VennCAD™: Software for Mouthpieces

VennCAD**™** is a CAD (computer-assisted design) software tool for visualizing, comparing, measuring, and designing brass instrument mouthpieces. It is designed to allow musicians who like to take a hands-on approach with their equipment to design and order custom mouthpieces.

Vennture Mouthpieces, Inc. created this tool to facilitate in-depth mouthpiece investigation and creation without requiring an engineering background or previous CAD experience. It is meant to be as intuitive and user-friendly as possible, and Vennture is committed to continuing to refine, improve, and expand VennCAD**™**. New features, new instruments, and new reference models will be baked into every new version.

Vennture has also designed the entire machining process – CAM software, tooling, and finishing – required to turn your VennCAD**™** design into a custom mouthpiece at a price comparable to what many manufacturers charge for stock models.

You can download VennCAD for free at www.vennture.mp/venncad.

This document is a user manual which is also subdivided into help files available within VennCAD**™**.

Feel free to contact us with any questions, comments, or suggestions. We look forward to continuing to develop both VennCAD**™** and Vennture's manufacturing capabilities to meet your needs.
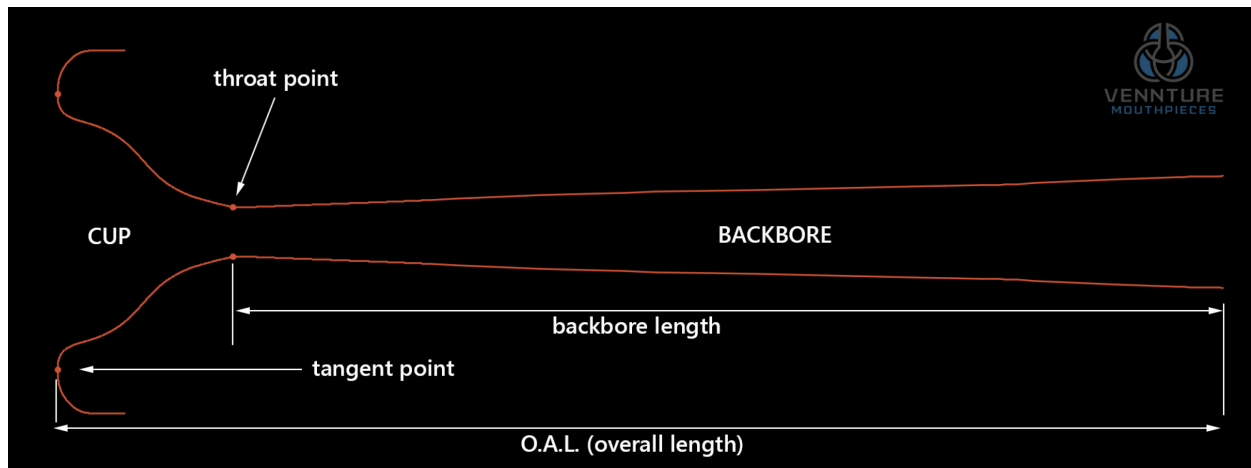
Mouthpiece Measurements and Terminology

Below are explanations of how VennCAD™ defines various mouthpiece measurements and, by extension, how VennCAD™ divides up the task of mouthpiece design into steps.

Mouthpiece Region Overview

Below we show a trumpet mouthpiece in cross-section:

We have immediately introduced several terms and measurements that begin to characterize the geometry of the mouthpiece.

The **cup** and **backbore**, as shown, are terms widely used to describe the parts of the mouthpiece depicted above.

The **overall length** is fairly self-explanatory.

Tangent point is terminology that is, we believe, unique to VennCAD™.

