

SOLIDWORKS WORLD 2014



3DEXPERIENCE

Will It Blend?

How to fillet and smooth pretty much anything in SolidWorks

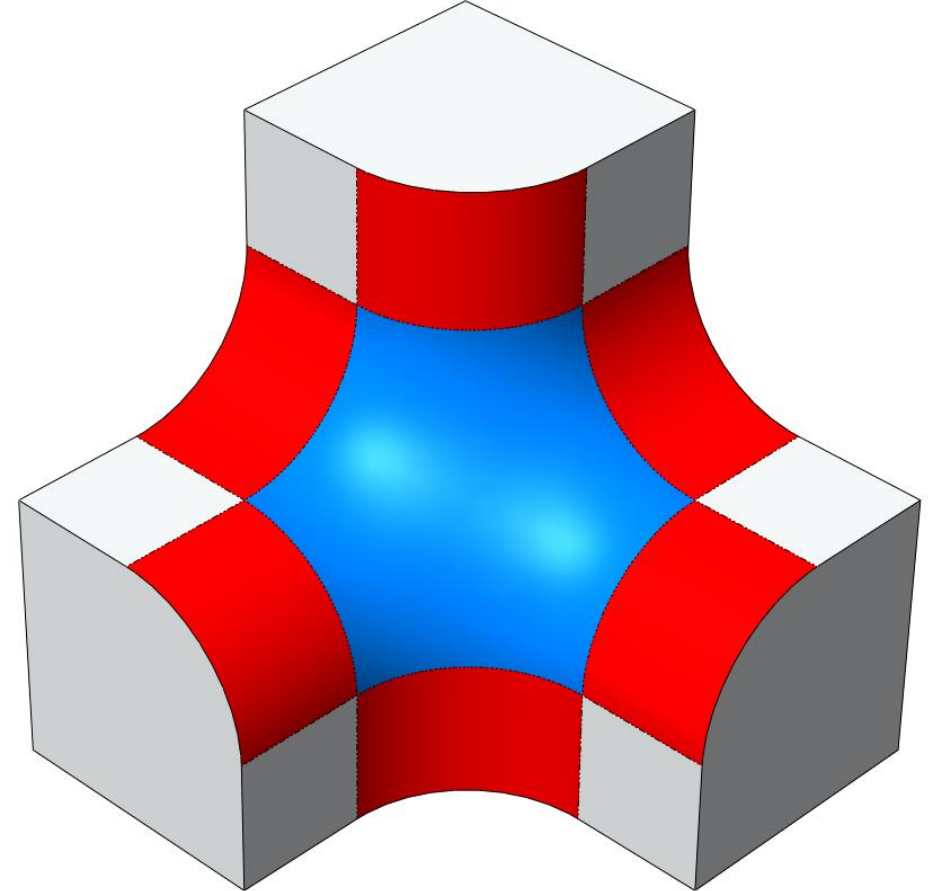
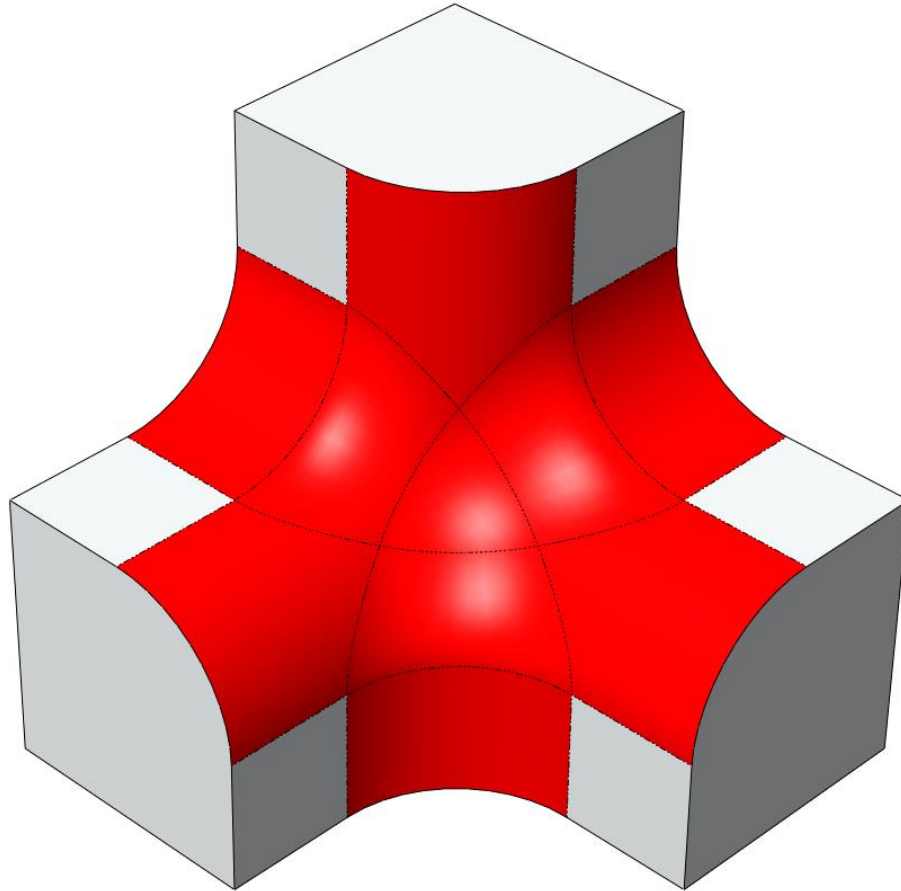
Andrew Lowe
Industrial Designer
DiMonte Group Inc



Fillet Vs Blend

Fillet

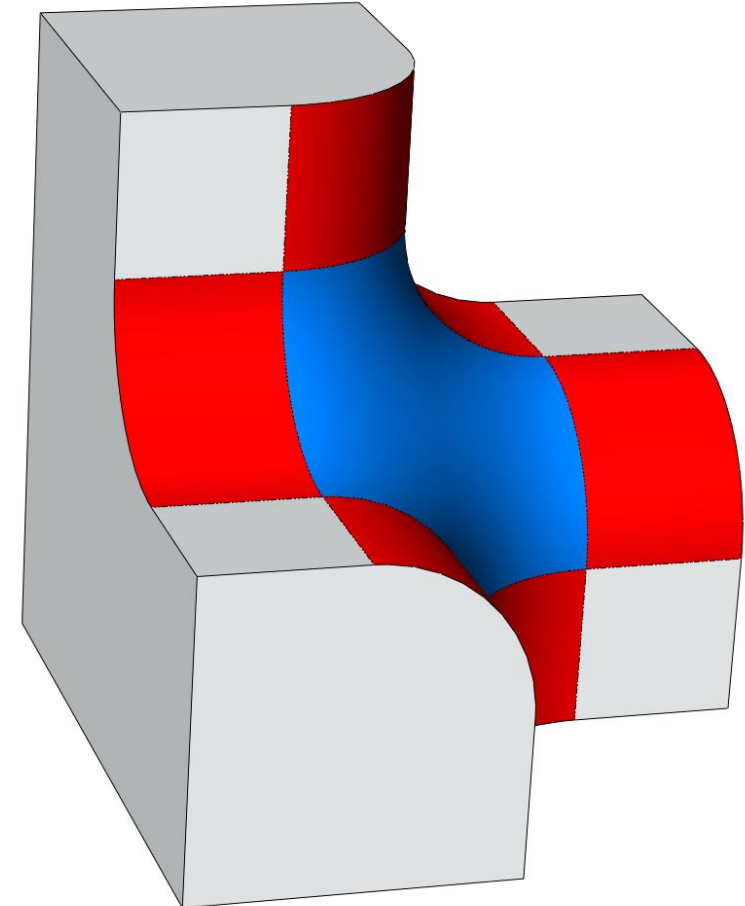
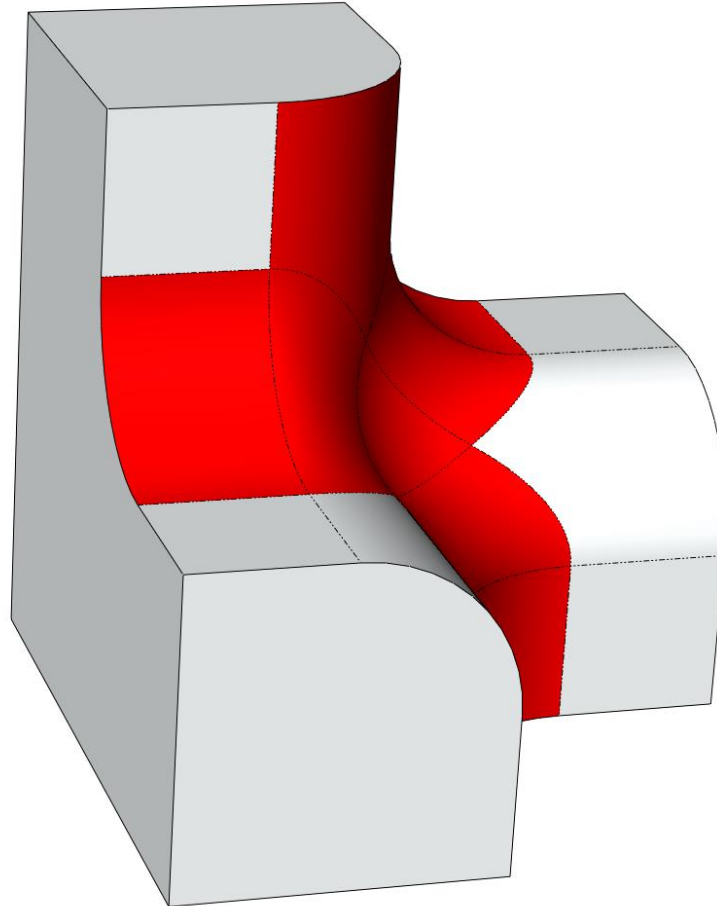
Blend



See the difference?

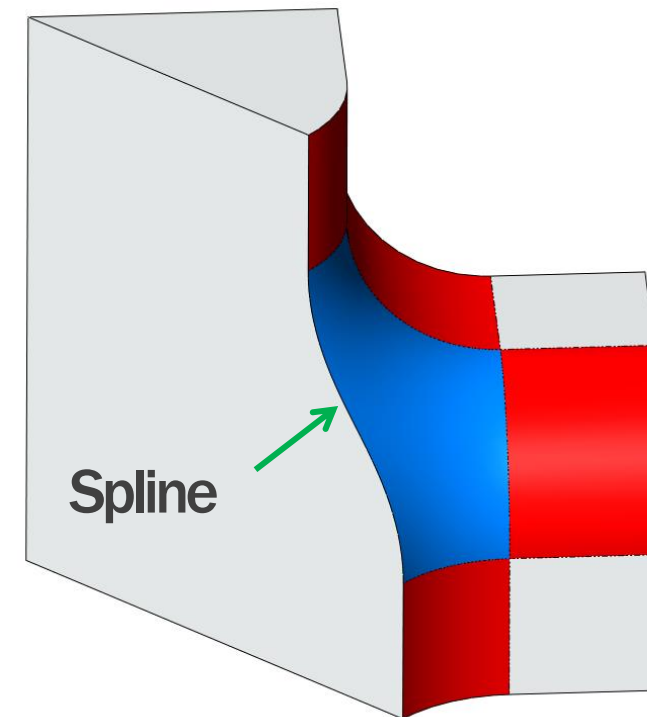
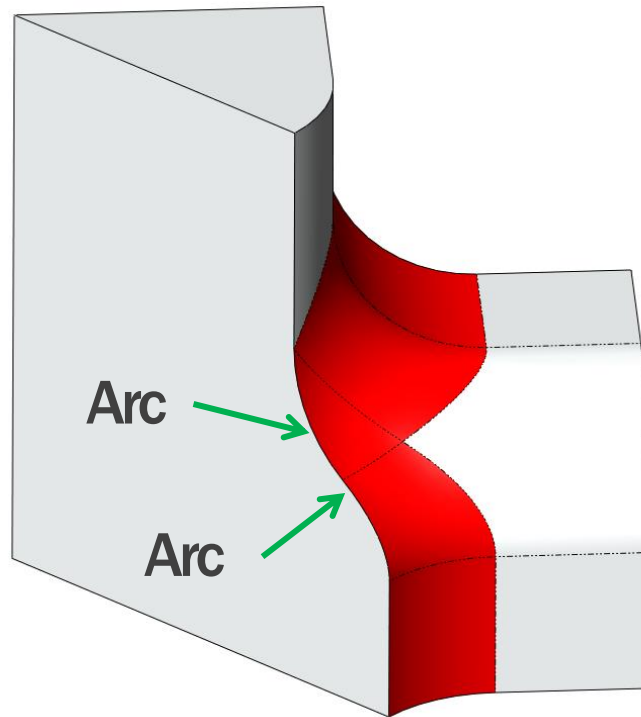
Fillet

Blend



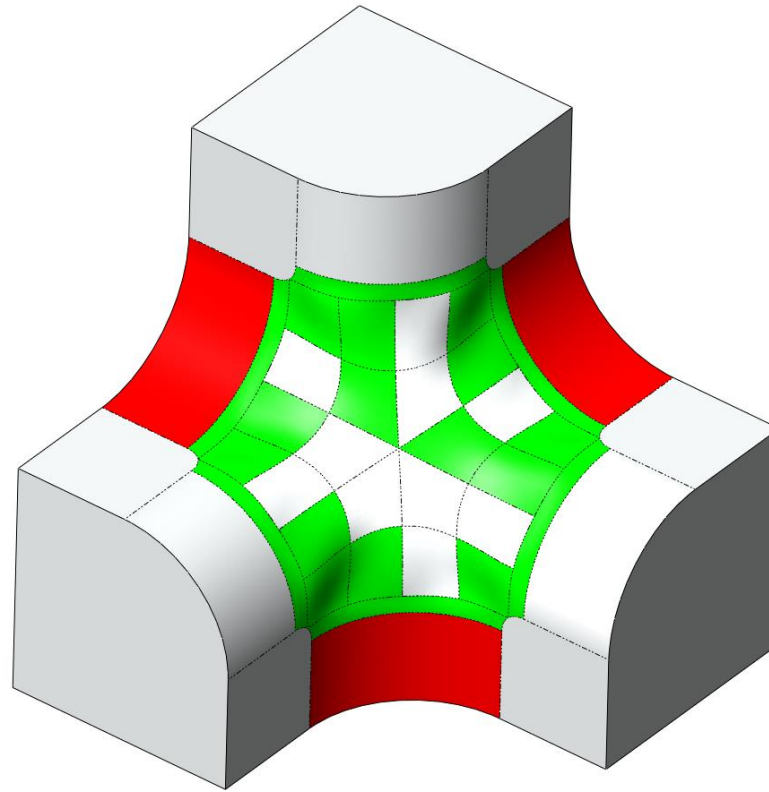
Compare and Contrast

Fillets rely on bridging transitions with sections of an arc. Blends involve shapes that cannot be described with arcs.

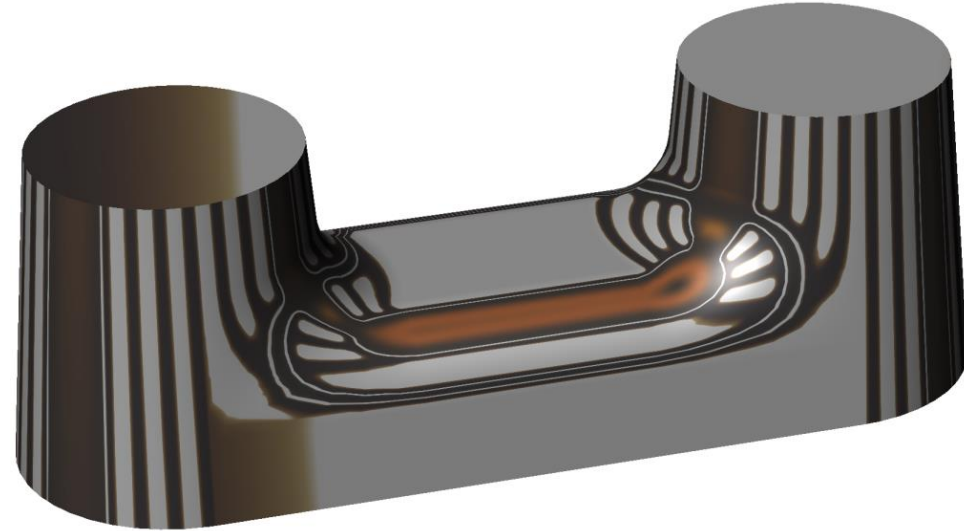
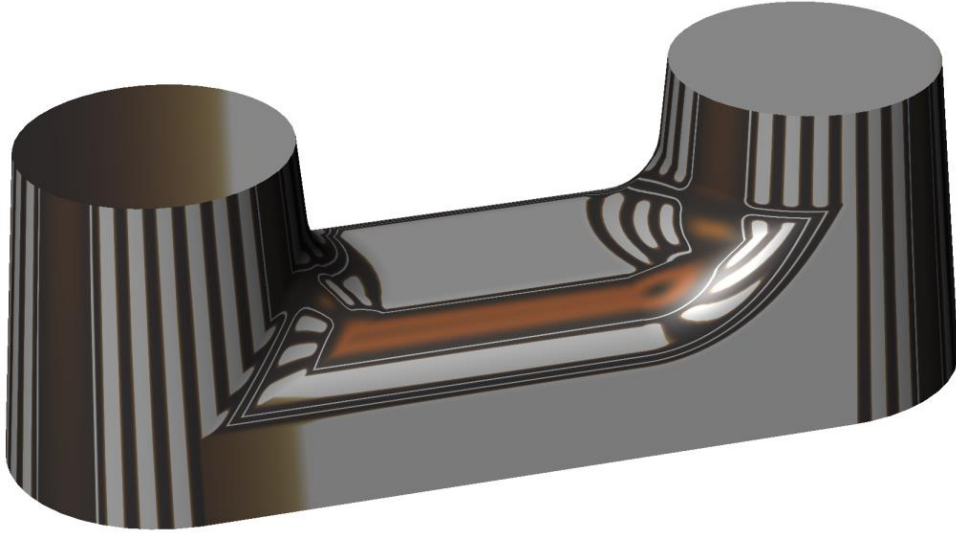


What about the Setback?

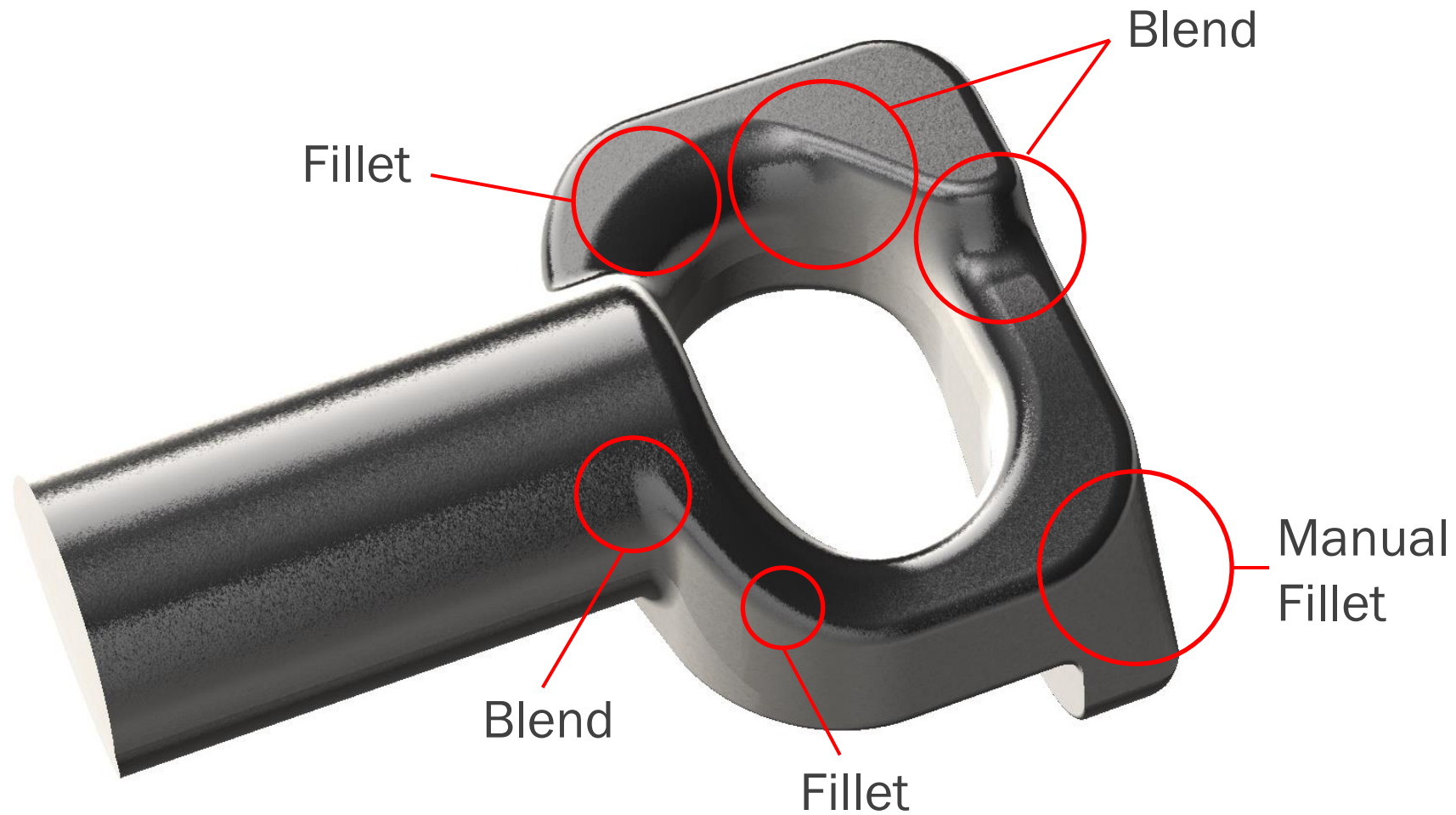
Some of you might be saying “The setback fillet was designed for this.” However, the results speak for themselves.



Sometimes we need blends to make things to look right.



A real world example.



And Who Am I?

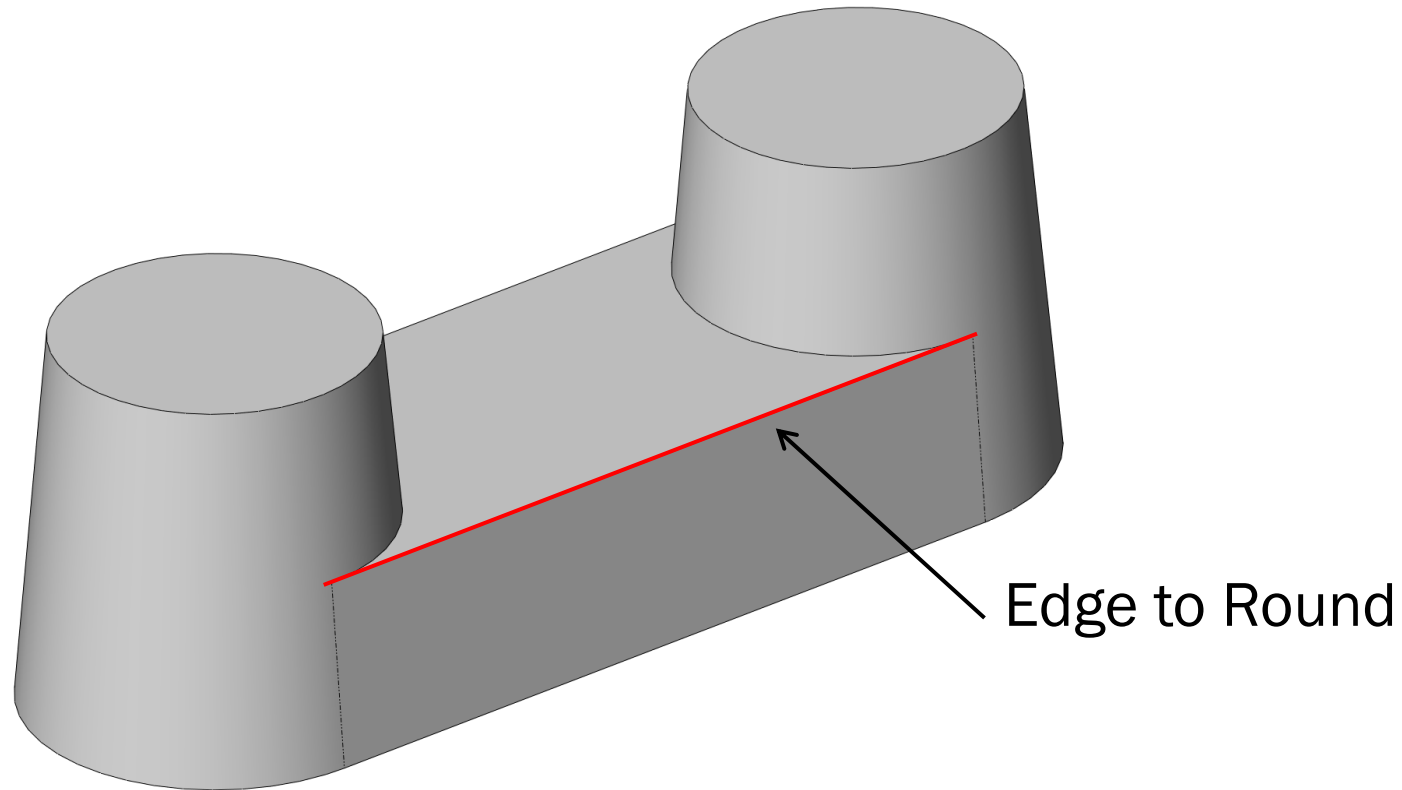
I work as an Industrial Designer at the DiMonte Group; a product development consultancy working across multiple industries, materials and processes. I don't let CAD dictate design decisions to our clients.



Filletlets

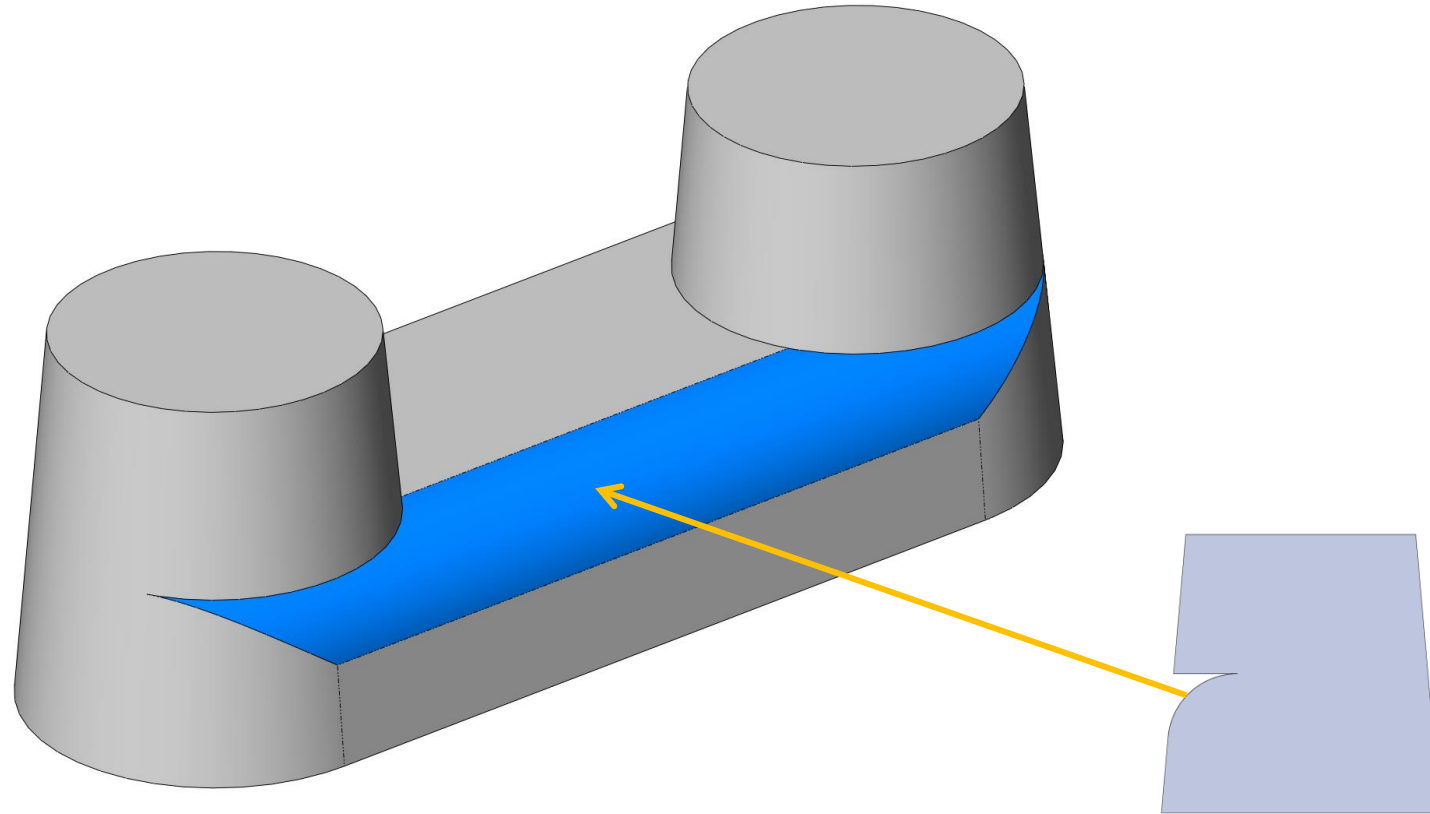
Understanding Fillets

Fillets need somewhere to end.



Understanding Fillets

Fillets need somewhere to end.

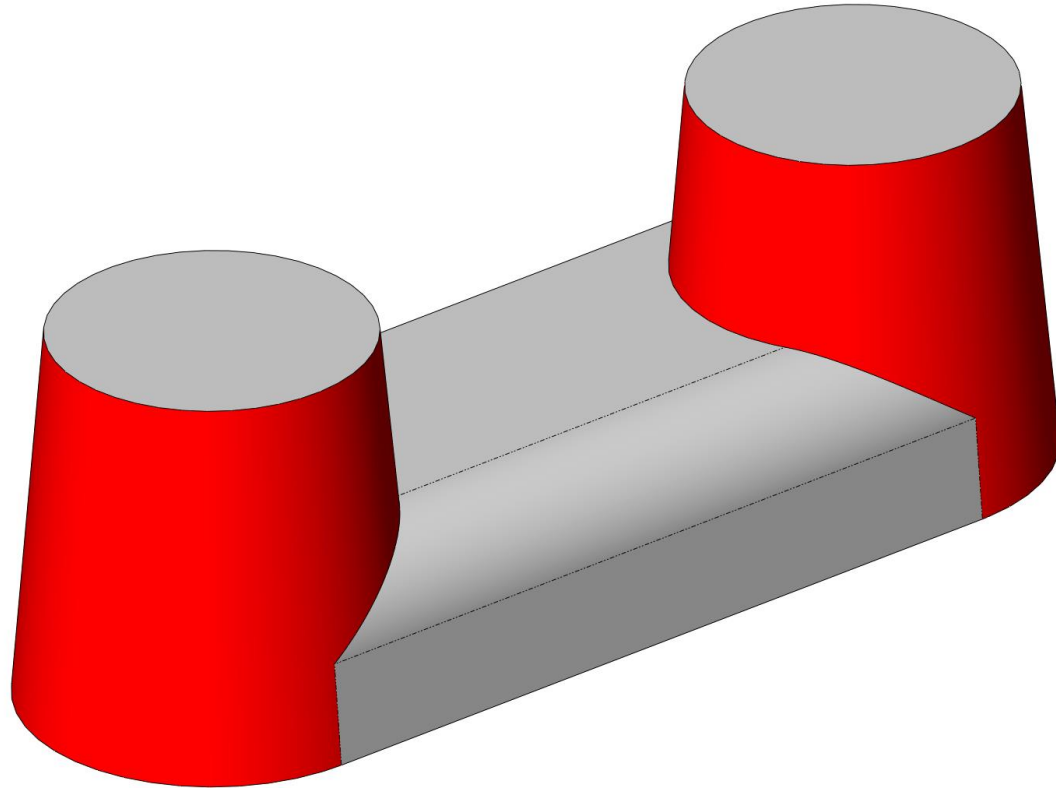


If the fillet tool were dumb, it would produce something like this.

Lucky for us, the fillet tool has a lot of intelligence built in.

Understanding Fillets

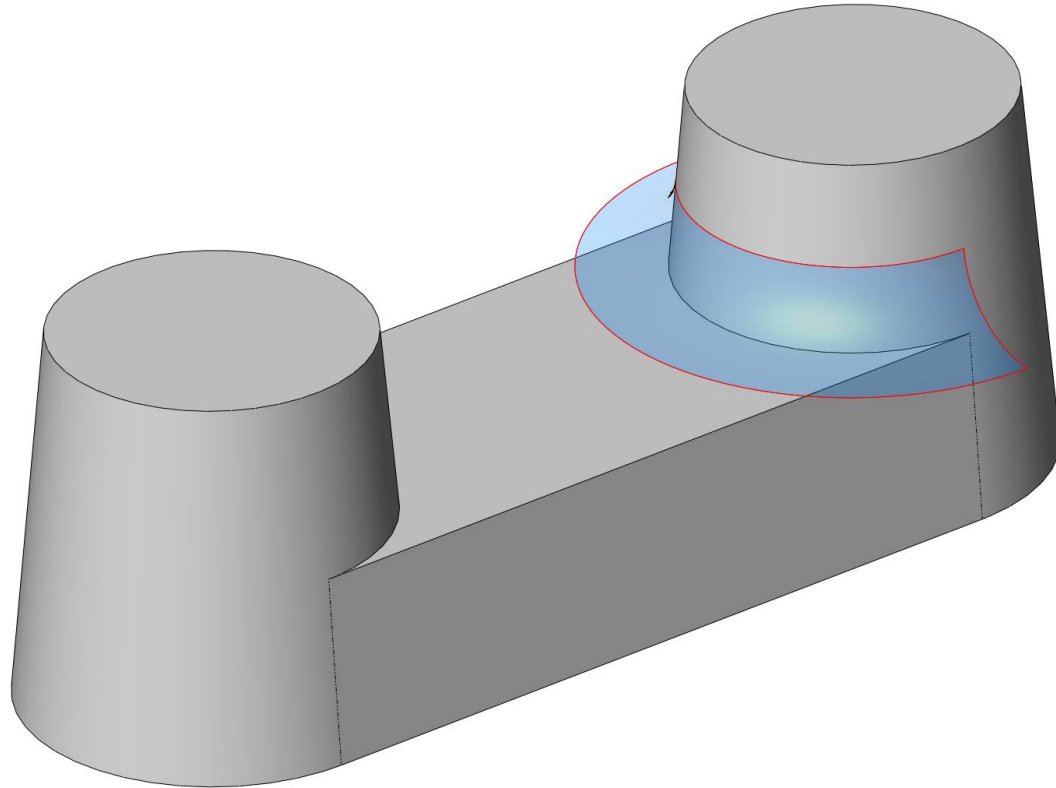
Fillets need somewhere to end.



The fillet tool is able to automatically extend the **RED** faces; the fillet now has a place to end.

Understanding Fillets

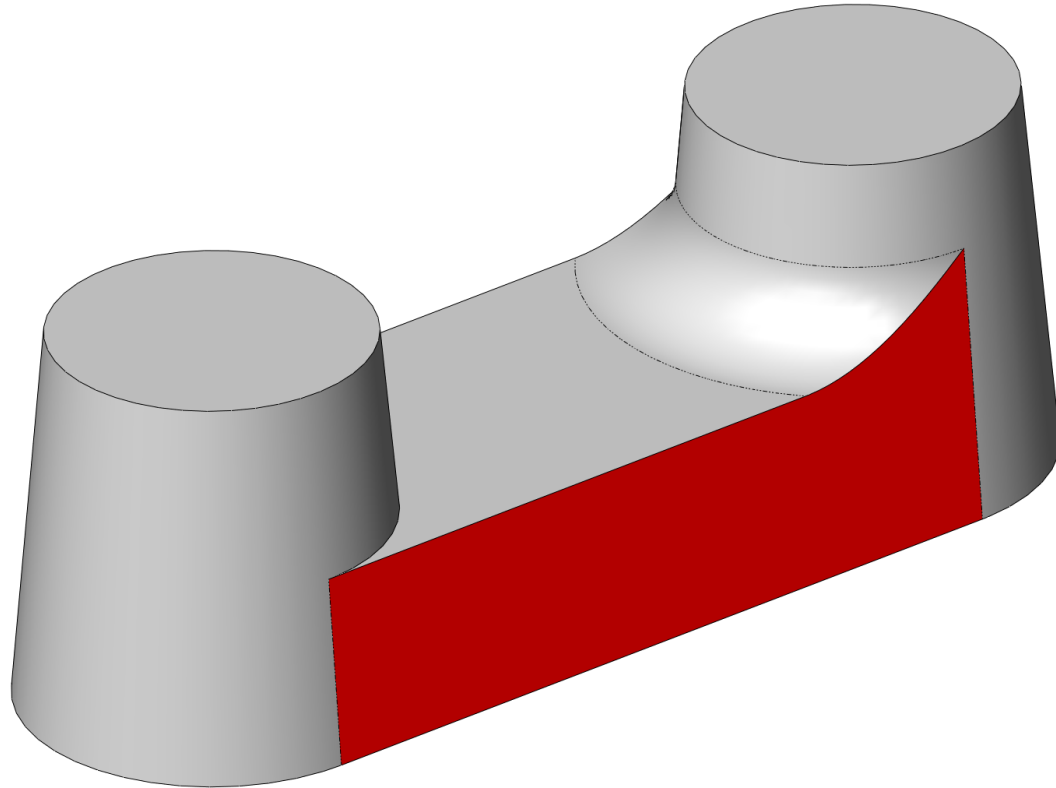
Fillets need somewhere to end.



If the fillet tool wasn't able to extend faces, the result might look something like this.

Understanding Fillets

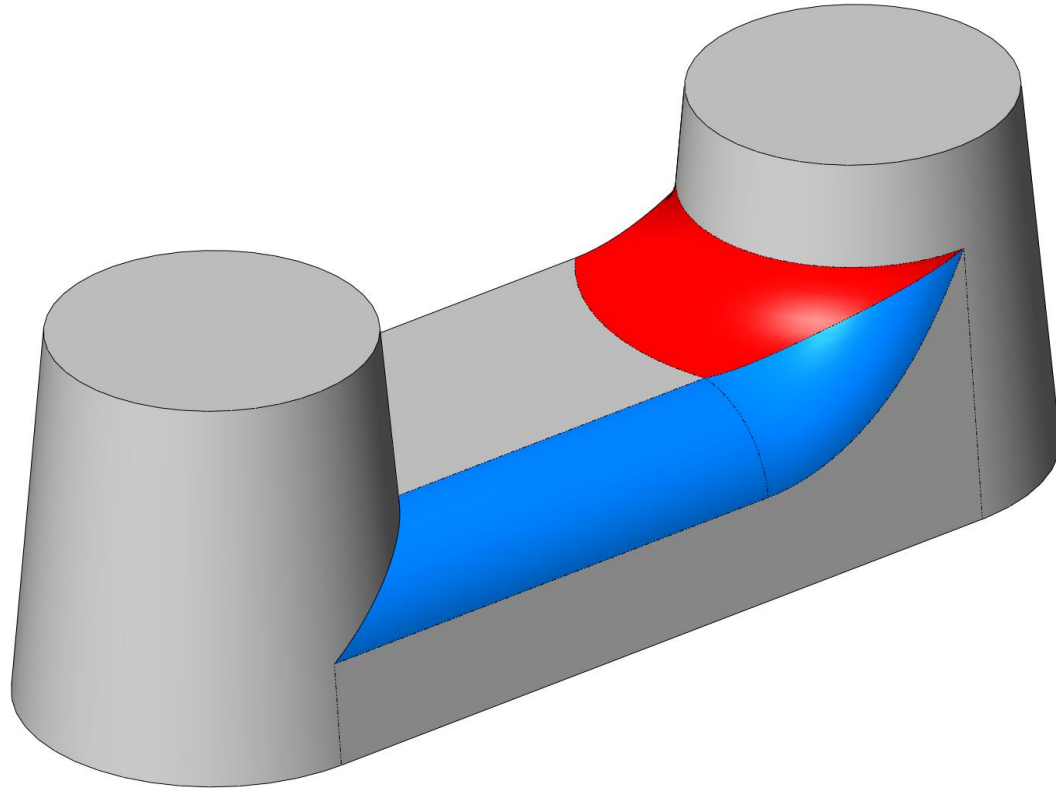
Fillets need somewhere to end.



Once again, the fillet tool extends the **RED** face giving the fillet somewhere to end.

Understanding Fillets

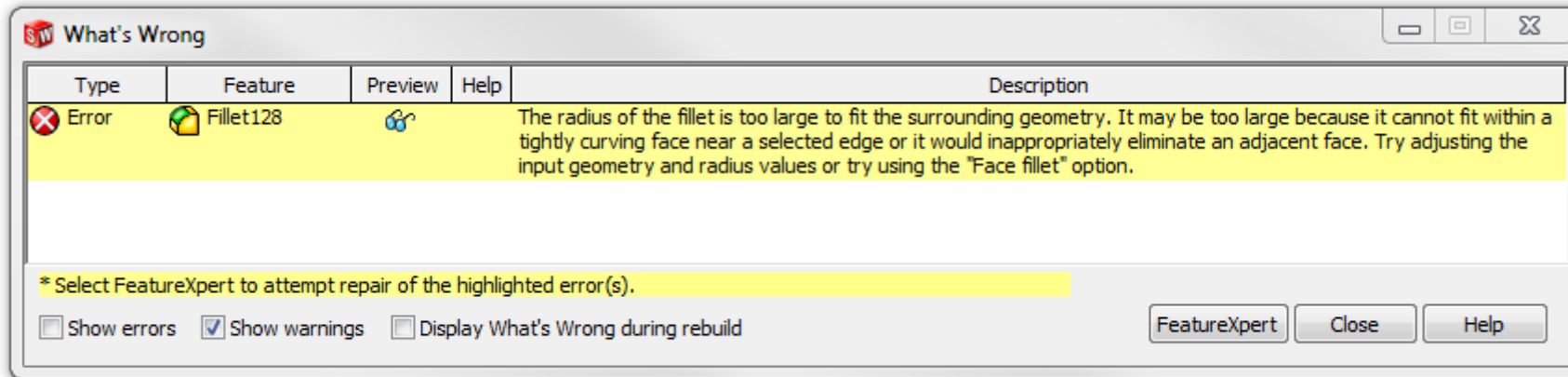
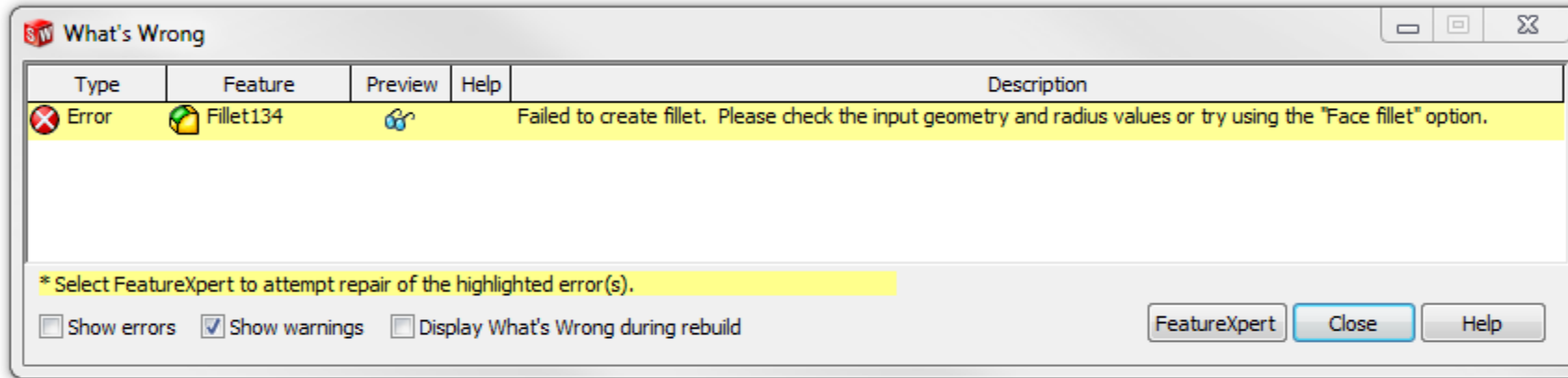
Fillets need somewhere to end.



When the **BLUE** fillet is applied, there are no faces able to end the fillet.

Instead the fillet tool tapers the fillet to nothing.

So you can't add a fillet?



So you can't add a fillet?

Despite SolidWorks cryptic error messages, fillets usually fail for one of two reasons:

- The software is unable to extend one or more faces along the path of the fillet giving somewhere for the fillet to end.
- The fillet is too large for the geometry. It might only be in one small portion of the fillet path, but it will still cause the feature to fail.

