surface that blends dissimilar cross sections.

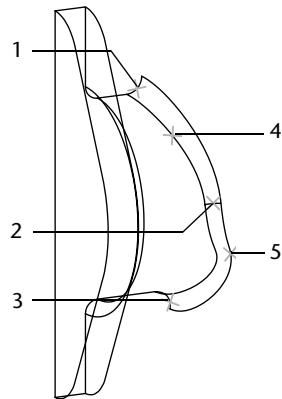
To create the outlet A surface

- 1 Thaw layer 40 and make it current, and then freeze all other layers.
- 2 Change to the Left Isometric view to make lines easier to select.

- 3 Choose Surface ► Create Surface ► Sweep. Use the three cross sections and two rails in a swept surface.

Select cross sections: *Select wires (1), (2), and (3)*

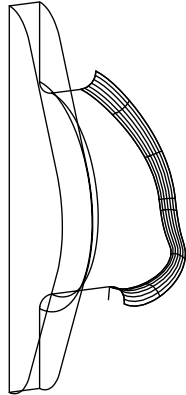
Select rails: *Select wires (4) and (5)*



In the Sweep Surface dialog box, specify:

Transition: *Scale, then OK*

Outlet A should look like this.



- 4 Use CHPROP to move outlet A to the OUTLET layer.

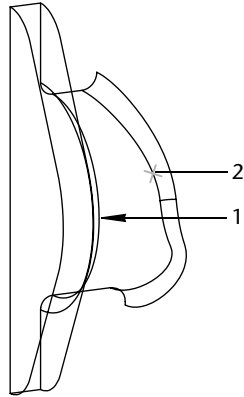
Next create a ruled surface for outlet B. The difference between this surface and the one you just completed is that outlet A is curved in two directions and outlet B is curved in one direction and flat in the other.

To create the outlet B surface

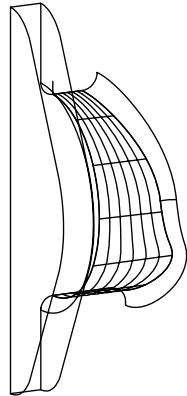
- 1 Choose Surface ► Create Surface ► Rule.

Select first wire: *Select wire (1)*

Select second wire: *Select wire (2)*



Outlet B should look like this.



- 2 Use CHPROP to move outlet B to the OUTLET layer.

For the next surfaces, you create another swept surface and another ruled surface.

To create the outlet C and outlet D surfaces

- 1 To make selections easier, rotate the model to the left with the Desktop View icons or set specific coordinates (6, -8, 1) with VPOINT.

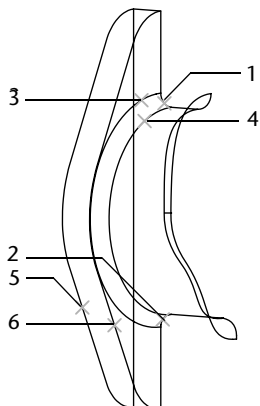
2 Choose Surface ► Create Surface ► Sweep. Create outlet C.

Select cross sections: *Select wire (1)*

Select cross sections: *Select the wire (2) and press ENTER*

Select rails: *Select wire (3)*

Select rails: *Select wire (4)*



In the Sweep Surface dialog box, specify:

Transition: *Scale, then OK*

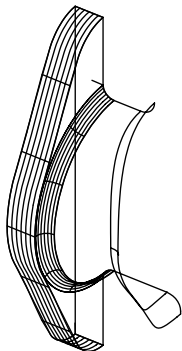
3 Choose View ► Model View ► Right Isometric.

4 Choose Surface ► Create Surface ► Rule. Create outlet D.

Select first wire: *Select wire (5)*

Select second wire: *Select wire (6)*

Your model should look like this.



- 5 Use CHPROP to move both of the surfaces to the OUTLET layer.
Next, you join lines to form the boundaries of body D and outlet F. From the newly created polyline, you create planar surfaces for the outlet.