Tangent Point

The **tangent point** is the point that was measured to be the left-most extent of the mouthpiece in the orientation shown above. We call it the tangent point because if the mouthpiece were placed cup-down on a table, that point would be where the mouthpiece was tangent to the table surface. Of course, in practice, for a mouthpiece with a flat rim, the mouthpiece remains quite flat near the tangent point, and it's more of a tangent line in cross-section. But for a mouthpiece with more curvature or sharpness in the rim, it really is a pretty tiny point. Consider the following comparison:
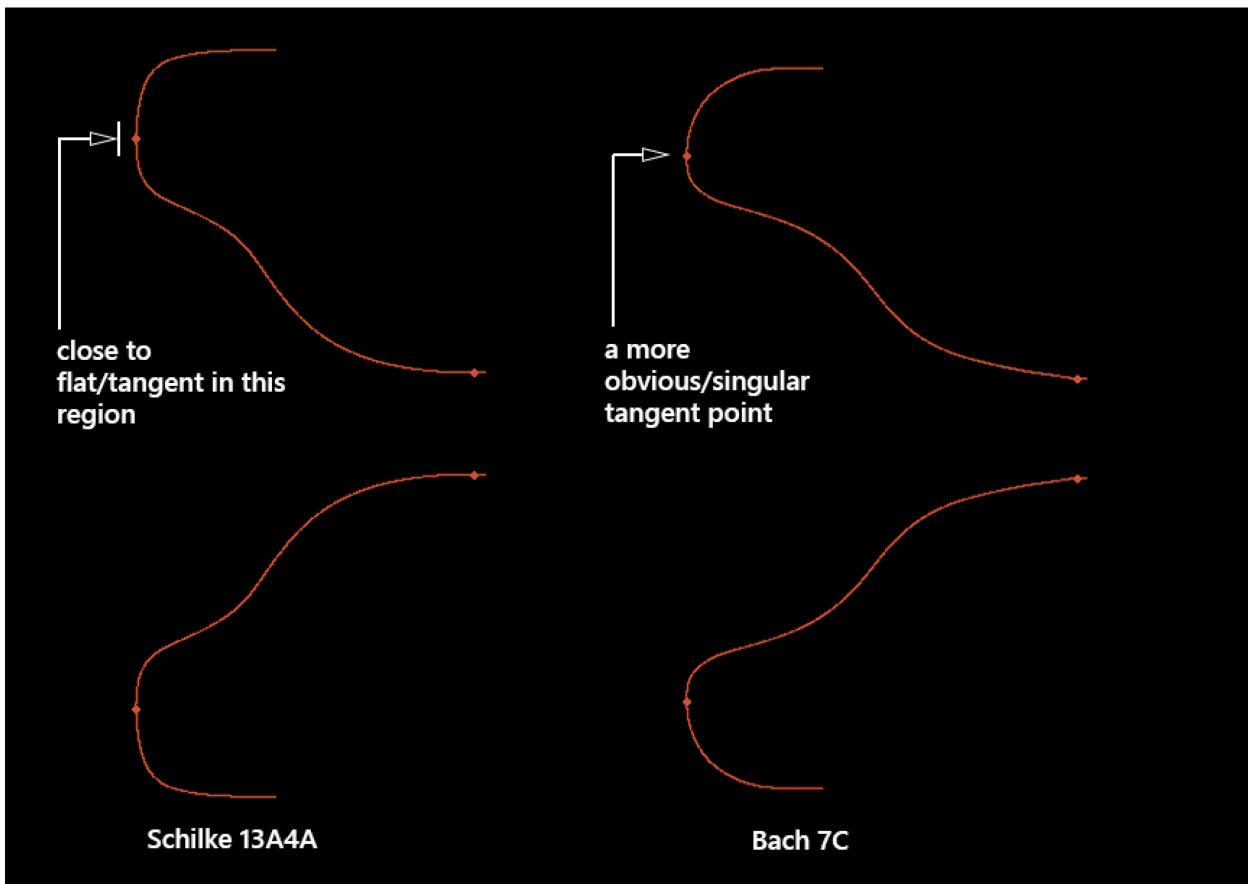
In the Schilke 13A4A shown on the left, picking the exact location of the tangent point is rather imprecise, since the mouthpiece would follow our theoretical table closely along the extent indicated by the white line before peeling away. In the Bach 7C, the curvature of the rim allows us to indicate with much more confidence an exact tangent point. So how do we determine the exact location of the tangent point for a flatter rim like the one on the left? Well, it's all down to our mouthpiece profiling machine and our proprietary software that zooms in and applies our mouthpiece parsing algorithms to what the profiling machine has measured. We look for the absolute minimum point. The machine can resolve down to 0.00002" (about 1/20 the width of a human hair), but zooming in to that level reveals a pretty bumpy surface due to surface imperfections. We obtain multiple (usually 8) traces, average them, mathematically account for any angular bias (as due to a tiny bend in the mouthpiece somewhere along its length), and, voila! There is your tangent point.

Throat Point

The **throat point** is how we refer to the narrowest point of the mouthpiece. Traditionally, the mouthpiece throat is thought of as a cylindrical region with some finite length. In our experience analyzing existing models, we have found that in some cases (as shown above), there's not much of a cylindrical region at all. In others, it is extensive. Consider this comparison:
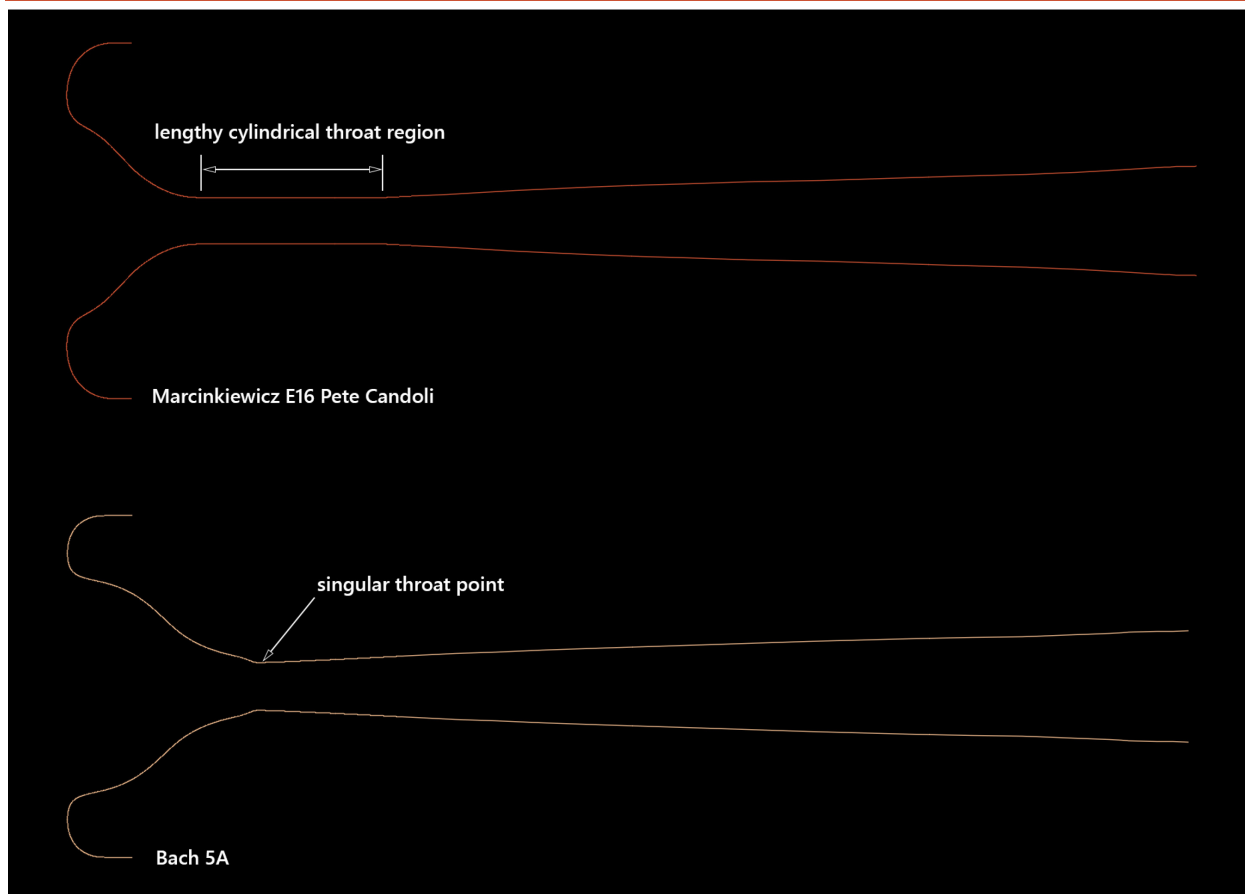
In the top example, the throat point's location is harder to determine. After all, the mouthpiece remains at a fairly constant diameter for quite a while. As before, the profiling machine plus our algorithm chew up the geometry and assign a throat point. In the bottom example, the throat point is quite singular: the diameter tapers down from the cup, briefly "kisses" its minimum at the throat point, and immediately begins flaring back out again in the backbore.