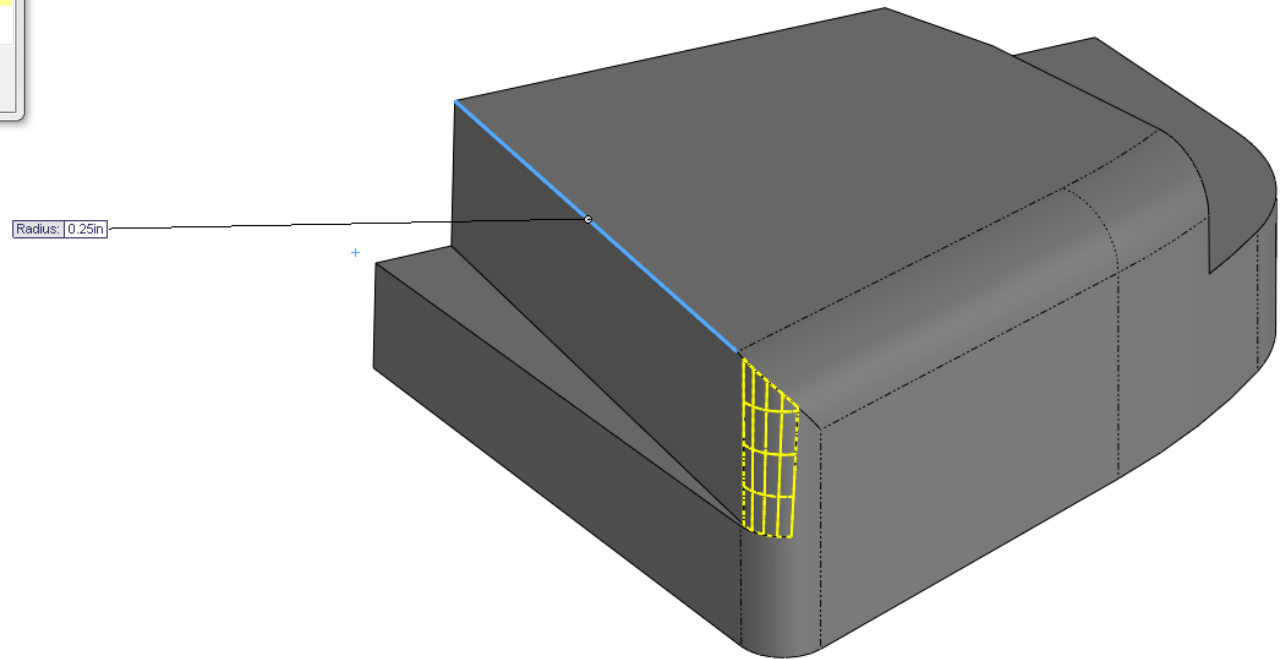
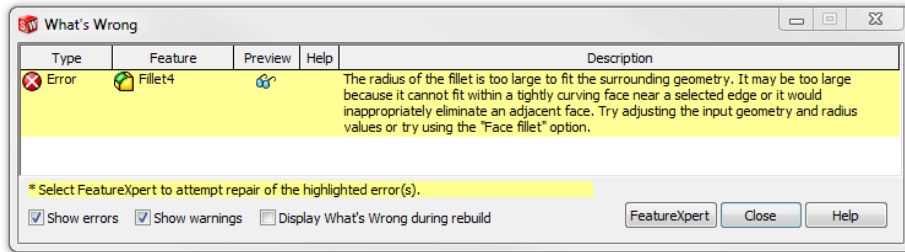
There is hope!

We now know that fillets fail because they need better faces to work with.

Luckily, there are a few different techniques we can use to give SolidWorks new faces to help terminate tricky fillets.

Resolving Failing Fillets

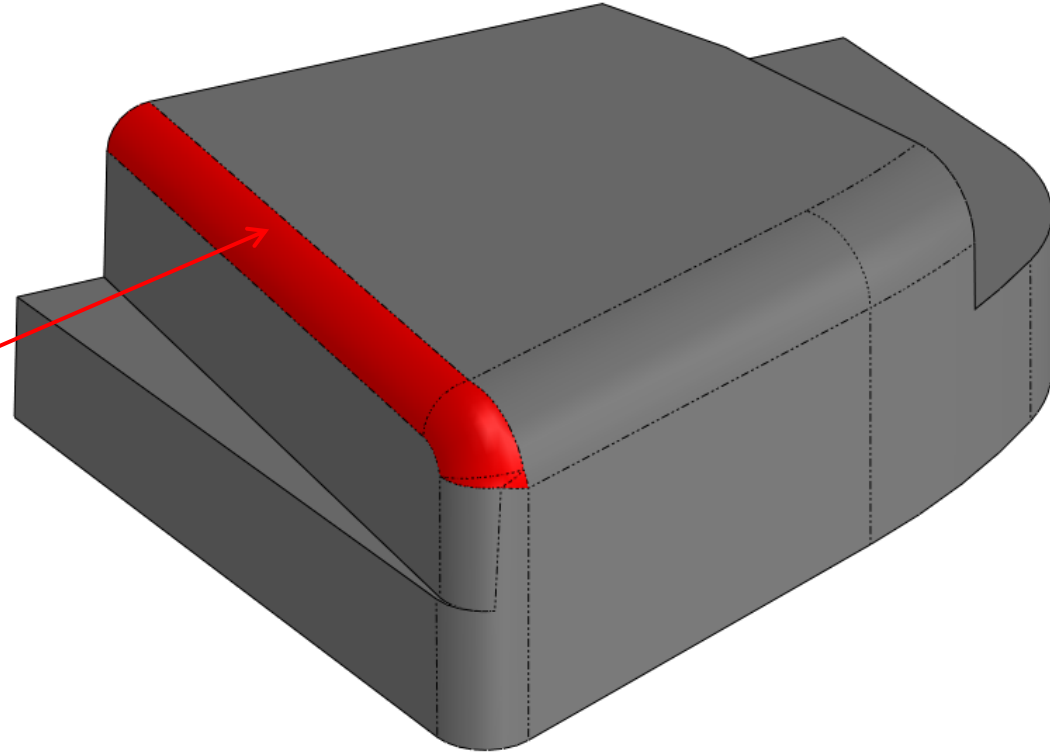
This part requires a .25" fillet along the highlighted edge. However, SolidWorks is unable to add a fillet at the desired radius.



Capture the Correct Design Intent

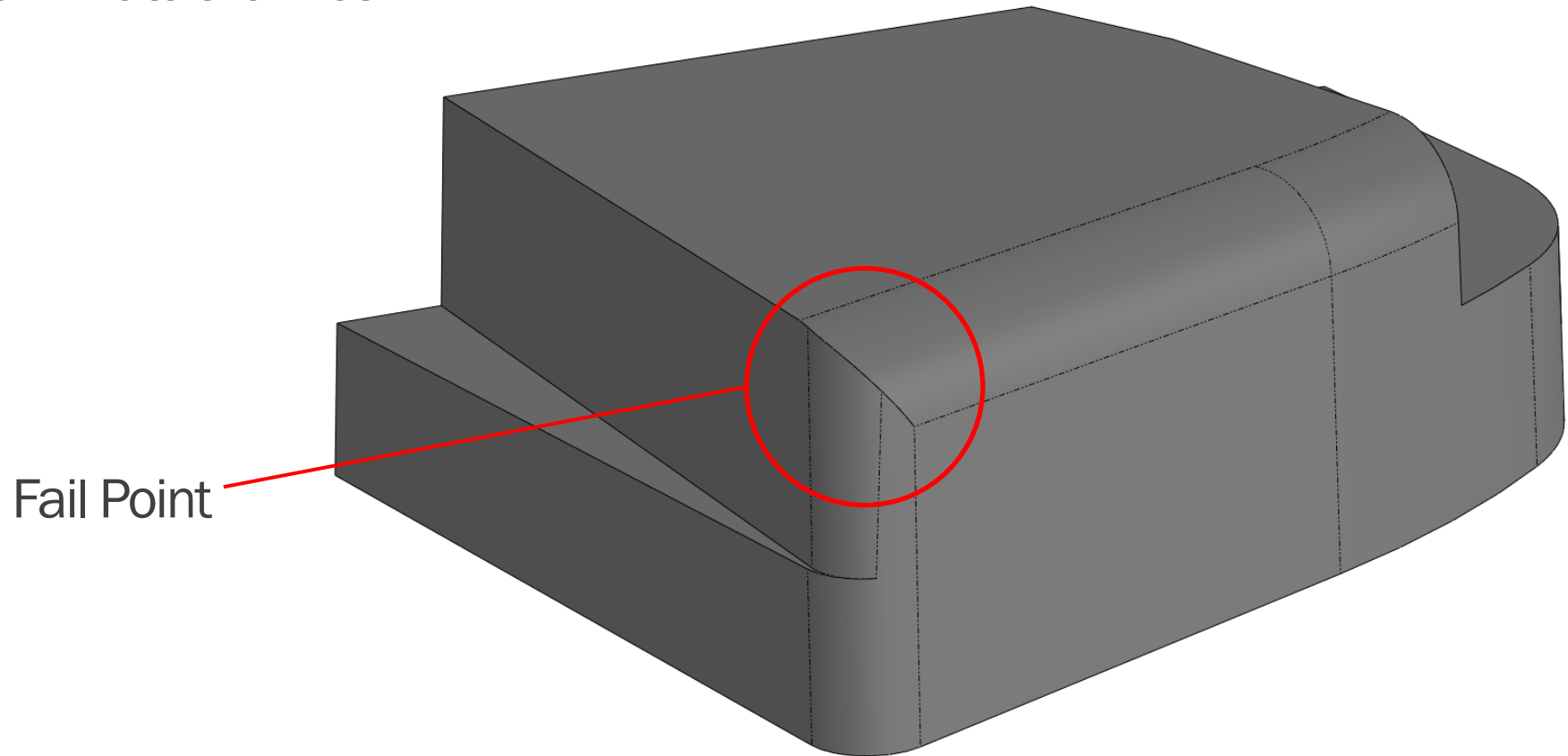
The fillet will complete at .22". But accepting this result would comprise the design intent of the part.

.22" fillet, NOT .25" fillet
as required



Identify Potential Fail Points

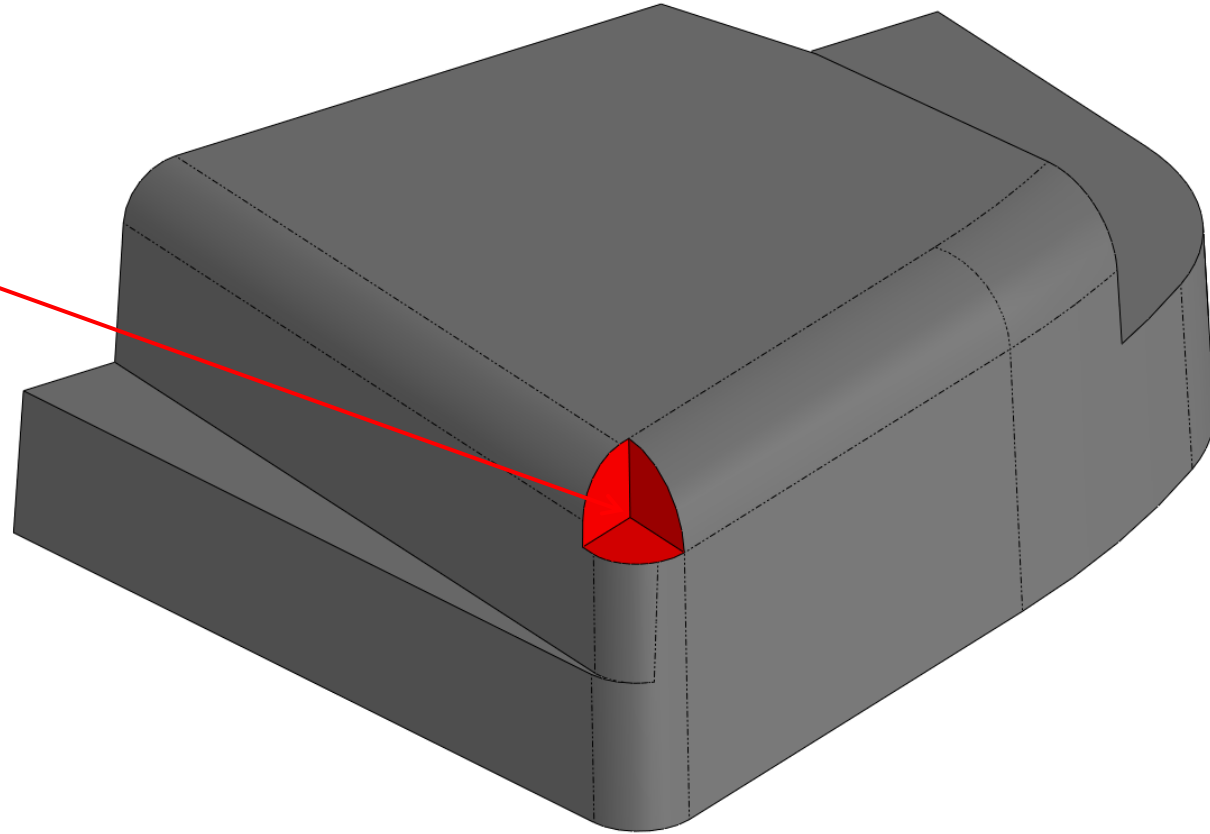
The fillet is most likely failing at the corner because SolidWorks is unable to extend the corner faces to terminate the fillet.



Cut Away the Fail Point

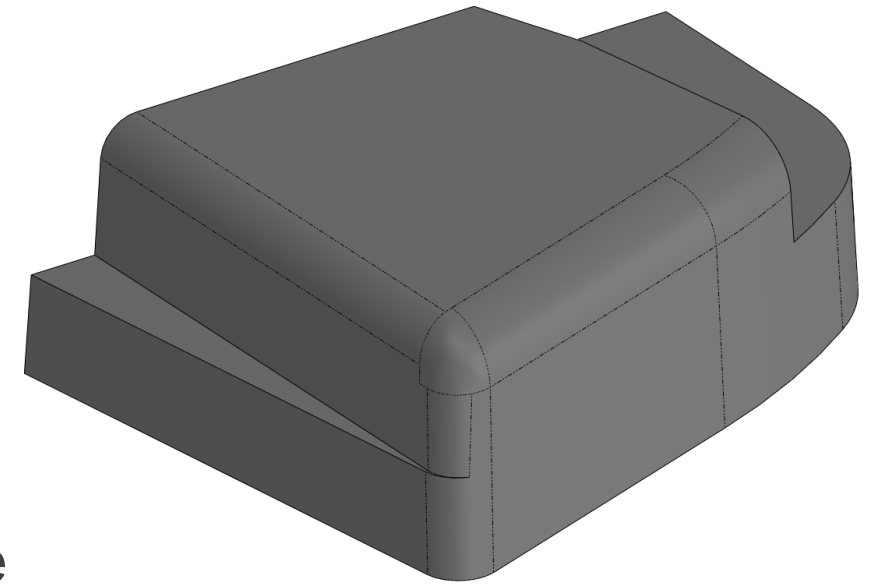
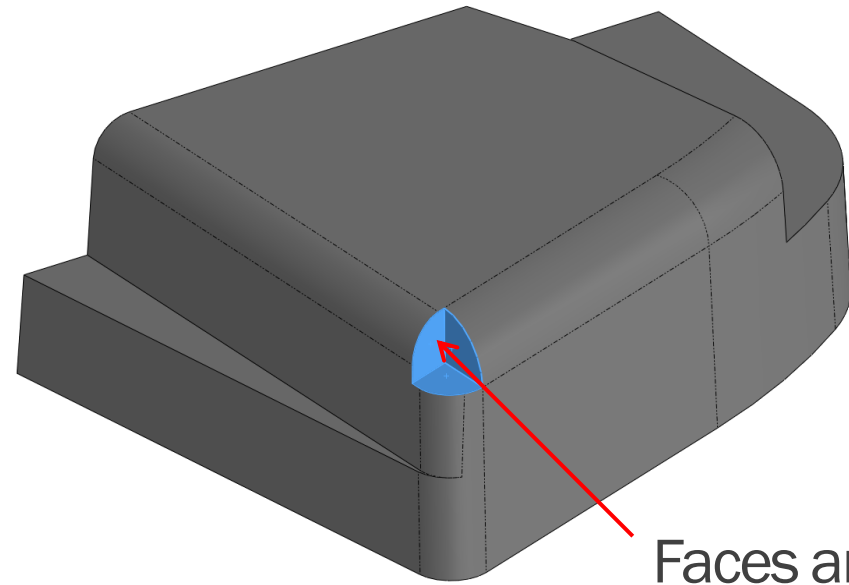
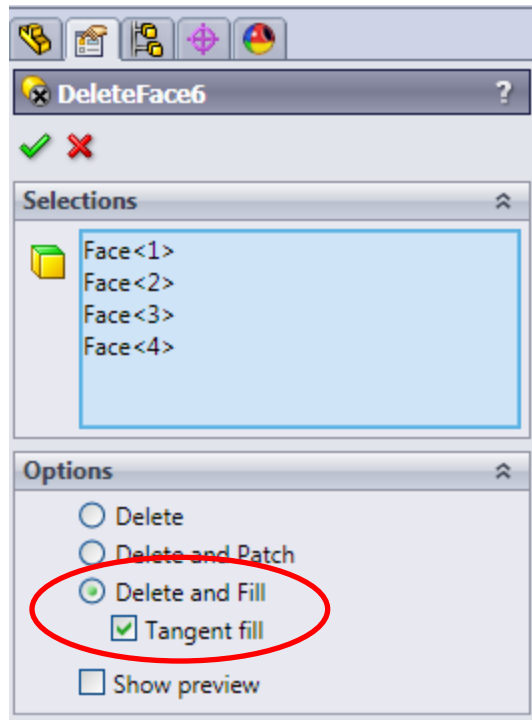
By cutting the fail point out of the model, the fillet can now successfully complete.

The fail point is cut out of the model. The fillet completes at the required .25" radius.



Repair the Corner

The missing corner of the model must be repaired. Delete Face can be used to patch the corner.

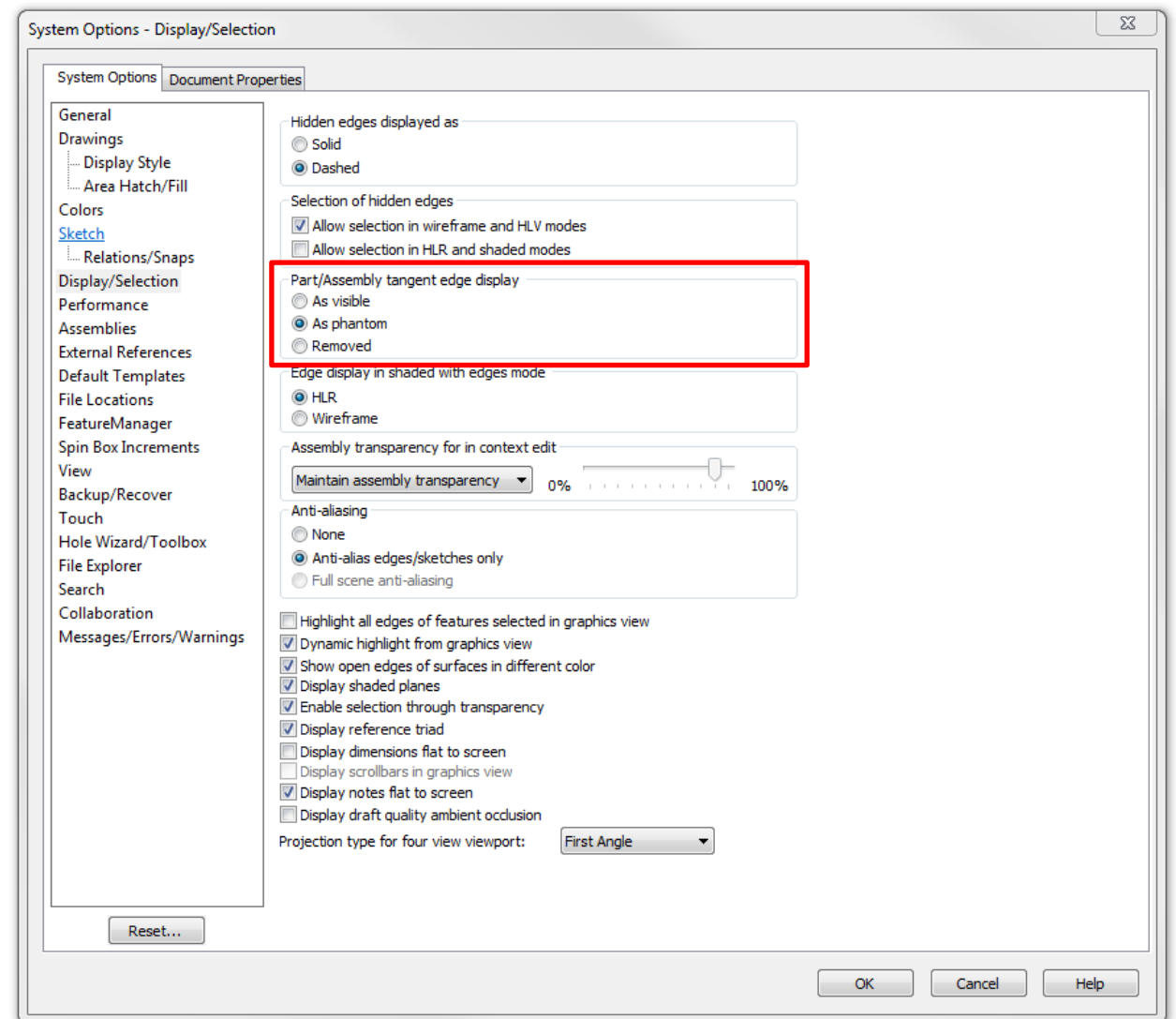


Faces are
selected for
deletion.

Tangent Edge Display

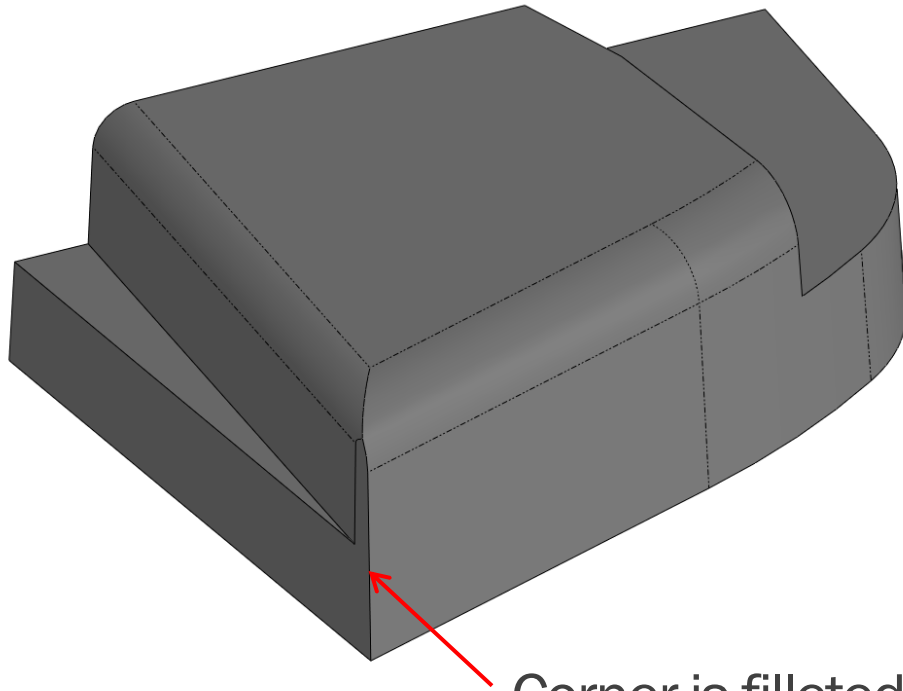
This is a sure fire way to know when edges are tangent or when they aren't.

I used to think this looked odd; now I can't work any other way.

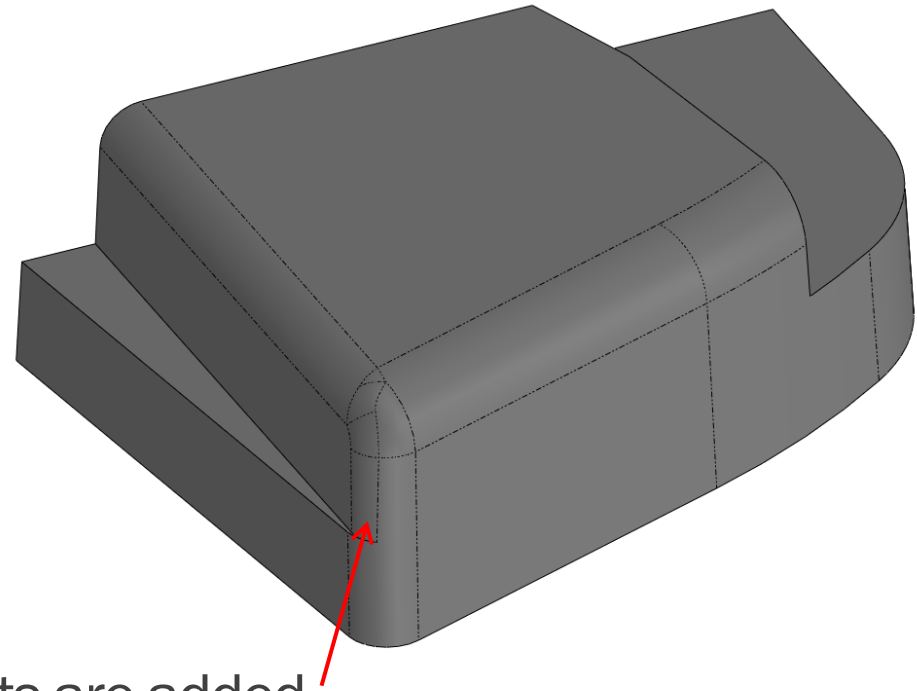


Rearrange Fillet Order

The order of fillets can be important. By re-ordering fillets, complicated corners can be prevented and failing fillets can be added to the model.

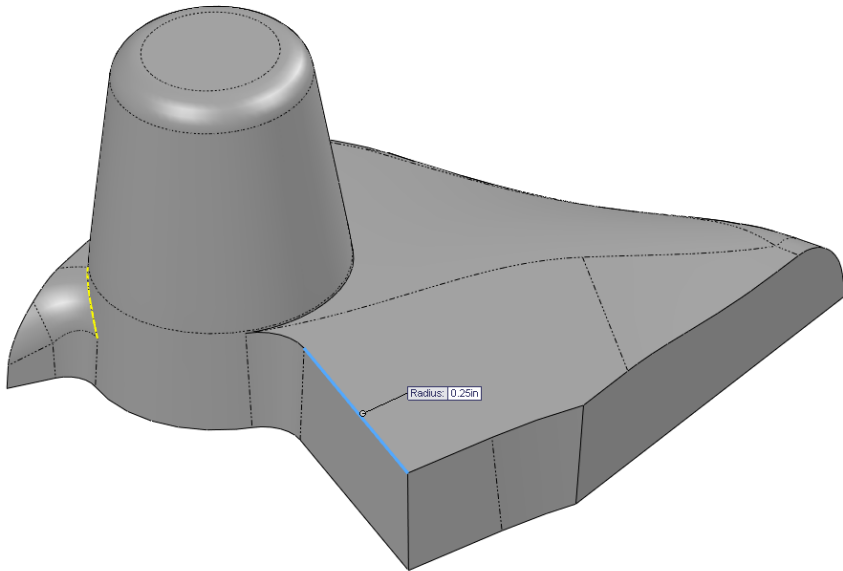
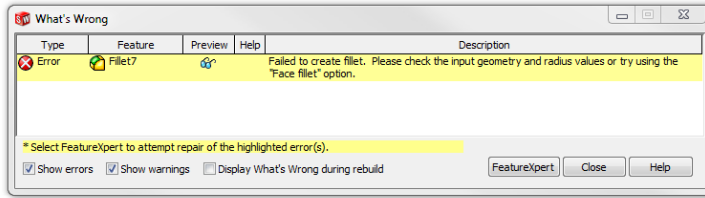


Corner is filleted after top fillets are added.
This eliminates the complicated corner.

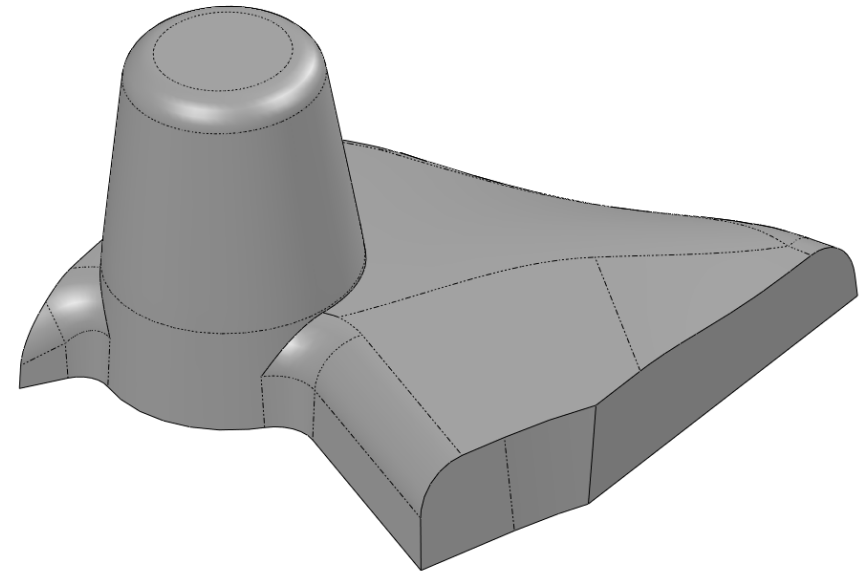
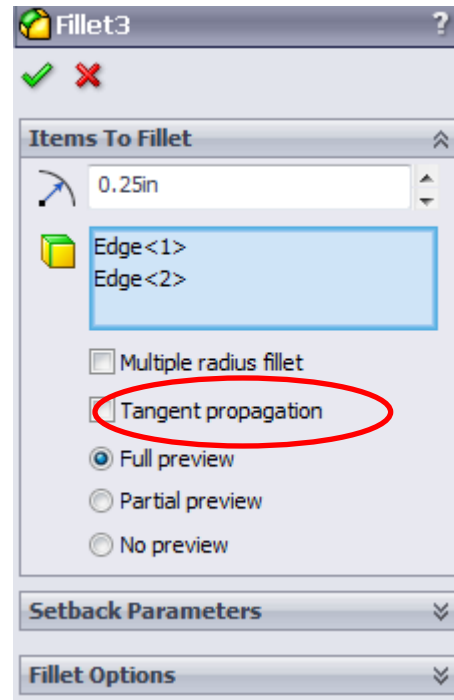


Turn Off Tangent Propagation

Failing fillets can sometimes be made to complete if Tangent Propagation is turned off. However, this will require manual selection of all edges to fillet.



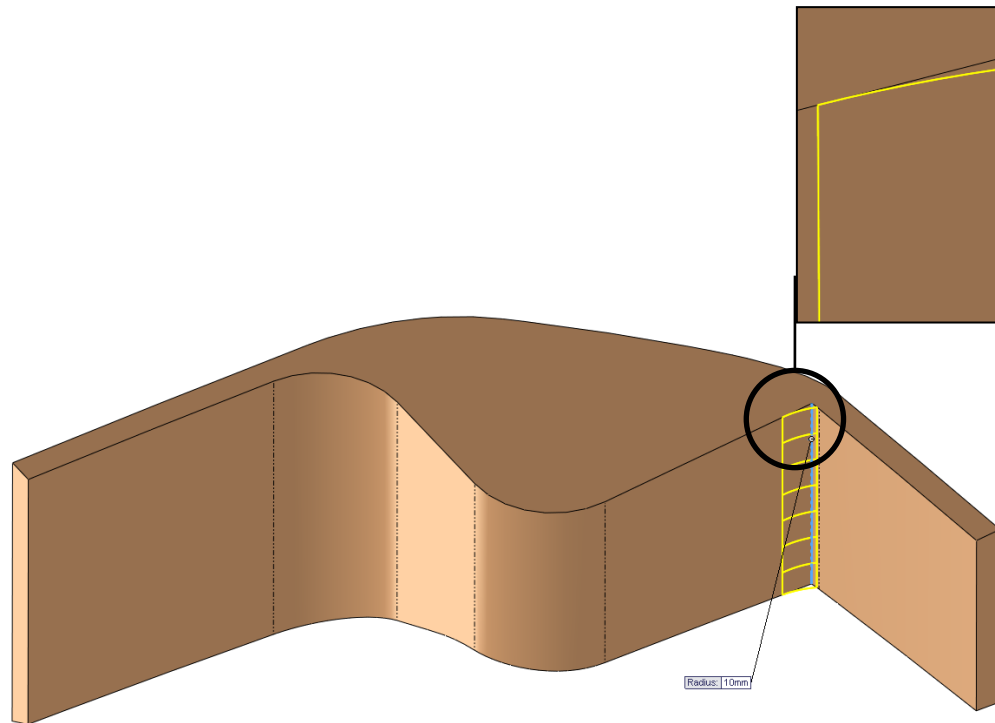
Tangent Propagation On



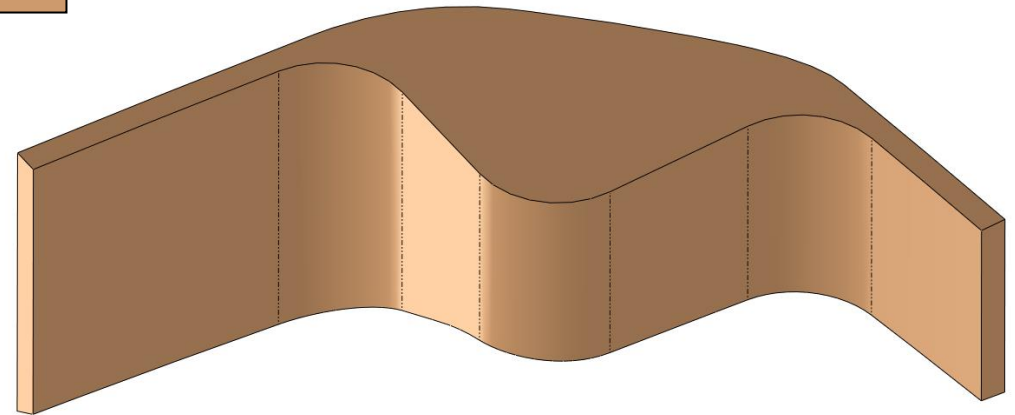
Tangent Propagation Off

Face Fillets

Because of the small “sliver” faces close to the corner, a standard fillet does not work correctly.



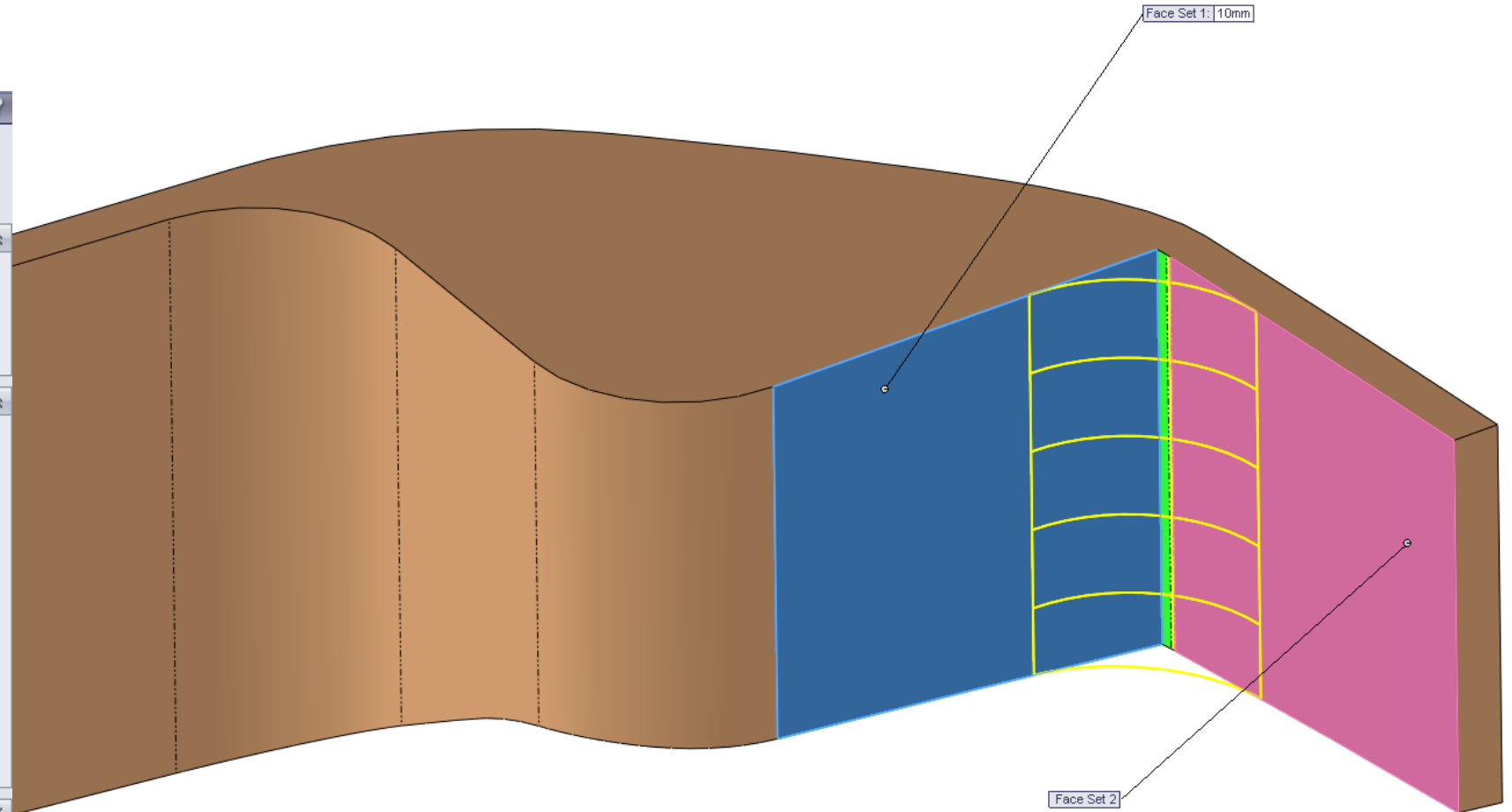
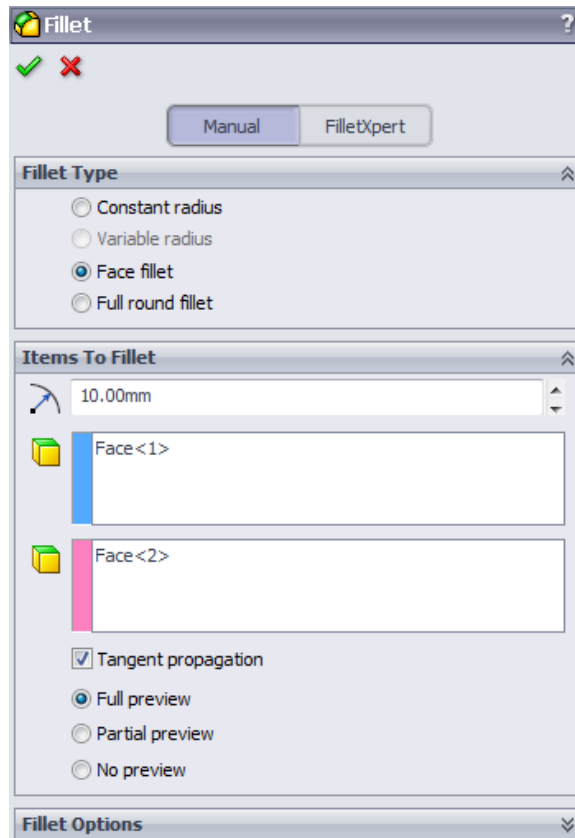
Small faces cause problems.



Desired Result

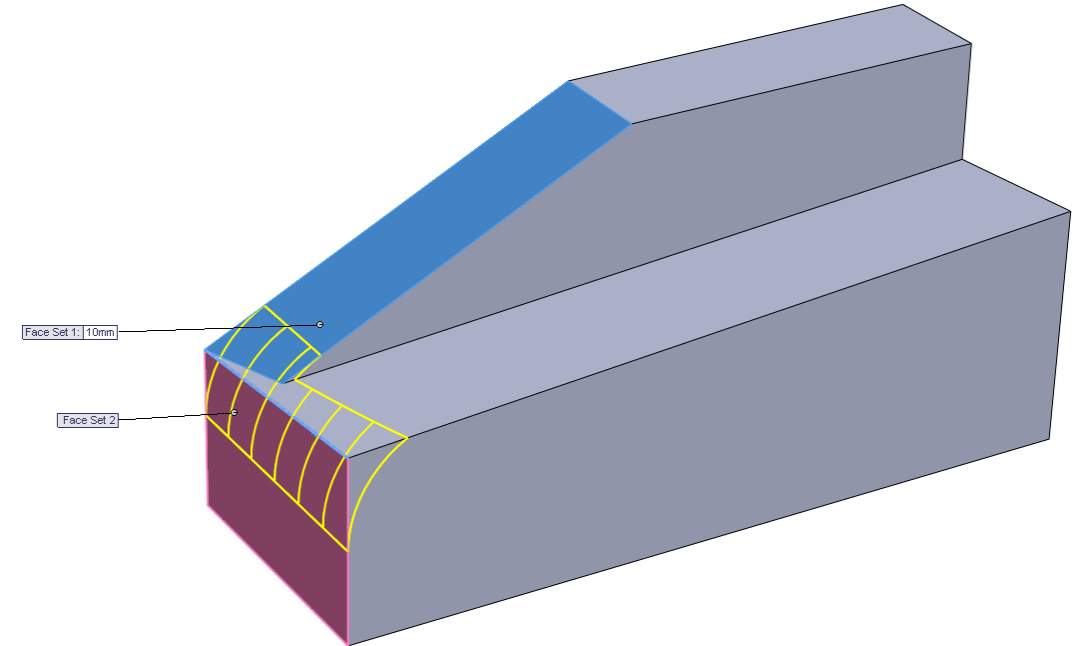
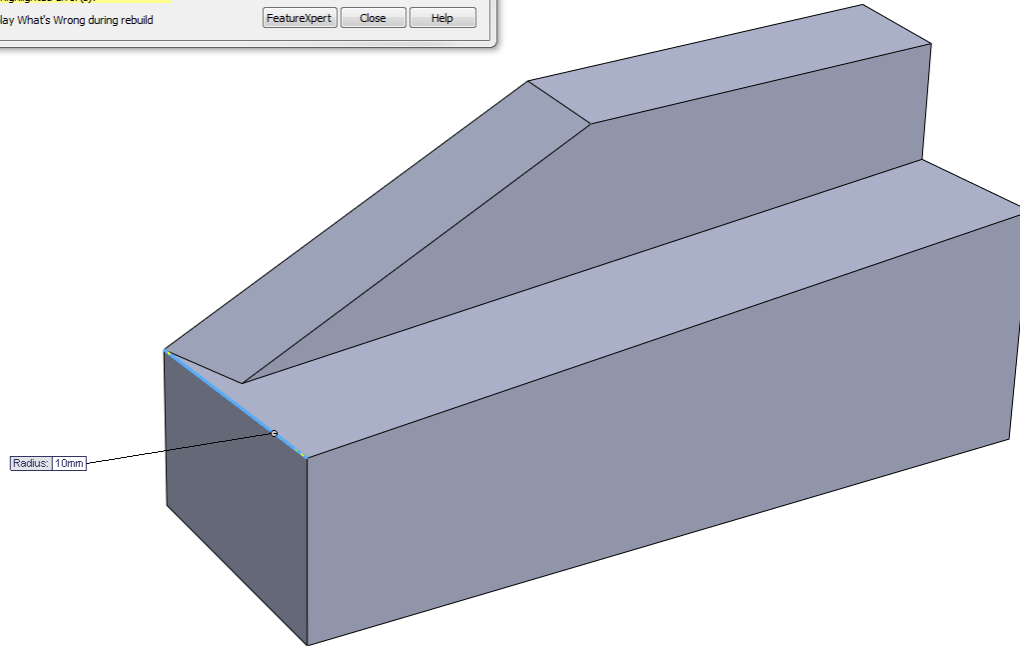
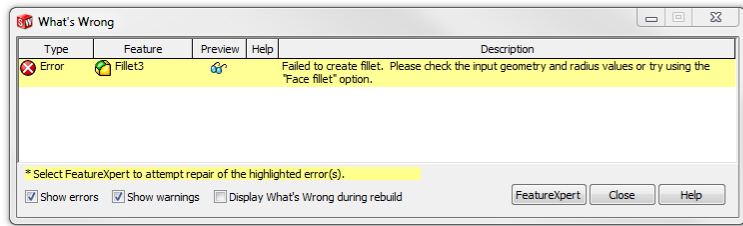
Face Fillets

The face fillet tool can bridge these small faces by applying the fillet between two faces, instead of an edge.