To create the outlet E and outlet F surfaces

- 1 Choose Surface ► Edit Wireframe ► Join. In the Join3D dialog box, specify:

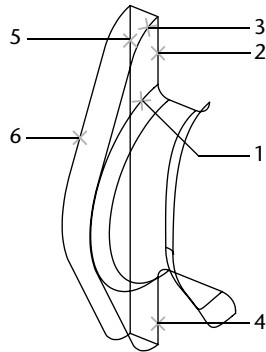
Mode: *Automatic*

Output: *Polyline, then OK*

Select start wire: *Select wire (1)*

Select wires to join: *Select wires (2), (3), and (4) and press ENTER*

Reverse? Yes/<No>: *Press ENTER to accept the join direction*



- 2 Choose Surface ► Create Surface ► Planar. Create outlet E surface.

Plane/Wires/<First corner>: *Enter w*

Select wires: *Select wire (1) and press ENTER*

- 3 Choose Surface ► Edit Wireframe ► Join. Combine lines that form the boundary for outlet F.

In the Join 3D dialog box, specify:

Mode: *Manual*

Output type: *Polyline, then OK*

Select start wire: *Select start wire (5)*

Select wire to join: *Select wire (6) and press ENTER*

Reverse? Yes/<No>: *Press ENTER*

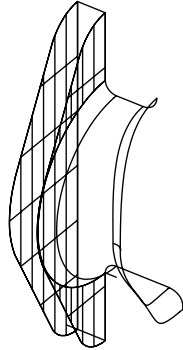
TIP Use the Manual mode to join lines even if they are far apart. It joins all the lines you select in the order you choose them.

- 4 Choose Surface ► Create Surface ► Planar. Create outlet F from the lines you just joined.

Plane/Wires/<First corner>: *Enter w*

Select wires: *Select wire (6) and press ENTER*

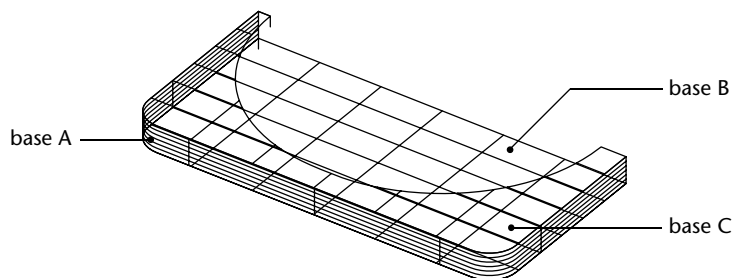
Your model should look like this.



- 5 Use CHPROP to move the surfaces to the OUTLET layer.
- 6 Save the file.

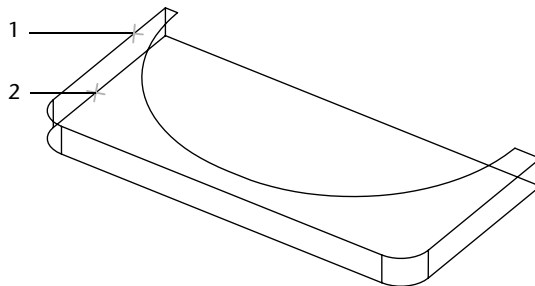
Using Projection to Create Surfaces

Next, you use projection to create ruled and planar surfaces for the base of the pump.

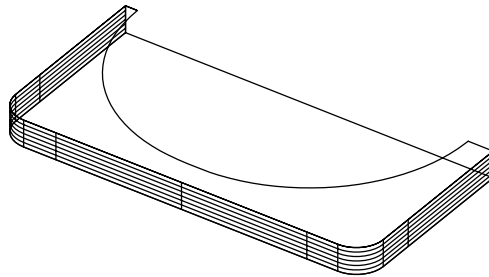


To create the base A surface

- 1 Thaw layer 50 and make it current. Then freeze all other layers.
- 2 Use ZOOM to enlarge the view.
- 3 Choose Surface ► Create Surface ► Rule. Create base A surface.
Select first wire: *Select wire (1)*
Select second wire: *Select wire (2)*



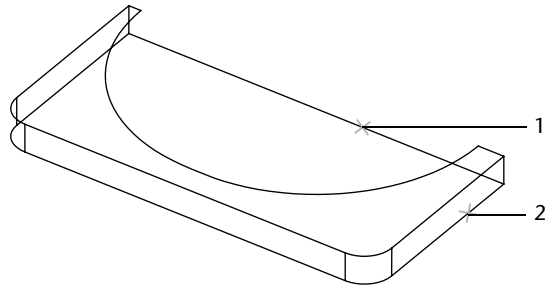
The illustration shows the ruled surface fit to the flat areas and corner curves.