Defining the Cup

We have had to make some executive decisions to chop up geometries into sections and then provide tools for investigating, tweaking, and designing your own geometries. We have decided that once we assign a singular throat point (again, that point in the horizontal axis is a bit more arbitrary in something like the Marcinkiewicz above that has a long cylindrical region), everything to the left of it is "cup" and everything to the right is "backbore." In general, in instances where the throat is "cylindrical" for a while, we assign the throat point as far to the left as we can, so most/all of the cylindrical part is considered part of the backbore when it comes to calculating the length of the backbore versus depth of cup, or the volume of backbore versus volume of cup. This is indicated in the following diagram:
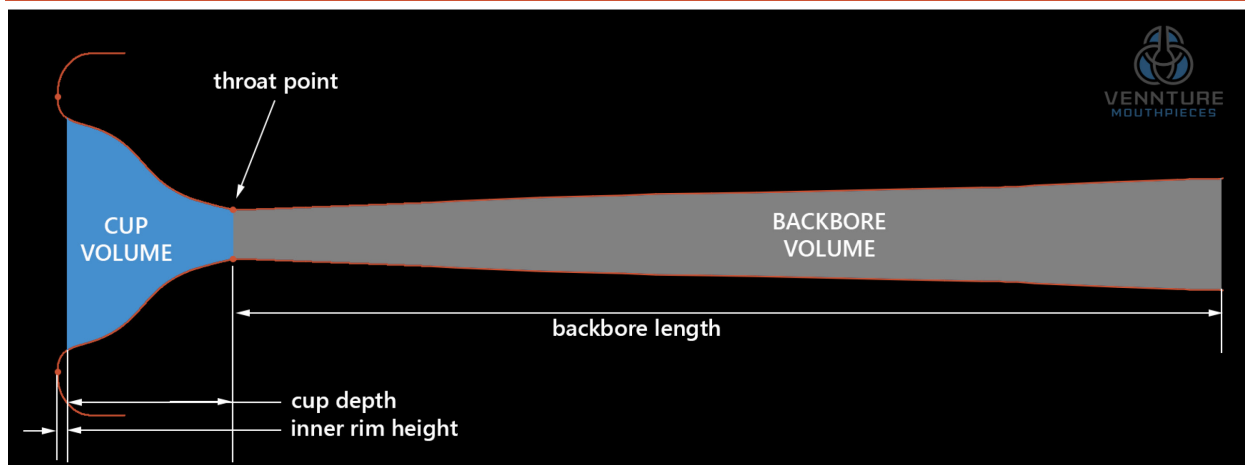
This drawing also introduces another important executive decision we made, and another piece of terminology we use: **inner rim height**.

Consider this: if we put our mouthpiece on our theoretical table and that tangent point made a perfect seal against the table, we could consider everything "inside" the seal to be part of the cup. And the diameter of that cup would then be the same as the diameter of the circle made by that tangent point as our cross-sectional view is rotated into three-dimensional reality. But nobody quotes cup diameters like that. In the mouthpiece industry, cup diameters are measured at some distance into the cup for a very sensible reason: our faces are not flat, rigid objects like our theoretical tabletop. To form a seal with the mouthpiece, we have lip engagement with the inner rim, reducing the cup diameter that we experience from the theoretical tangent diameter to something smaller. Our lips protrude somewhat into the cup, filling up some of the theoretical cup volume.

How much do our lips engage the inner rim or protrude into the cup's volume? Well, you will surely recognize that this varies greatly from player to player. It surely even varies for a given player depending on the volume they're playing with, or what register they're playing in, or their level of fatigue, or even the alignment of the planets. It's variable. We are not machines.

Measuring Cup Width

It is entirely possible that you may experience a mouthpiece with a larger tangent diameter to be smaller than one with a smaller tangent diameter, depending on the curvature of the inner rim and your level of lip engagement. Consider the following example:

The Schilke shown has a flatter rim, so while it has a somewhat larger tangent diameter than the Bach 5C (examine where the small dots indicating the tangent points lie; the Schilke measures 0.814" at the tangent point, whereas the Bach measures 0.791"), many (if not all) players will experience the Bach as having a wider cup diameter because it has a narrower rim and "peels off" into the cup faster.

So where do we measure the cup diameter? In some ways, picking a point at which to measure the diameter is arbitrary, and not the best way to compare different geometries. That is why VennCAD™ allows you to open up and overlay geometries, and then use a measurement cursor to measure the diameter at any level of protrusion into the cup you want.