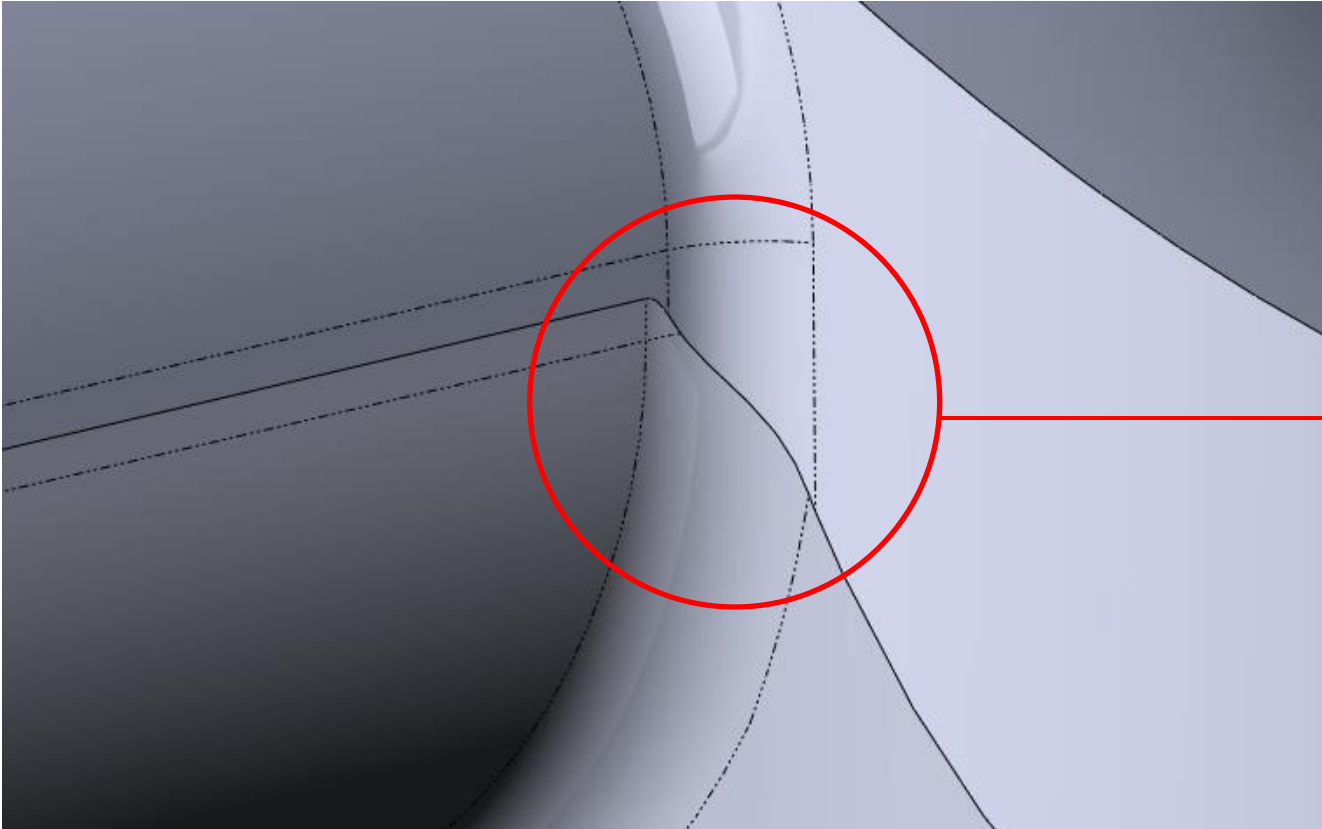
More Face Filleting

Because the Face Fillet tool can bridge faces, it can create fillets where the standard fillet tool fails.



Fillets Across the Parting Line

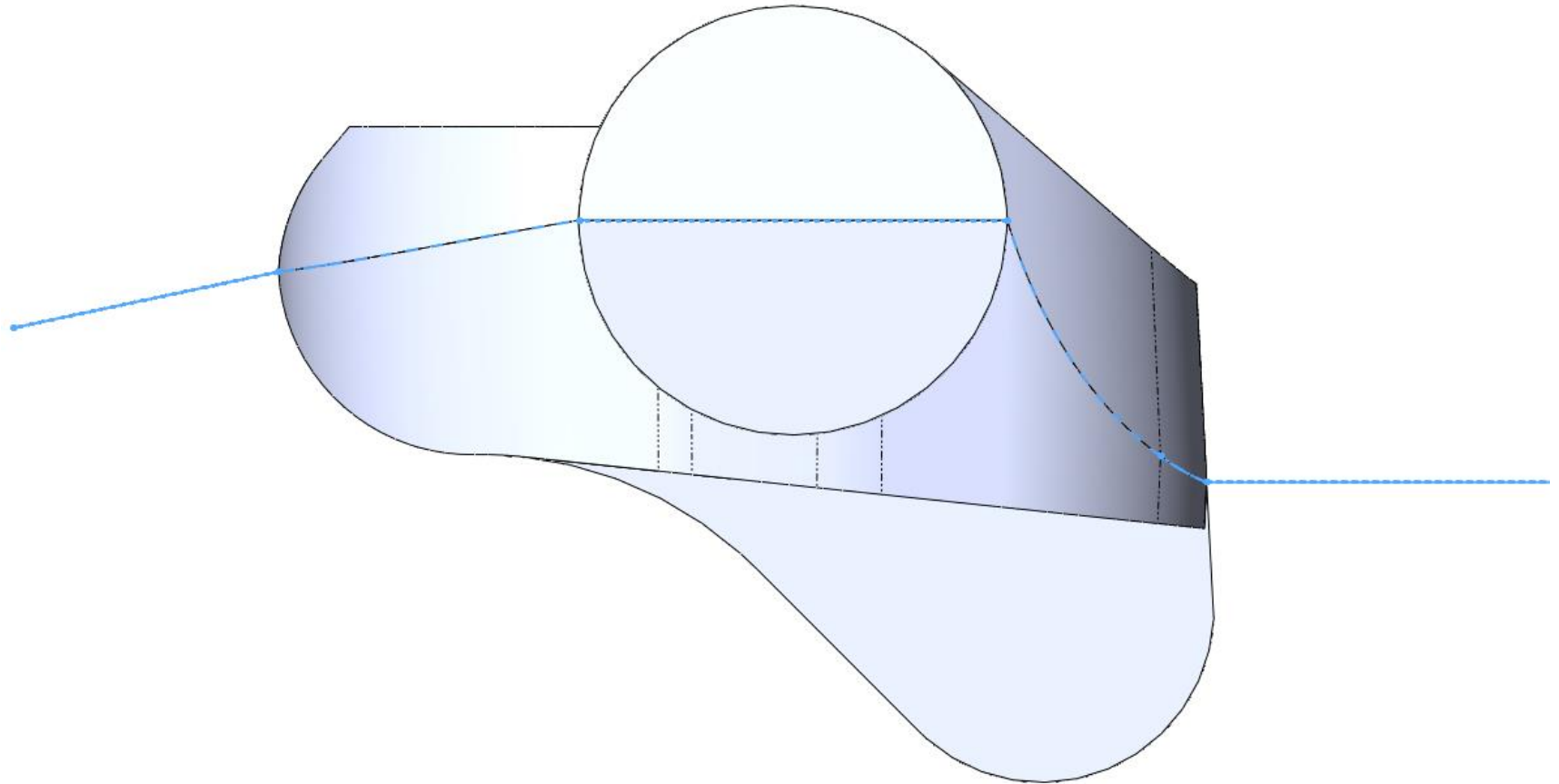
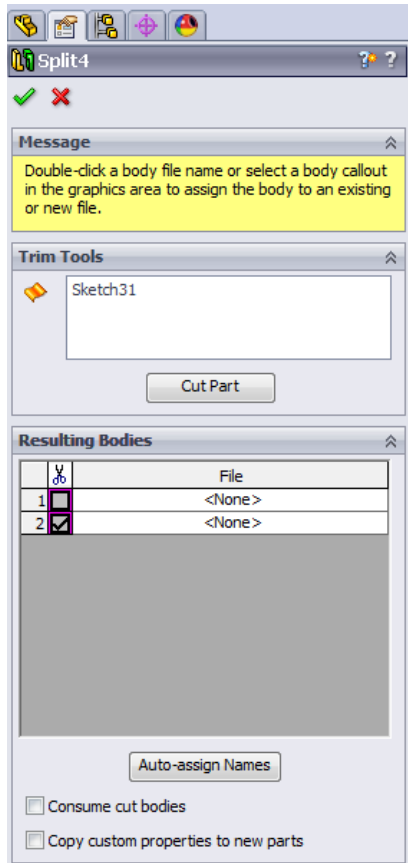
Fillets across the parting line can be wonky. There are ways to improve these transitions.



Filleting across the parting line is sloppy.

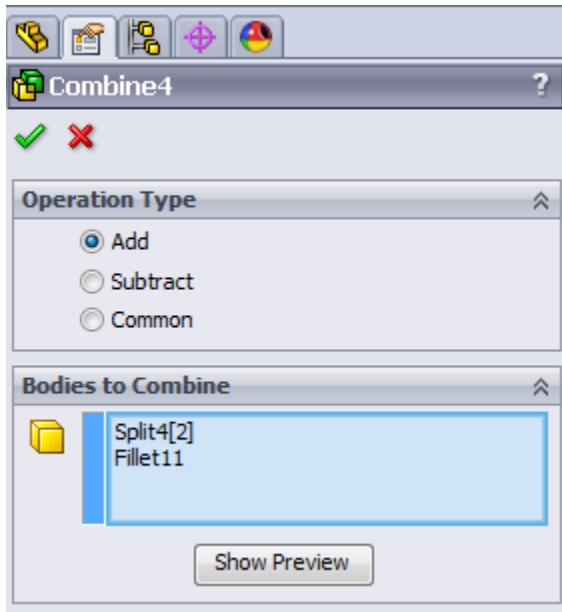
Split Part

Split part can be used to stop the fillet.

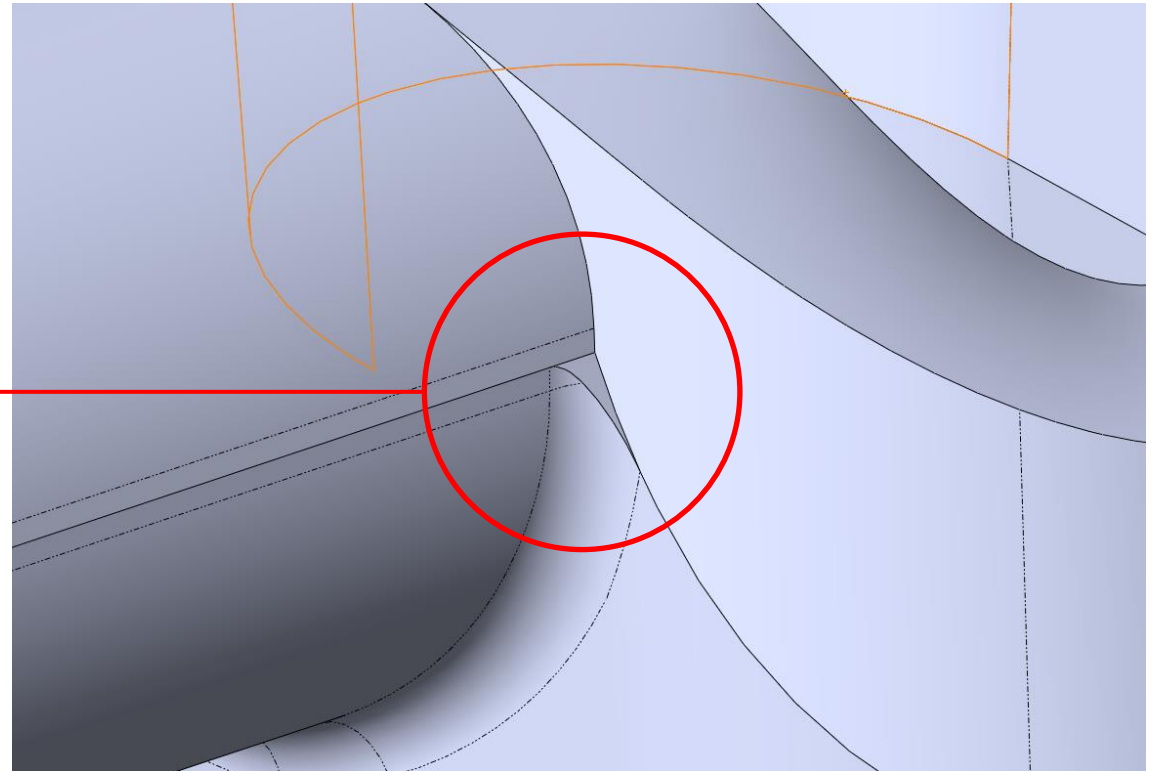


Combine

With the part cut in half, the fillet stops nicely along the parting line. Combine is used to put the part back together.

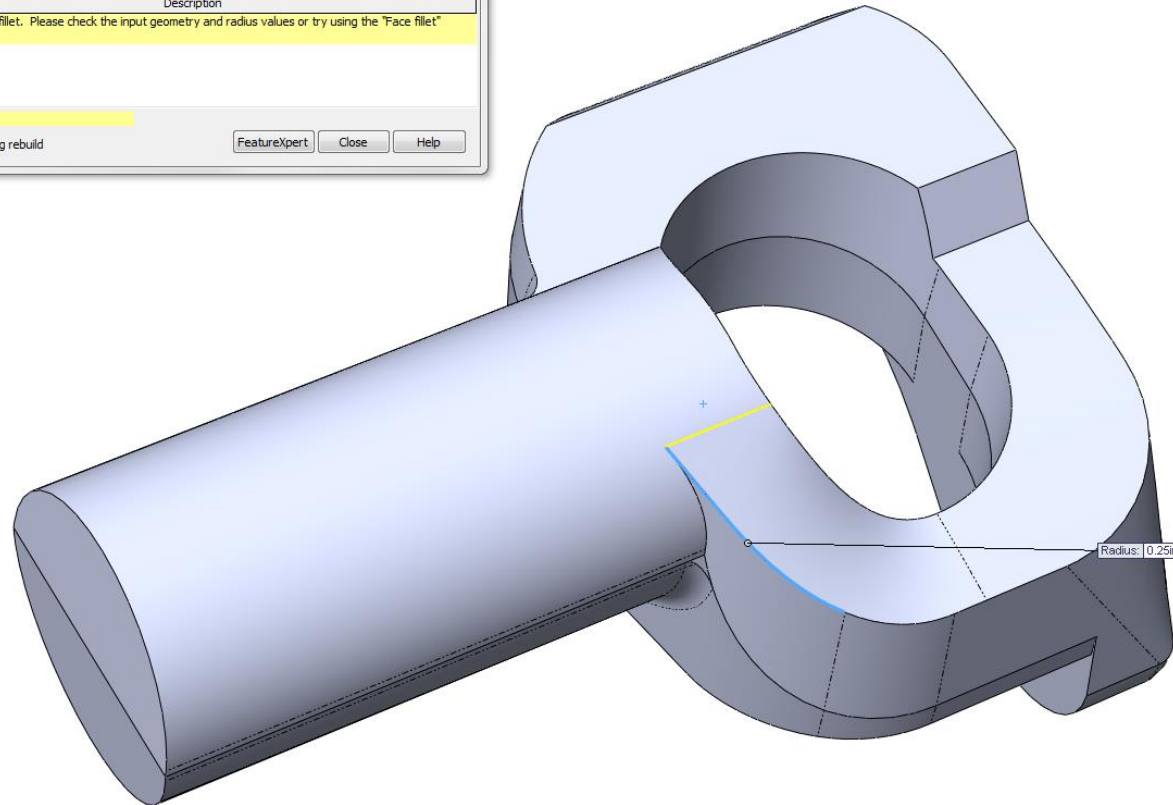
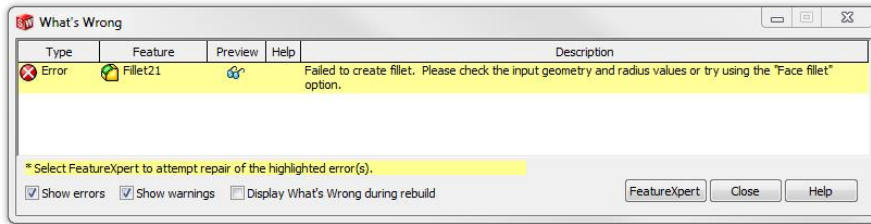


Clean Parting
Line



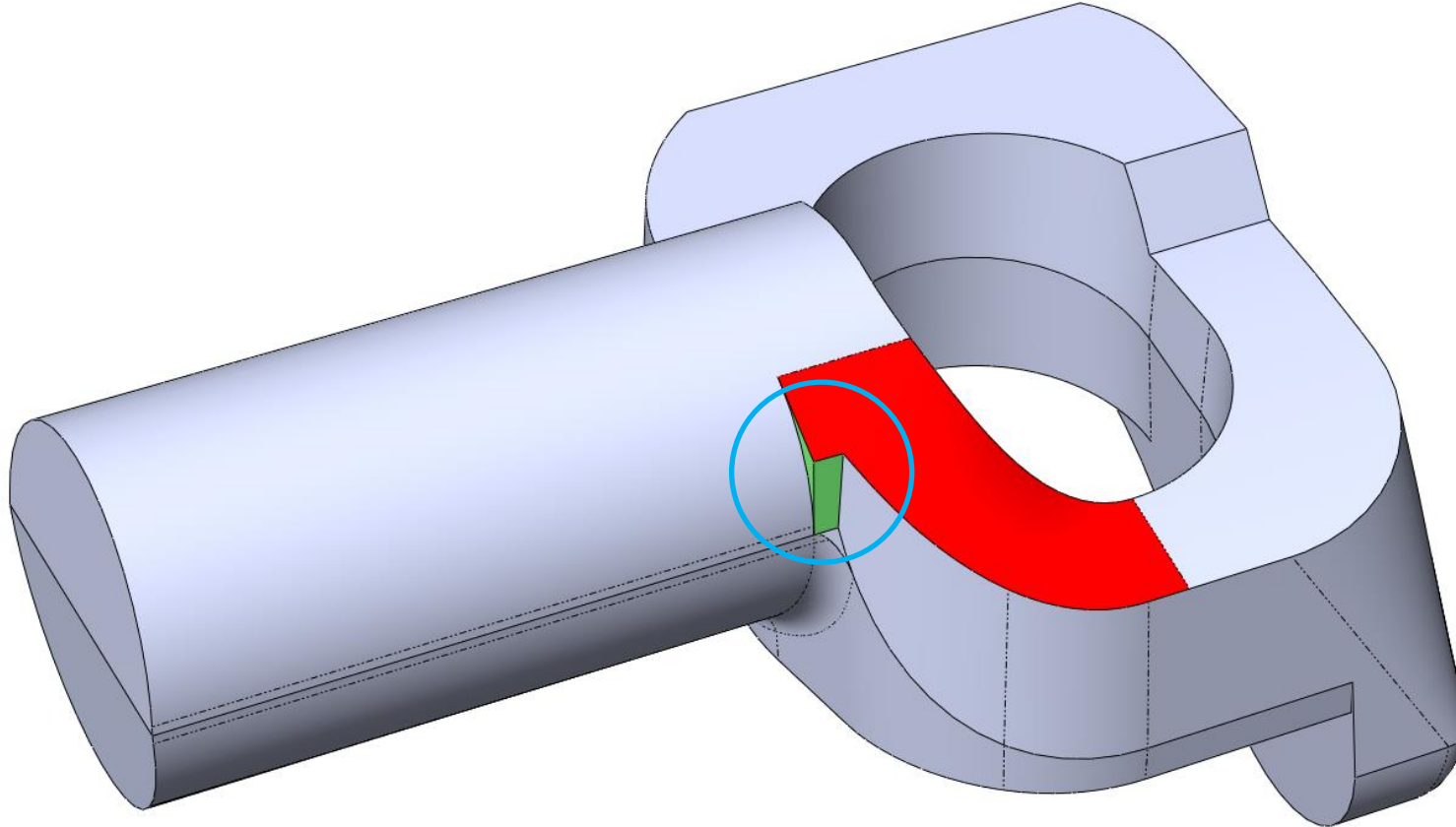
Edges That Tangentially End

Another failed fillet. Where is the fail point on this example?



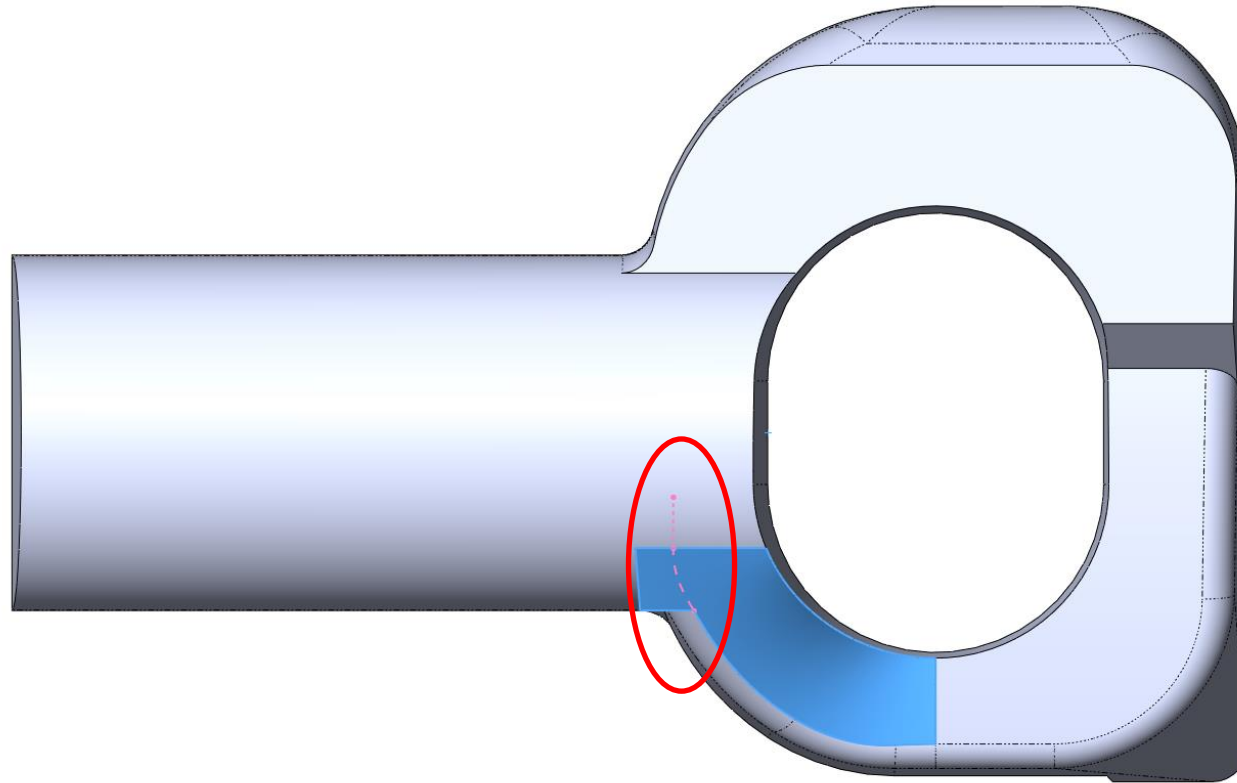
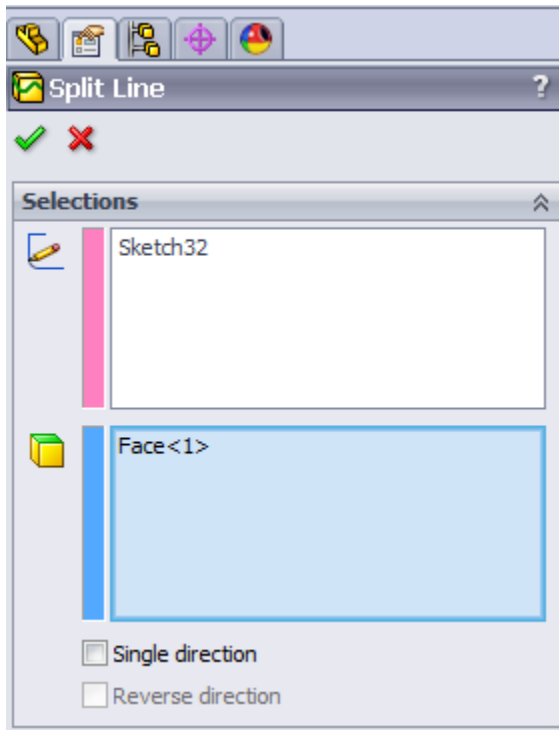
New Faces to End the Fillet

Create an **extrusion** up to the **RED** up to the red surface. Now the fillet can end.



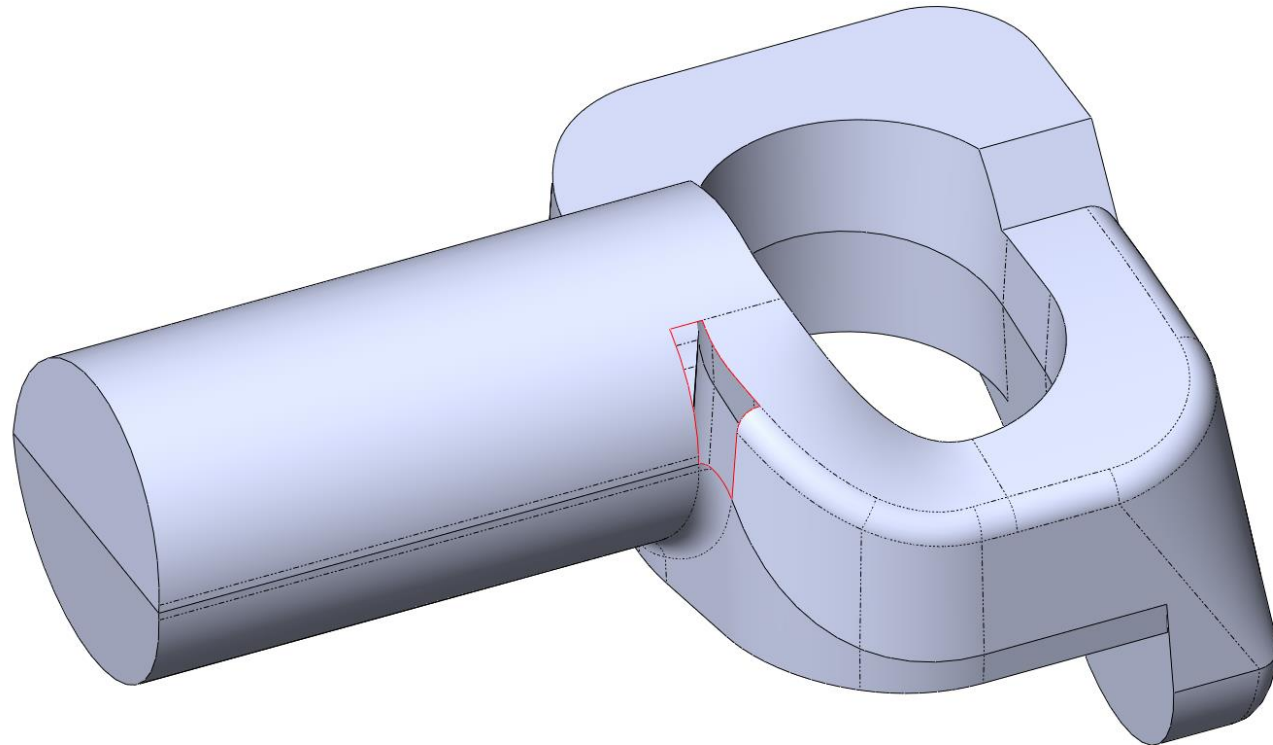
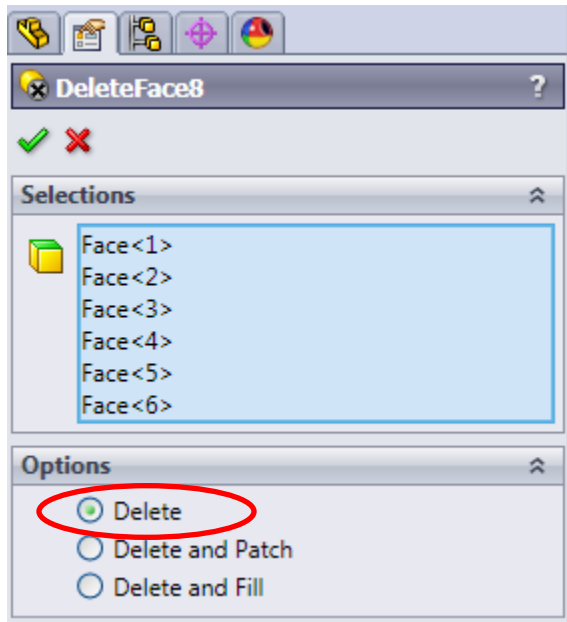
Split Line

We need to remove the block that was stopping the fillet. Split line is used to create new edges on the model.



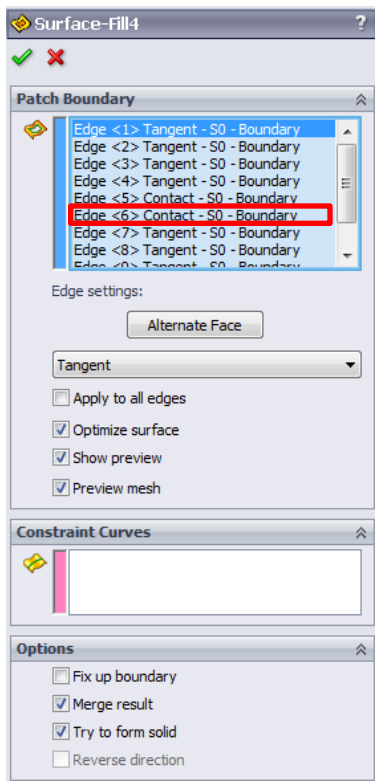
Create the Blend Area

Delete Face is used to remove the faces from the model. The correct location of split lines can aid in the flow of the blend.

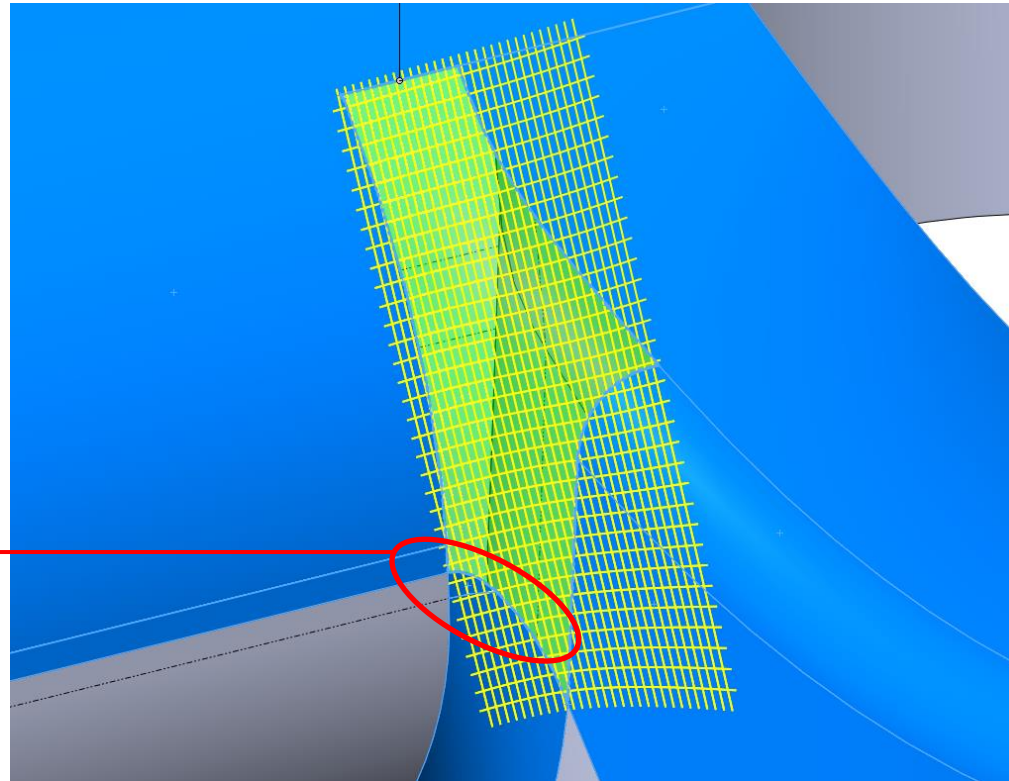


Surface Fill

Delete and Fill is an automated surface fill: it automatically applies tangency end condition to all edges. Using Surface Fill allows end conditions to be selected for each edge.



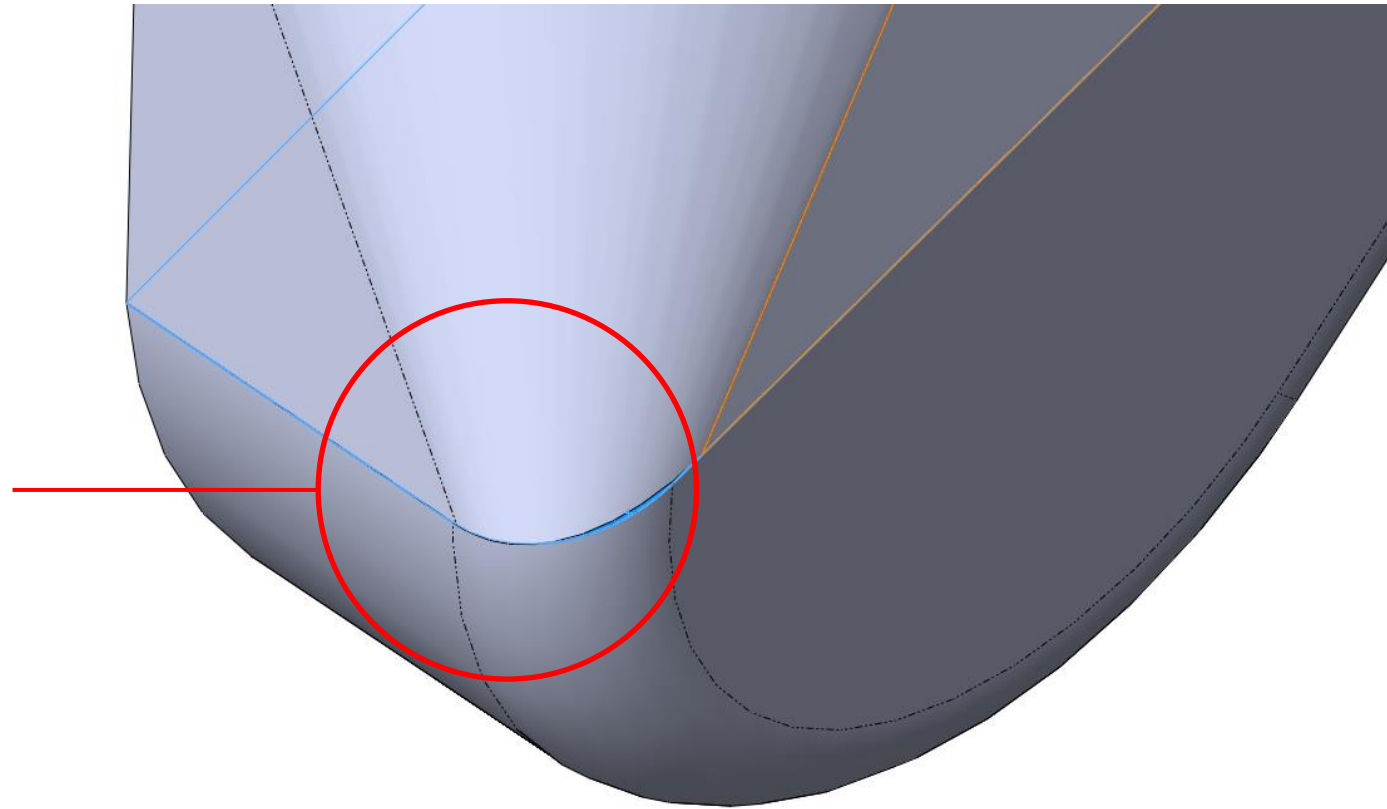
Parting line edge
is non tangent



Manual Fillets at the Parting Line

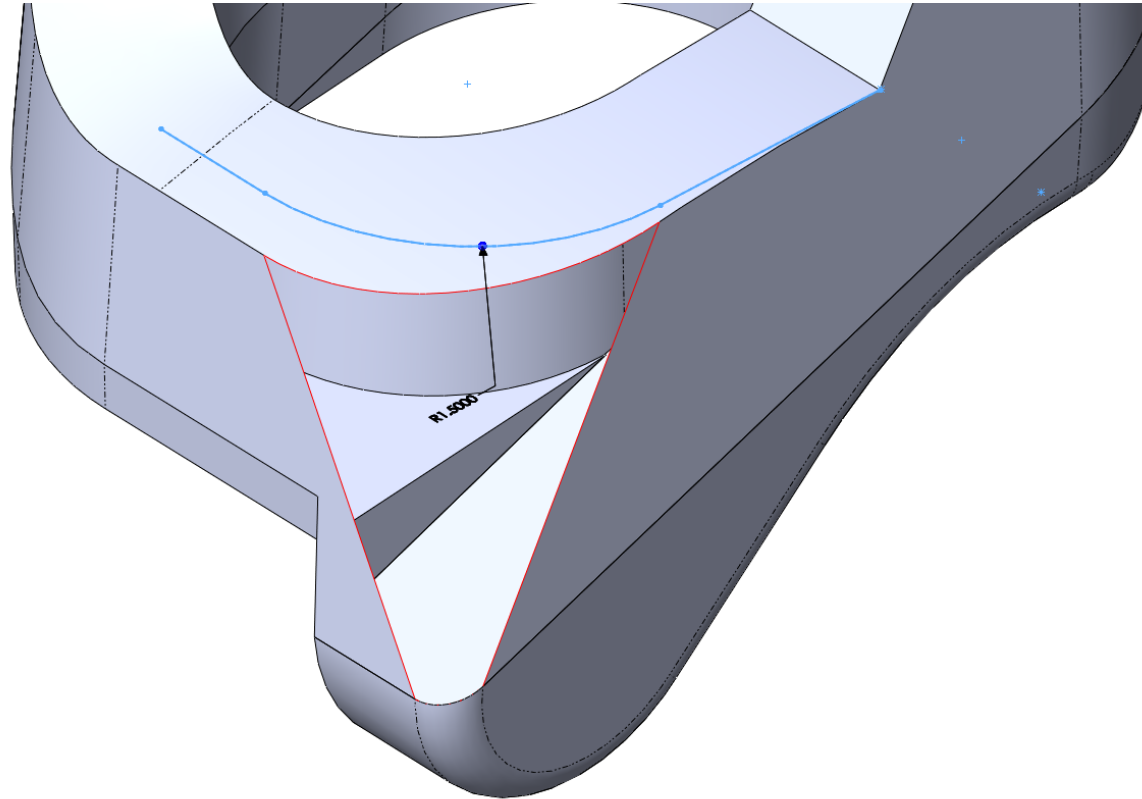
When trying to add the second half of the fillet crossing the parting line, things don't quite line up. Time to build the fillet manually.

Sliver faces caused by
fillets not quite lining up.



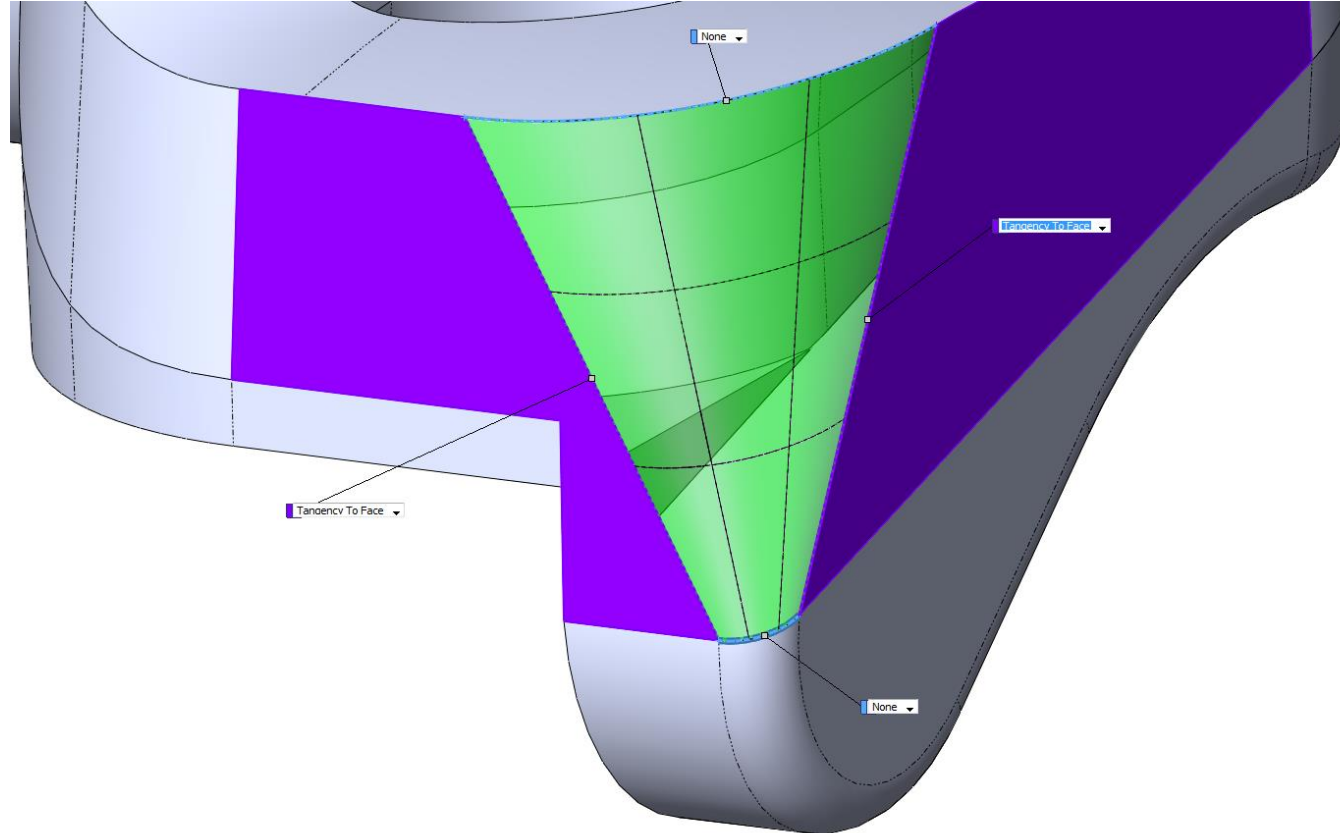
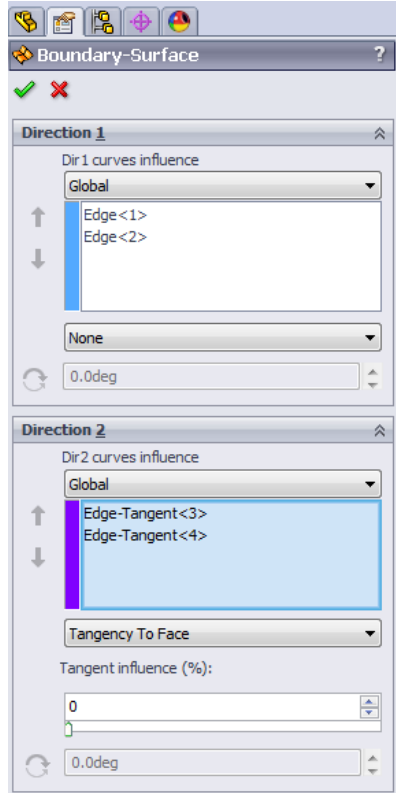
Manually Define Fillet Edges

Using the split line tool, the three required edges of the fillet can be defined. Delete face then “opens up” the fillet area.



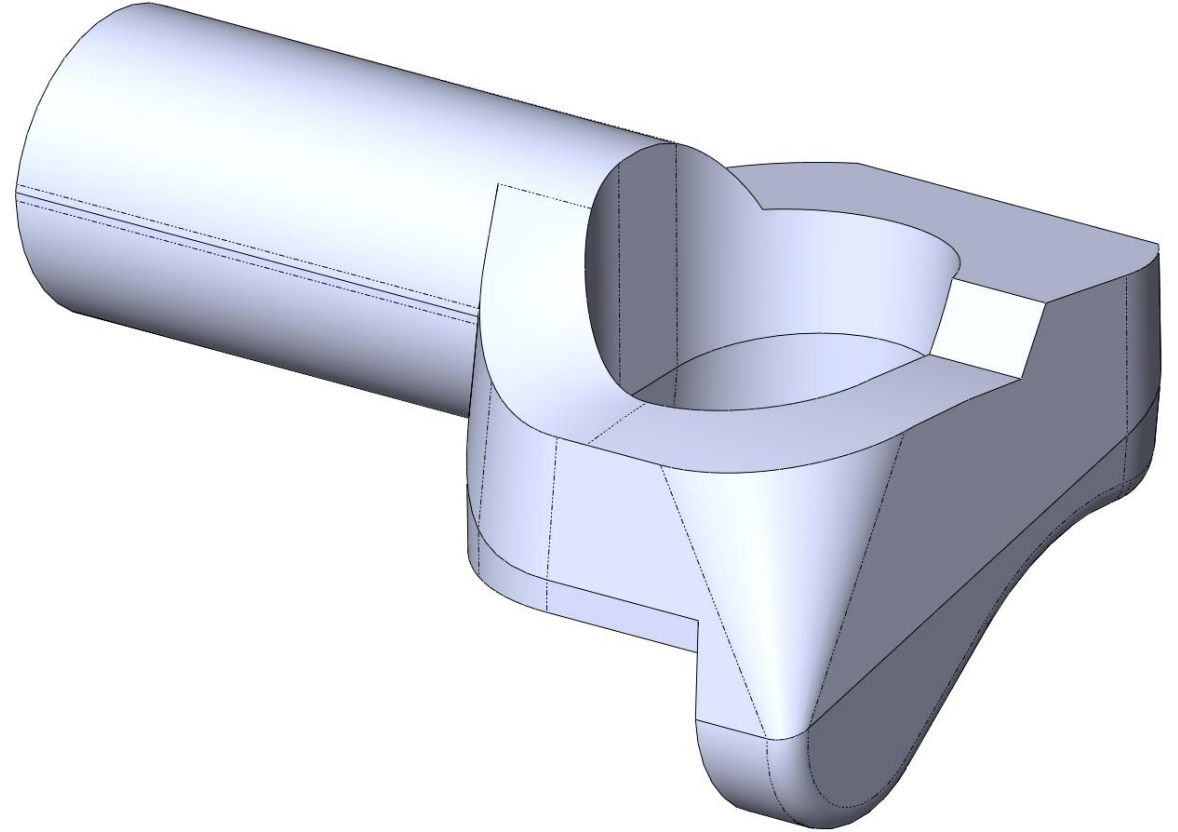
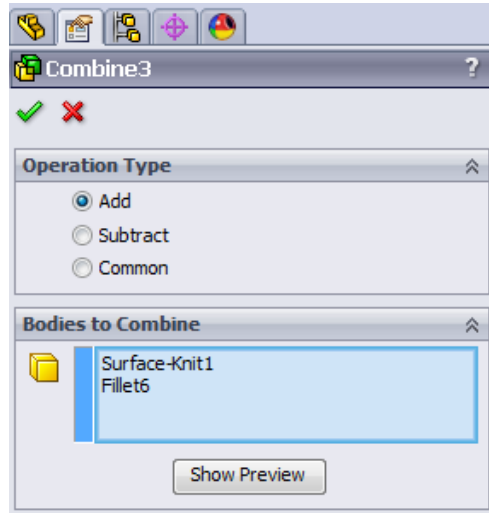
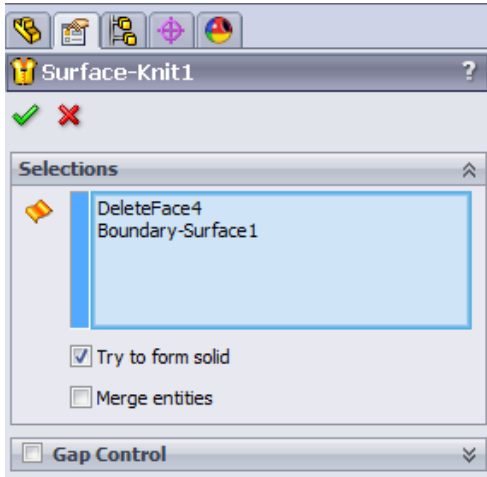
Boundary Surface

The fillet is created with a Boundary Surface.



