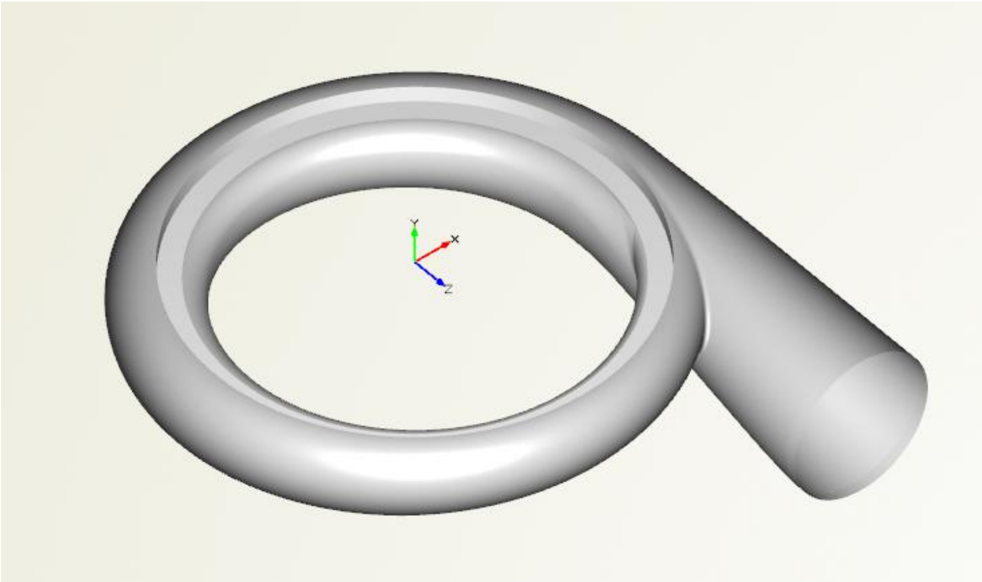
Volute Modeling

This document gives a general overview of volute modeling in CAESES. Volutes are used for example in pumps, centrifugal compressors and turbochargers.



Prerequisites for this best-practices-tutorial are to have a fundamental understanding of feature definitions and meta-surface modeling (these topics are covered in detail in the CAESES tutorials). In particular, the user needs to be familiar with surface uv-domains and modeling within these domains for trimming purposes.

The presented steps are independent of company-specific volute know-how so that each step can be further customized to individual needs.

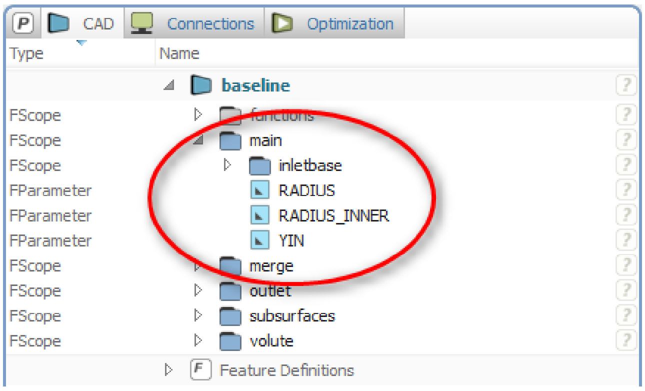
CAESES Project

Note that CAESES comes with a set of sample volute models (see the documentation browser, e.g. meta > compressor volute). In addition, check out www.friendship-systems.com/forum for additional content about volute and tongue fillet modeling.

1 Parameters for Main Dimensions

All relevant values for the main dimensions of the volute are usually controlled by parameters. Whenever you need these values as a reference, involve and assign these parameters in your model.