But, forced to plant a flag somewhere, we decided to adopt a standard apparently originally devised by Marcinkiewicz. In the anatomy of a mouthpiece section of their website, they state that they measure mouthpiece diameter at 0.032" protrusion into the cup for trumpet/cornet/flugelhorn/French horn, 0.047" for trombone, and 0.064" for tuba. We haven't been able to determine where these numbers came from or whether they are used by other manufacturers, but we have found them to be useful parameters that jibe with our measurements and play testing of other mouthpieces. By the way, in our considered opinion, Marcinkiewicz makes some of the most hella comfortable rims out there. Not too flat, not too sharp. Super nice. Everyone should have some Marcinkiewicz in their collection.

Anyway, when measured 0.032" into the cup at the "Marcinkiewicz point," the Schilke 13A4A above measures 0.652" and the Bach 5C measures 0.678", squaring with what most people would perceive: the Bach has a wider cup diameter as we experience it when playing, even though it has a narrower tangent diameter.

Complete Annotated Cup Model

So when we measure cup diameters, we measure them (for trumpets) at .032" into the cup (i.e. 0.032" to the "right" of the tangent point when viewed in the orientation of all of our diagrams). When we measure cup depths, we measure from that .032" point to the throat point (as defined above). We measure the volume starting at 0.032" up to the throat point. All of this is easier seen and understood by a diagram, so here you go:
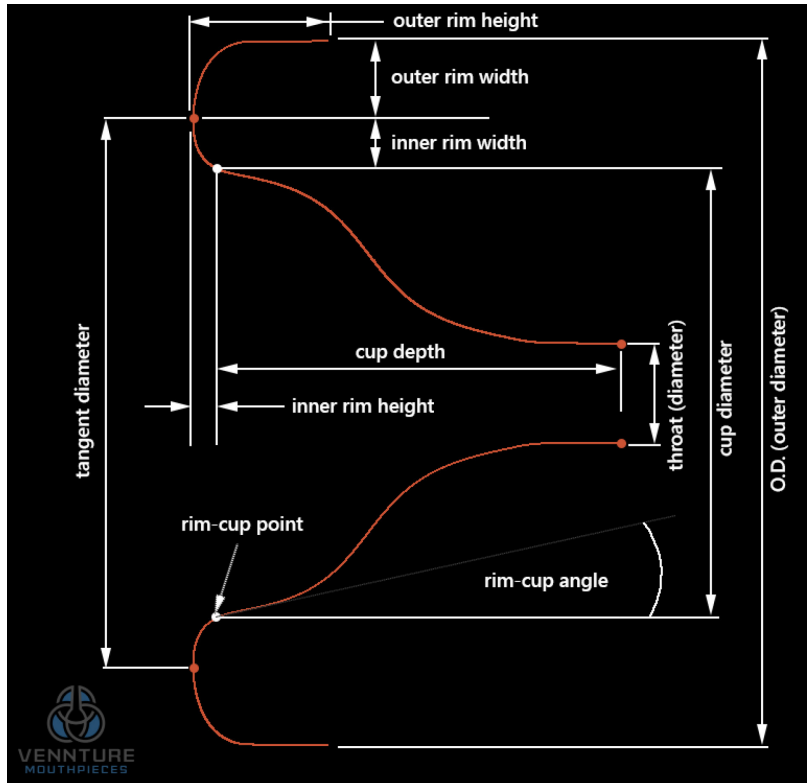
We have added a few new terms as well, but hopefully they are fairly intuitive.

The **inner rim height** is that Marcinkiewicz distance of 0.032" (for trumpet/cornet/flugelhorn/French horn) that we've been discussing.

The **rim-cup point** is located at exactly that depth, and represents the semantic division between "rim" and "cup." Of course, this is rather arbitrary, and your experience of the cup may vary depending on your lip engagement/protrusion. But it helps to at least have some terminology. And as always, you can fire up VennCAD™ and measure stuff at shallower or deeper points.

The **rim-cup angle** is the angle of the mouthpiece at that rim-cup point, as shown above. This measurement is also referred to by Gary Radtke of GR Mouthpieces as alpha angle.

The **outer rim height** is the farthest point (measured horizontally and starting at the tangent point) of the outer rim that VennCAD™ considers. We set this by royal decree at 0.20" for trumpet/cornet/flugelhorn. Now some makers (e.g. Marcinkiwiecz) start tapering their pieces down before this point (i.e. following the curvature of their outer blank, eventually ending in the shank). Others (e.g. Bach and Schilke) carry their max outer diameter past this point, or maybe don't even reach max OD until after this point. In VennCAD™, we extend those truncated outer rims or trim "longer" outer rims to this standard dimension. We figure, your

chops don't interact with this outer rim anywhere past 0.20". Unless you have a really weird embouchure. Like, weird enough to creep us out.

The reason for this 0.20" is that it's plenty of space to finish the geometry far from the reach of your chops, but not so much that they blank gets unnecessarily heavy/chunky. 0.20" is where our blank starts its relentless taper down to the shank. More on that later. So it follows directly that the **outer rim width** is the vertical distance from the tangent point to the "end of the line," where the OD is measured. And the **inner rim width** is the vertical distance from the tangent point to the rim-cup point, which we discussed earlier. Do you see how it all fits together?

The upshot of this is that **the outer diameter (O.D.)** that we quote may be smaller than if you measured the max OD of the physical piece, since we are not measuring anywhere past that 0.20" cutoff. But we should agree with what you'd measure if you took the diameter 0.20" in from the tangent point.

When we say **throat**, we mean "diameter at the throat point," which we discussed at some length above. It is, as we said, the very narrowest diameter of the whole geometry.

Shank and Blank

In VennCAD™, for reference models from the library we only show what we consider the "wetted" surfaces of the mouthpiece: the entire backbore, the cup, the inner rim (up to the tangent point) and the outer rim (which ends at the point where we quote mouthpiece OD). This is the active geometry of the mouthpiece.