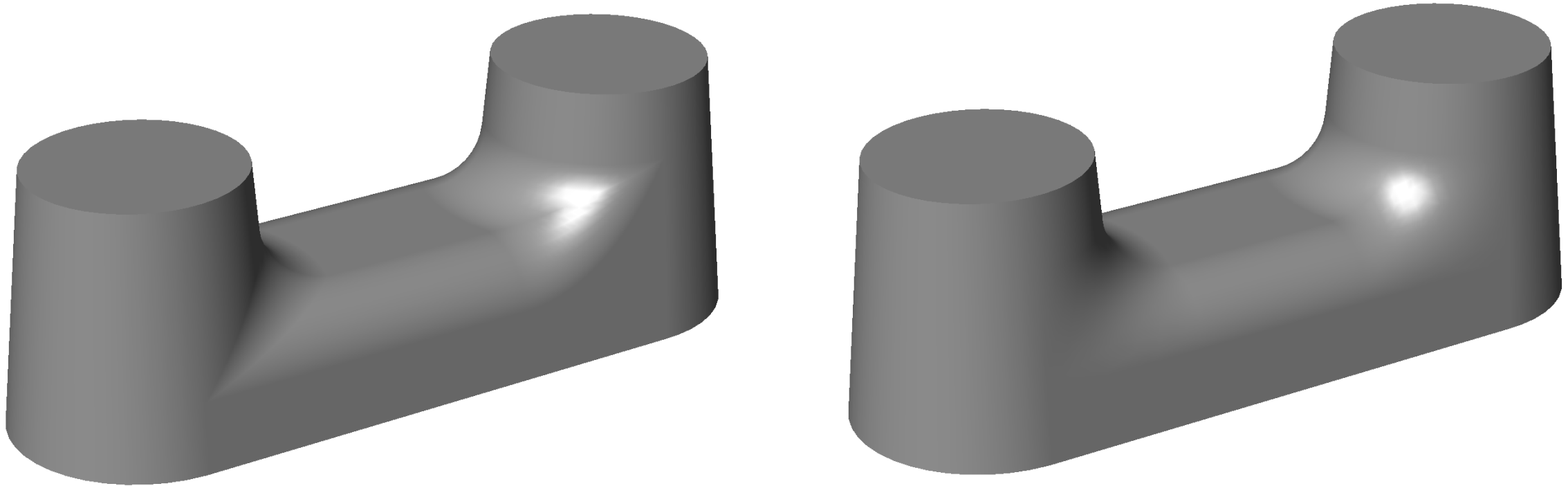
Surface Knit

The Boundary Surface is joined back into the part with Surface Knit.



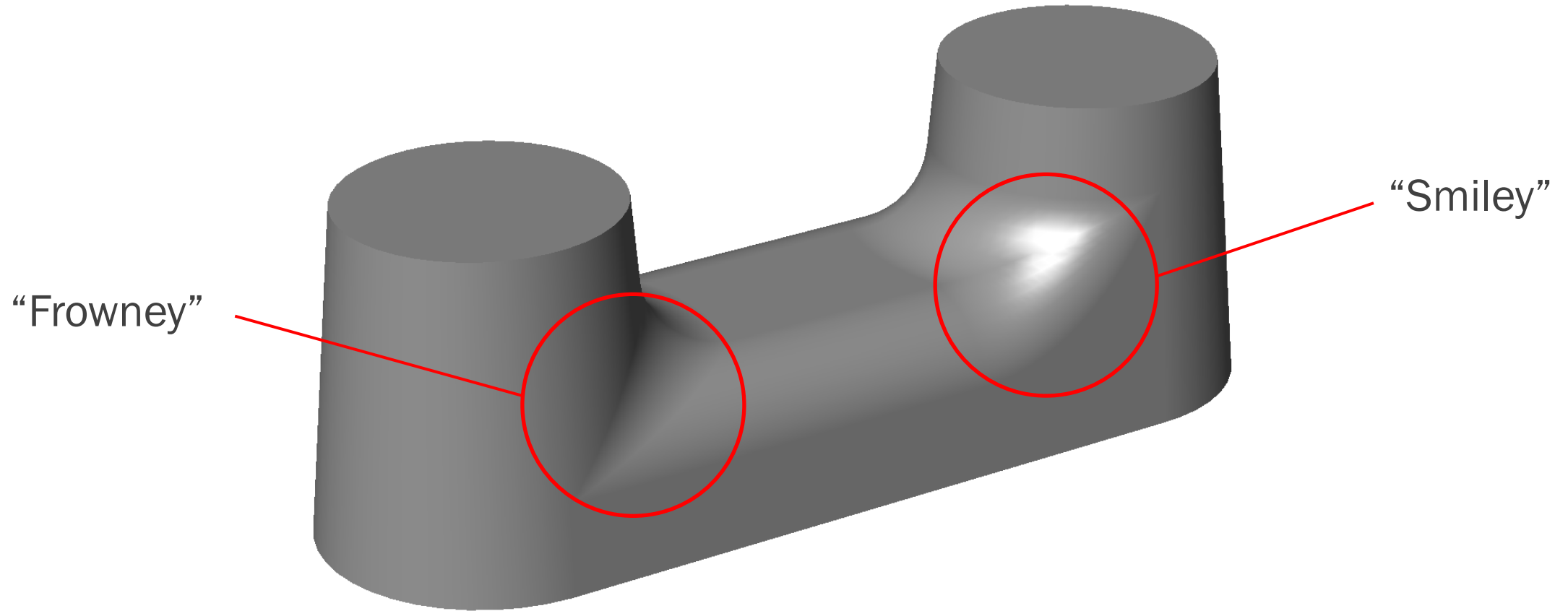
Optimizing Fillet Intersections

Sometimes the fillet tool can get us 90% of the way there. Surface Fill and Delete Face can help with the rest.



Corner Blends

For parts that have high aesthetic requirements, the fillet tool can create awkward corners.

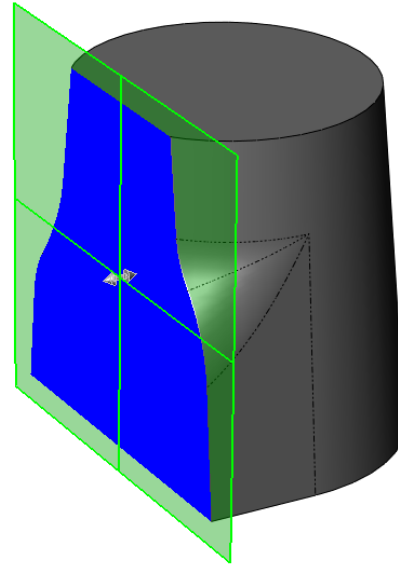


Engineering Considerations

The frowney removes materials from the model and may create a stress riser. The smiley adds extra material.

Smiley

Frowney

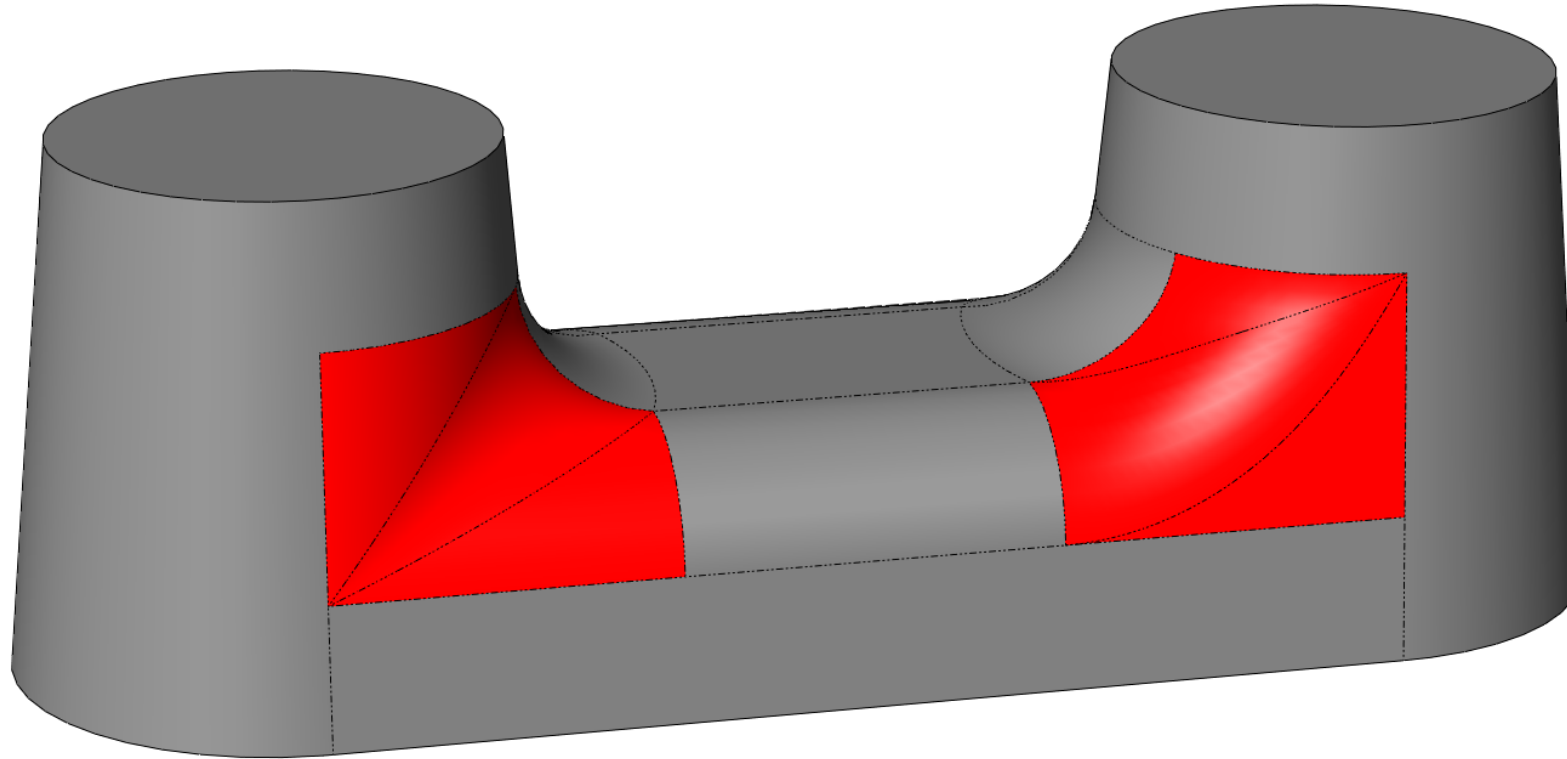


Blend

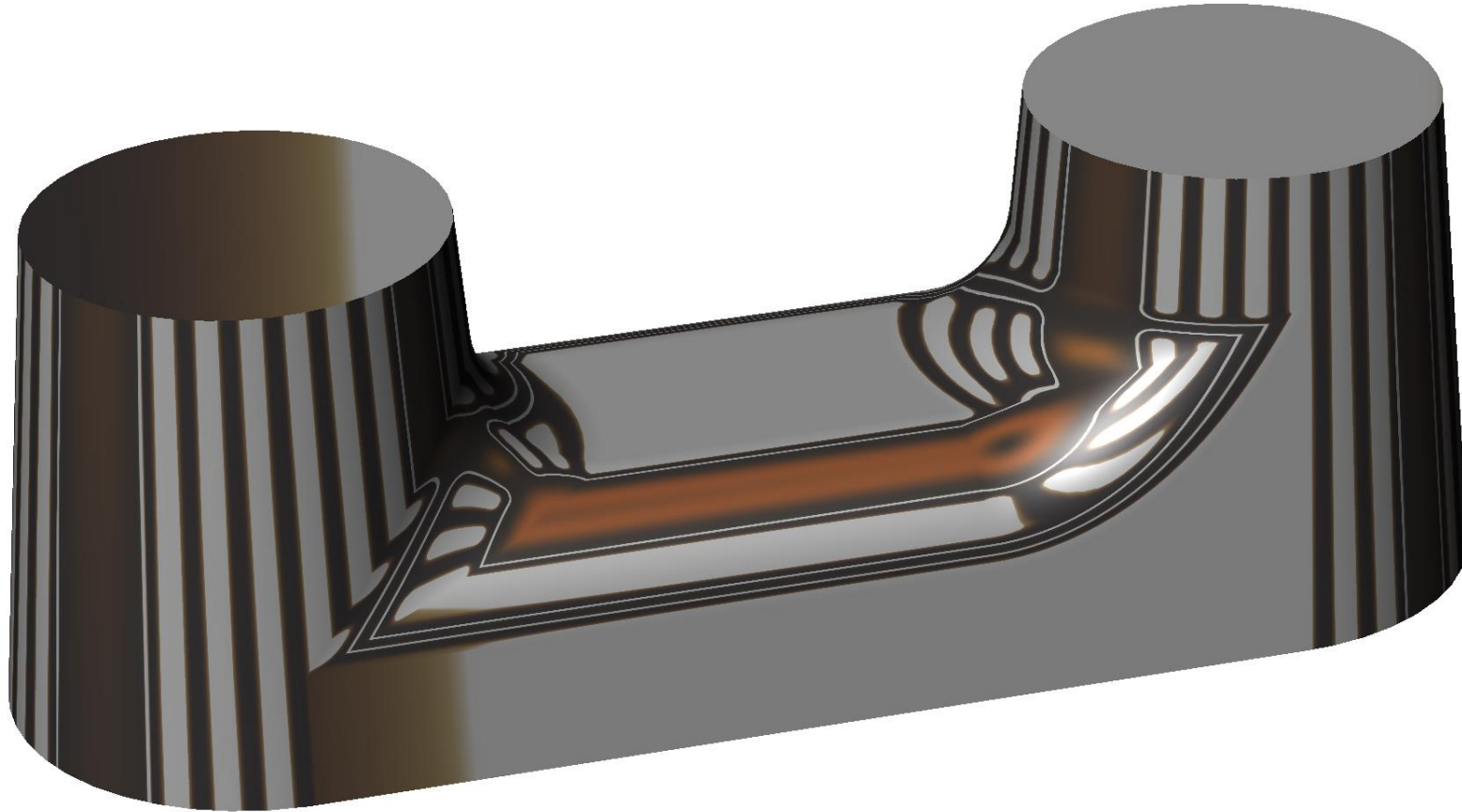
Blend

Split Lines & Delete Face

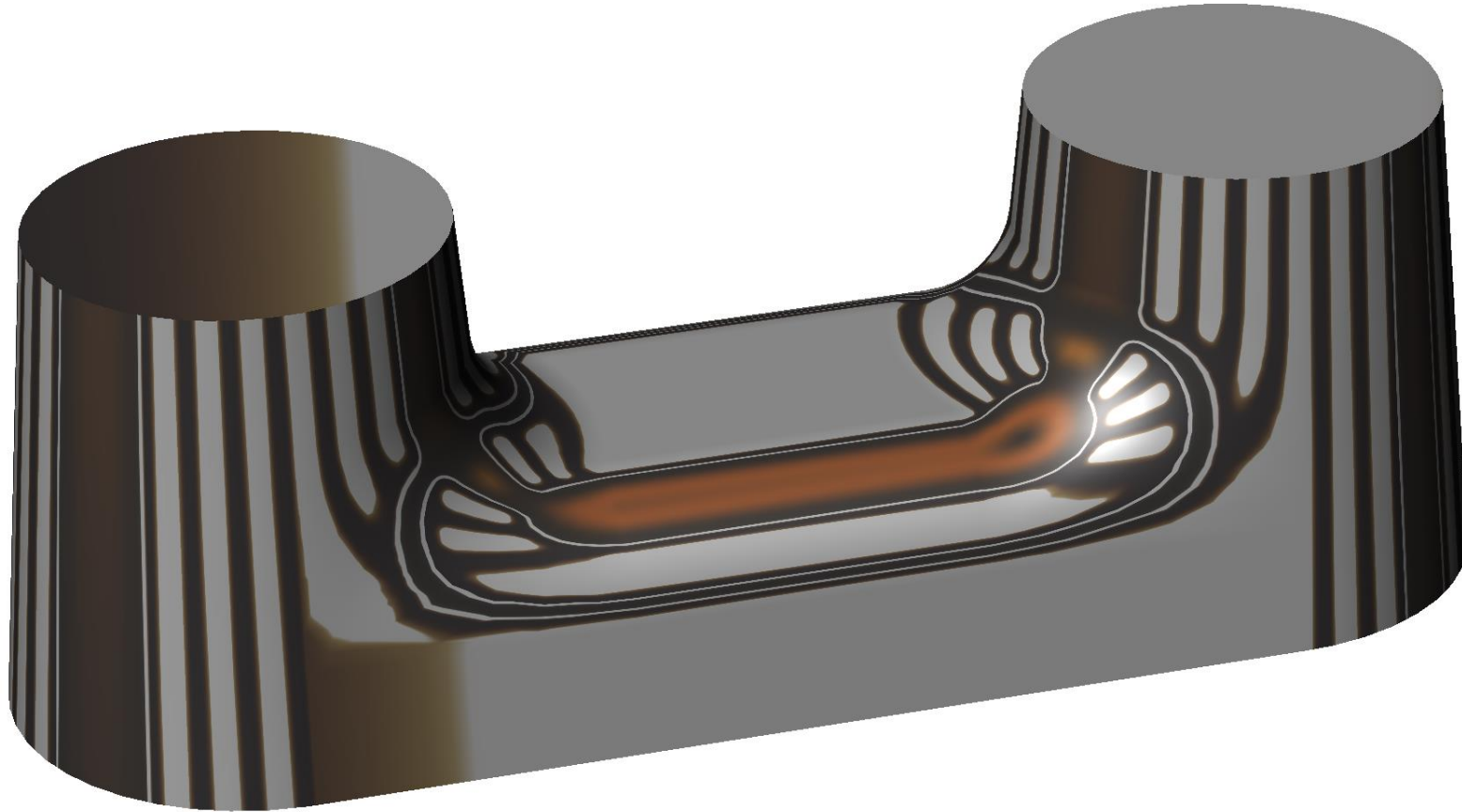
Vertical and horizontal Split Lines are added at the vertices of the fillets. The faces in RED are patched using Delete and Fill with the tangent option turned on.



Compare and Contrast

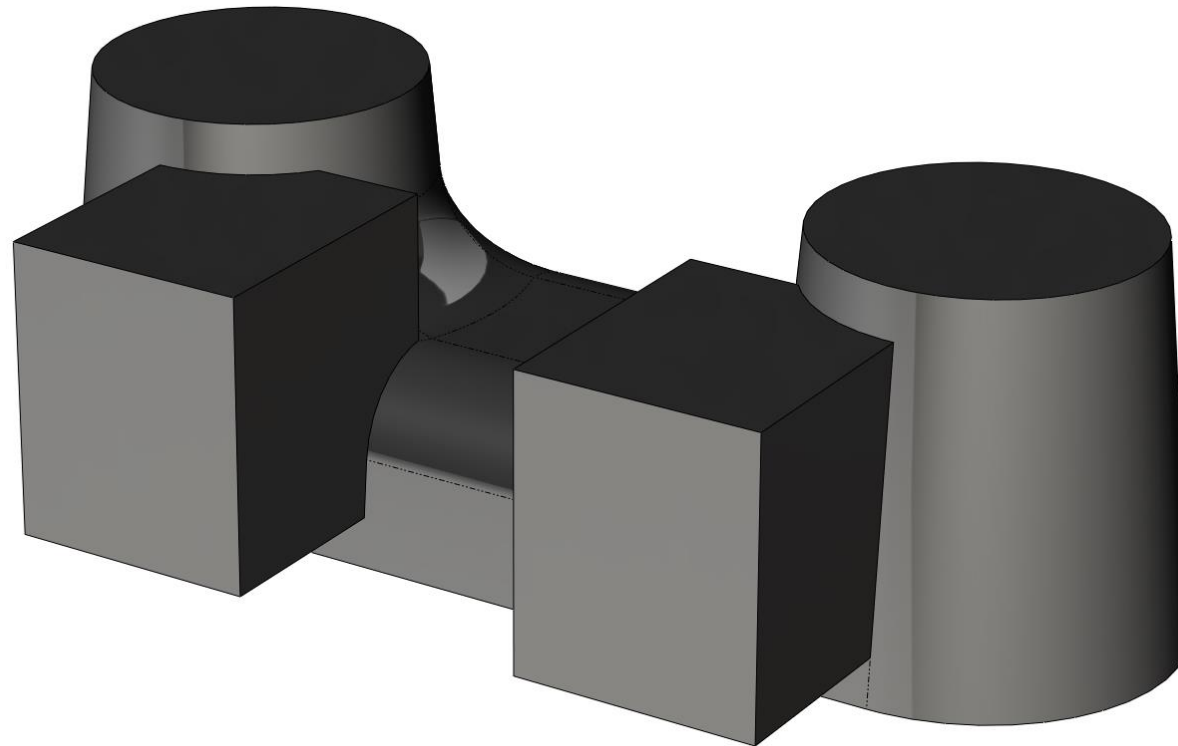


Compare and Contrast



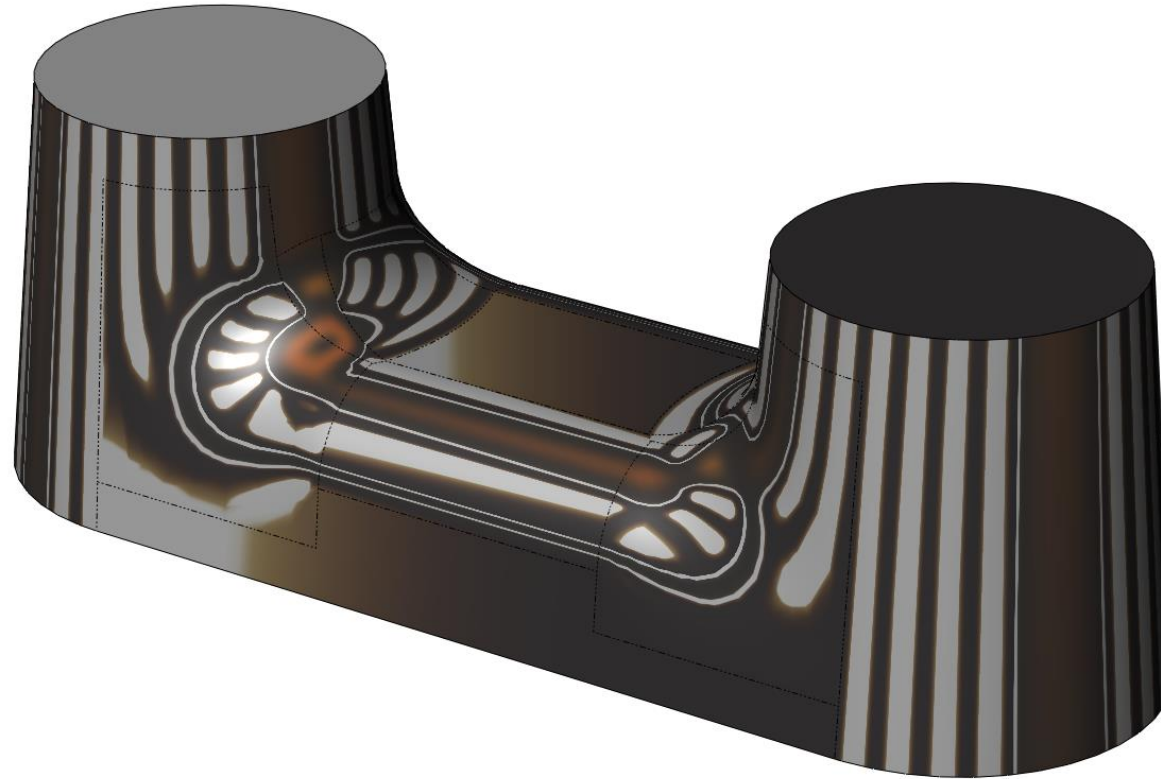
Another Solution

Stop the fillets from forming their own corners with large blocks.



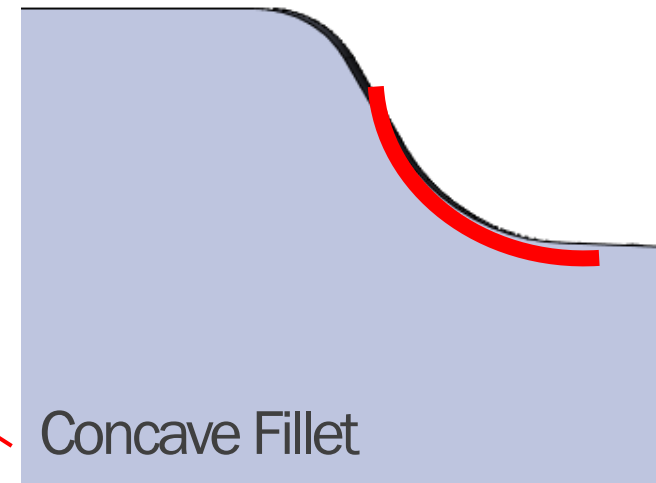
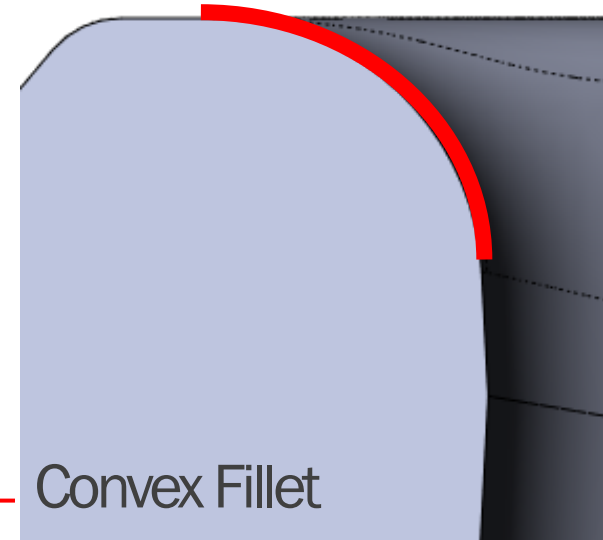
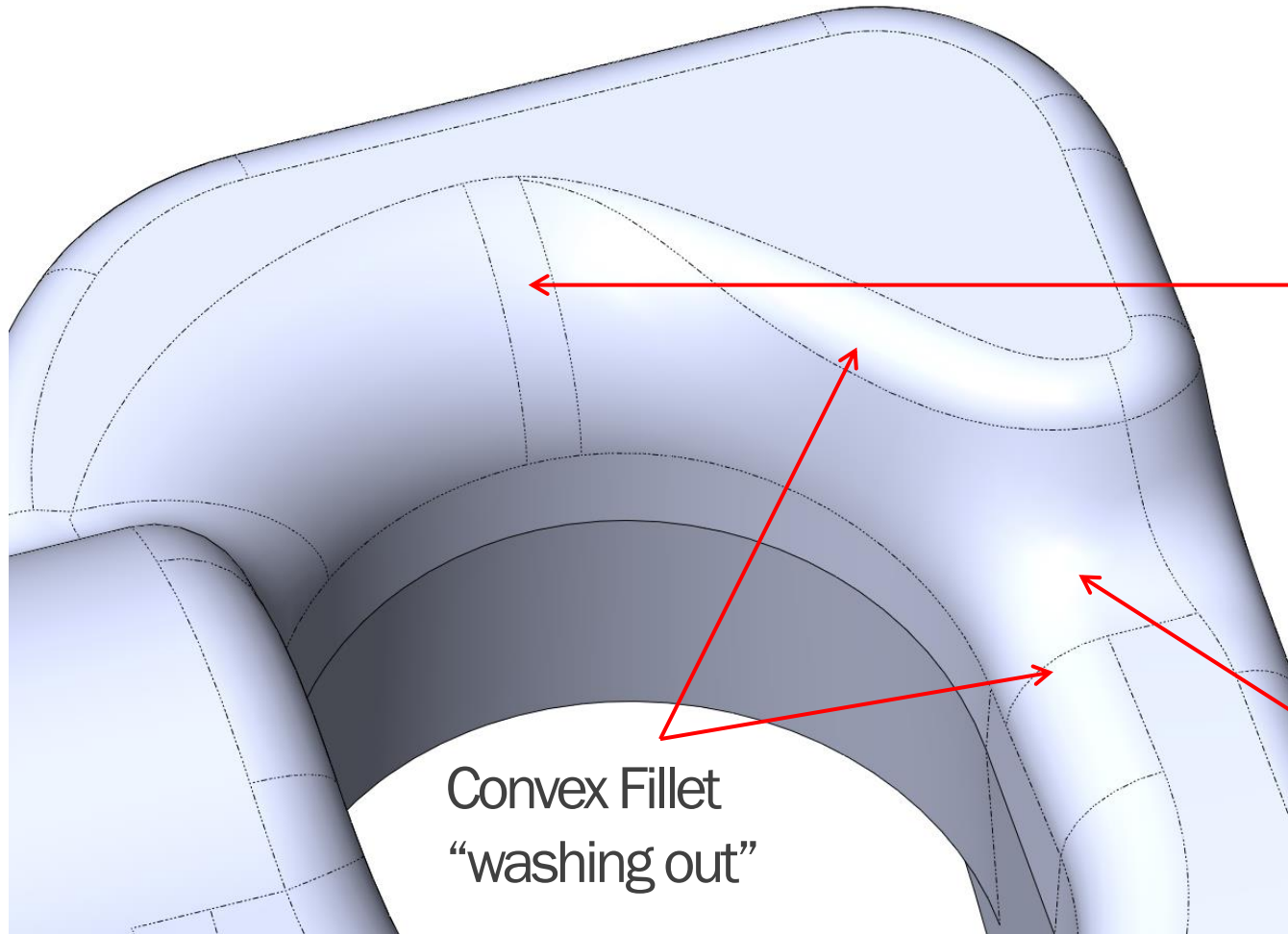
Another Solution

Delete and tangent fill to remove the blocks. The downside is that the Delete Face “pollutes” the straight faces of the model.



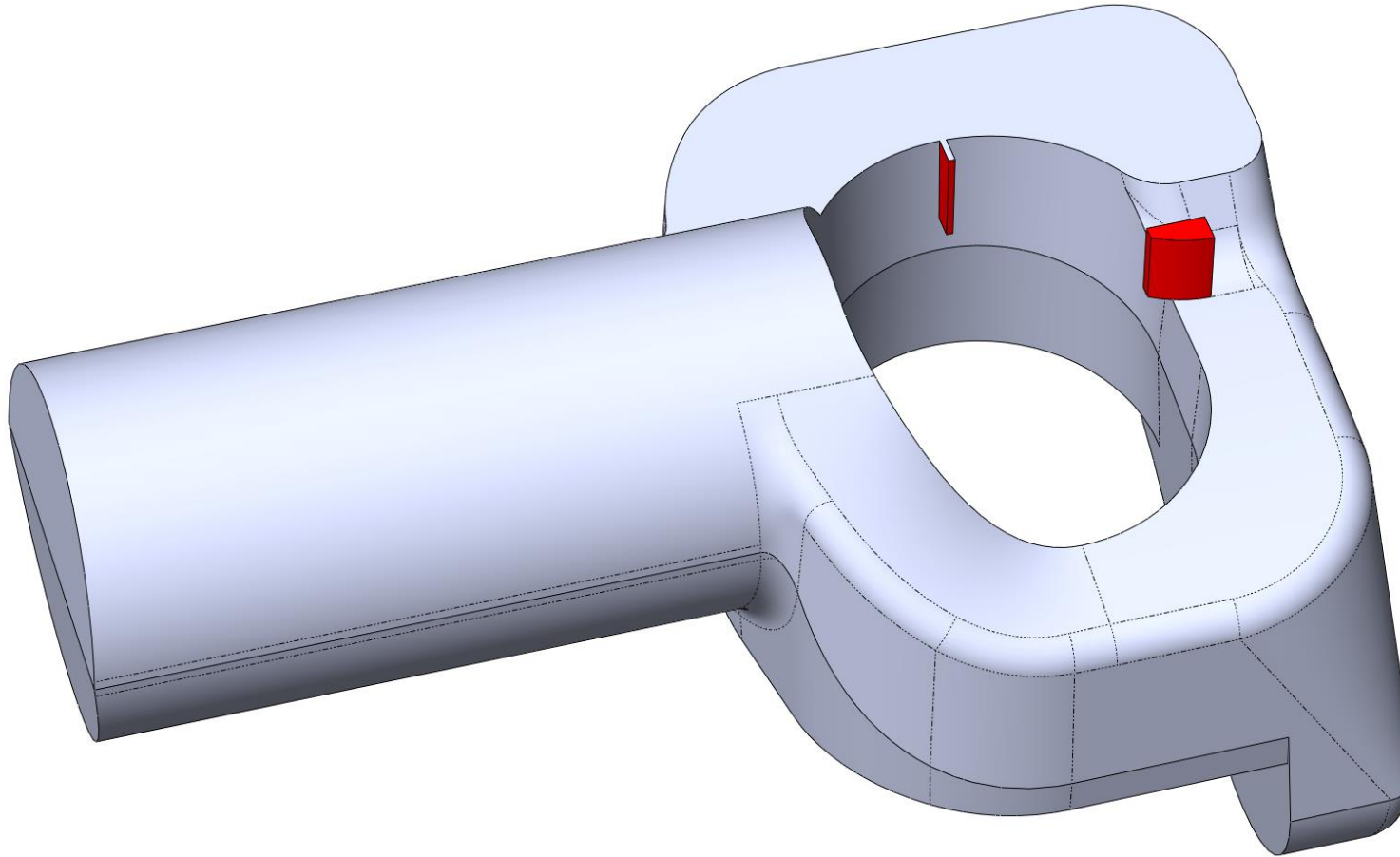
Blends

Convex to Concave Fillets



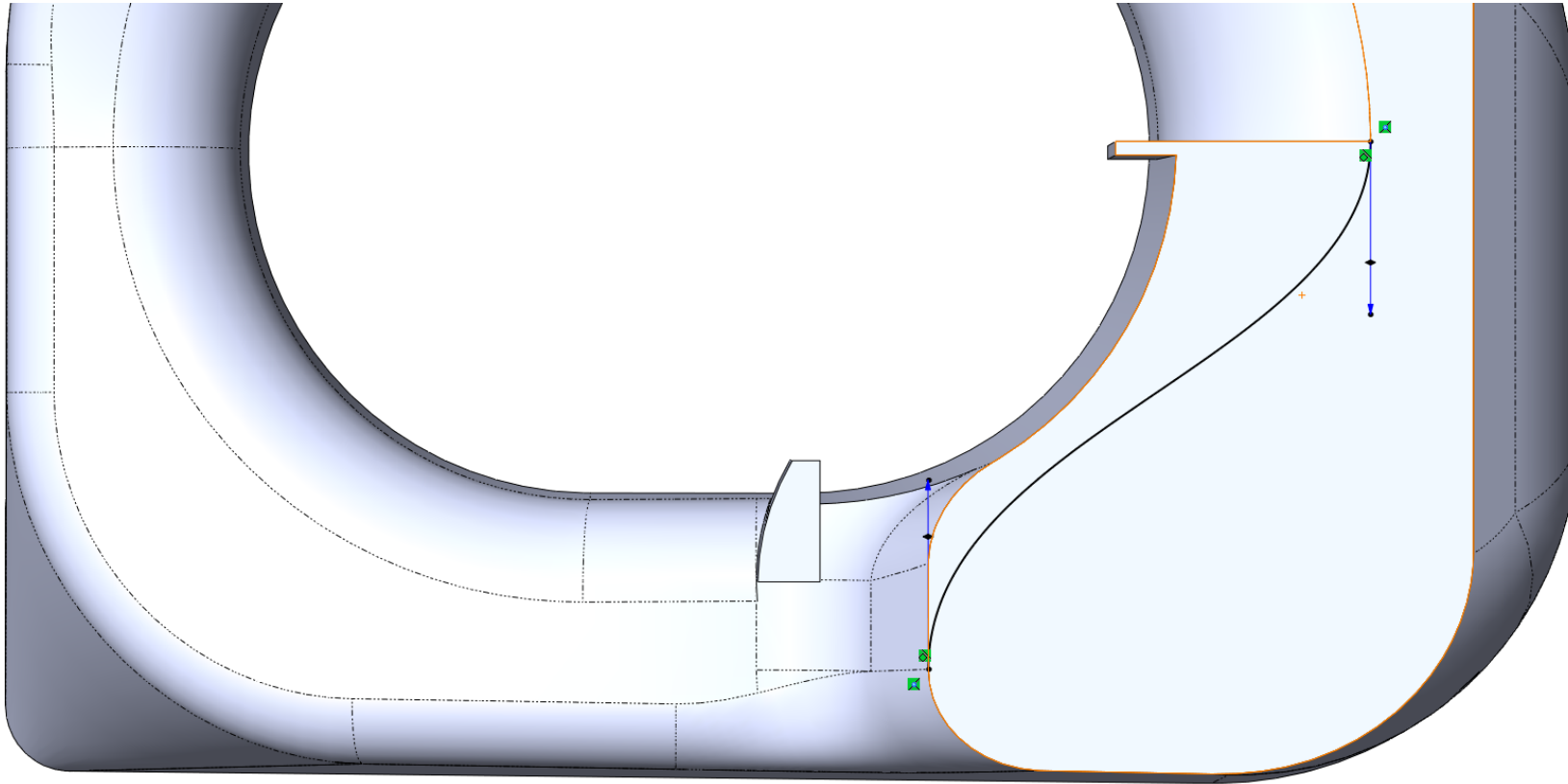
Add What Fillets You Can

We already know how to end fillets. We can use this technique to get us to our blend starting point.



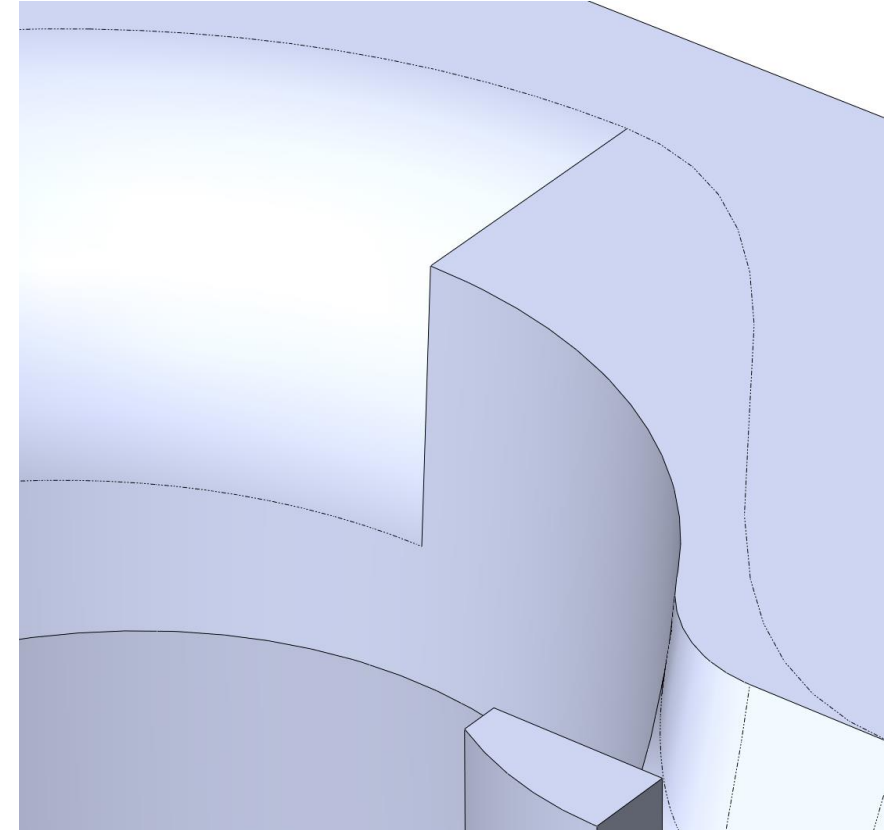
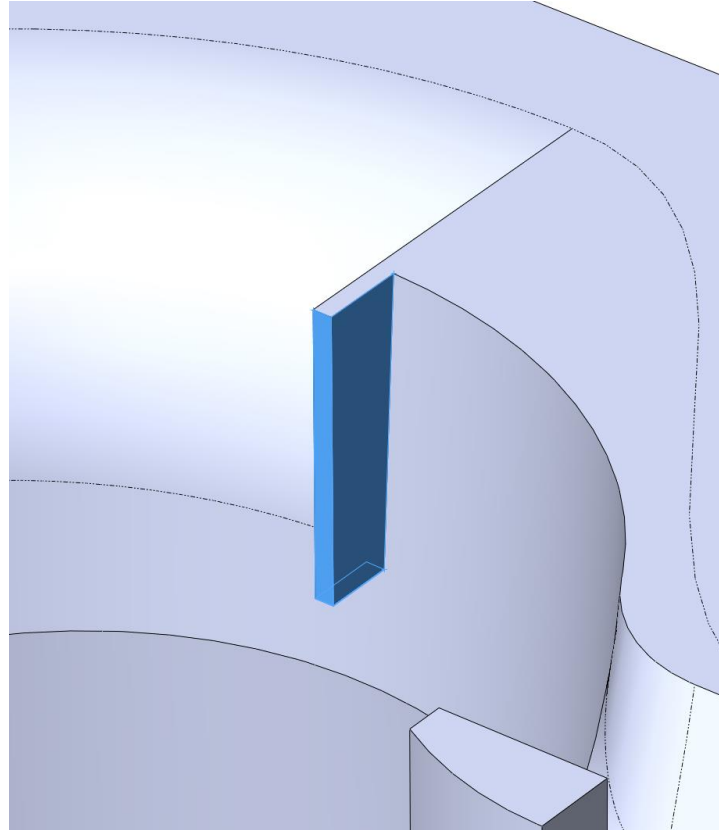
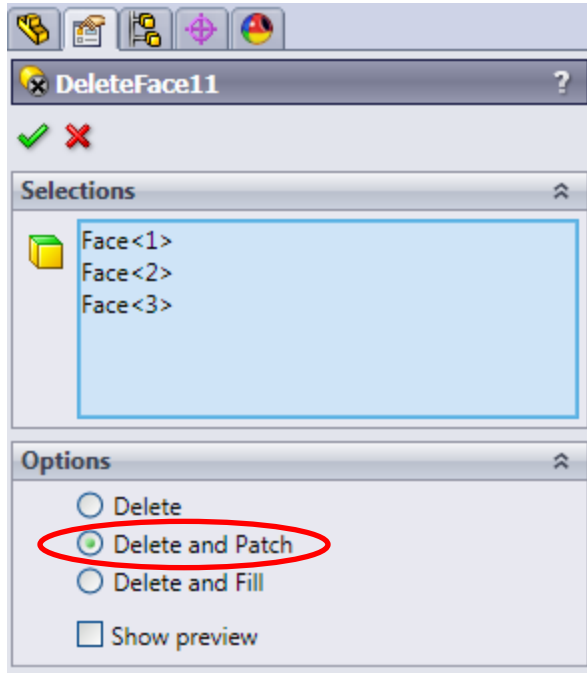
Splines

A new edge is needed for the blend. A spline is used to quickly create this edge. Lines and arcs could also be used.



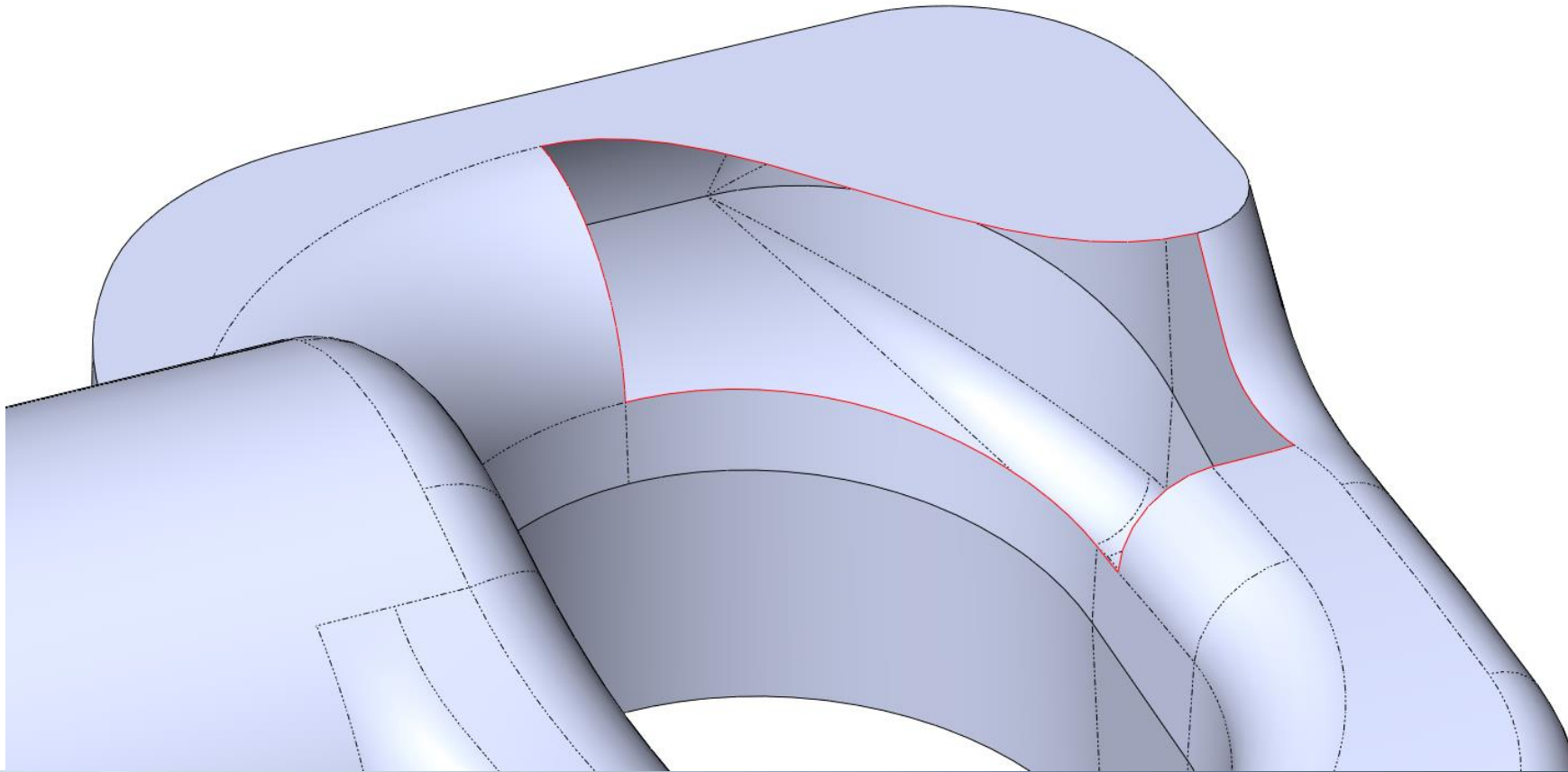
Clean Up Stop Blocks

The blocks used to stop the fillets can interfere with a clean blend. Delete Face quickly removes them from the model.