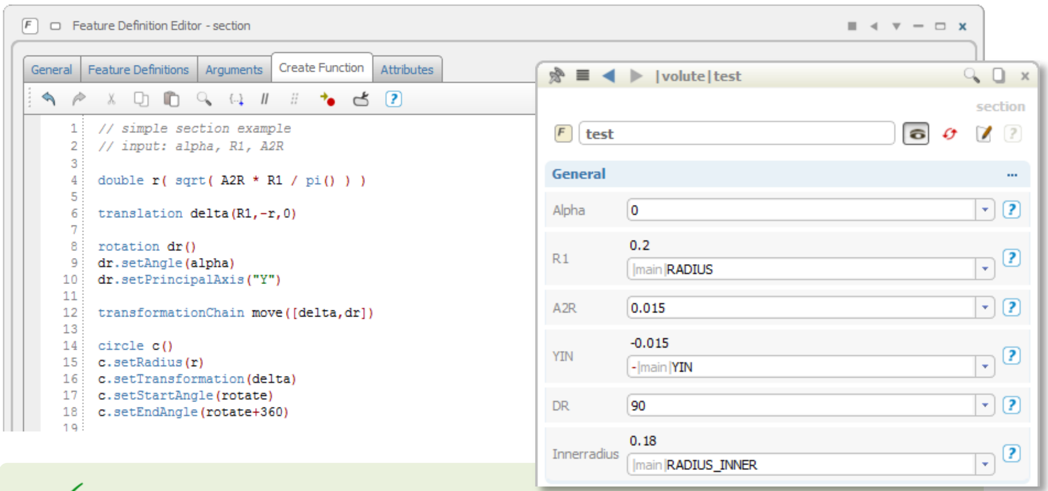
- Create parameters for important values (e.g. main radius).
- Put these parameters in a separate scope for a better overview.



2 Section Definition

Define your custom cross section by using feature definitions. See below for a very basic section description which is based on the input *alpha* (cross section circumferential position), *R1* (main volute radius) and A/R. For simplicity, in this example *R1* equals *R* (center of area).

- Create a new feature definition.
- Define your cross section and make sure you have a final single curve, which can be used for surface generation in step 3.
- Use any kind of geometry from CAESES or mathematical definitions for this purpose.



✓ While you are working on the cross section, use a persistent feature of this definition and visually check what you type in. As an alternative to typing, you can also create your feature defintion from a selection in the object tree (see the features tutorial for more information).