However, for mouthpieces designed in VennCAD™ to be manufactured, we must also design the **shank** geometry (for where the mouthpiece seats in the receiver) and the **blank** geometry (i.e. the method of tapering from the outer rim point down to the taper).

In the diagram below, we show the throat point, inner rim point, tangent point, and outer rim point for reference.

Our convention at Vennture is to consider the **blank** to begin right at the end of the outer rim and blend seamlessly into the **shank**:
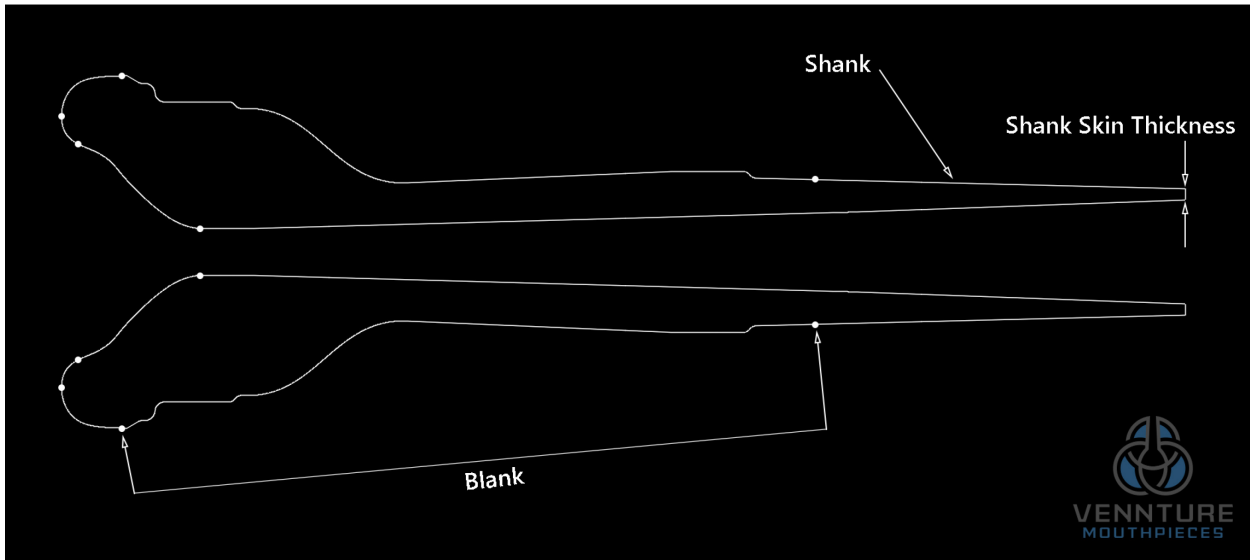
The shank is a perfectly conical taper. A conically tapered section (geometrically speaking, a frustum) has four important dimensions:

- A starting diameter
- An end diameter
- A taper rate (expressed in degrees or slope)
- A taper length

Note that if you know any three of the dimensions above, you can figure out the fourth.

For nearly every modern brass instrument (note the straight Flugelhorn "taper," used on older Couesnon instruments, as the sole exception below), the taper rate is the same: 5%, meaning that the diameter expands at 5% of the change in length. Thus, for every inch of shank length, the diameter expands by 0.05". (Or, for every cm of shank length, the diameter expands by 0.05cm.)

Bach has helpfully published on a page of its mouthpiece manual the starting diameter dimension for all the mouthpieces it makes. This information has been entered in the table below along with the industry-standard taper rate's and Vennture's choices for taper length and the resultant end diameter. Vennture bases its manufacturing on these numbers.

Instrument	Starting Diam. (in)	Taper Rate (in/in)	Taper Length (in)	End Diam. (in)
Trumpet	0.3820	0.05	1.100	0.4370
Piccolo (Trumpet Shank)	0.3820	0.05	1.100	0.4370
Cornet	0.3410	0.05	0.975	0.3898
Flugelhorn (small morse taper)	0.3550	0.05	1.100	0.4100
Flugelhorn (large morse taper)	0.3800	0.05	1.100	0.4350
Flugelhorn (straight taper)	0.3930	**0.00**	1.000	0.3930
French Horn	0.2940	0.05	0.725	0.3303
Trombone (Small Shank)	0.4220	0.05	1.163	0.4802
Trombone (Large Shank)	0.4960	0.05	1.100	0.5510
Tuba	0.5190	0.05	1.225	0.5803

Note that for all lines of the table above, we have listed all four taper elements (starting diameter, taper rate, taper length, and end diameter). For any line, note that if you multiply the taper rate by the taper length, you get the amount of change in diameter, and if you add that to the starting diameter, you get the ending diameter. For example, consider the trumpet line. It tapers for a length of 1" at a rate of 0.05 inches (of expansion) per inch (of length). Thus, the diameter expands from 0.382" at the start to 0.382"+0.05"=0.432" at the end of the taper.