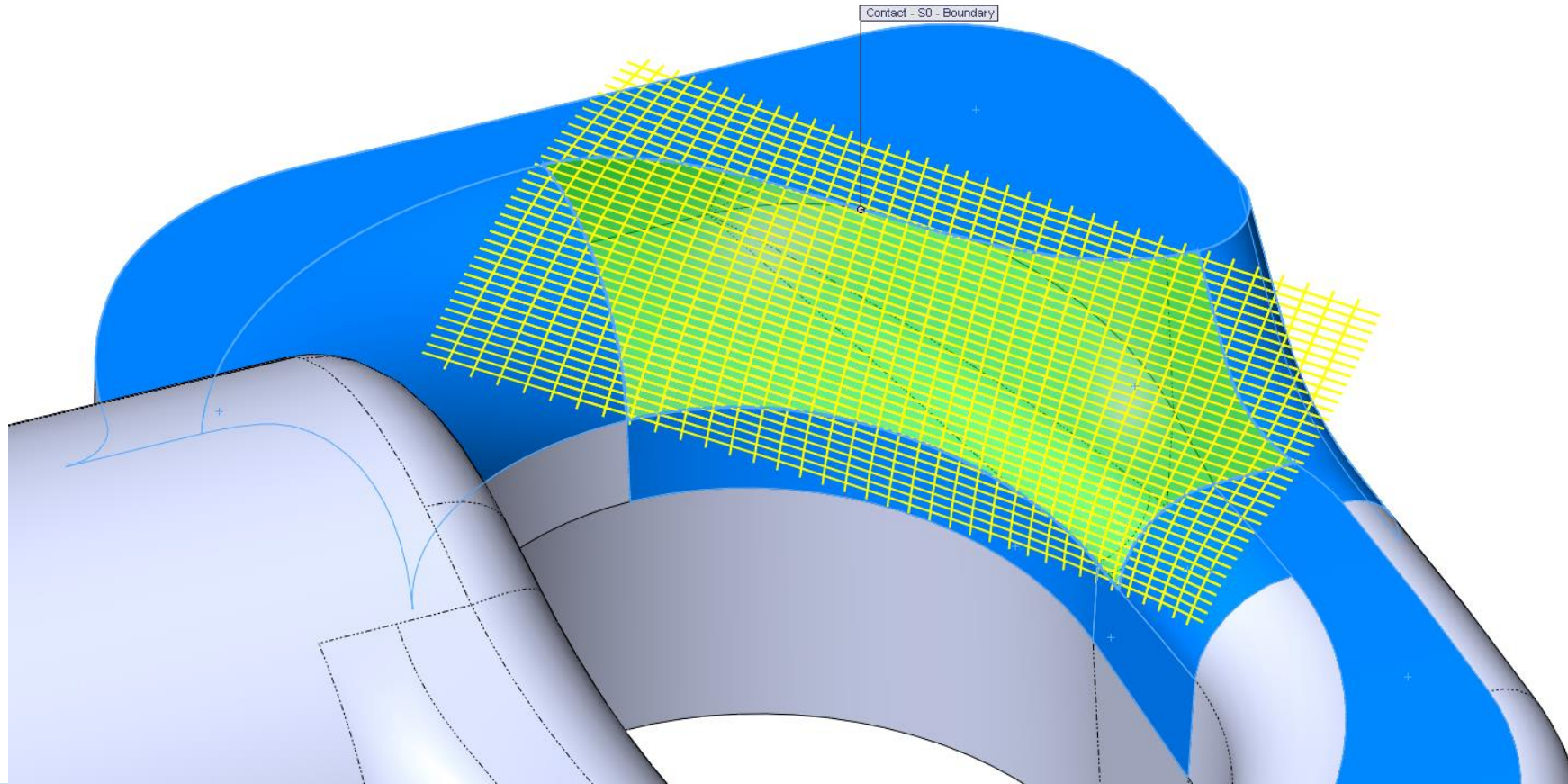
Create the Opening

Split lines further define the outline for the blend. We now have an opening in the part that the blend will be created in.



Surface Fill

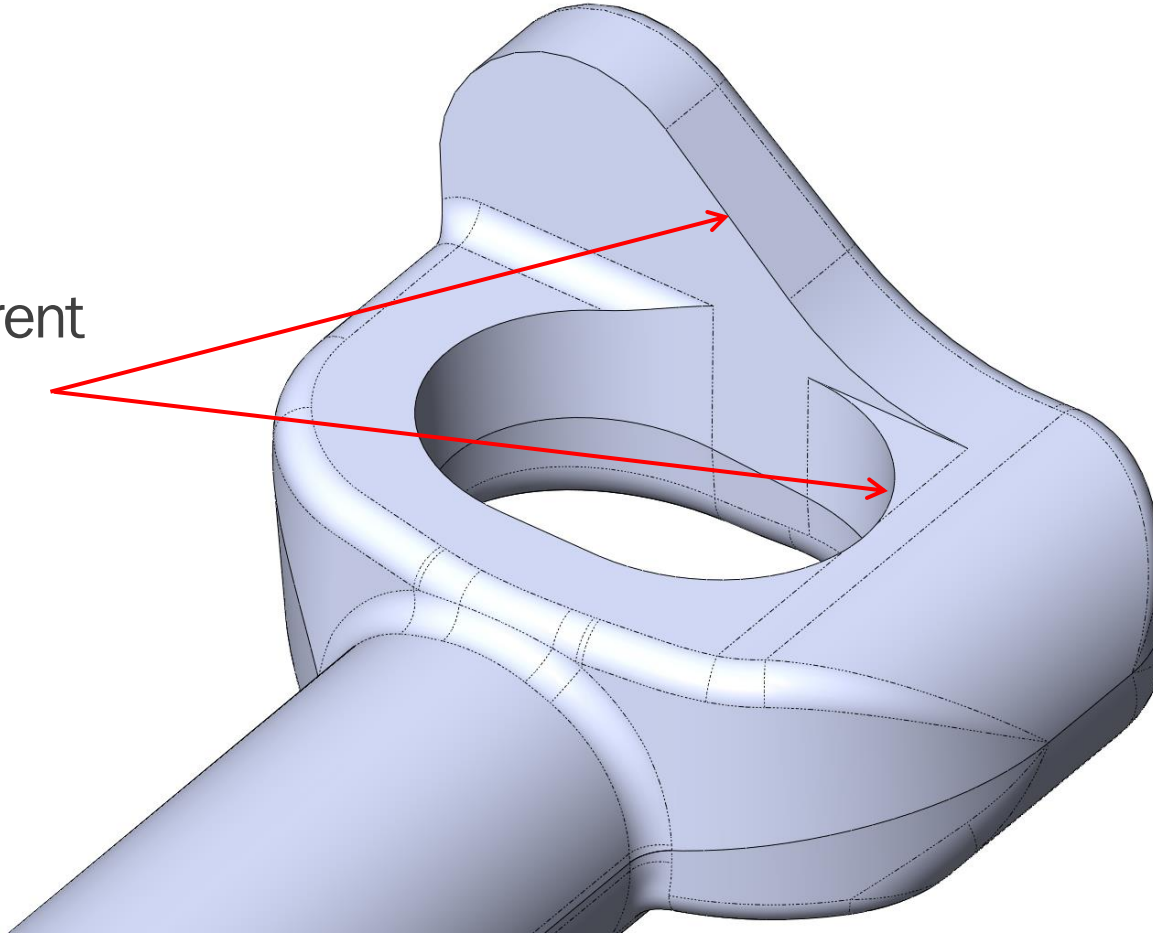
Surface Fill is used to complete the blend between the convex and concave fillets.



Forcing Fillets to Flow Into Each Other

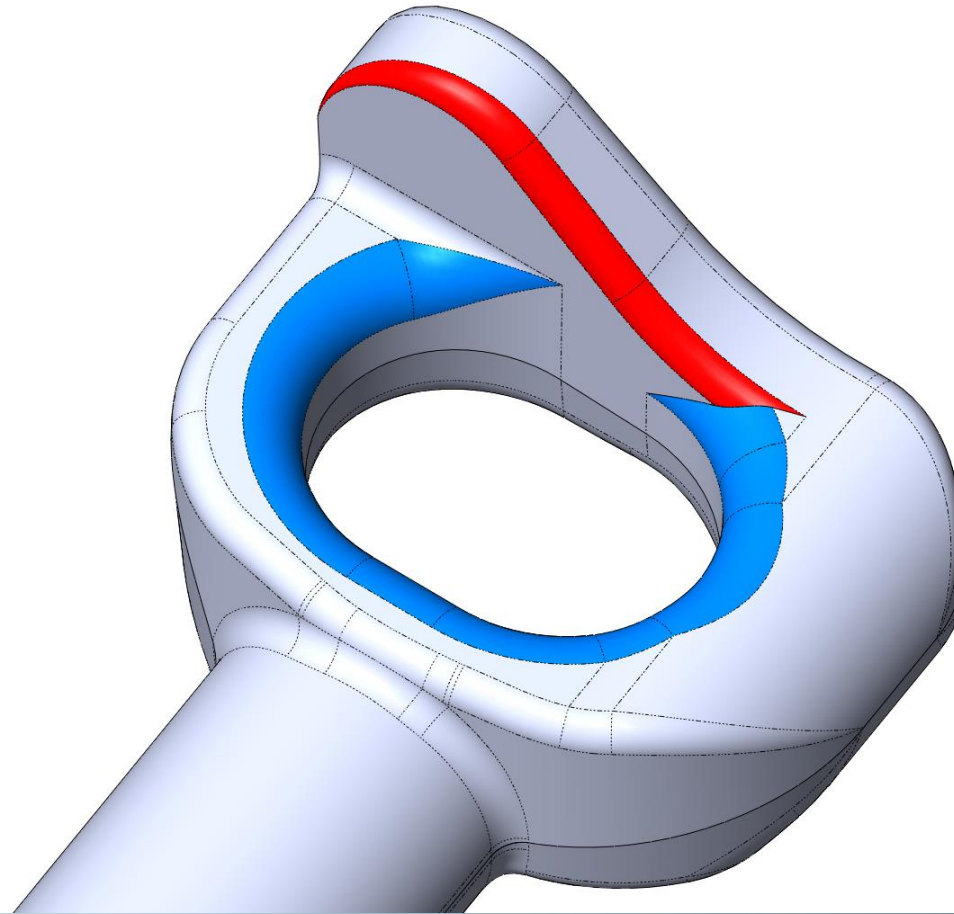
The way the part was modeled prevents these edges from being filleted together (but does make modeling easier).

These edges need fillets of different radii that flow into each other.

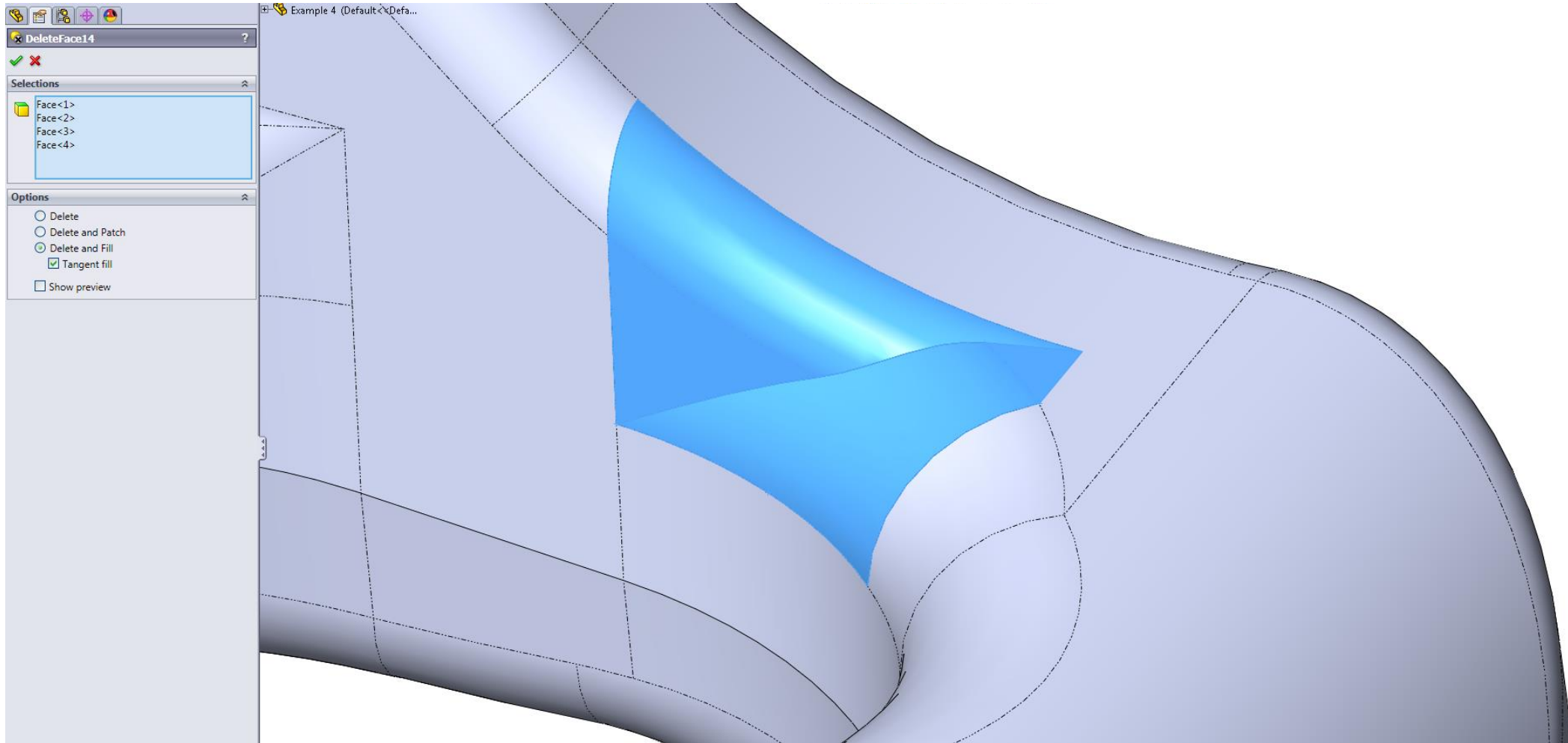


Fillet What You Can

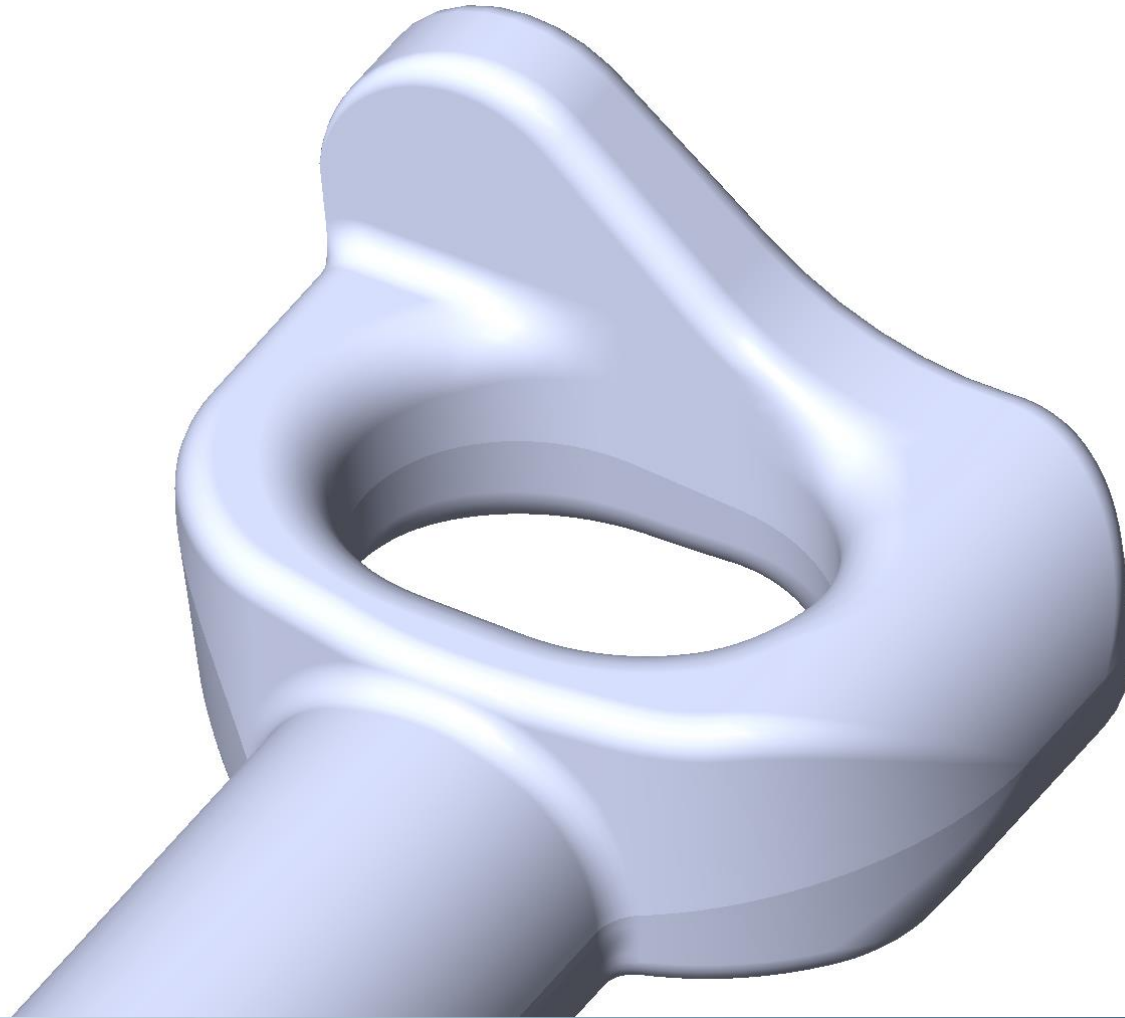
Use the fillet tools to get as much of the fillets as possible.



Delete and Tangent Fill



Finished Transition



Face Fillet Blends

The face fillet tool has powerful options for quickly creating certain blends.



Constant Radius Fillet



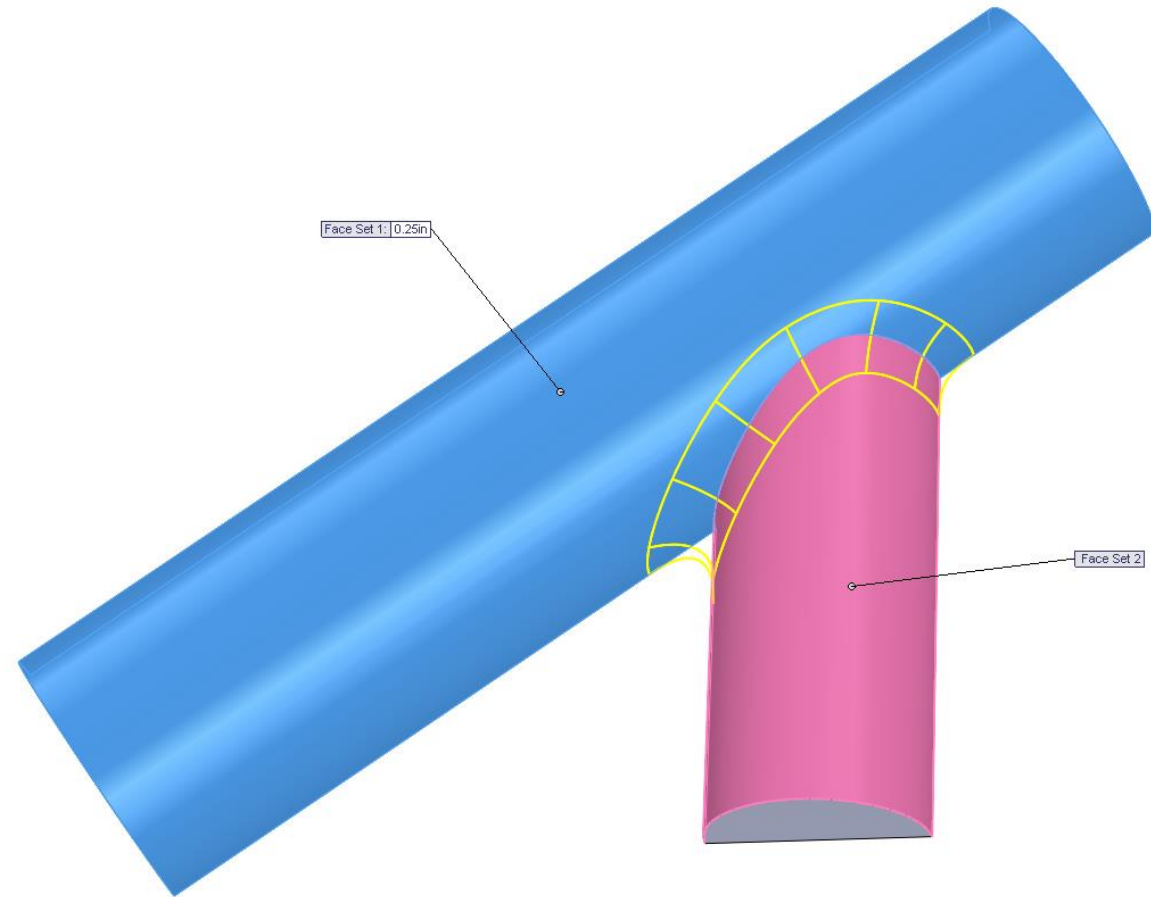
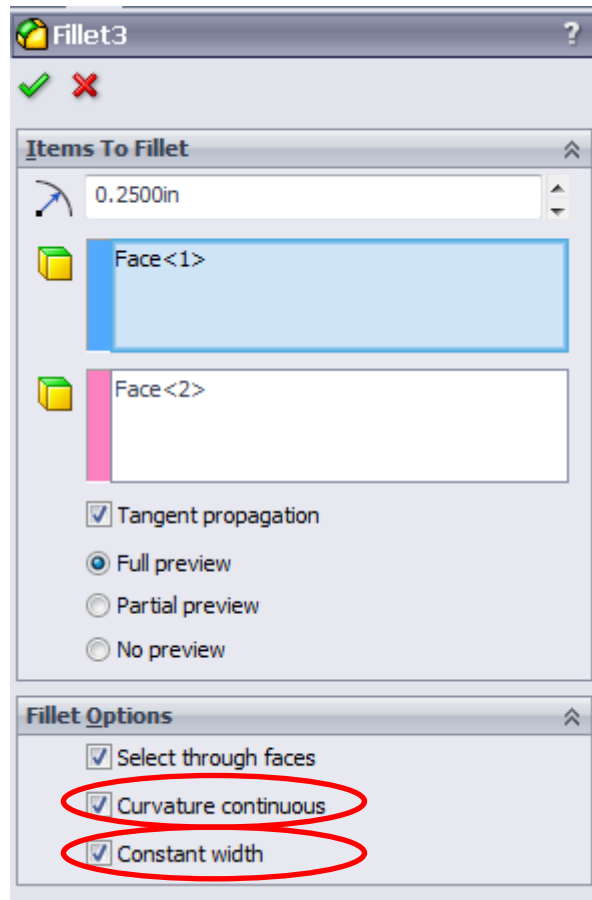
Variable Radius Fillet



C2 Constant Width Fillet

Face Fillets

Constant Width fillets can offer aesthetically superior results.

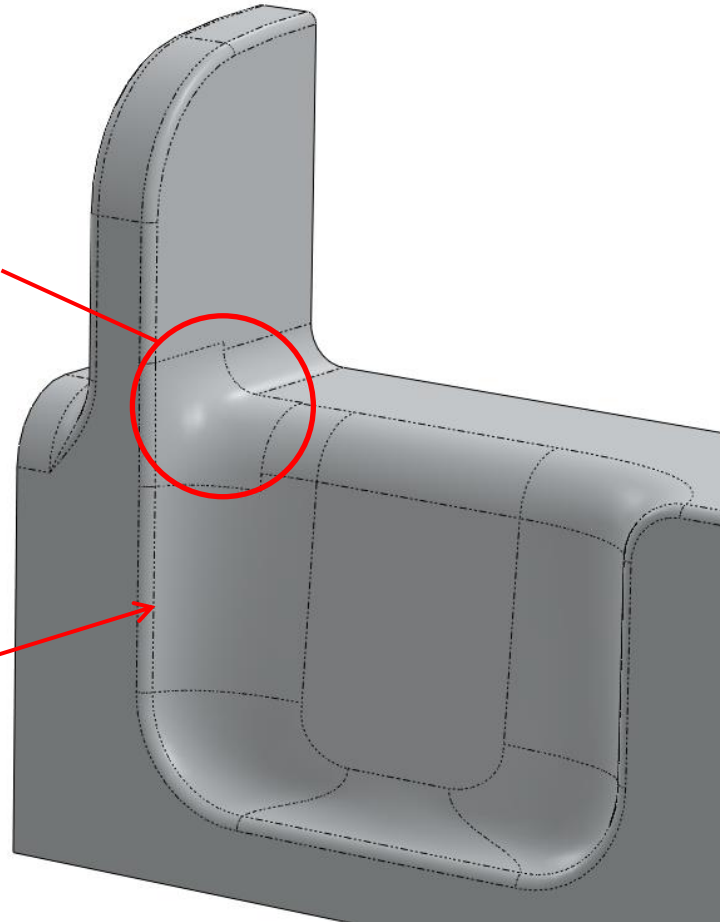


Managing Tricky Corners

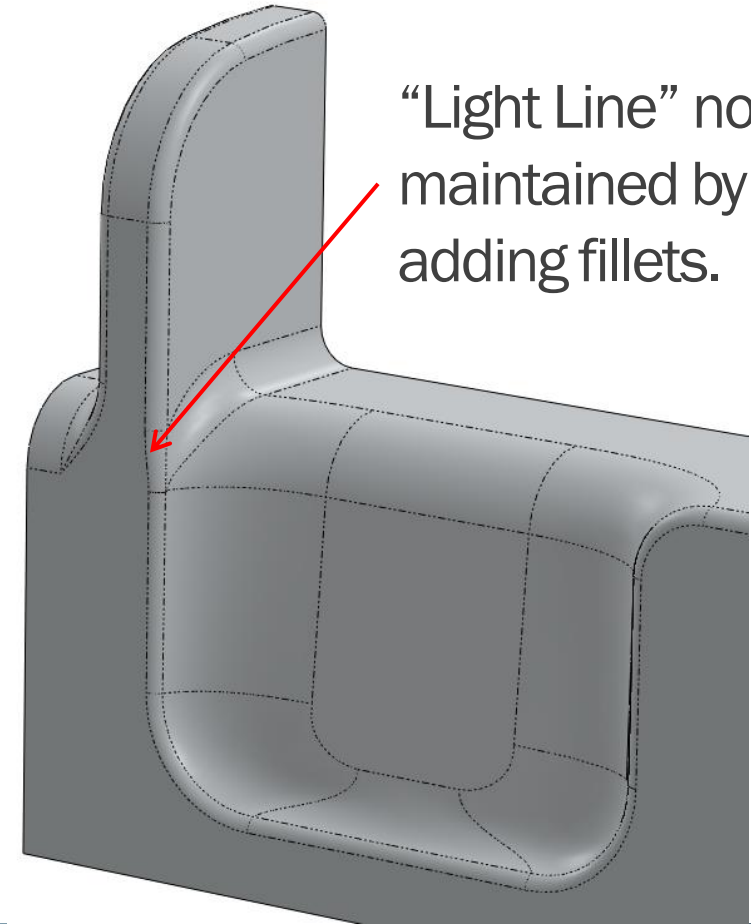
Corners with multiple converging fillets can be tricky to get right. Stopping the fillets and completing the transition with surfaces offers a solution.

Intersection of 4 fillets
and surfaced indent.

“Light Line” must be
maintained.



“Light Line” not
maintained by just
adding fillets.

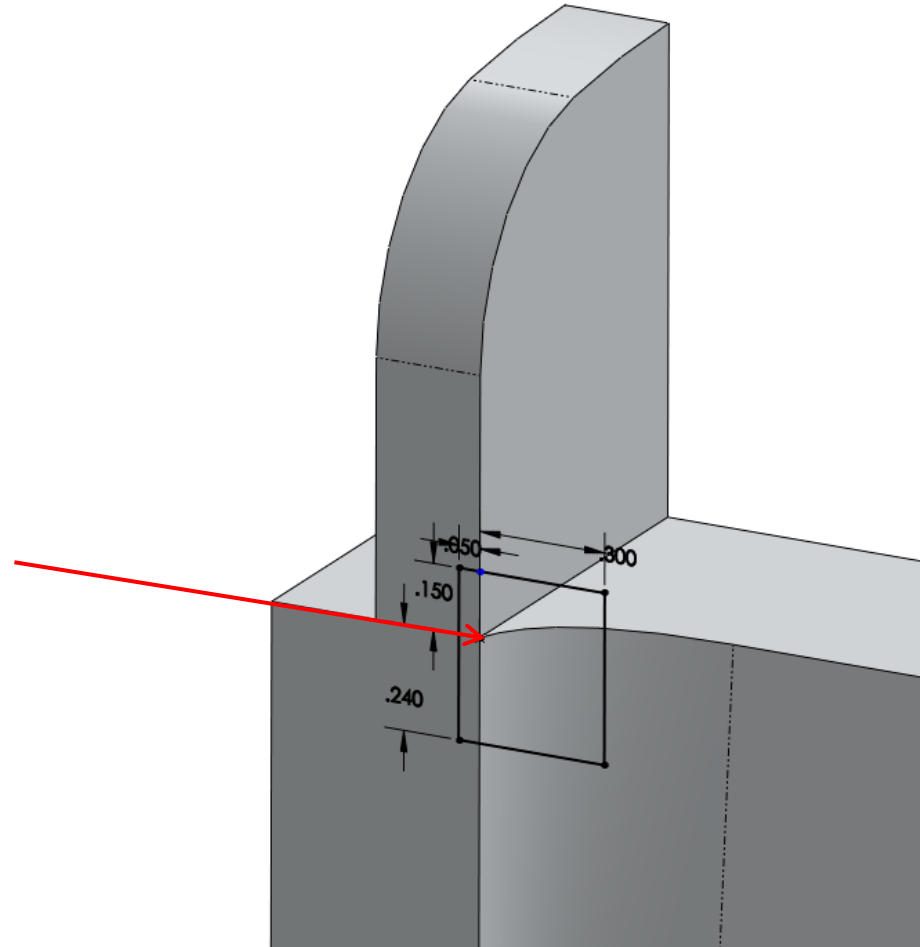


Create the Stop Block

A block extruded into the model will stop the various fillets.

The block should be roughly positioned at first.

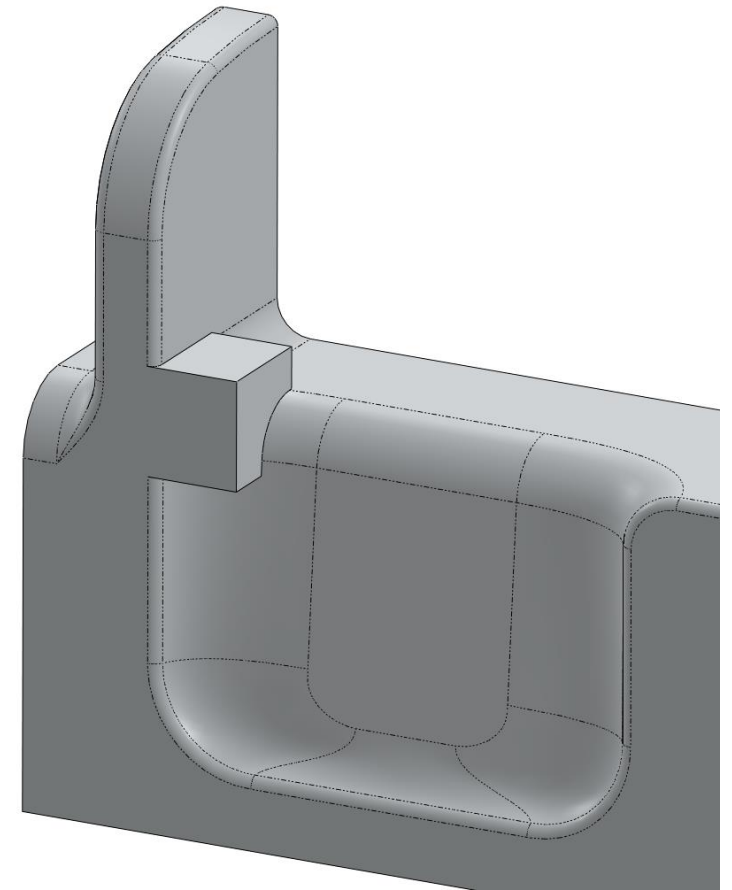
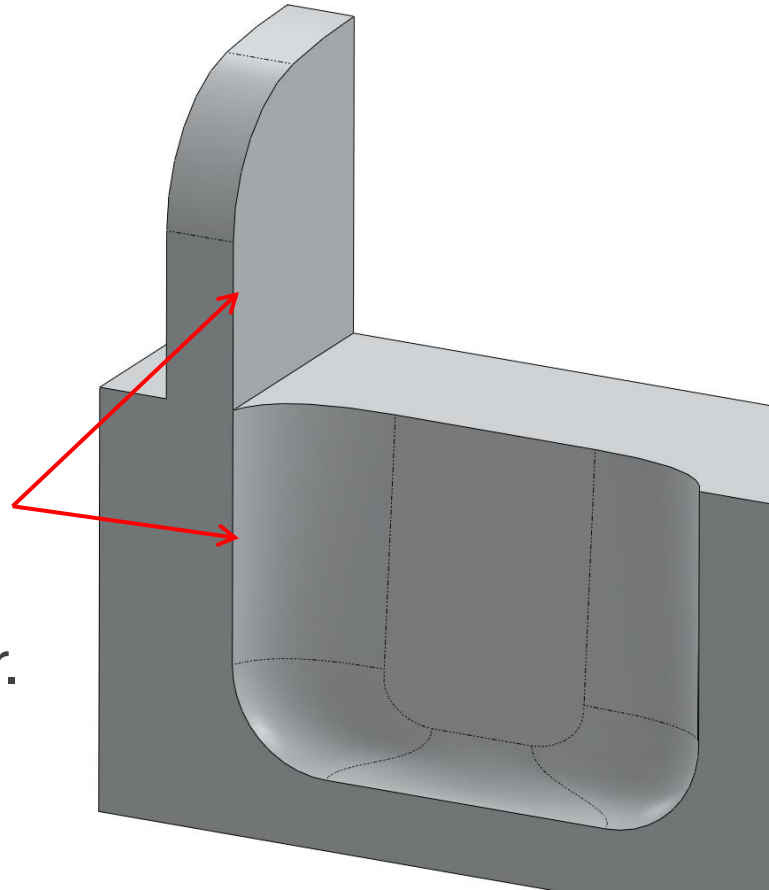
Once the fillets have been added, the block can be dialed to the smallest size possible while still allowing the fillets to complete.



Add the Fillets

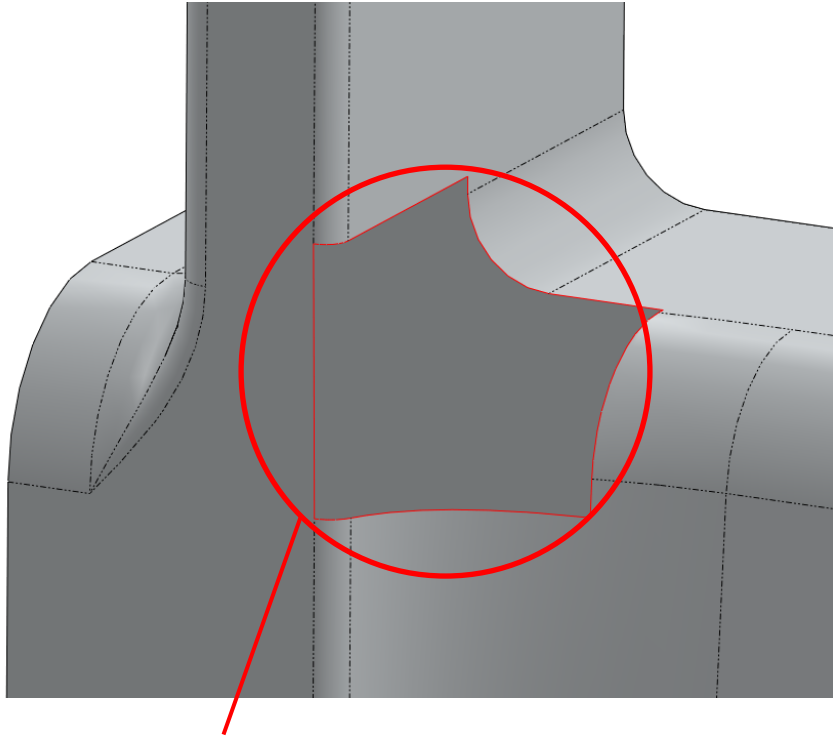
The required fillets are added to the model.

The block makes it possible to add these fillets; before there was no way to bridge the corner.

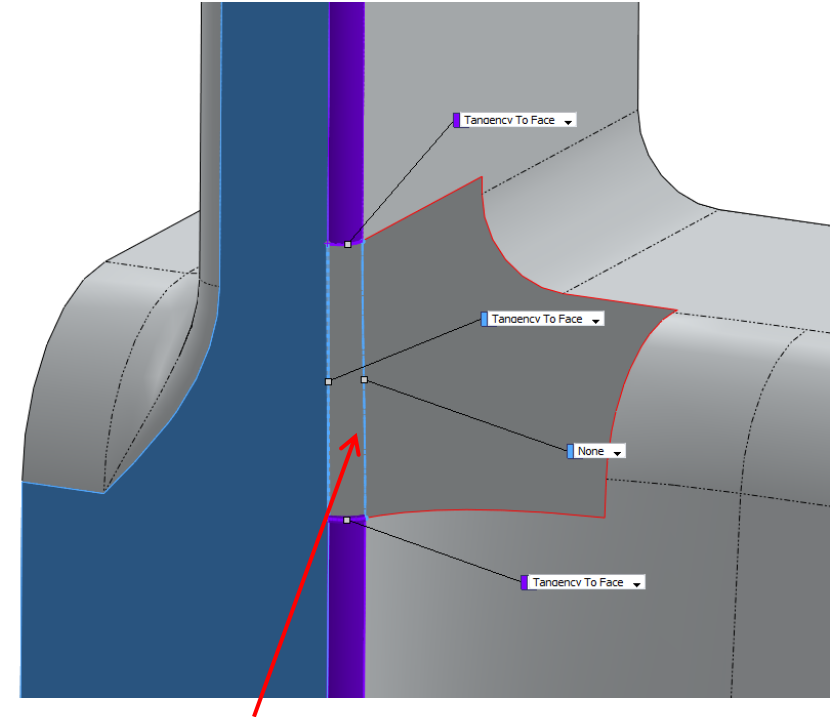


Maintaining the Light Line

Delete face is used to open the area for blending. A boundary surface is used to build a transition between the two fillets.



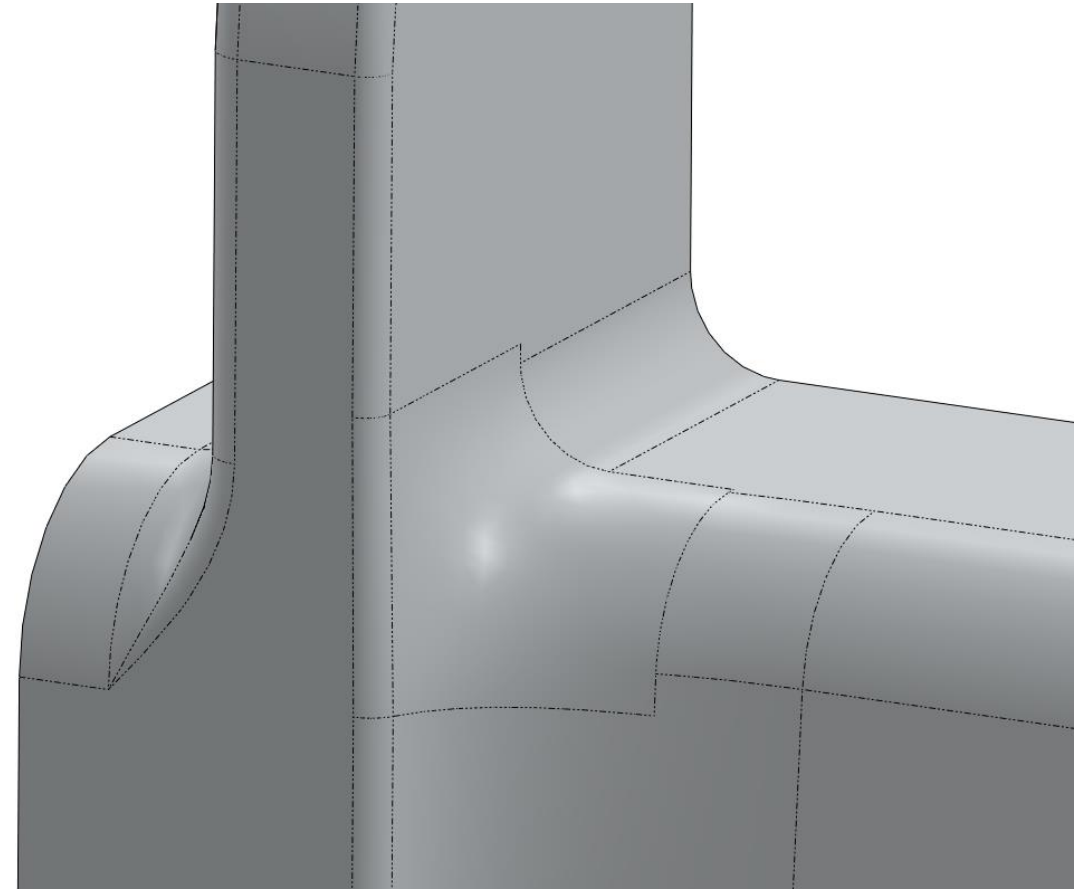
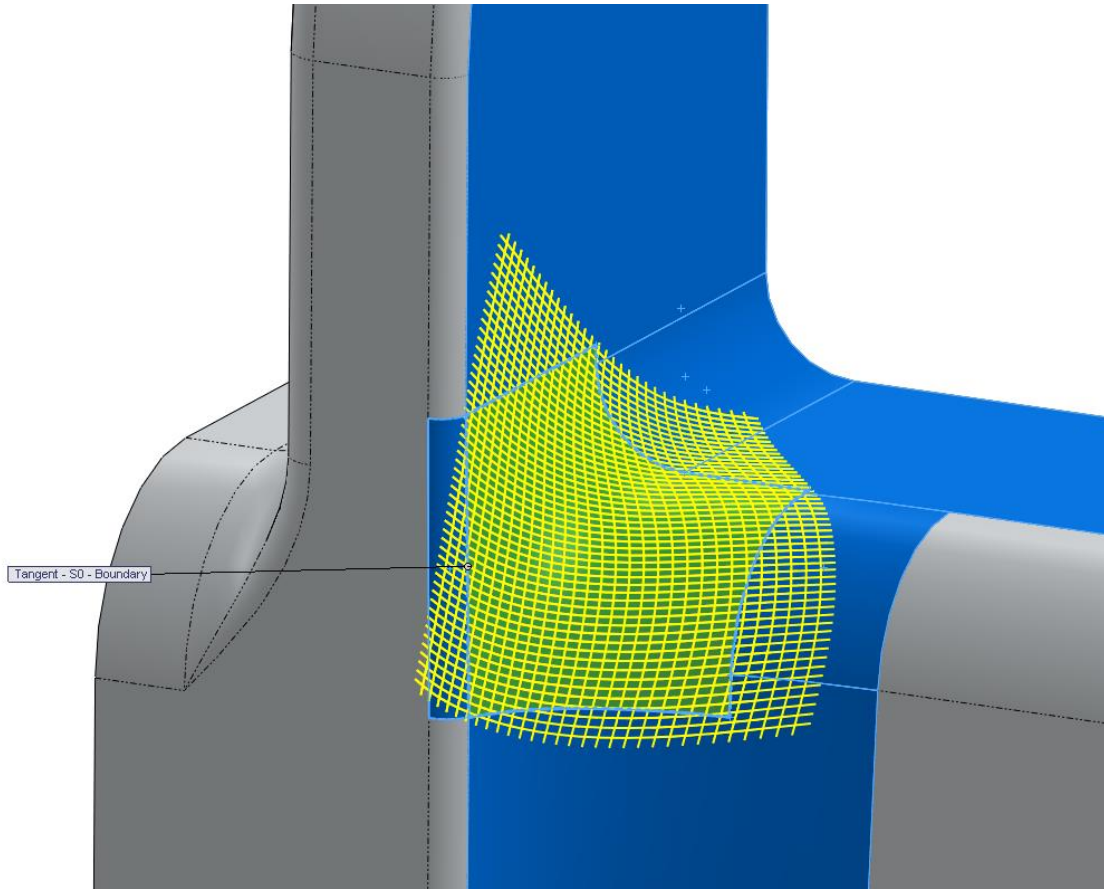
Split Line and Delete Face



Spline in 3D Sketch to
guide Boundary Surface

Complete the Corner

The Boundary Surface is knit into the model. A surface fill completes the tricky corner.