- 4 Use CHPROP to move base A to the BASE layer.
Next, you join the lines needed to create a planar surface on the bottom of the pump. Then copy the surface and trim it.

To create the base B and C surfaces

- 1 Choose Surface ► Edit Wireframe ► Join. Create a polyline from two wires.
In the Join3D dialog box, specify:
Mode: *Automatic*
Output: *Polyline, then OK*
Select start wire: *Select wire (1)*
Select wires to join: *Select wire (2) and press ENTER*
Reverse? Yes/<No>: *Press ENTER*



- 2 Choose Surface ► Create Surface ► Planar. Create a planar surface on the bottom of the base.

Plane/Wires/<First corner>: *Enter w*

Select wires: *Select wire (1) and press ENTER*

The planar surface is created.

- 3 Copy the last surface.

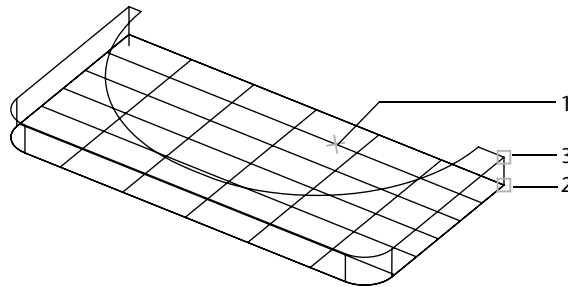
Select objects: *Select surface (1) and press ENTER*

<Base point or displacement>/Multiple: *Enter end*

of: *Select point (2)*

Second point of displacement: *Enter end*

of: *Select point (3)*

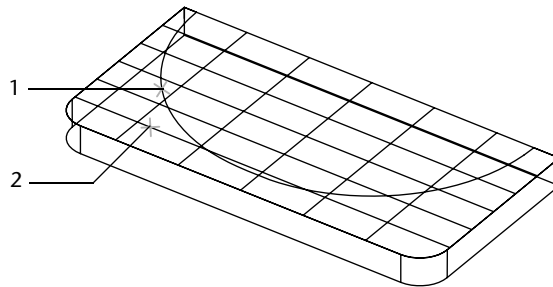


- 4 Use CHPROP to move the bottom surface to the BASE layer.

5 Choose Surface ► Edit Surface ► Project Trim. Project the curve of the body onto the top surface of the base.

Select wires to project: *Select polyline (1) and press ENTER*

Select target surfaces: *Select surface (2) and press ENTER*

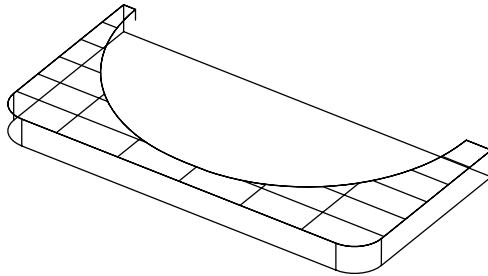


In the Project to Surface dialog box, specify:

Direction: *Normal to Surface*

Output type: *Trim Surface, then OK*

Your model should look like this.

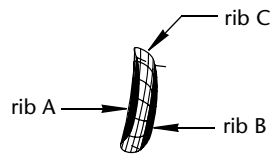


6 Use CHPROP to move the surfaces to the BASE layer. Save the file.

Using Advanced Surfacing Techniques

Next, you create the support rib from the surfaces. Using the techniques you have already learned, you should be able to surface the support rib from these general instructions.

Save the file before you begin working on your own.