3

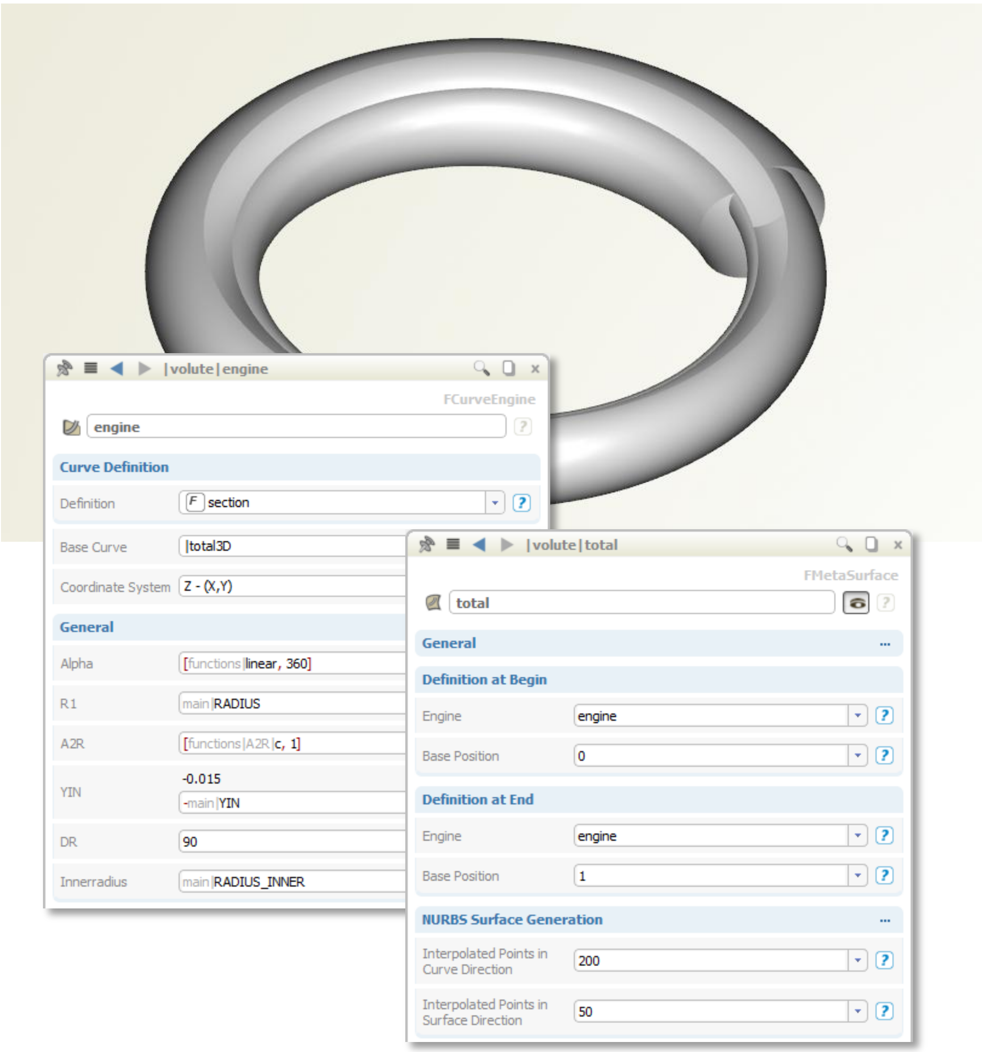
Volute Main Surface

Based on the cross-section definition, an initial volute surface can be generated. See the meta-surface tutorial for more details about the following steps:

- Create a curve engine for your cross-section definition.
- Create functions such as A/R for the input parameters of your cross section and set them at the curve engine.

✓ These functions are typically varied in automated optimizations.

- Create a meta-surface that uses the curve engine as input.



Extension Surface

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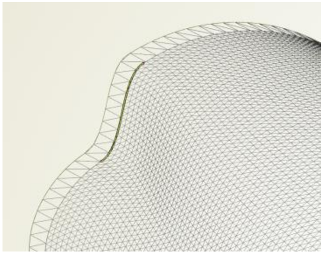
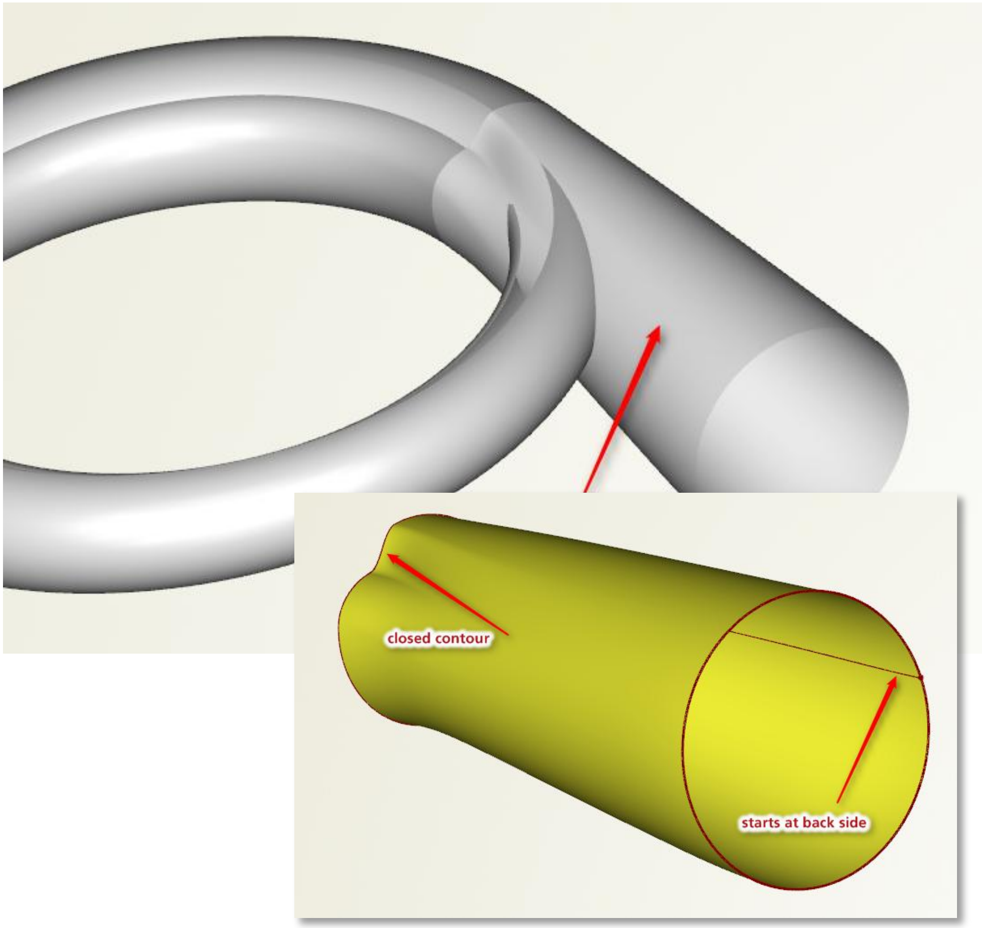
Create the extension surface (which for pumps or compressors represents the outlet, and for turbines represents the inlet).