Advanced Blends

Some shapes cannot be created with fillets; they require complex blends to achieve the correct look. The Aluminum Group Lounge Chair by Charles and Ray Eames is an excellent example.

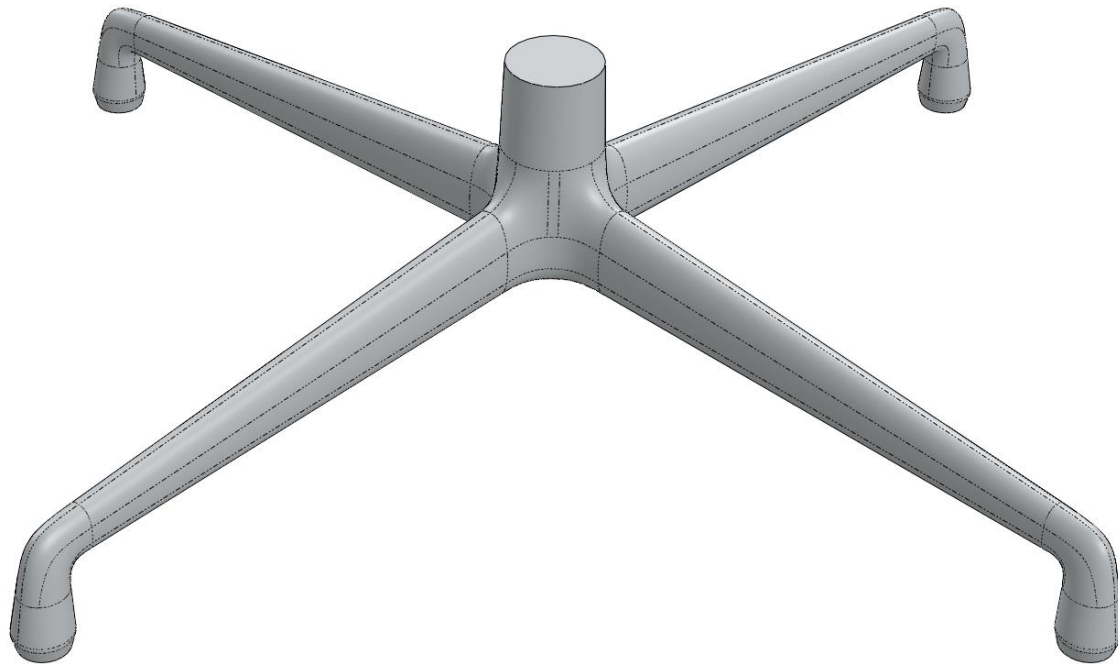


Image courtesy of Herman Miller

Continuity | Zebra Stripes



C0
Contact

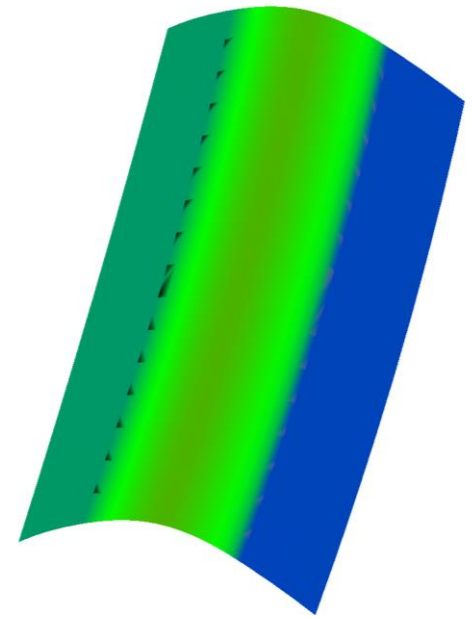


C1
Tangent

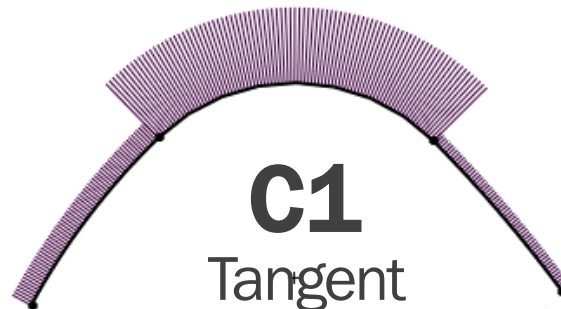


C2
Curvature

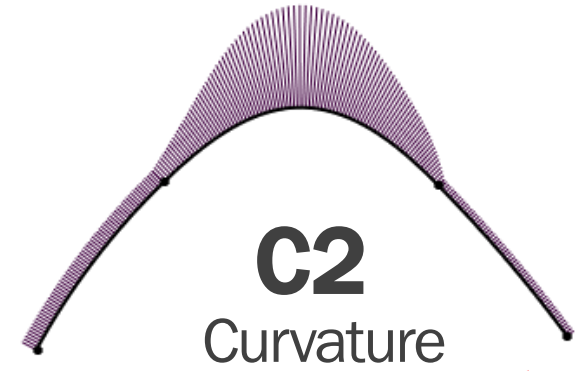
Continuity | Curvature Display



C0
Contact



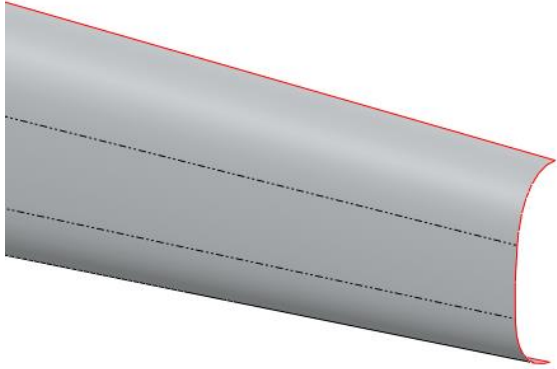
C1
Tangent



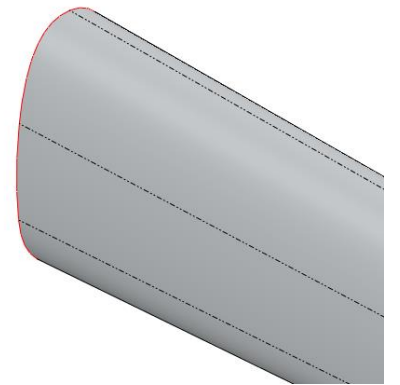
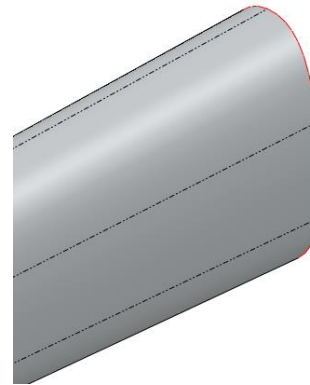
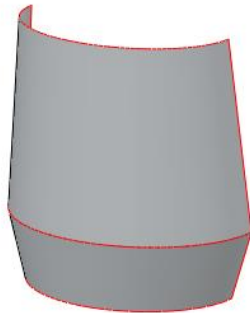
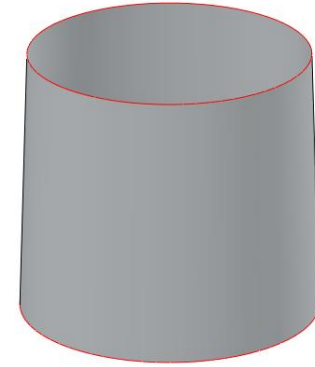
C2
Curvature

Advanced Blends

Model the individual portions to be blended together as separate shapes.

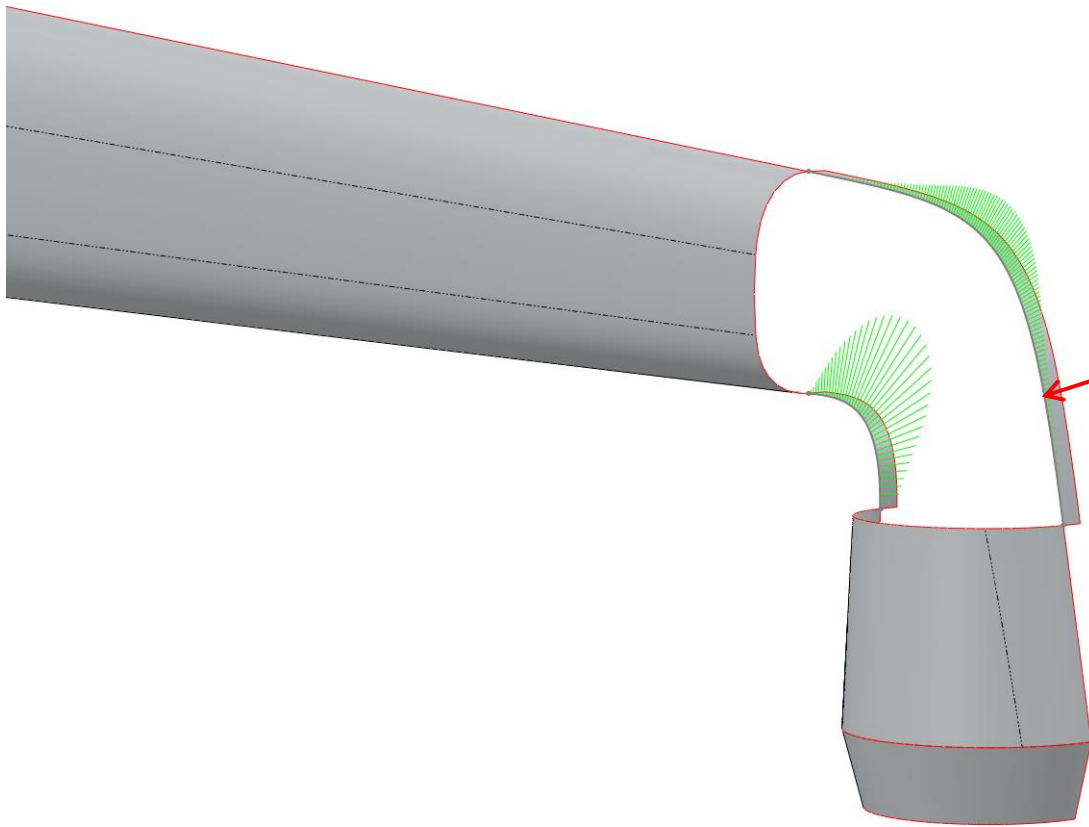


The starting point for these blends could be solids or surfaces, but the blends themselves will all be surfaces.



Connect the Shapes

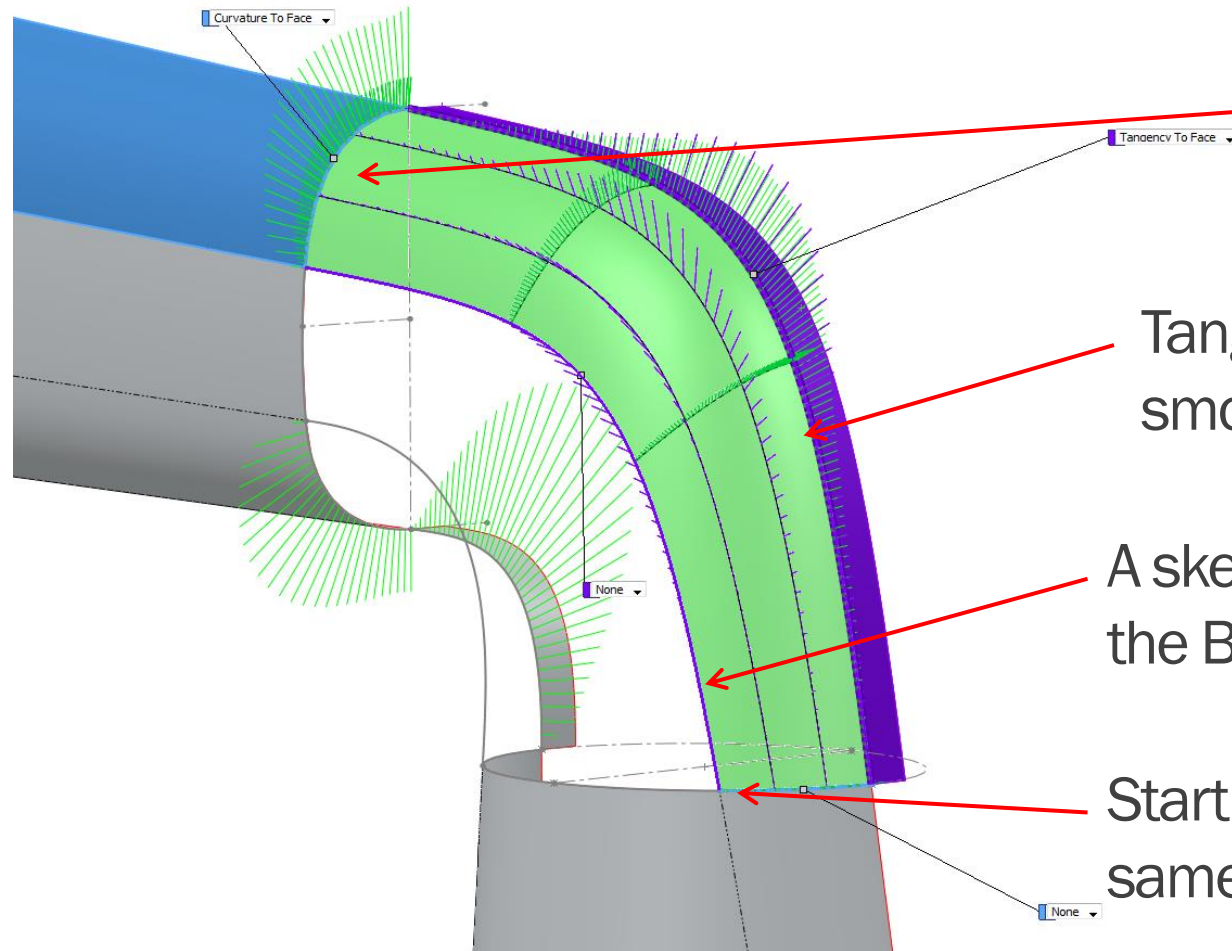
Reference surfaces are created to define the shape of the transition. Splines with the equal curvature relation are used to create the surfaces.



To ensure tangency along the mirror plane, a reference surface is required. Future surfaces will be made tangent to the reference surfaces.

Model the Transition

Boundary Surfaces are used to model the transition.



Curvature to face to ensure C2 connection.

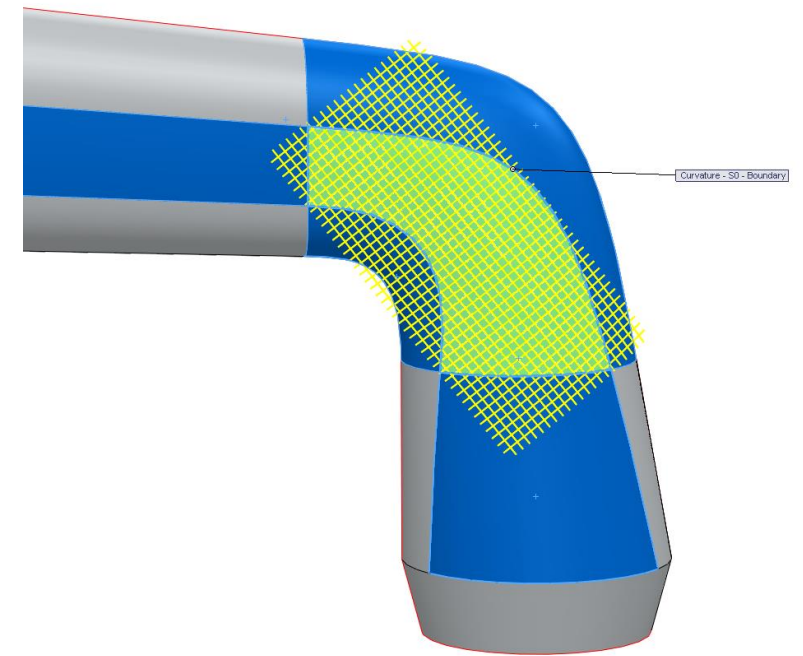
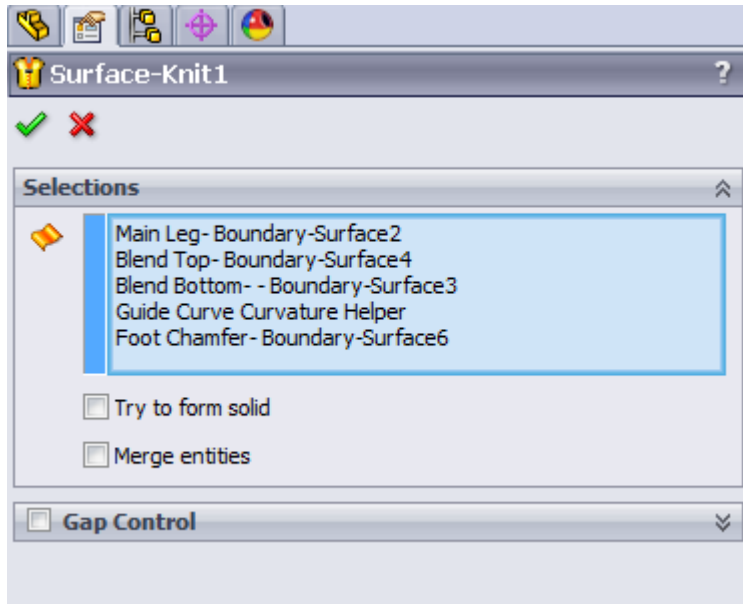
Tangency to this surface for smooth mirroring.

A sketch provides the last profile of the Boundary Surface.

Start and End profiles are roughly the same size.

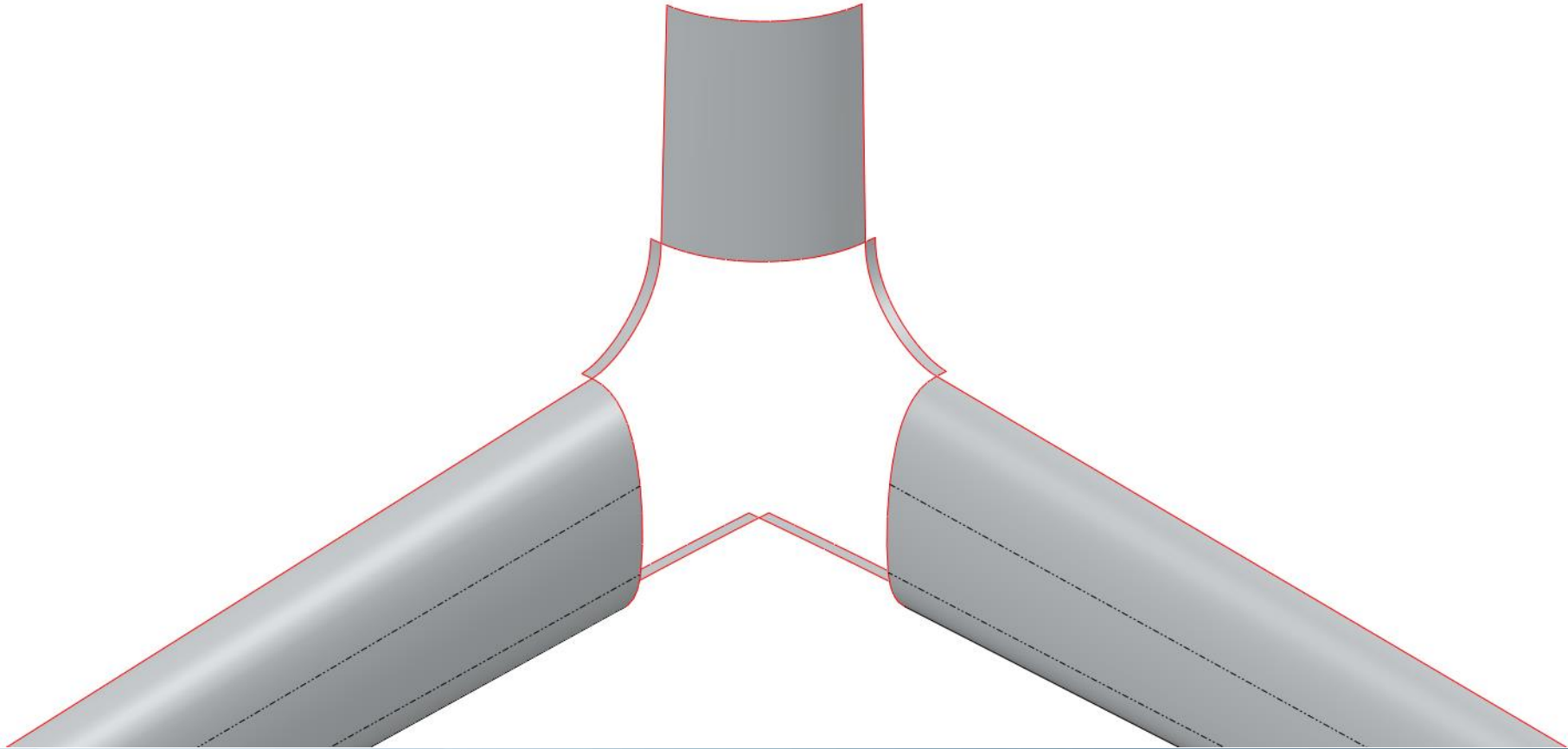
Knit and Fill

The transition boundary surfaces are knit into the model. The resulting opening is then patched with Surface Fill. Knitting first results in a better Surface Fill.



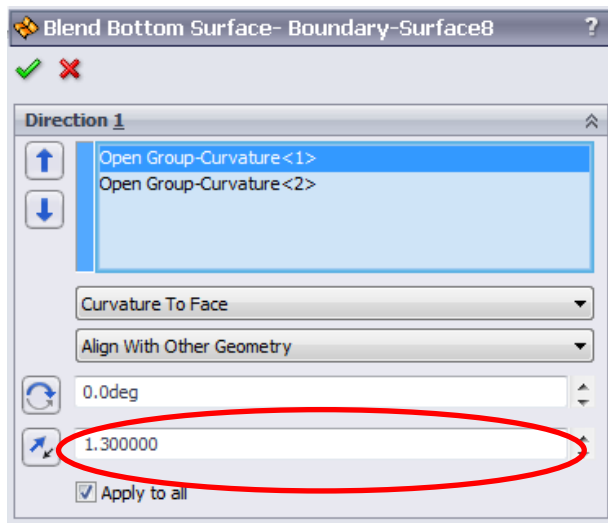
Y Blends

Y Blends are some of the trickiest to get right. With the right approach they can be conquered.



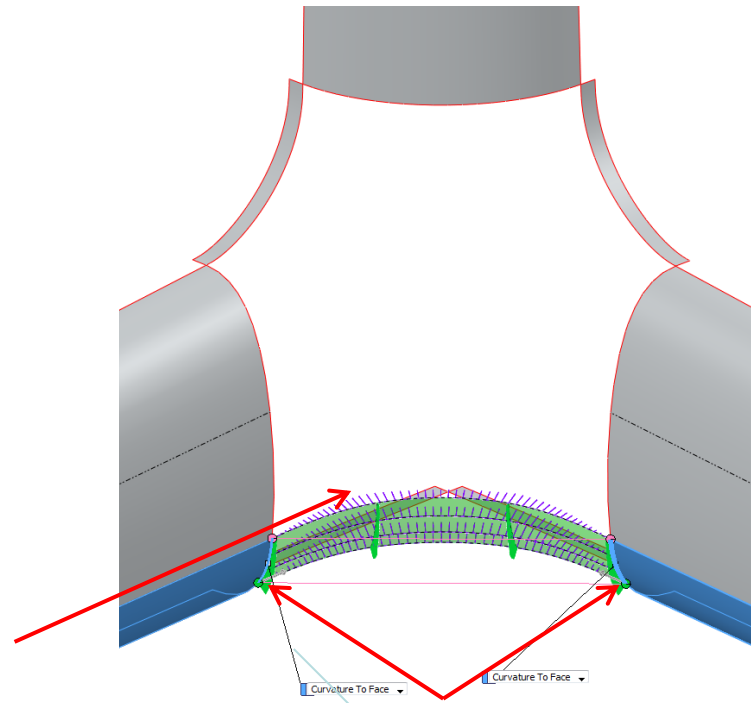
Start the Blend

Start the Y Blend with surfaces you know. Here the legs are blended together first.

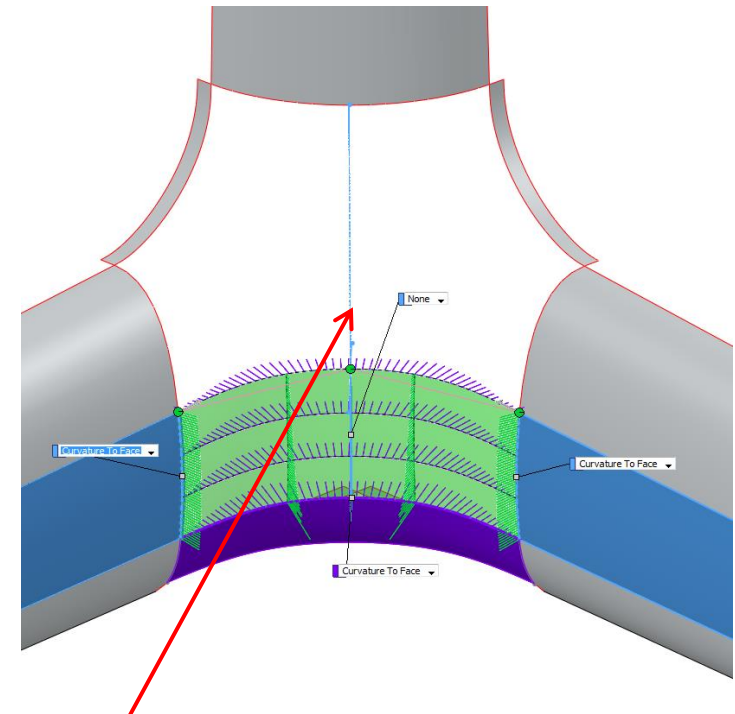


Shape the Surface with
Tangent Length Control.

Use the Curvature Combs to
Evaluate.



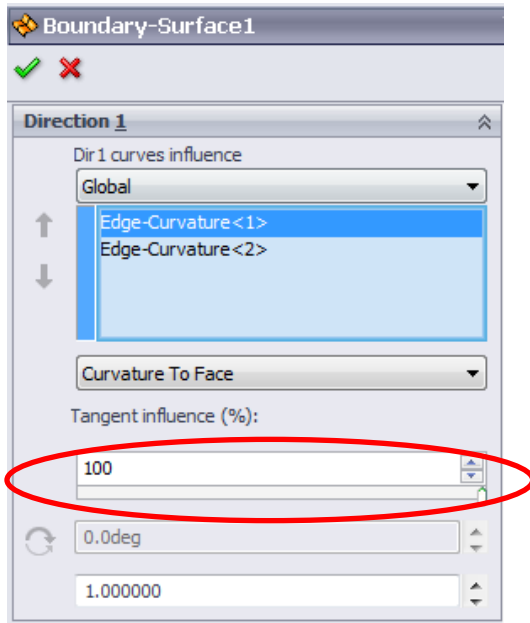
Edges converted into 3D sketch
to control length.



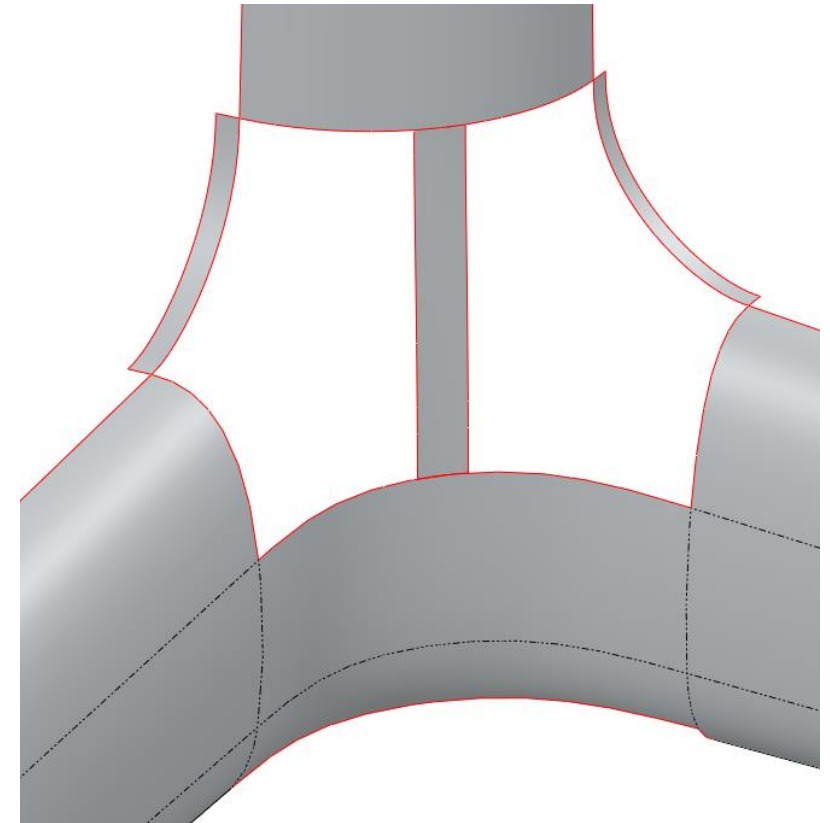
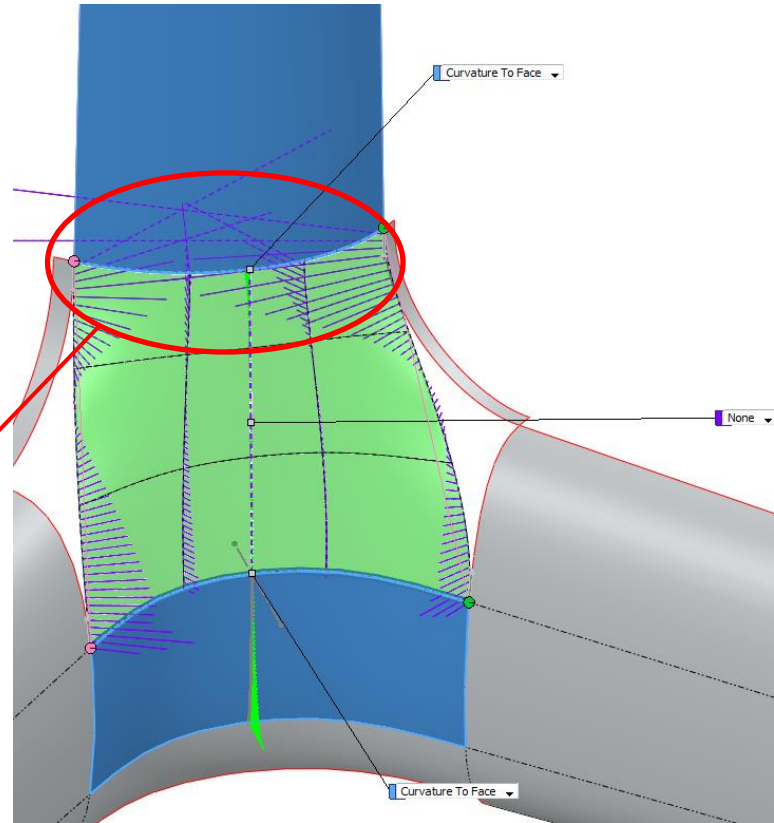
2D Sketch to control middle of Y
Blend.

Frame the Blend

A Boundary Surface will be used to provide guidance to Surface Fills that complete the Y blend. The Surface is built large and trimmed back.

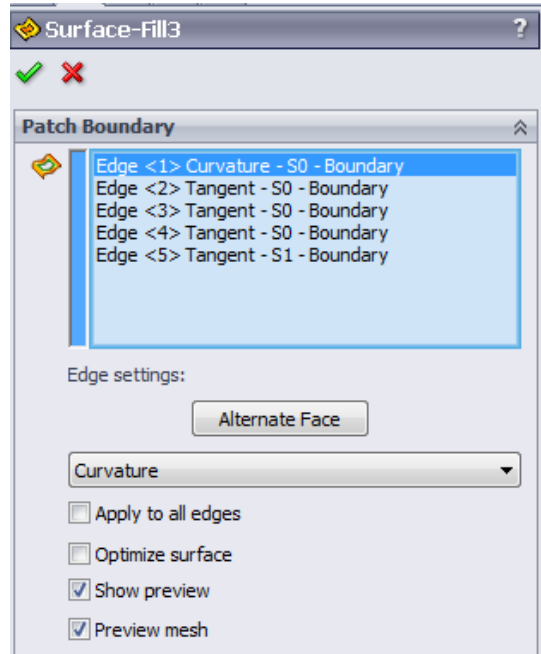


Increase the Tangent Influence to tame errant curvature spikes.

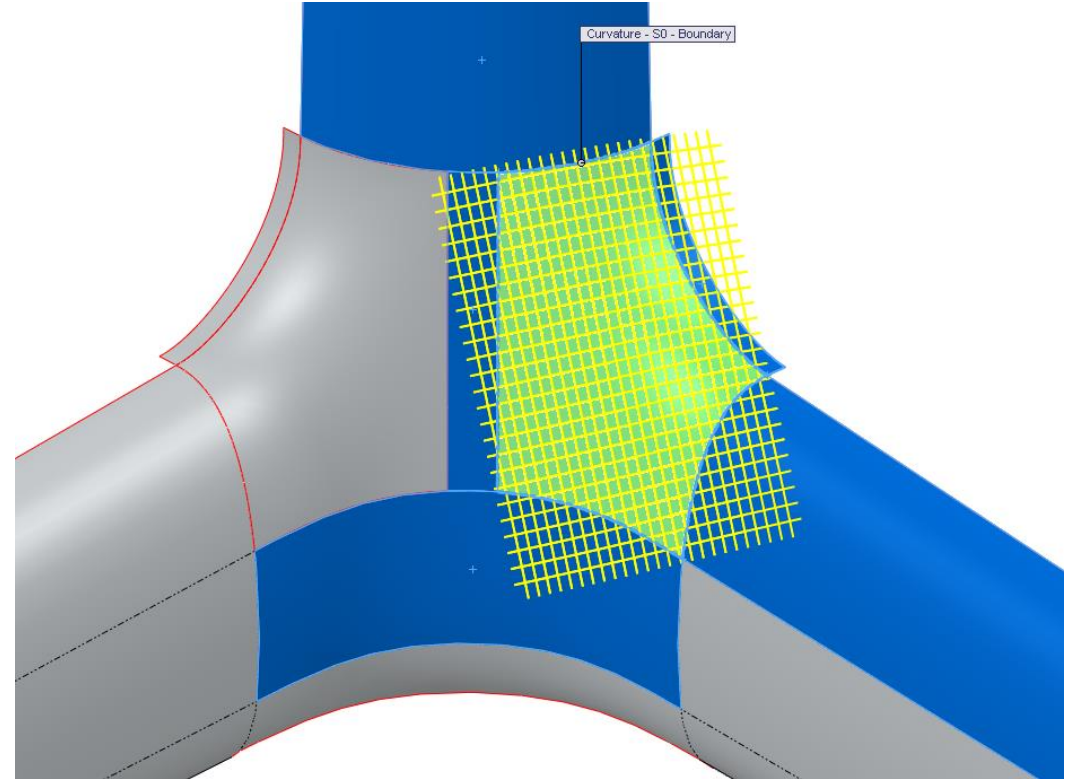


Complete the Blend

Surface Fill is used to complete the transitions.

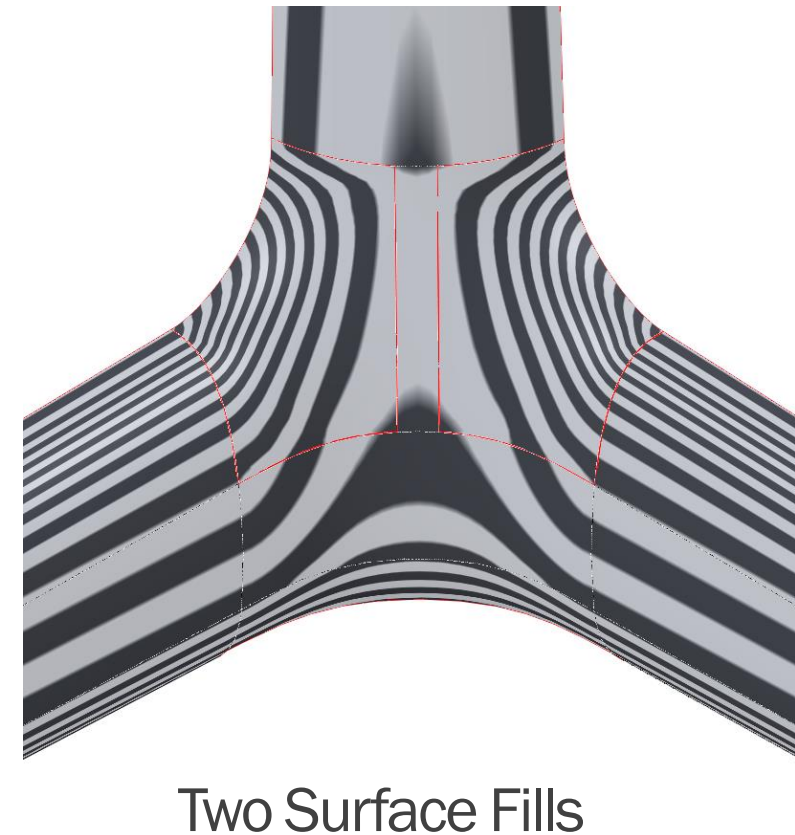
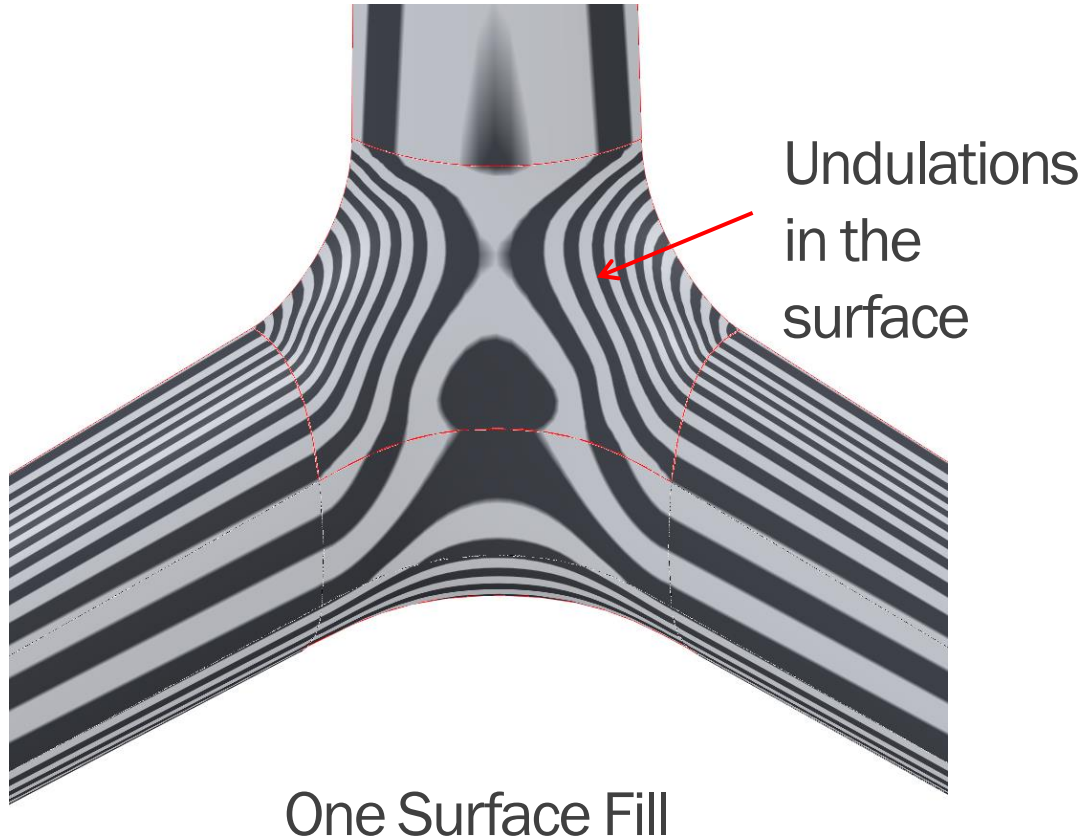


Use curvature only where absolutely required. Use zebra stripes to evaluate C1 vs C2 after the fill is created.



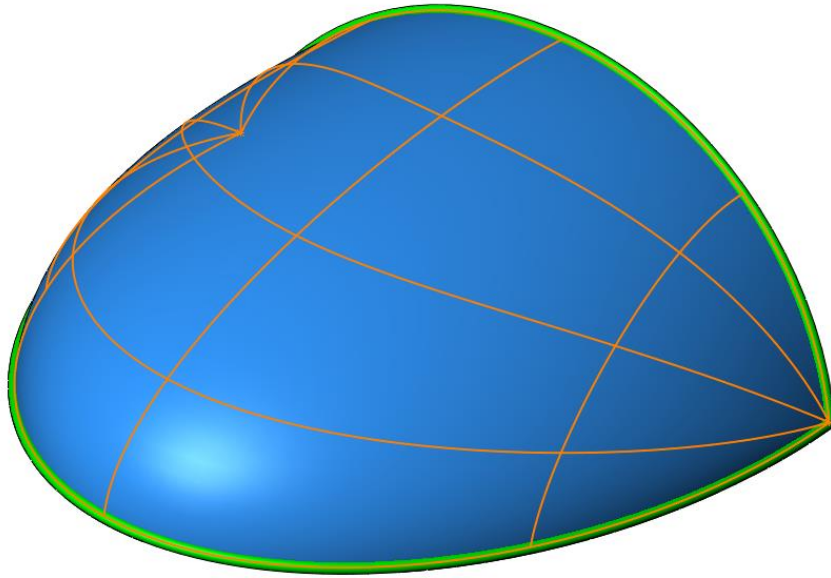
Two Surface Fills Vs One

While it is possible to create the blend with one Surface Fill. However, guiding two Surface Fills with a surface creates a better result.

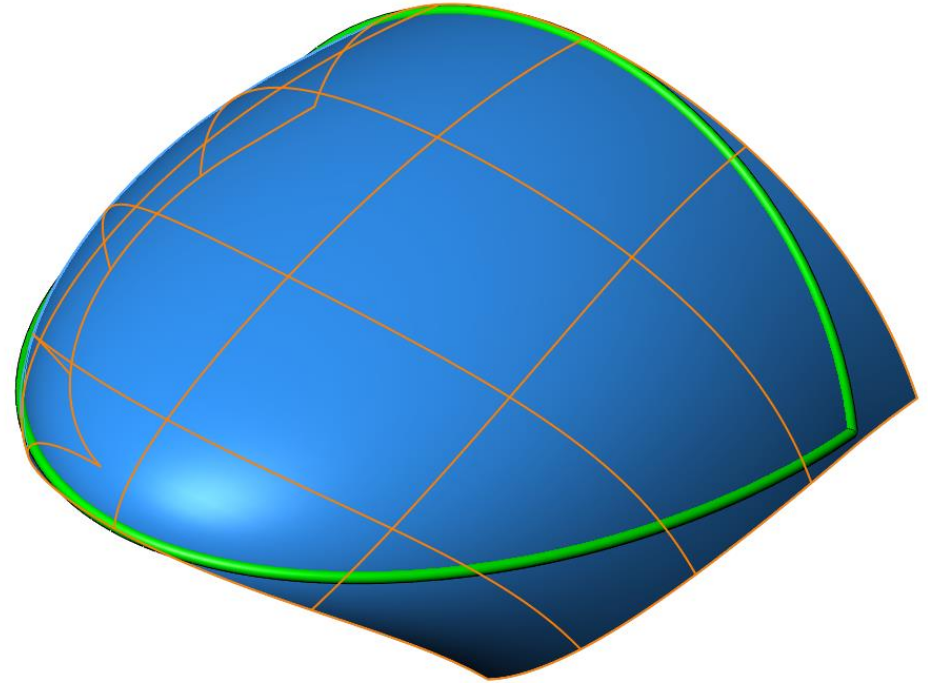


Boundary Surface vs Surface Fill

Imagine the outline of the patch as a frame of poles a tarp will be stretched over. The tarp can be any shape and size, but always has to have 4 sides.



Trying to fit the tarp over this shape results in bunched up corners.