Below, we introduce several new terms relating to the shank of the mouthpiece:
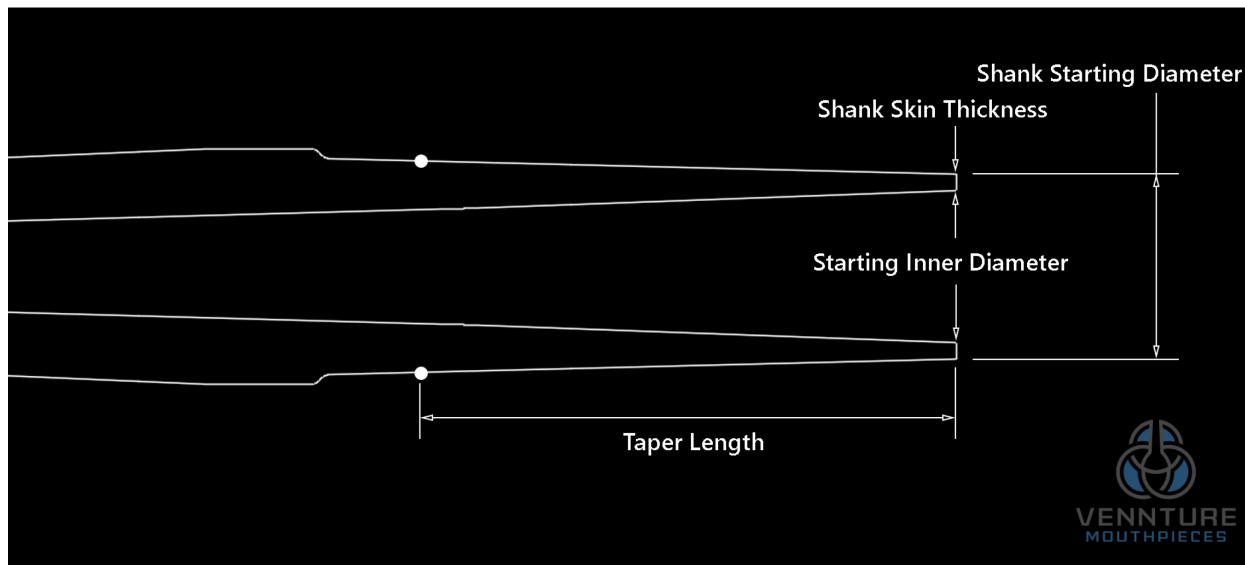
Shank Starting Diameter and **Taper Length** are as defined in the table above.

Starting Inner Diameter is the widest part of the backbore.

The Shank Skin Thickness is the minimum amount of material (the "skin") at the very end on the mouthpiece where the backbore is at its widest and the shank taper is at it narrowest. You may have noticed that this varies somewhat for different mouthpieces. In the trumpet world, "lead" pieces intended for high register work tend to have fairly tight backbores, so this skin is rather thicker. Others with more open backbores feature a thinner skin thickness. For example, the Bach 3E, which features a deep plunge of Bach's already-roomy #117 backbore reamer (reamers are tapered, and plunging them more deeply into a given mouthpiece creates a larger Starting Inner Diameter and, consequently, a lesser Shank Skin Thickness), has been described by my good friend Kent as "possibly useful for doing lumbar punctures."

Mouthpiece Gap

Consider the following diagram:
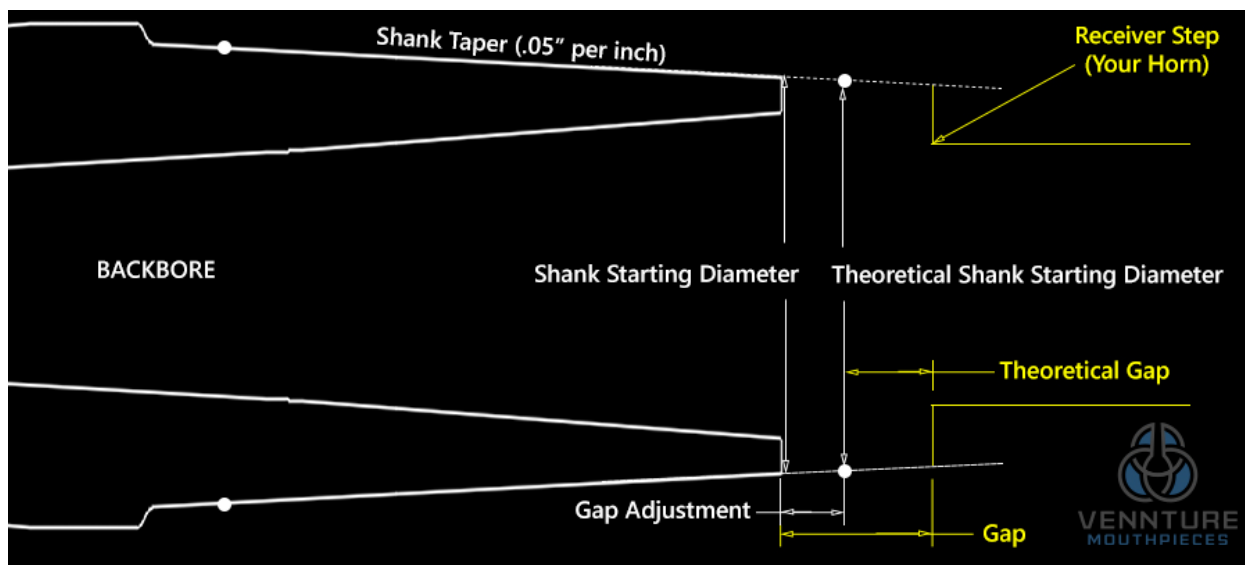
Note that the vertical axis has been stretched somewhat to make the taper more apparent. This can be done in VennCAD™ by adjusting X-Magnification - a useful feature for seeing differences in backbores and shanks, where the taper rates are modest.

The mouthpiece gap is defined as the distance between where the mouthpiece shank ends and the **Receiver Step** in the leadpipe. You can see this step by looking into your leadpipe, possibly with the help of a flashlight.

Note that the seating of the mouthpiece (i.e. where the mouthpiece ends up relative to the **Receiver Step**) is determined when the taper of the mouthpiece and the taper of the mouthpiece receiver interfere (i.e. when you insert the mouthpiece and bash it with the palm of your hand...just kidding! Please don't do that; a gentle twist will suffice). The mouthpiece does not butt up against anything.

This gap depends both on the mouthpiece and the mouthpiece receiver. A given mouthpiece seated in different instruments may leave different gaps in those instruments, depending on the geometry of the instruments' mouthpiece receivers. Likewise, different mouthpieces in one instrument may produce different gaps depending on their starting diameters.