- It is recommended to create a closed surface which starts at the "back" (outer circumference): The upcoming tongue modeling will then take place in the inner region of the surface. In this example, an fspline curve is used to close the open cross-section definition.
- Based on the closed definition, use a fillet surface or meta-surface for surface generation.



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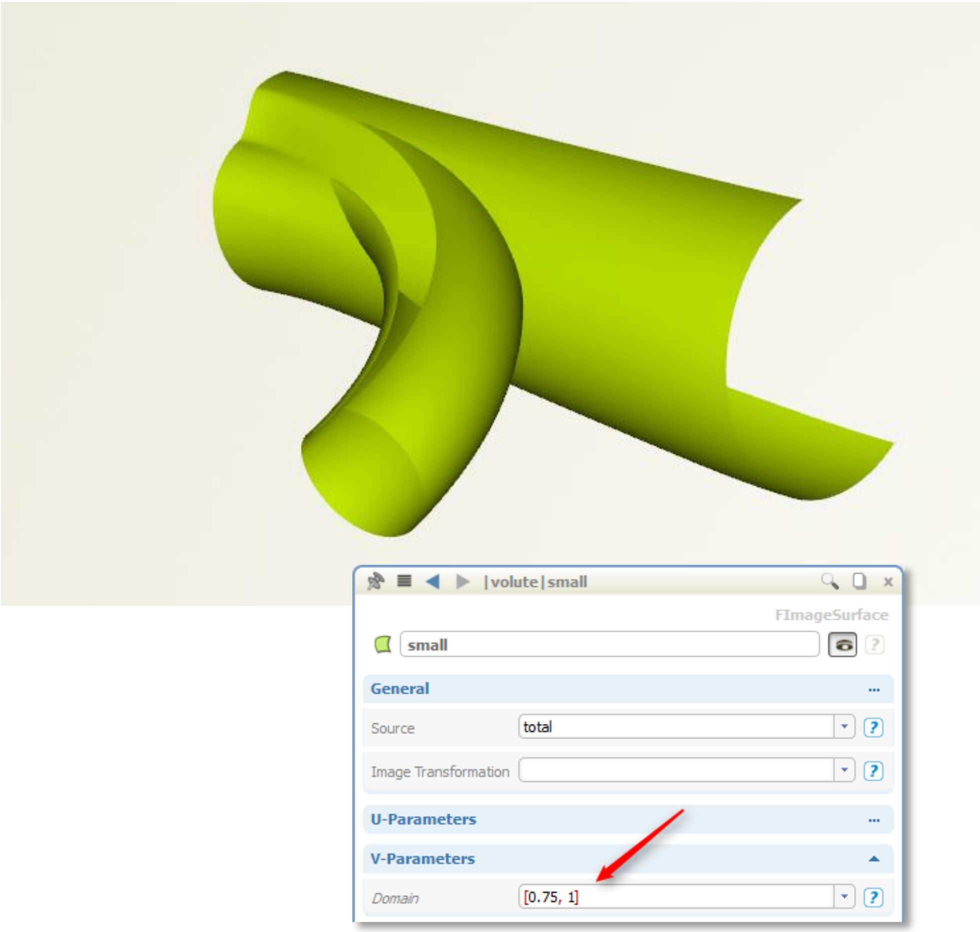
Prepare Tongue Modeling

The volute and the extension surface will be intersected in step 6. For this purpose it is convenient to split the surfaces to have a better focus on the participating geometry. It will also provide a better situation in the uv-domain when working with the intersections' domain curves, see also step 6.