To create the support rib

- 1 Thaw layer 60.
- 2 Create a ruled surface on the left side of the support rib (rib A).
- 3 Create a ruled surface on the right side of the support rib (rib B).
- 4 Move the surfaces to the SUPPORT_RIB layer.
- 5 Create a swept surface for rib C.
- 6 Move the surface to the SUPPORT_RIB layer.
- 7 Add the support rib onto the body and base surfaces.

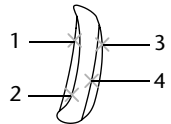
If you need to, follow these specific instructions to create the support rib.

To create the rib A and rib B surfaces

- 1 Thaw layer 60 and make it current. Then freeze all other layers.
- 2 Choose Surface ► Create Surface ► Rule. Create a ruled surface on the left side of the support rib.

Select first wire: *Select wire (1)*

Select second wire: *Select wire (2)*



- 3 Choose Surface ► Create Surface ► Rule. Create a ruled surface on the right side of the support rib.

Select first wire: *Select wire (3)*

Select second wire: *Select wire (4)*

The surfaces should look like this.



- 4 Use CHPROP to move the surfaces to the SUPPORT_RIB layer.

To create the rib C surface

- 1 Choose Surface ► Create Surface ► Sweep.

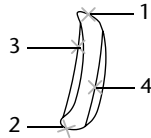
Select cross sections: *Select wire (1) and (2)*

Select cross sections: *Press ENTER*

Select rails: *Select wires (3) and (4)*

In the Sweep Surface dialog box, specify:

Transition: *Scale, then OK*



Your surface should look like this.



- 2 Move the surface to the SUPPORT_RIB layer.

- 3 Choose Surface ► Edit Wireframe ► Join.

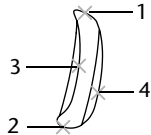
In the Join3D dialog box, specify:

Mode: *Automatic*

Output: *Polyline, then OK*

Select start wire: *Select wires (1), (2), (3), and (4) and then press ENTER*

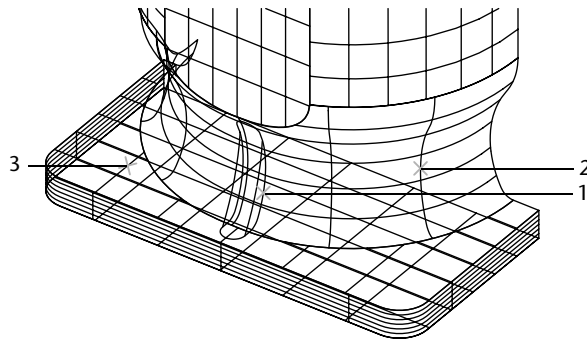
Reverse? Yes/<No>: *Press ENTER*



The support rib wires are joined and ready to project onto the pump.

To add the support rib

- 1 Thaw the BODY and BASE layers.
- 2 Choose Surface ► Edit Surface ► Project Trim.
Select wires to project: *Select wire (1) and press ENTER*
Select target surfaces: *Select surface (2)*
Select target surfaces: *Select surface (3) and press ENTER*

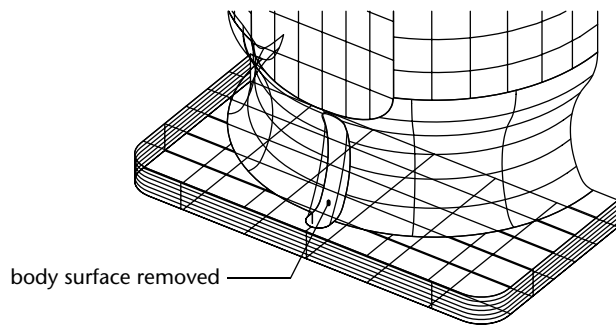


In the Project to Surface dialog box, specify:

Direction: *Normal to Surface*

Output: *Trim Surface, then OK*

The support rib is projected onto the body and the base.



- 3 Save your file.

Viewing the Completed Surfaced Model

To view the completed model, freeze all layers except BASE, BODY, INLET, OUTLET, SUPPORT_RIB, and TOP.

Use the Extents option of the ZOOM command to view the entire wireframe model.