Measuring the gap left by a certain mouthpiece in a particular horn may be accomplished with a gap measurement tool such as the one available here from Warburton.

VennCAD™ allows the user to request a given **Gap Adjustment**, which is a change in gap from what would be achieved by a mouthpiece that conforms precisely to the table above.

Consider an example of designing a trumpet mouthpiece. A "standard" trumpet mouthpiece shank would start at 0.382". If we inserted it in the trumpet shown above, it would seat itself leaving the **Theoretical Gap** shown. This, as discussed earlier, is dependent on the horn's particular mouthpiece receiver. Let's suppose for this example that the **Theoretical Gap** would be 0.06". Suppose you want your actual **Gap** (i.e. for the mouthpiece you want to order) to be 0.10". Your Gap Adjustment would then be 0.04". (A negative **Gap Adjustment** would make the actual **Gap** smaller than the **theoretical gap**, seating your new mouthpiece closer to the **Receiver Step** than a standard mouthpiece would seat.)

Of course, it would be nice to be able to simply specify what **Gap** you want, but it depends on your receiver, so we use **Gap Adjustment**, since it makes sense as a parameter on its own.

A **Gap Adjustment** of +0.04" instructs Vennture to make the mouthpiece's shank **Starting Diameter** larger than the standard diameter of 0.382" by the amount of 0.04"(i.e. the adjustment)×0.05(i.e. the taper rate)=.002". Thus, we will make the **Starting Diameter** at 0.384", thereby pushing the mouthpiece away from the **Receiver Step** by 0.04", yielding an actual **Gap** of 0.10".

Graphing Functionality

Z and X Axes

VennCAD™ refers to the length (i.e. along the axis of the leadpipe) as the Z-axis, and the diameter axis as X. This convention, different from what most math students learn by default (i.e. a horizontal X-axis and vertical Y-axis) is based on the usual convention of the lathes that are used to manufacture mouthpieces.

Consider the example below:
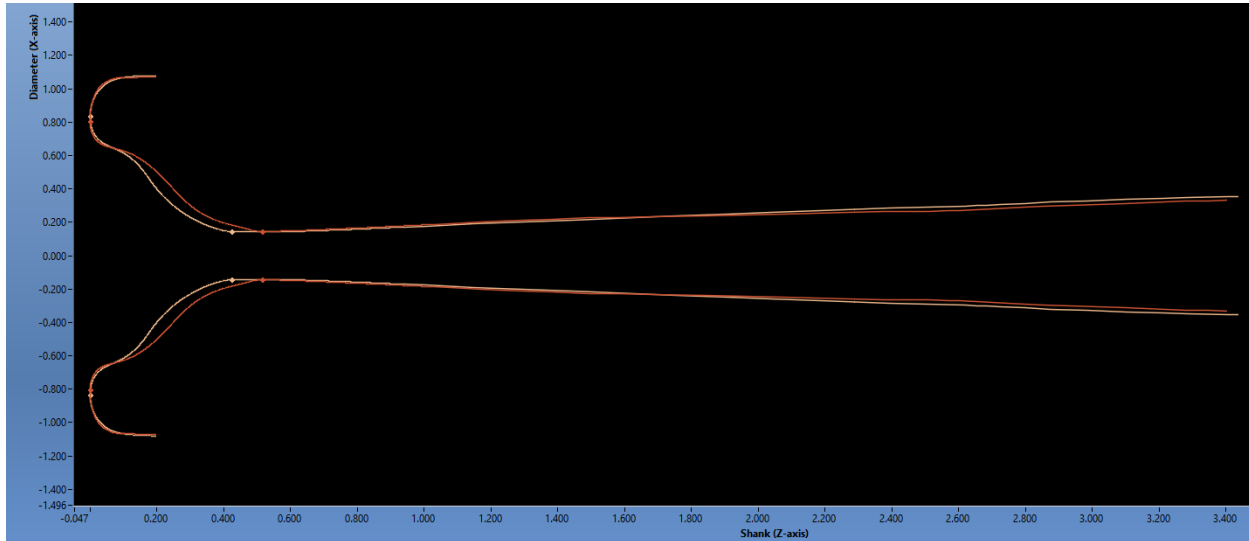
Note that the X-axis is in diameter inches, and the Z-axis is in linear inches. Both models start at Z=0 and extend to approximately 3.4". Thus the mouthpieces are approximately 3.4" long. Note that the max diameter (outer diameter) of both is approximately 1.08". Normally, a linear axis would show this as a radius, going from 0 to 0.54" to the "top" and from 0 to -0.54" of radius to the bottom. Showing this in diameter units is again a machining convention. You measure the mouthpiece with calipers, which indicate diameters and not radii. That is how we check our work, since the outer (and inner) diameters are easy to locate; measuring radii is more difficult. And similarly, cup widths, throat sizes, and shanks widths are measured and discussed as diameters.

X-Magnification
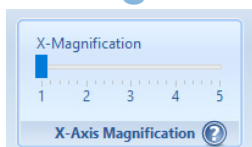
When X-magnification is set to 1, the graph displays the mouthpiece's length and width proportionally to scale. As you zoom in and out with the scroll wheel of the mouse, this proportion remains. Note that the Z-axis is in linear inches, and the X-axis in diameter. That is, if the mouthpiece is 3.5" long and has a max diameter of 1.08", it will be drawn on the z-axis from 0 to 3.5" (if alignment is set to rim), but the x-axis of the widest point will go from -1.08" to +1.08". This is again a machining convention, but it is generally easier to think about diameters. You measure the mouthpiece with calipers, which indicate diameters and not radii. Thus, X-magnification of 1 means that 0-1" on the x-axis is only half as many pixels or screen inches as 0-1" on the Z-axis.