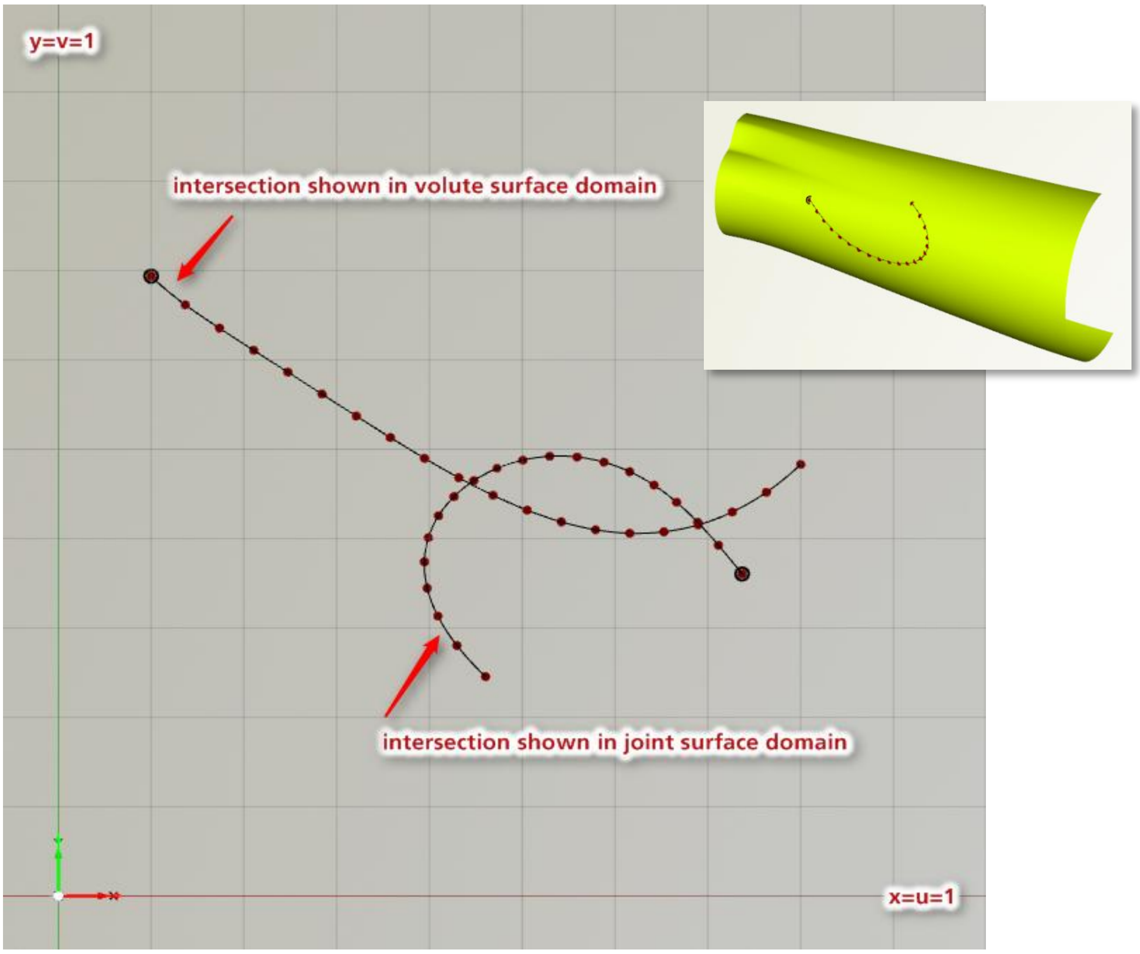
- Create image surfaces of the volute and the surface from step 4.
- Restrict the v-domain of the volute to e.g. [0.75,1].
- Restrict the uv-domain of the extension surface e.g. as shown below.



6 Intersection

There are different methods to intersect the two surfaces. For instance, you can utilize an intersection curve. However, in most of the provided example volutes, a feature is used to find a discrete number of intersection positions. This feature is used to ensure that the start location and direction of the intersection curve does not flip during variations and in addition, it is 100% robust.