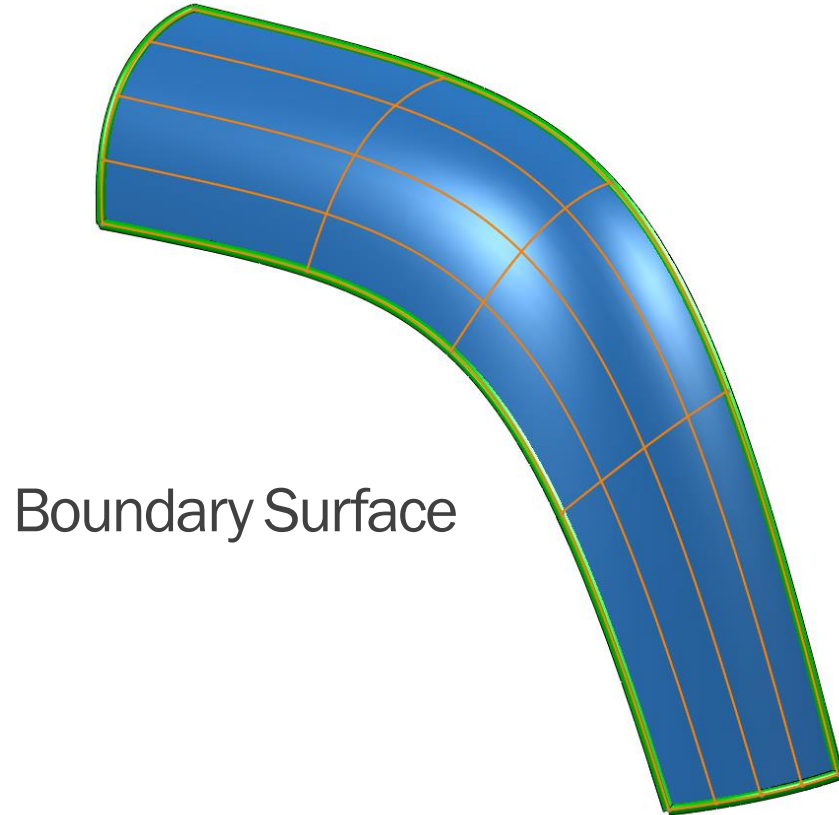


Draping the tarp over the frame and then trimming prevents the corners from bunching.

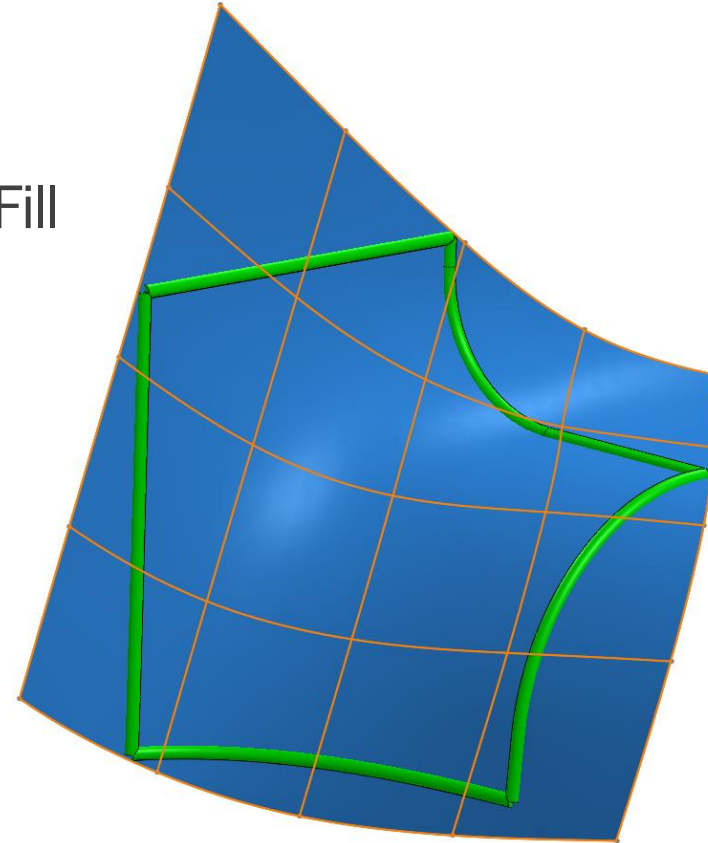
When to Use Boundary Surface vs Surface Fill

When the surface to be created is 4 sided, use Boundary Surface for more control.

When the surface to be created is 2,3 or 5+ sided, use Surface Fill due to its ability to trim back.



Surface Fill

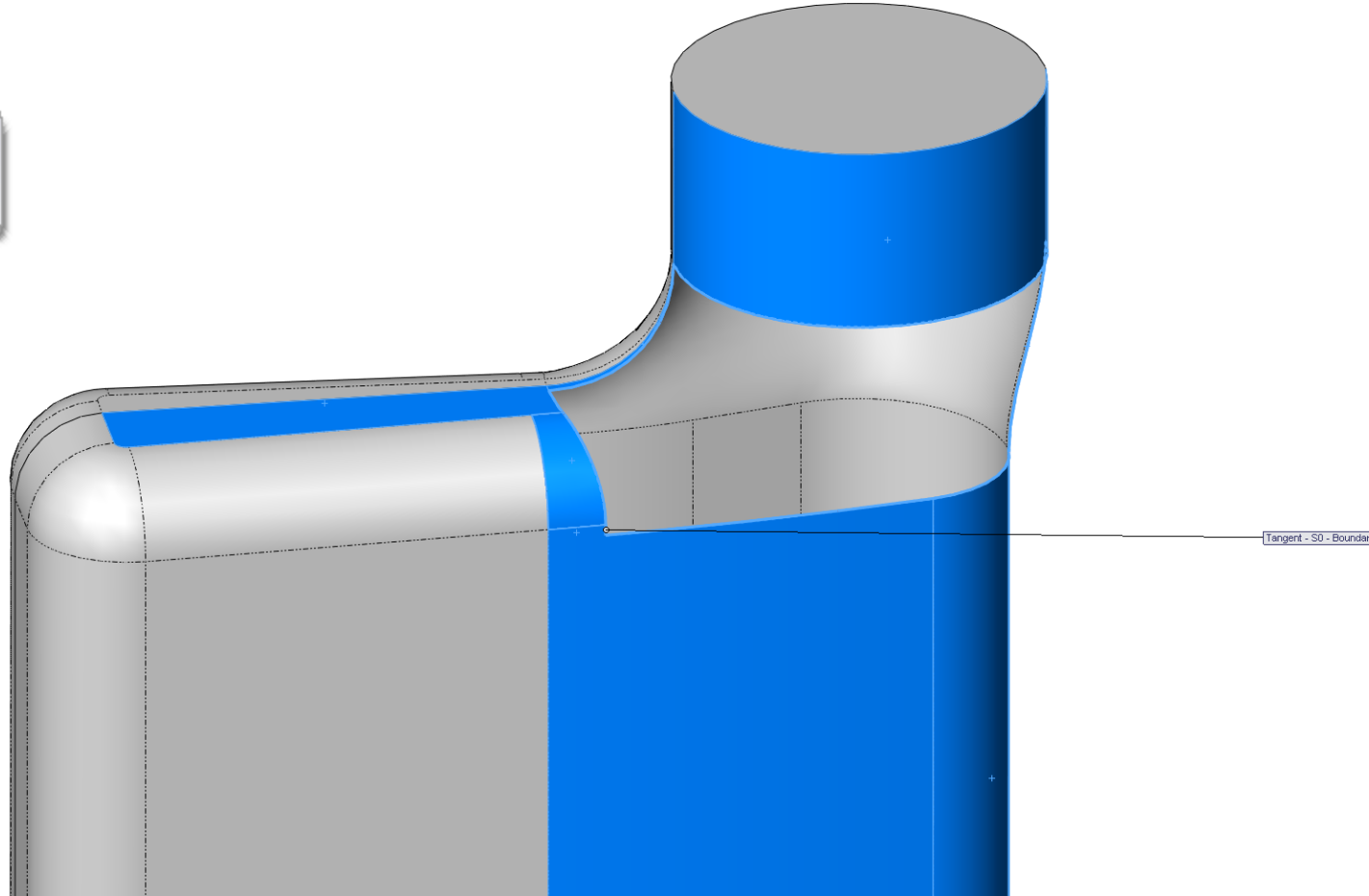


When Surface Fill Doesn't Work

Sometimes Surface Fill can't work its magic. Most likely it is being asked to do too much. We can help it along though.

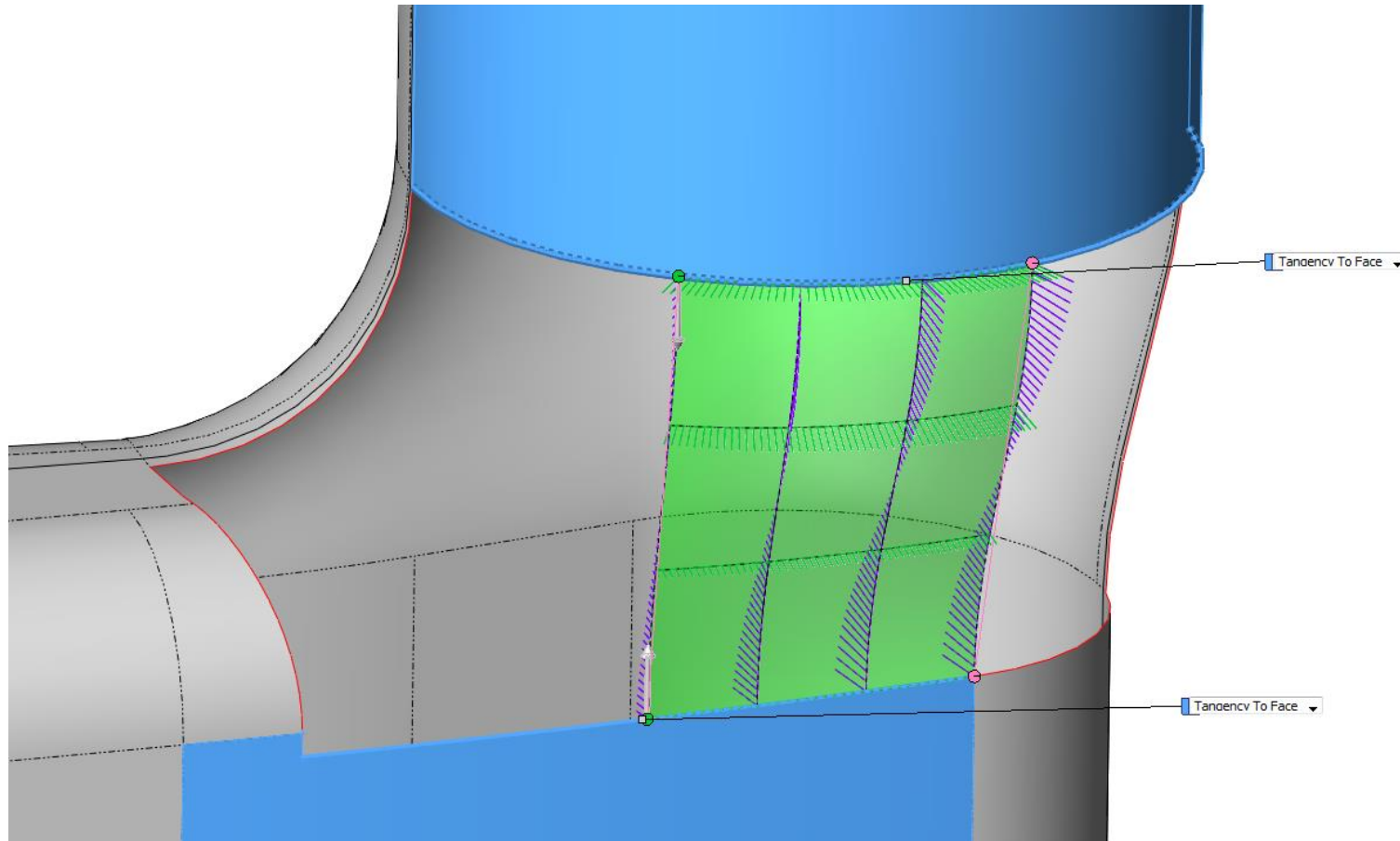
✖ Rebuild Errors

The patch cannot be created. Try a different curvature method, alternate face or surface quality setting.



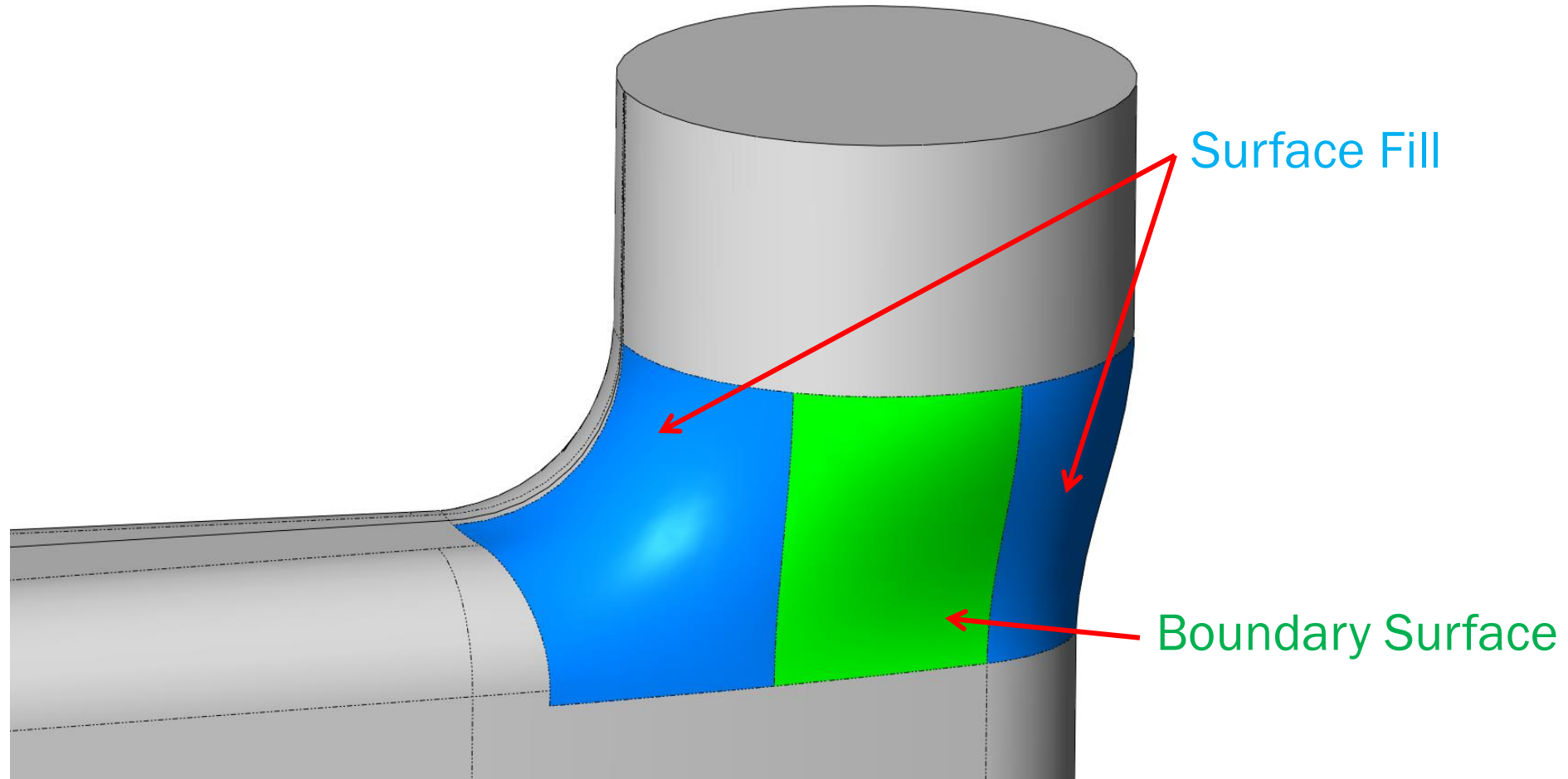
Make the Surface Fill Area Smaller

Bridge the middle of the blend with a new Boundary Surface.



Complete the Blend

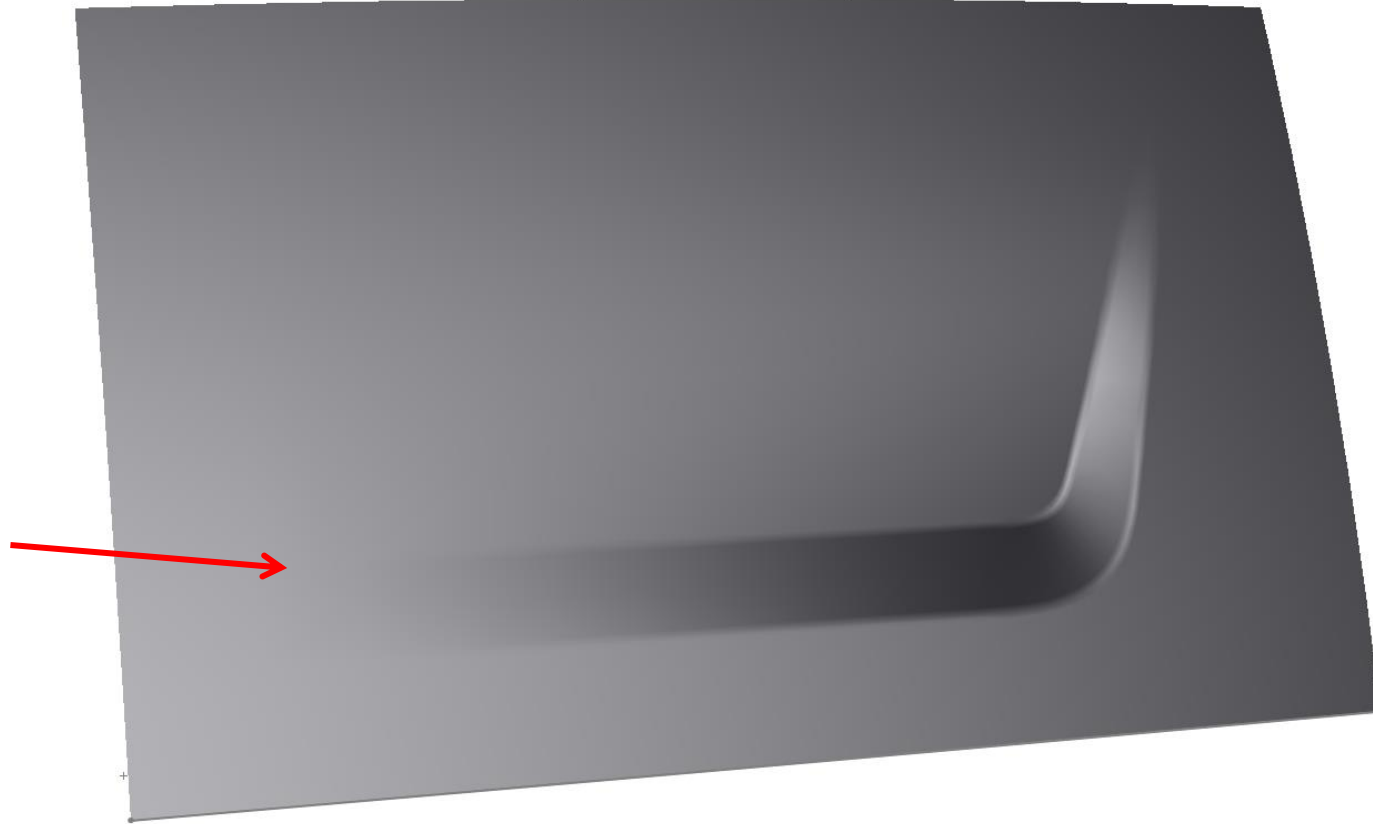
Use Surface Fill to patch the two smaller areas of the blend.



Washouts

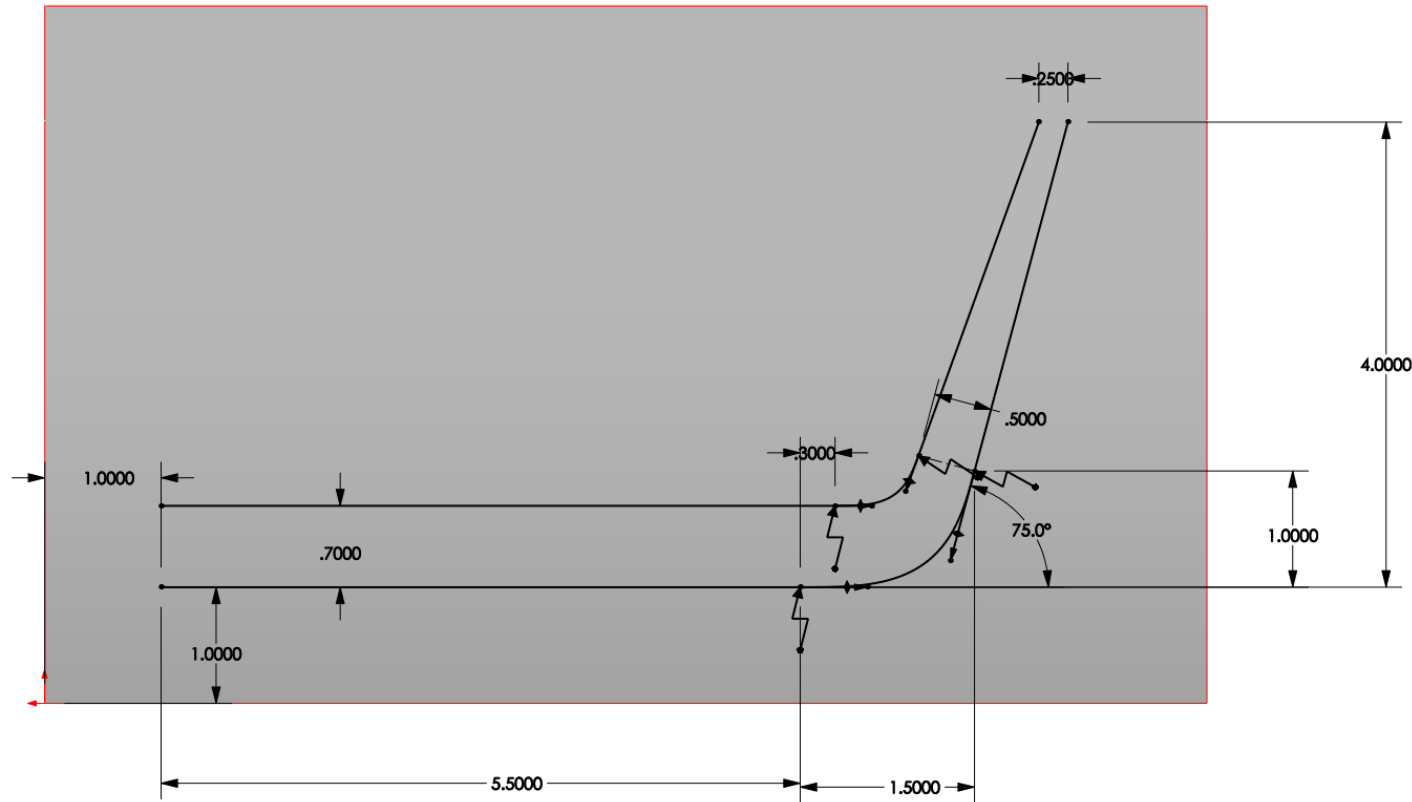
A washout refers to a type of transition where a hard edge seamlessly fades into the surrounding geometry. This is one of the trickiest blends to get right.

Hard chamfer washes
out to nothing



Layout the Blend

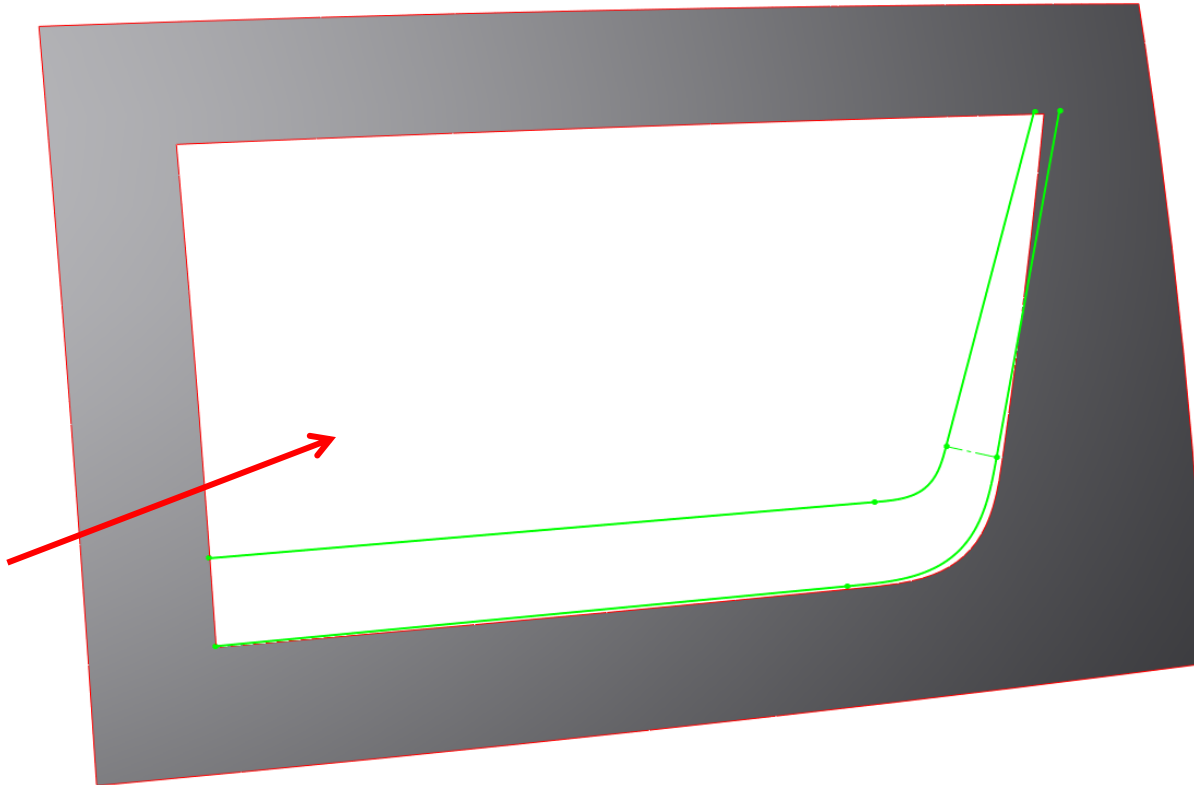
A layout sketch will make modeling the blend much easier. Future sketches will be converted from entities in the layout sketch.



Create the Blend Opening

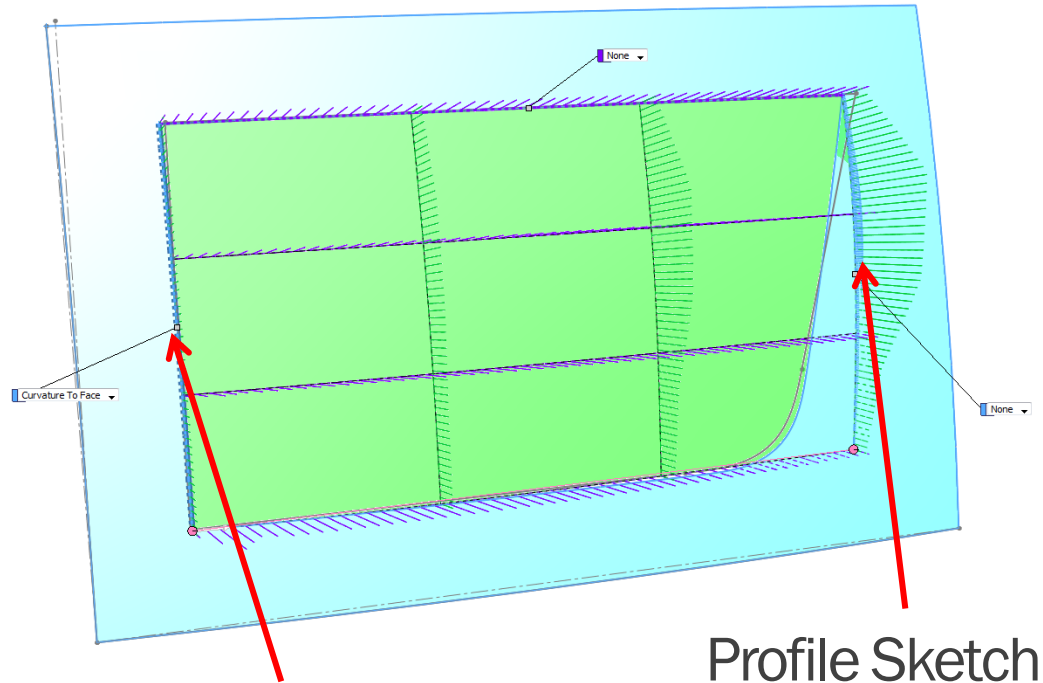
A new recessed surface is required for the chamfer to bridge. An opening in the main surface is created for this new recessed surface.

New surface will be created
in this opening.



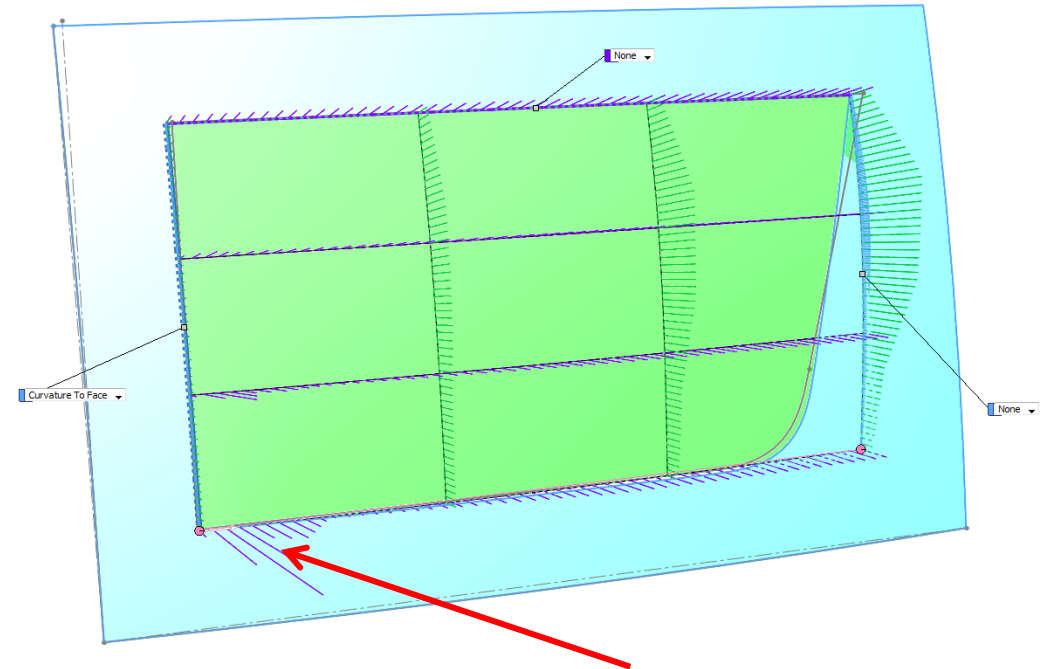
Create the Recessed Surface

The recessed surface is created with a boundary surface. The tangent influence is increased to 100% to prevent ripples in the surface.



Existing Edge

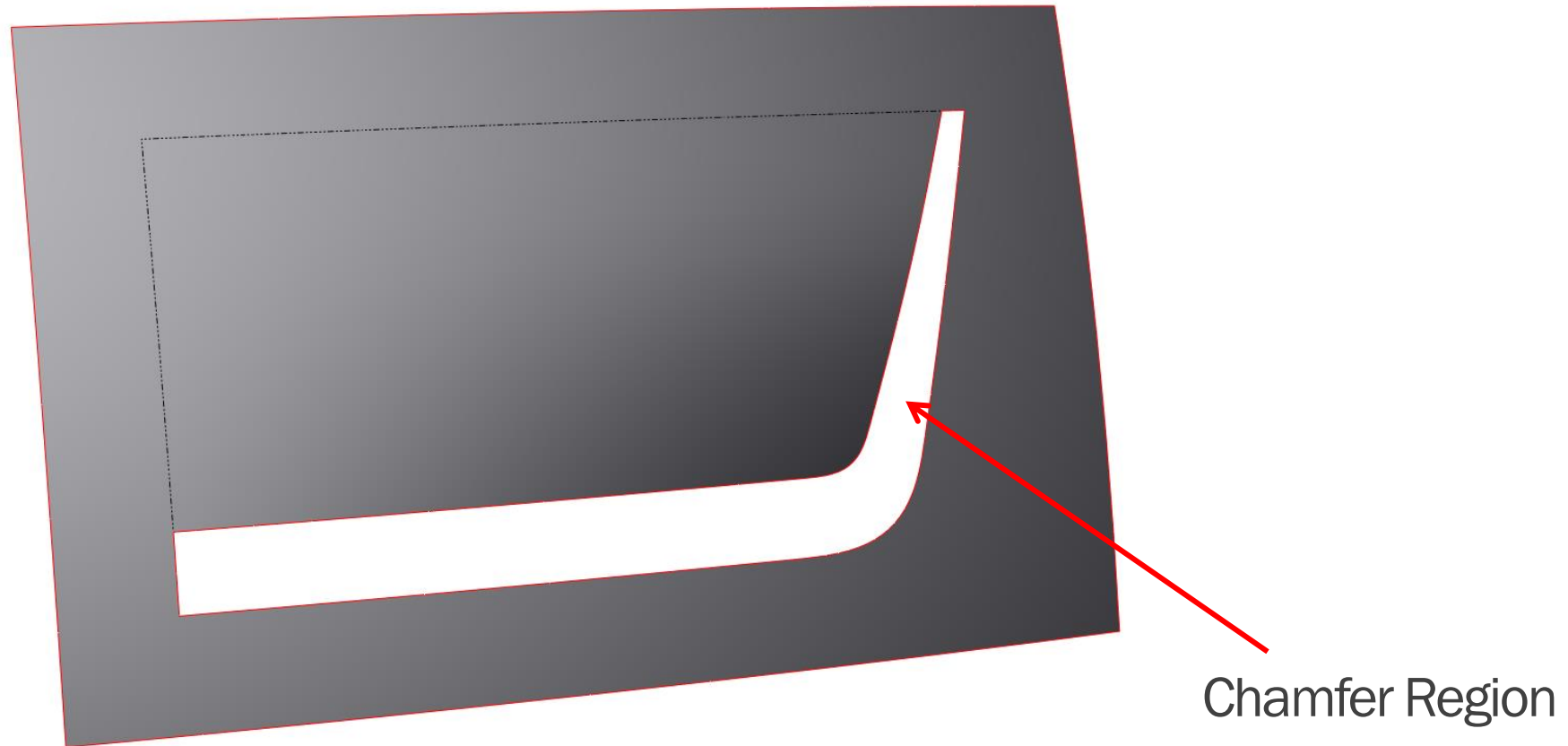
Profile Sketch



Increasing the tangent influence to 100% eliminates these ripples.

Trim and Knit

The recess surface is trimmed to the chamfer profile and knitted into the original surface.



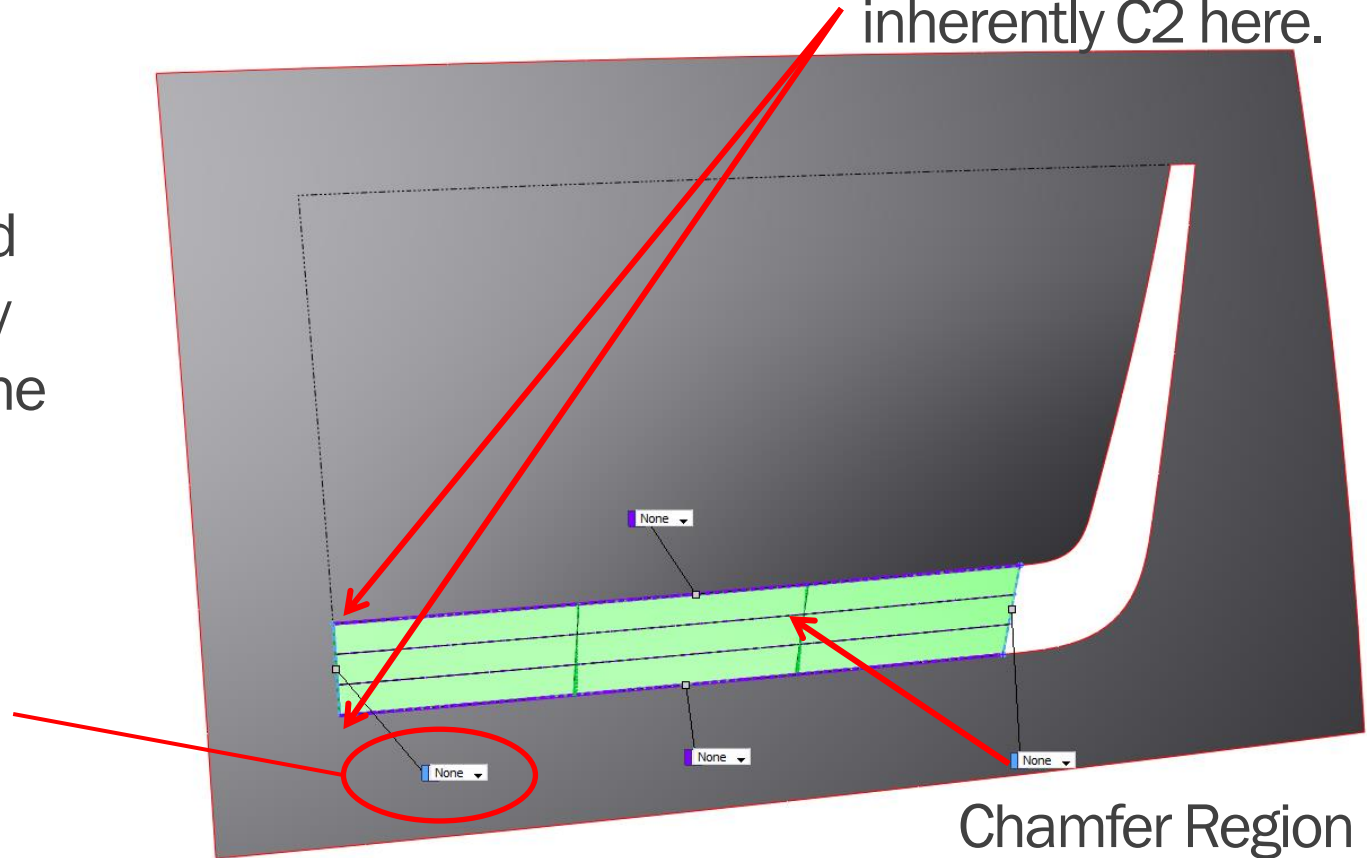
Build the Chamfer

The chamfer is built with Boundary Surfaces.

Tangency or Curvature is not used here. The surface is automatically curvature continuous based on the profiles used in direction 2.

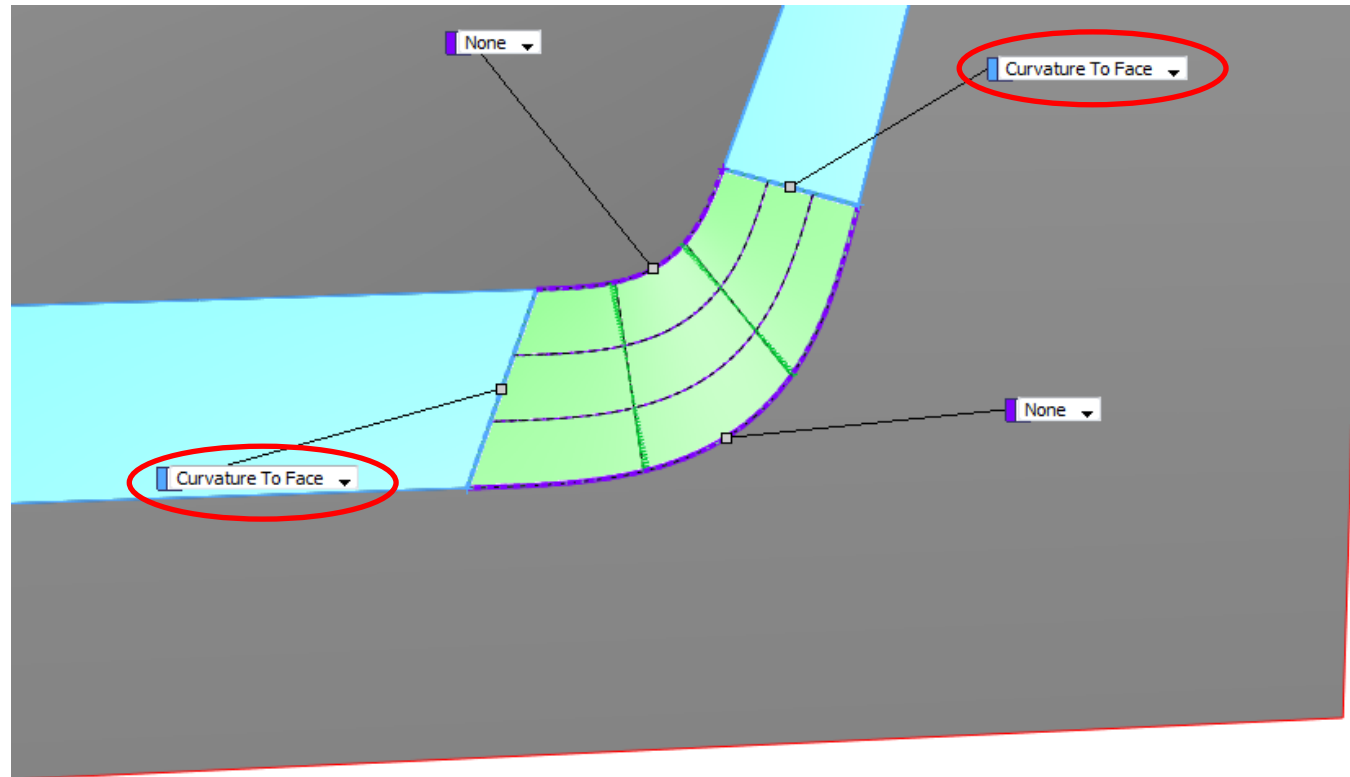
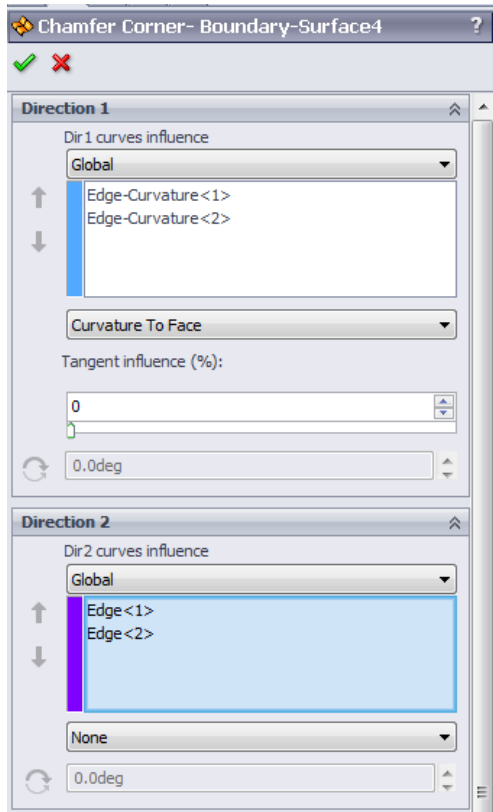
Adding the end condition only introduces ripples in the surface.

These curves are inherently C2 here.



Complete the Chamfer

The chamfer is completed with another Boundary Surface. Unlike the previous chamfer surfaces, the corner requires tangency or curvature end conditions.

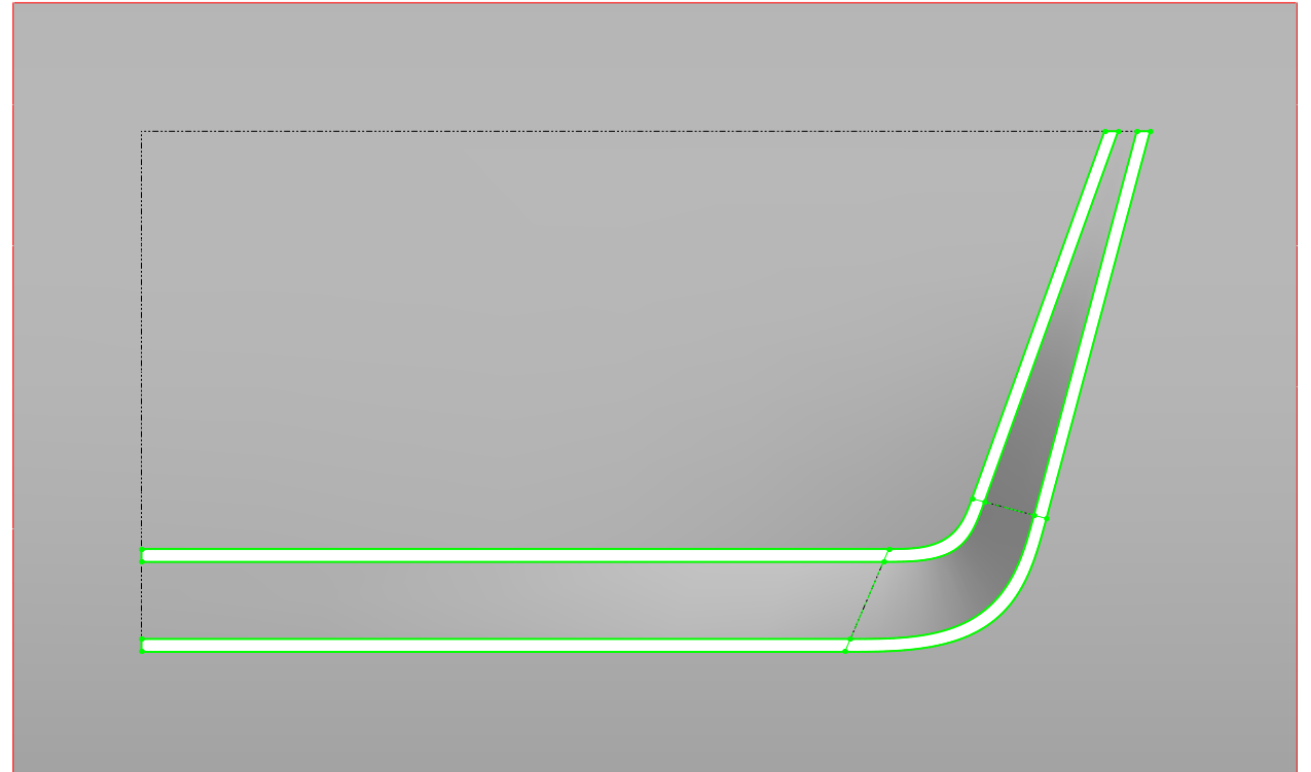


Adding Fillets

Using techniques previously discussed, the fillet tool could be used here. Manually building the fillet will provide a superior cosmetic result.