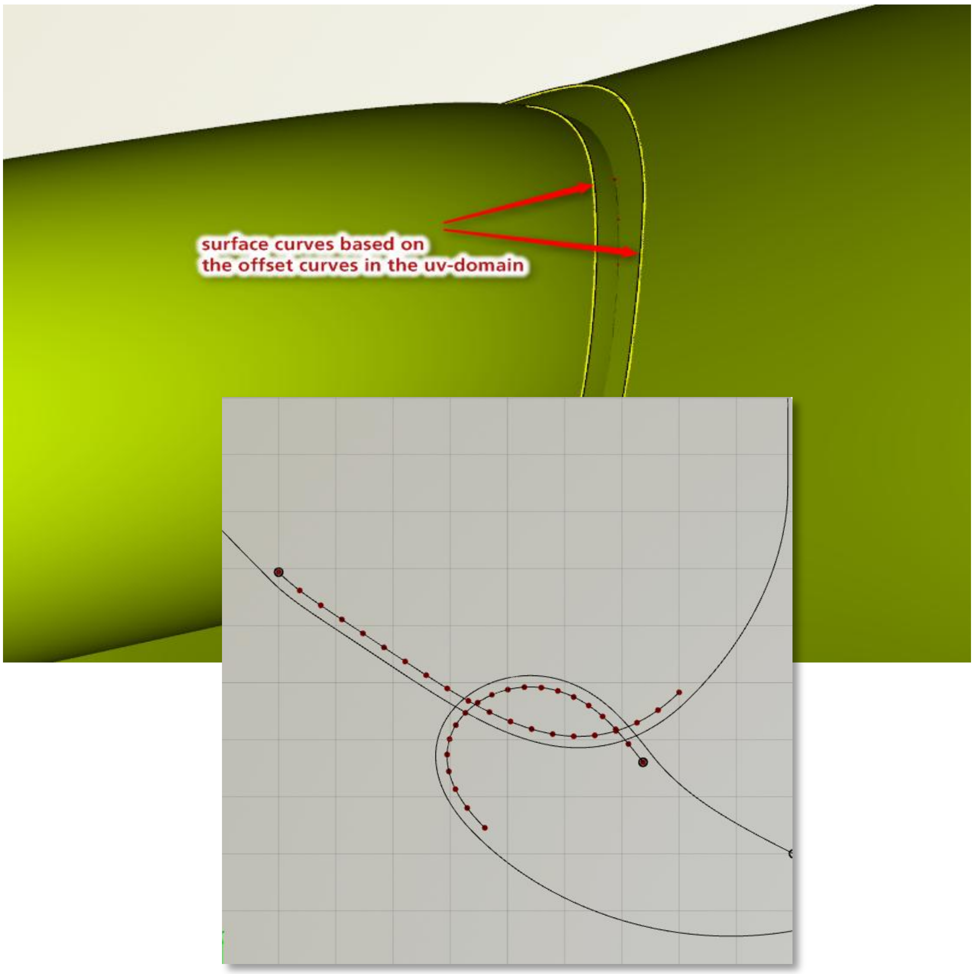
As a result, the intersection is available in 3D space and in the uv-domain of the two surfaces (large screenshot below, uv-domain information is always shown in the xy-plane!). These 2D domain curves will be used for subsurface modeling ("trimming"), see step 9. If you use an intersection curve, this curve provides the command "getDomainCurve()" which can be used as input for an image curve (e.g. for visualization purposes of the 2D domain curve).



7 Fine-tuning the Surface Curves from Intersection

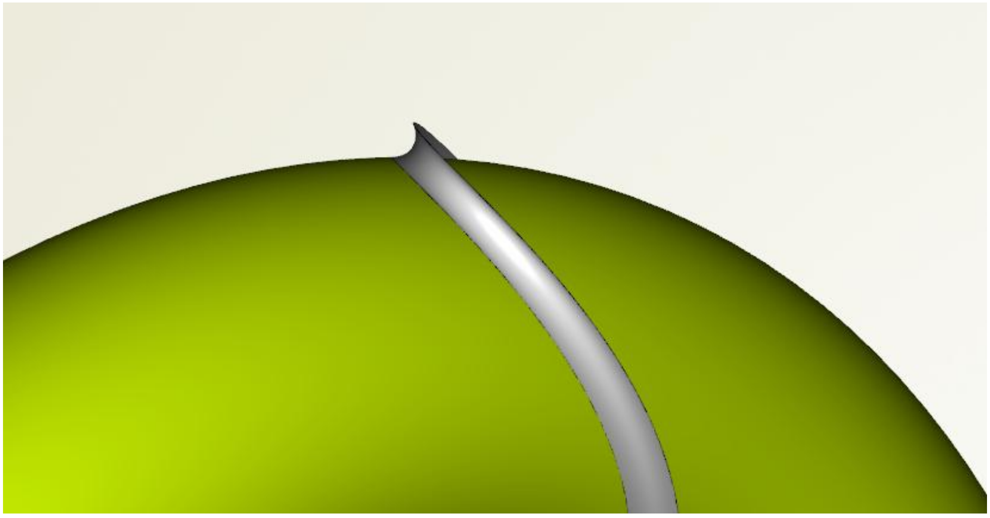
In order to have some space for tongue modeling between the two surfaces, we apply an offset to the uv-curves and extend them to the domain so that we end up nicely at a surface boundary – recommended for easier sub-surface modeling.