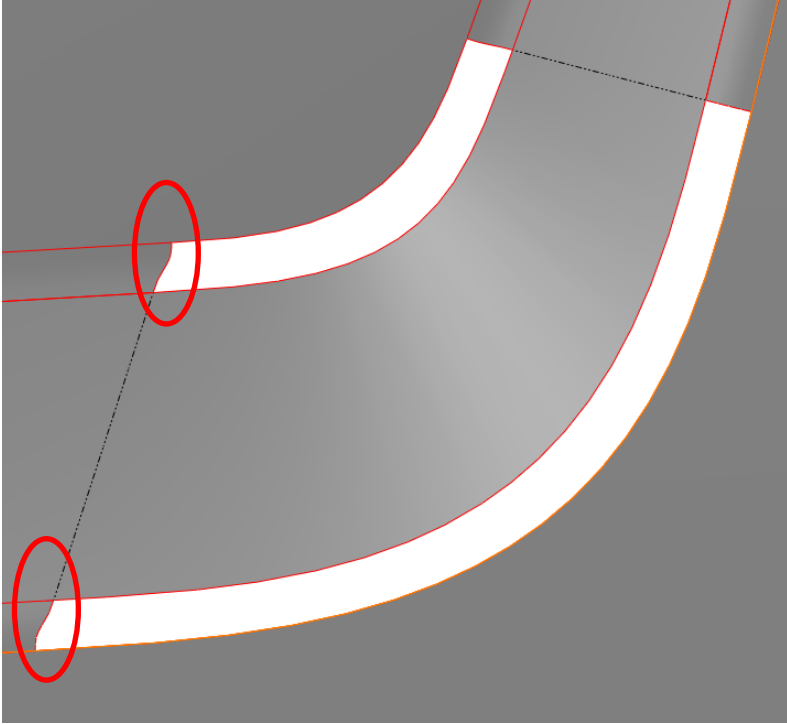
Sketch entities are offset from the layout sketch to create a sketch to trim with (in **GREEN**).

Surface trim is used to trim an area for a fillet to be manually built.

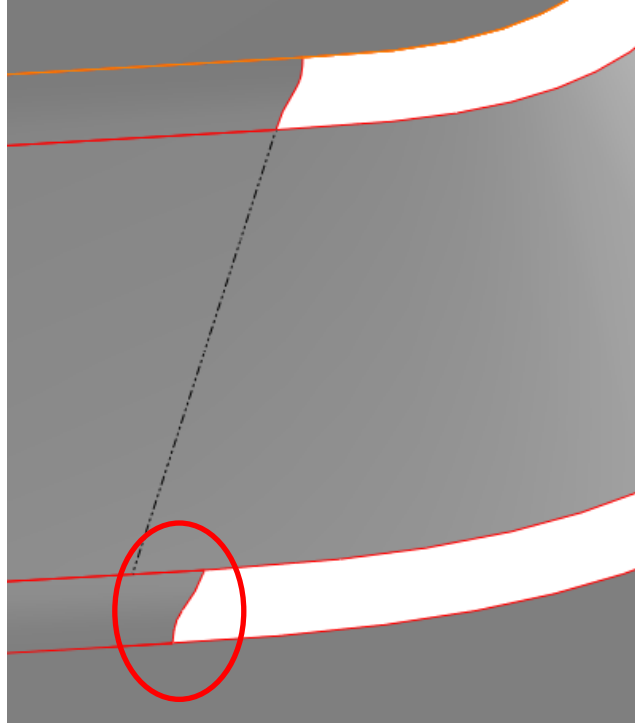


Clean up the Fillets

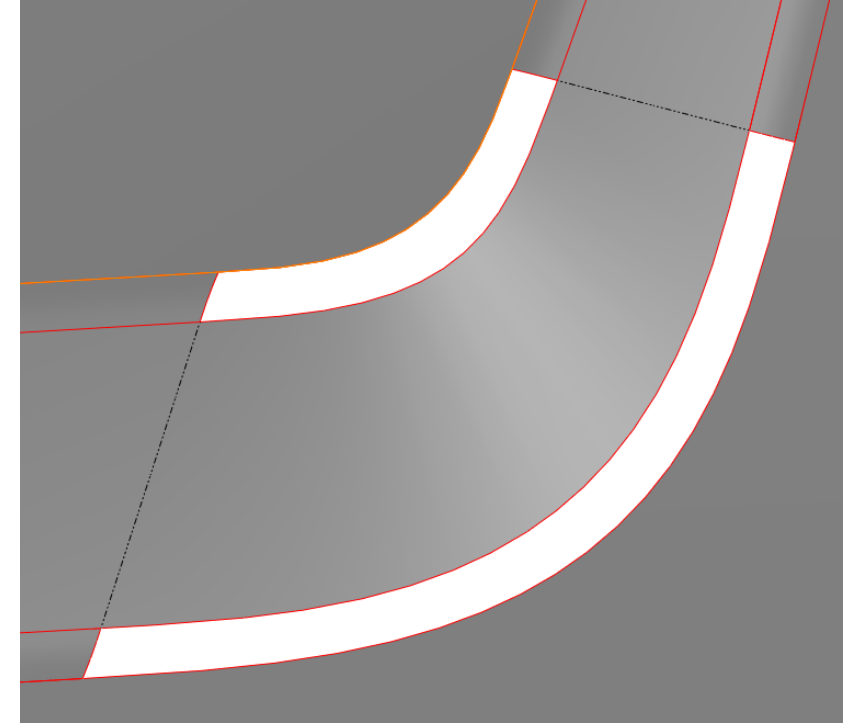
The ends of the fillets are wavy. Trimming them straight will improve the quality of the surface completing the fillet.



Wavy Surface Ends



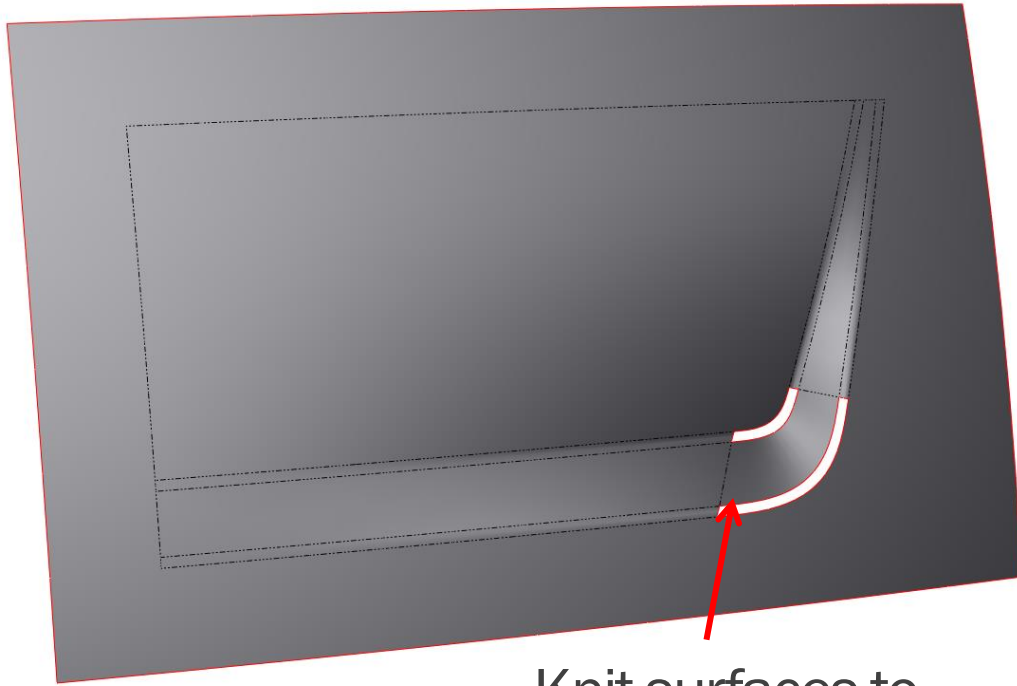
Surface Extend



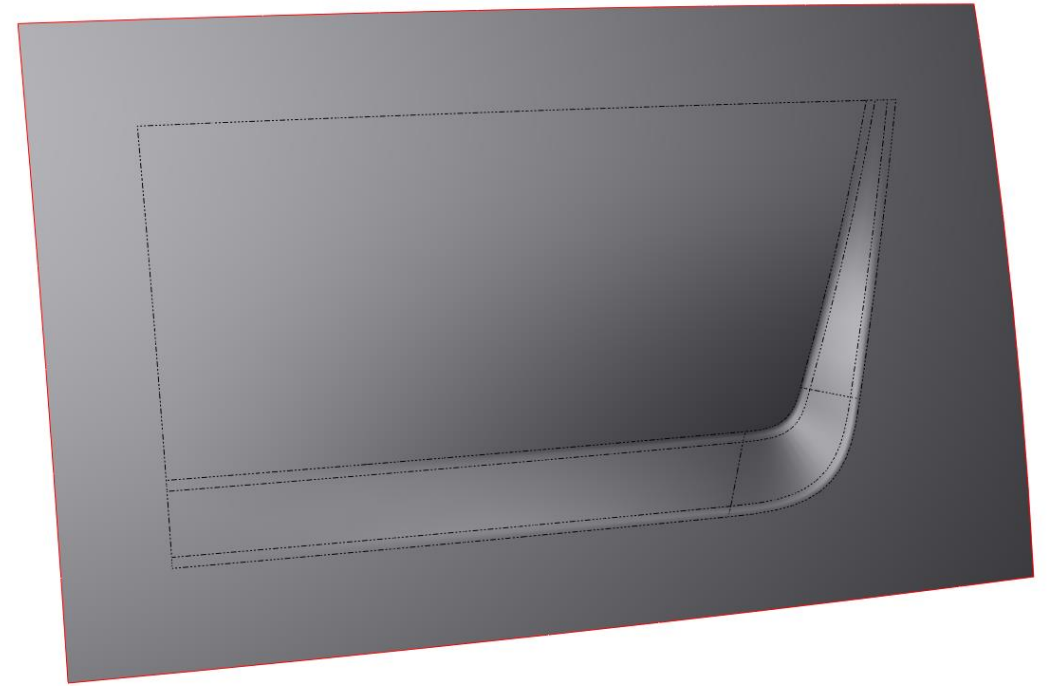
Surface Trim for clean ends

Knit and Finish

The fillet surfaces need to be knitted into the whole. This creates new edges to finish the transition. Complete the washout with boundary surfaces.



Knit surfaces to
generate new edges.



Still Won't Fillet?

The surefire way to add a fillet to any model 100% of the time.

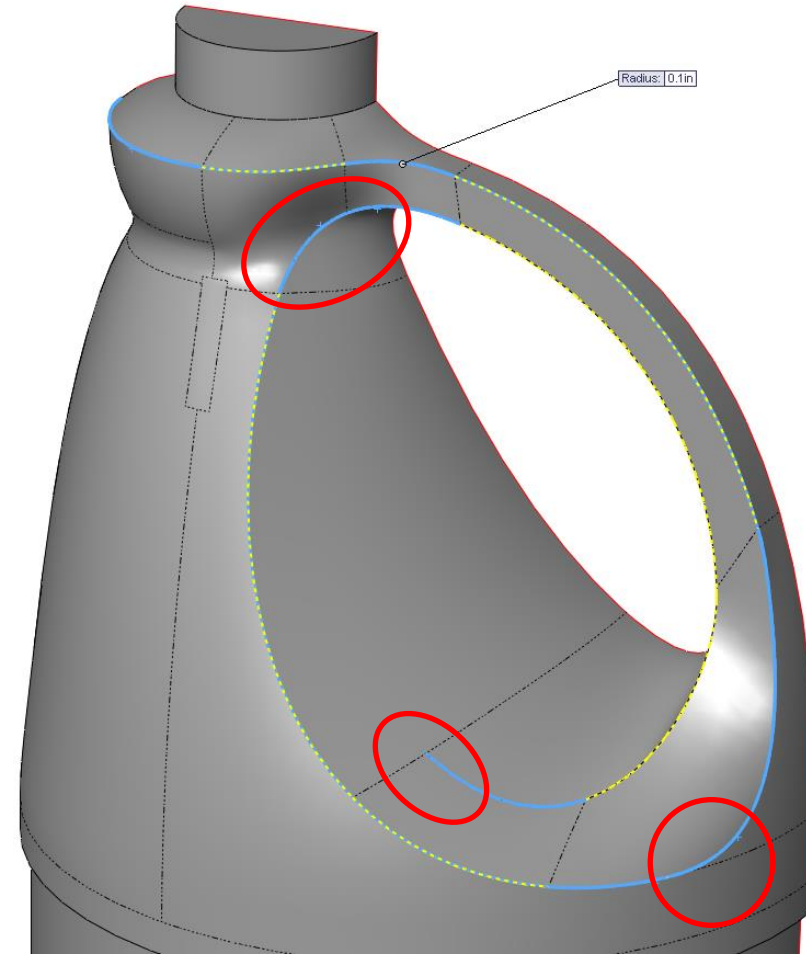
Fillets from Hell

The Fillet tool has no chance here: different areas of almost tangent surfaces, and the fillet ends by “washing out” to nothing.

✖ Rebuild Errors

A common corner of the selected faces/edges is too complex. Try to fillet one face/edge at a time.

While a fillet could be added using the previously discussed techniques, for this situation, there is a better way.

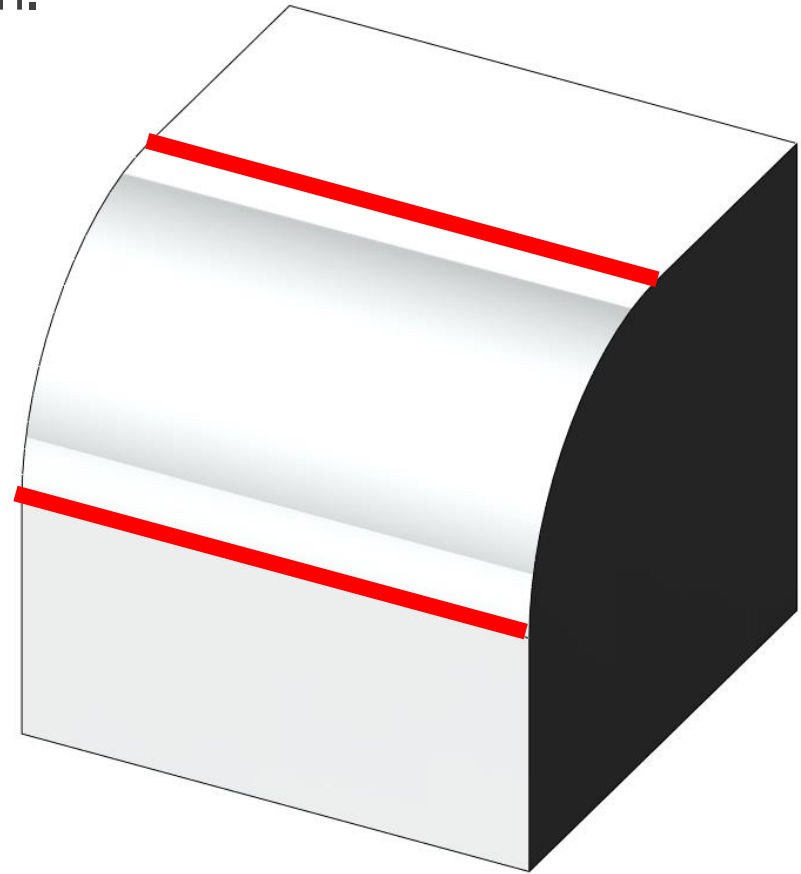


Manual Filleting

Q: What does the fillet tool always generate?

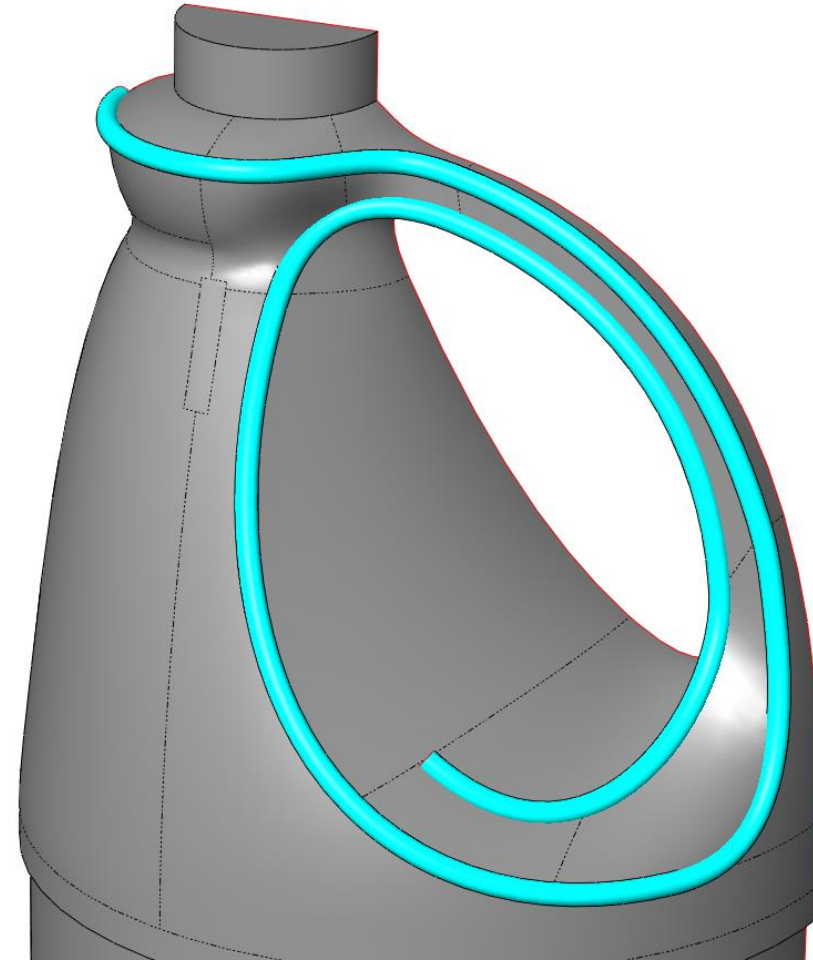
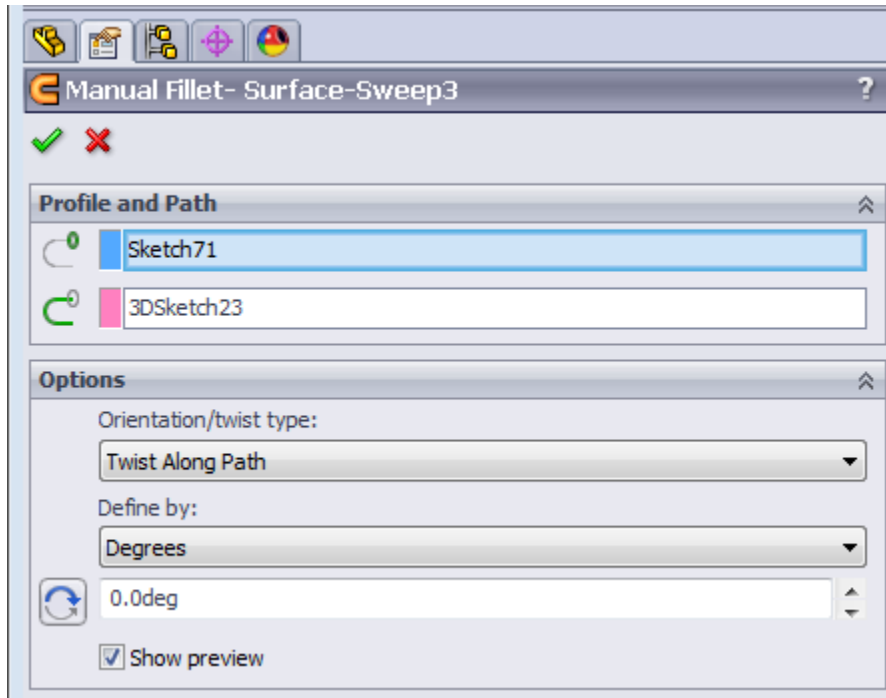
A: Two new sets of edges with a transition in between them.

It would be possible to create the edges for a fillet with a series of Split Lines. But on parts with complicated geometry, it becomes extremely difficult.



Sweep Fillet

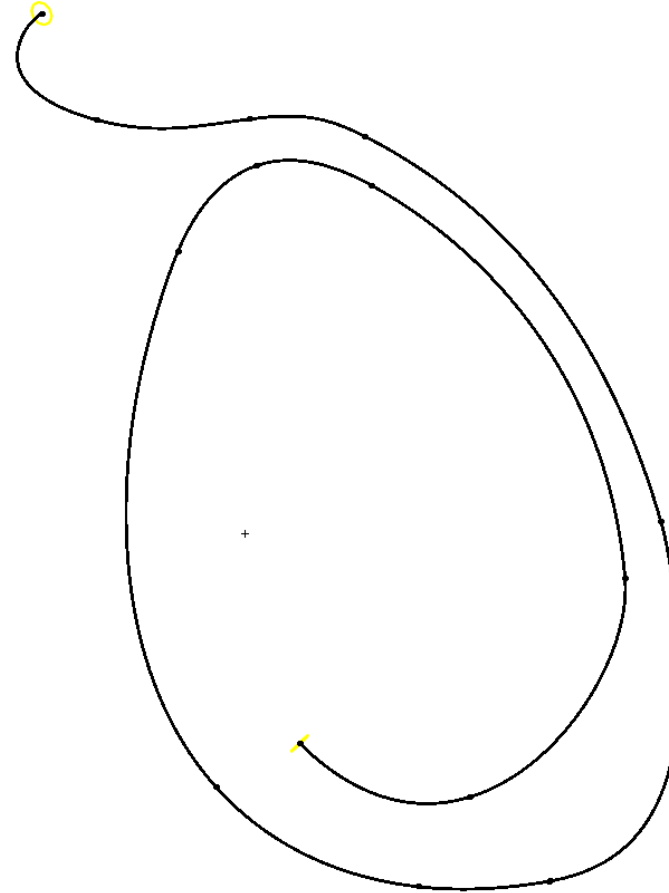
By sweeping a circle along the edge of the part, two new sets of edges can be generated at the two points of intersection.



Sweep Path

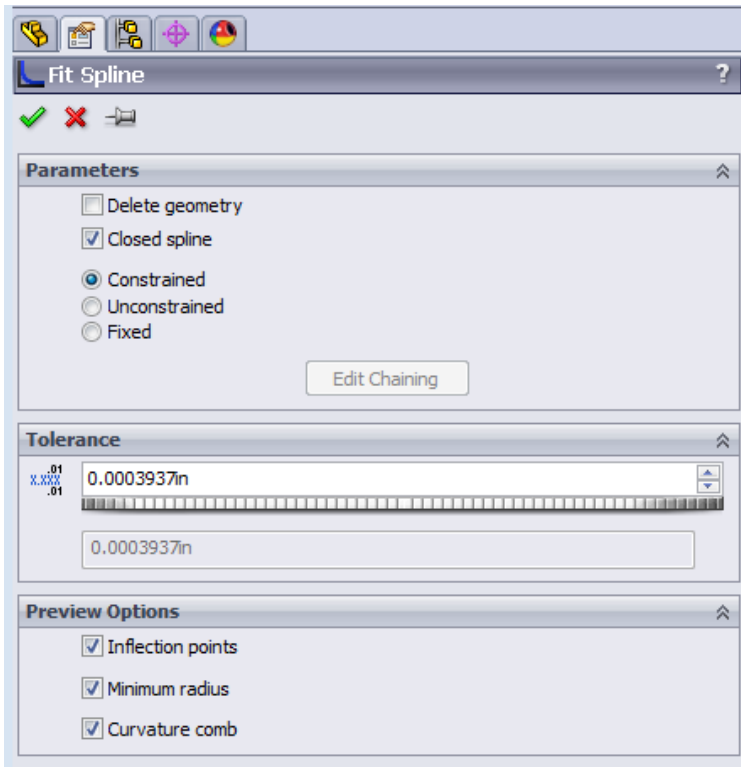
It can be more convenient to use a 3D sketch as the sweep path instead of picking edges with the selection manager.

Convert the required edges into the 3D sketch.



Fit Spline

A Fit Spline takes selected sketch segments and “fits” a single spline over the top. This means the sweep builds a single face.

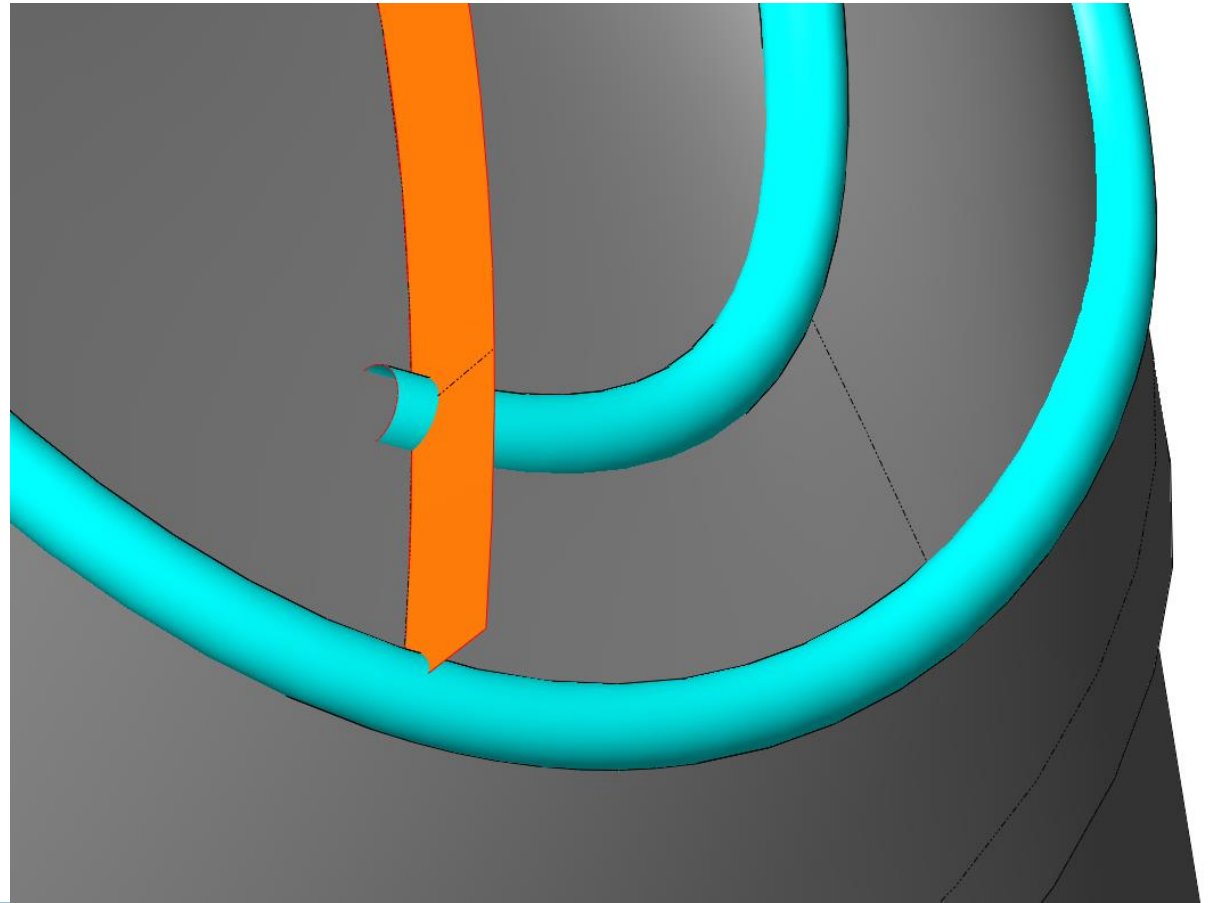


The tolerance controls how closely the fit spline matches the original sketch segments. A lower value is better here.

Cap Ends

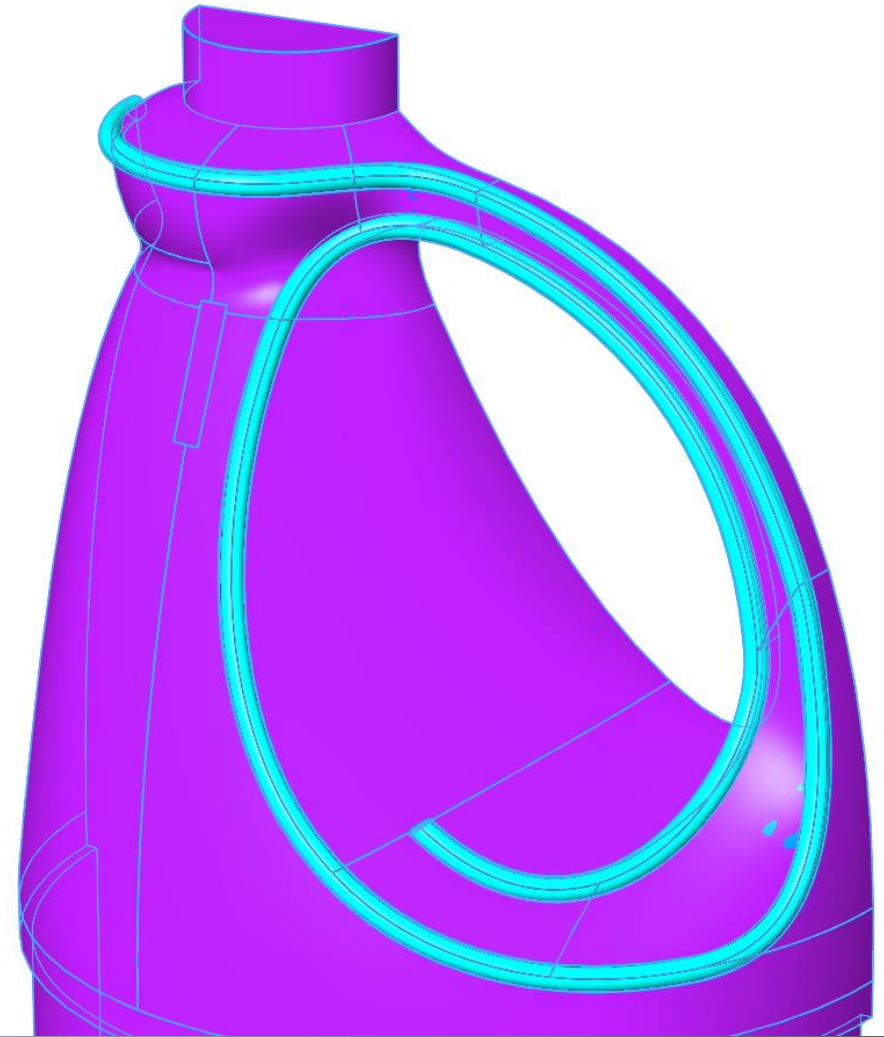
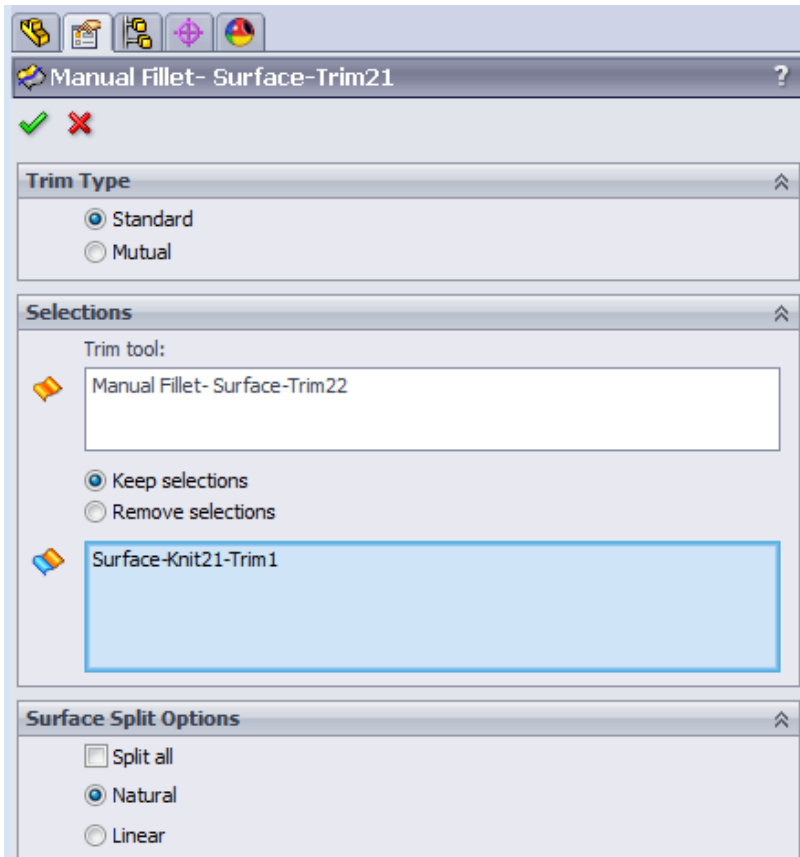
The sweep needs to be capped at the end point of the fillet in order to correctly trim out the area to be filleted.

Here Surface Extend is used to extend the sweep, then a Ruled Surface is used to trim it back. Finally, the end is capped with a Surface Fill.



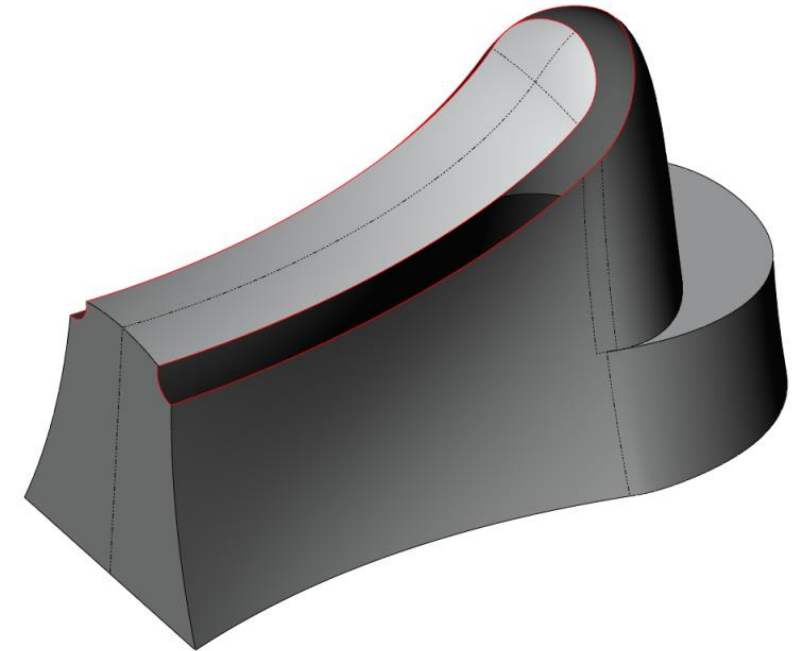
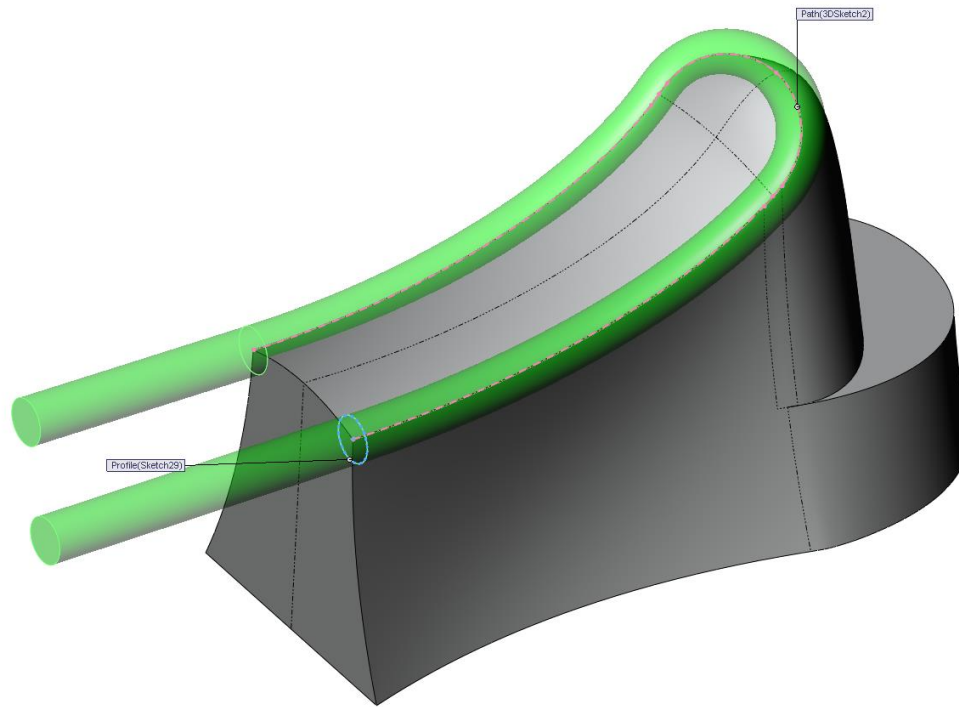
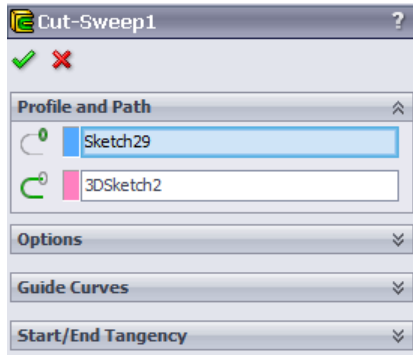
Trim the Fillet

The Sweep can now be used to trim back the Fillet area.



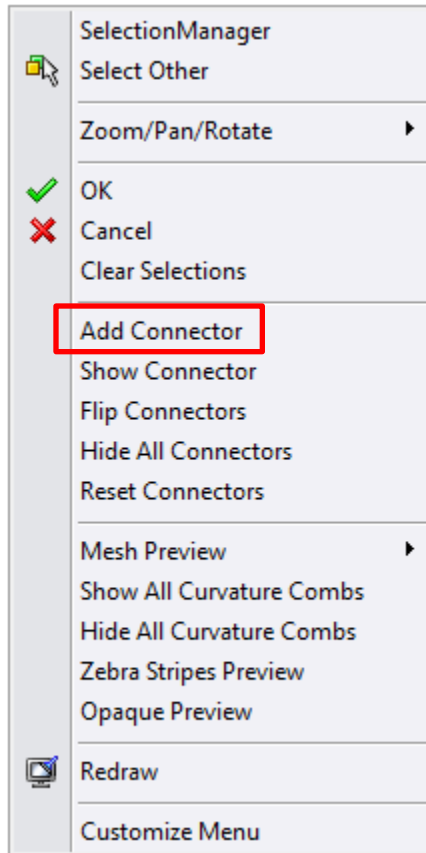
Application to Solids

This technique can also be used on Solids. Use a Swept Cut instead of a Surface Sweep and then delete the face from the model.

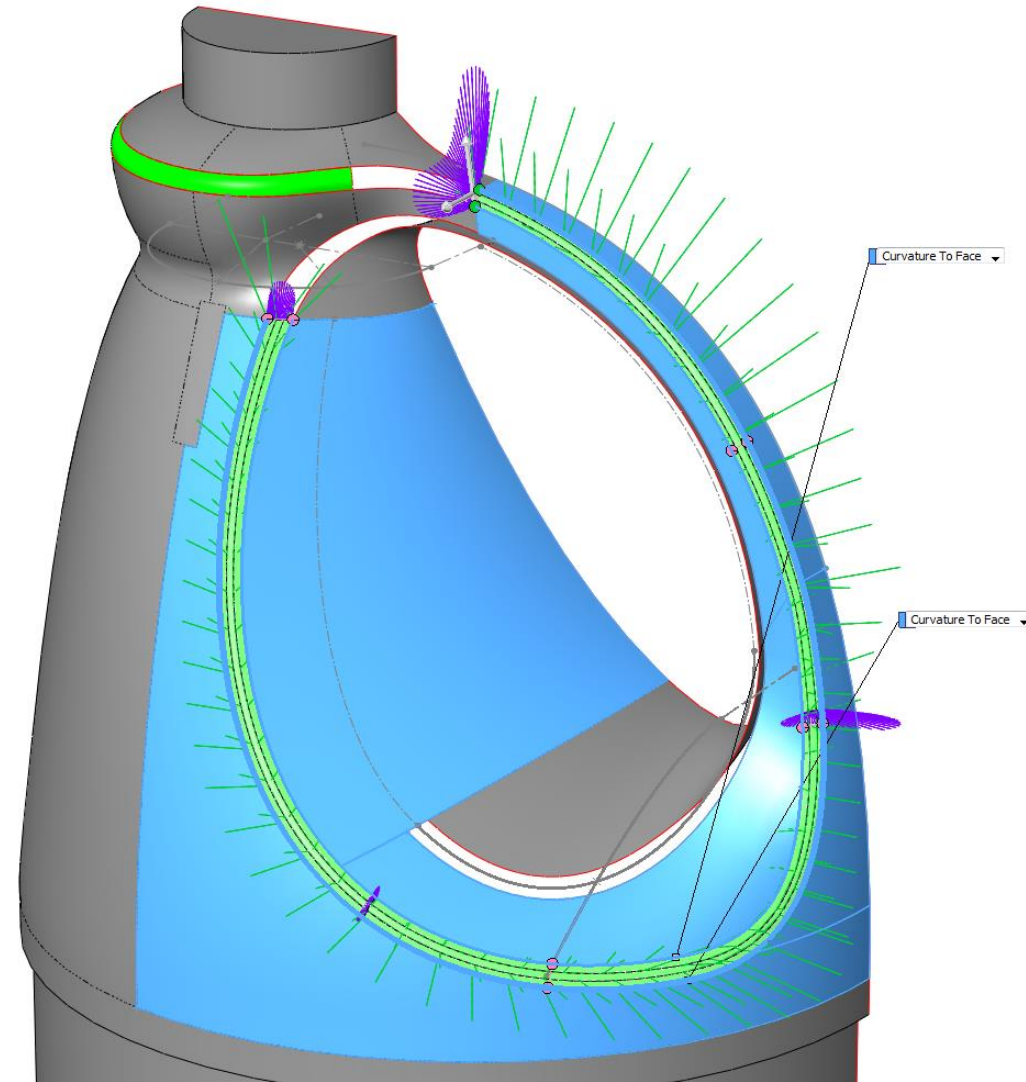


Build the Fillet Faces

Build the Fillet in portions with the Boundary Surface.

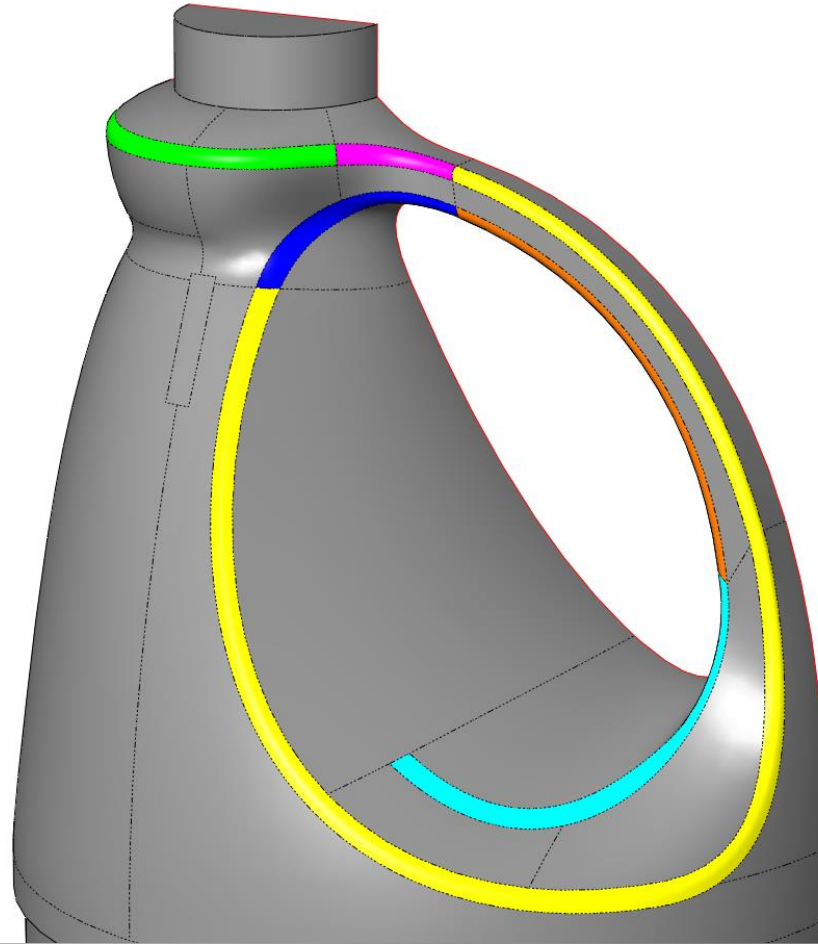


Connectors will most likely need to be added to the surface to direct the flow of the surface.



Complete the Fillet

Use Surface Fill to fill in the remaining portions of the fillet.



All Done

And that is the sure fire way to add a fillet to any model 100% of the time.



SOLIDWORKS WORLD 2014



Questions?

Presentation and sample files will be available on our website soon.

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