- Use an offset curve for the 2D domain curves of the intersections in order to “move away” the surface curve from the actual intersection.
- Connect the curve endings of the domain curves with fspline curves which allow a tangentially smooth transition.
- Create a polycurve from the extended and the original curves so that a single domain curve can be used for surface curve creation.
- Create surface curves with the new extended domain curves for both surfaces.



8 Tongue Modeling

The volute samples that come with CAESES demonstrate different ways of tongue modeling, depending on the degrees of freedom that are required. Usually, a meta-surface is utilized for this purpose, running between the two surface curves from the previous step. In all cases, the generating curve definition is constructed such that it runs tangentially to the two surfaces. Usually, the fillet can be additionally controlled by functions along the generation direction, e.g. for optimization purposes.



✓ In addition to the volute samples provided with CAESES, check out the forum where volute and tongue/fillet modeling are also discussed:

www.friendship-systems.com/forum

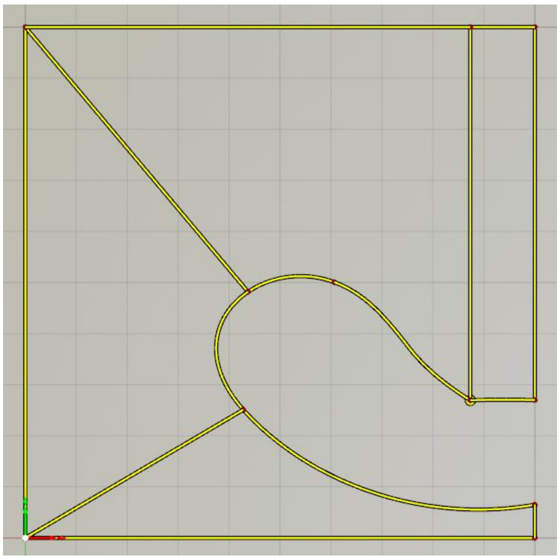
✓ Tongue modeling is easier if the surface curves run from one boundary to the other. For an example, see the sample "Parametric volute with symmetric profile" in the documentation browser. In such a case, it is easy to create sub-surfaces for the remaining parts for trimming out the hole.

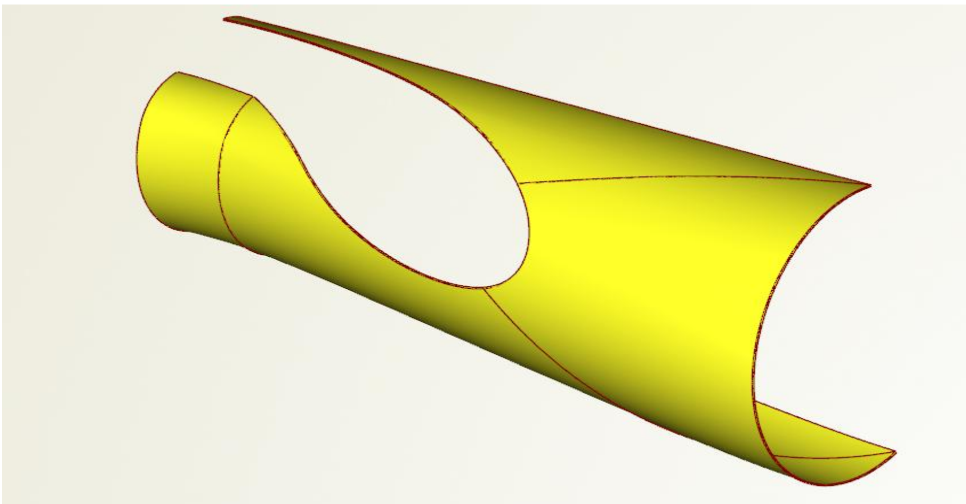
9 Sub-Surfaces for Trimming

In order to cut-out the hole between the two surfaces by using sub-surfaces, the domain information from the intersection is used again.

✓ Remember: For creation of a sub-surface, four surface curves are required, representing a four-sided patch. For each surface curve, a corresponding domain curve needs to be available.

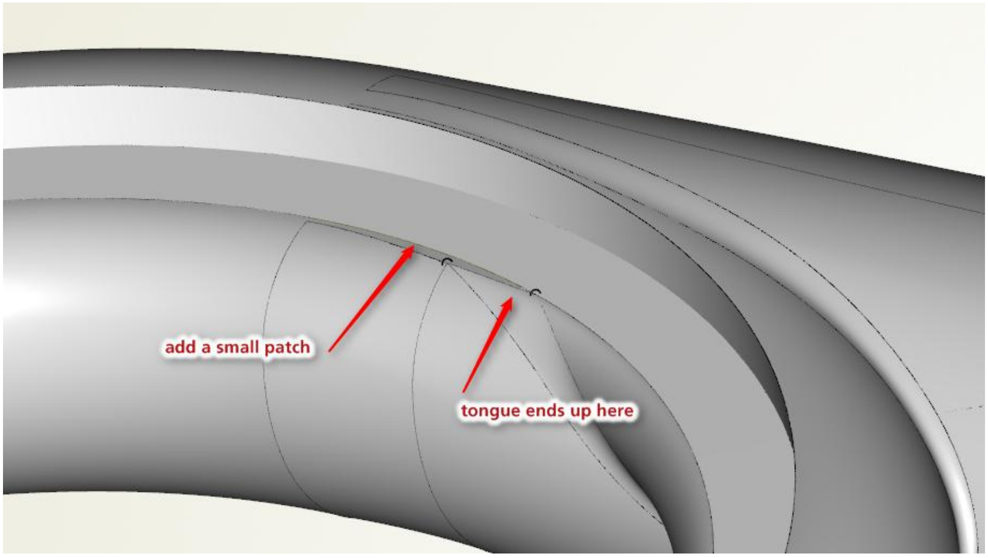
- Again in the xy-plane, create the required line elements to connect the domain curve from the intersection with the outer boundaries, so that four-sided patches are defined in the range x=y=[0,1].
- Create surface curves for each new domain curve (i.e. line).
- Create sub-surfaces from these surface curves.

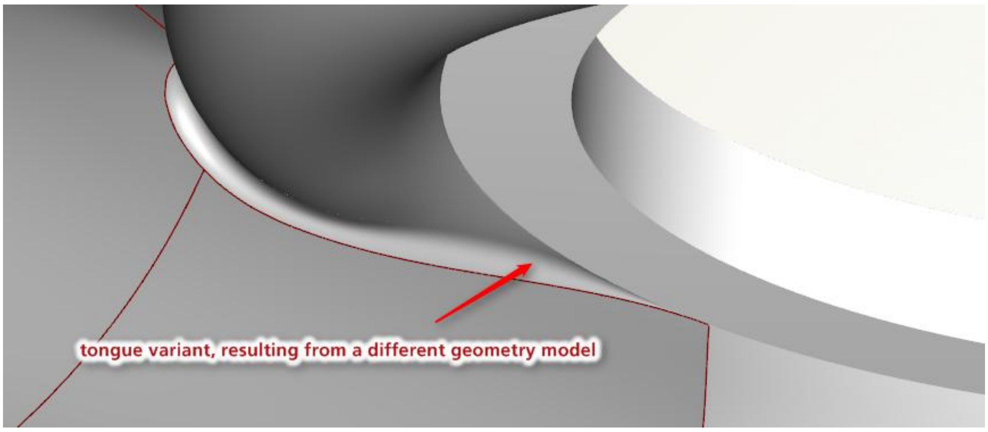




10 Conclusion

This advanced tutorial shows a general modeling process for volute modeling in CAESES. Typically, the volute shape changes from company to company, incorporating the experience and expertise of the company's CAD and CFD engineers. See the screenshot below: In this case, the tongue does not end up at the 0° position but rather somewhere before it. This needs to be modeled individually as well as the small additional patch that is also shown in the picture.





To summarize, the modeling details depend on the cross-section definition and the inlet/outlet surface. Furthermore, geometric constraints are often given such as dimensional restrictions (maximum width, etc.), which need to be included in the design.