Increasing X-magnification makes it easier to visualize details in the parts of the mouthpiece with modest X/Z slopes: specifically, the shank and backbore.

Graph Alignment

VennCAD™ allows three convenient ways to align your Reference(s) and your design on the graph:

- Rim aligns the tangent point of each design (i.e. the left-most point, where the rim and cup geometries meet. Also, the point where the mouthpiece would touch the table if it was placed cup-down/shank up on a table.
- Throat aligns the narrowest diameter of each design. It is where VennCAD™ considers the cup to end and the backbore to begin. Note that, in general, if there is a lengthy cylindrical throat region, VennCAD™ reckons the left-most point of this to be the throat point, considering the rest of the cylindrical throat region to belong to the backbore.
- Shank aligns the right-most extent of the mouthpiece-the narrowest OD.

Changing the alignment does not affect your design in any way other than how it is compared to the reference(s) on the graph. Note that the measurement cursor's zero is relative to the alignment point, so rim alignment means that the mouthpiece's Z-axis will be shown from 0 to the positive length of the mouthpiece, shank alignment means that the tangent point (leftmost point) will be reckoned as negative length of mouthpiece, and throat alignment means that the backbore goes from 0 to positive as you approach the shank and the cup goes from zero to negative as you go from throat point to tangent (leftmost) point.

Graph Tools

All three of the main software windows (the Main Design window, Cup Design window, and Backbore Design window), there are three tools available from buttons to the left of the graph:

- Graph Cursor
- Graph Panning
- Zoom to Fit
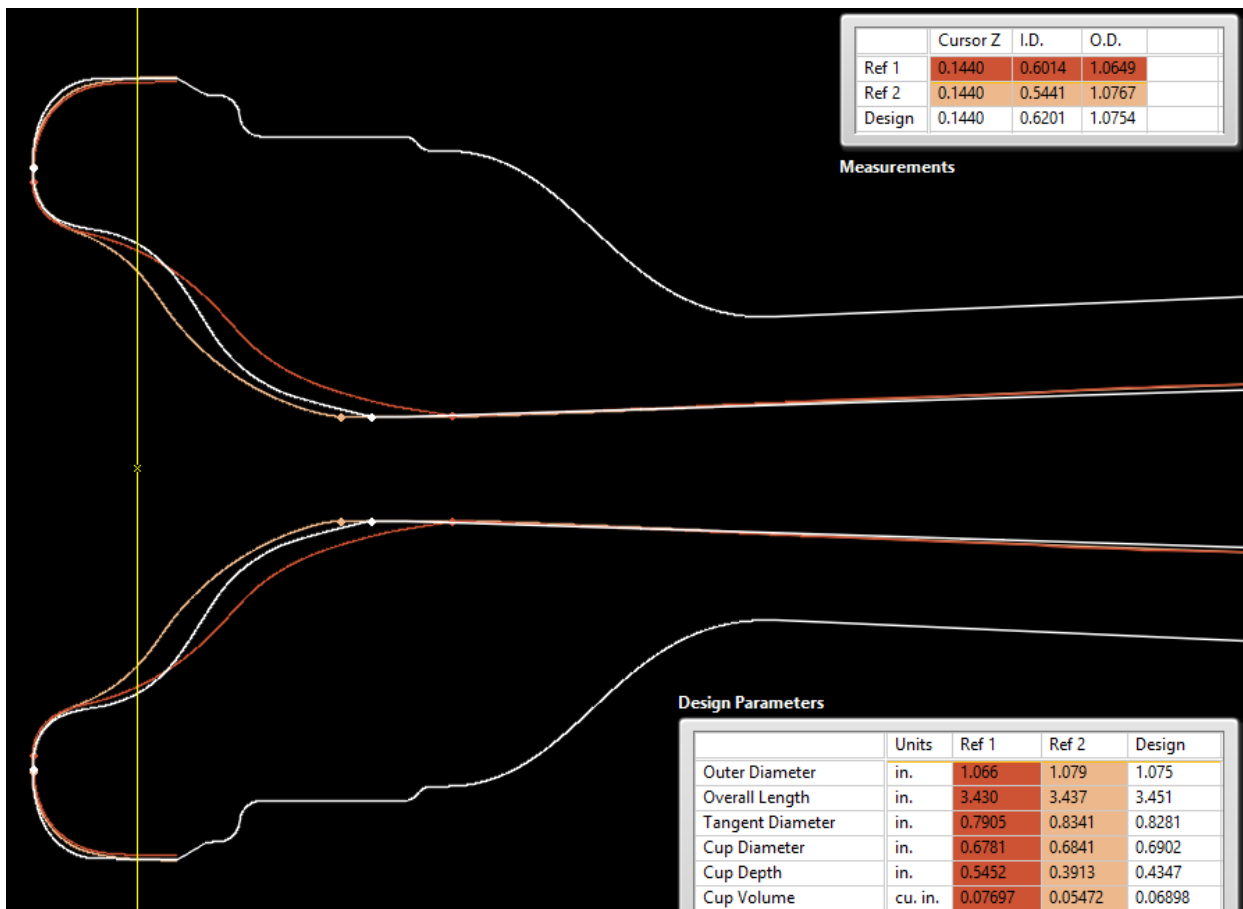
In the Cup Design window, there is an additional button, Edit Points on Graph, made available when the CAD Tools are activated.

In addition, the user may zoom in and out with the scroll wheel of the mouse.

Graph Cursor

Activating this button will cause the button to darken (indicating it is latched on) and will cause a yellow vertical line to become visible on the graph. Hovering the mouse over it and dragging it left and right will cause it to intersect the reference(s) and your design at different points along the Z-axis:

Measurements

	Cursor Z	I.D.	O.D.
Ref 1	0.1440	0.6014	1.0649
Ref 2	0.1440	0.5441	1.0767
Design	0.1440	0.6201	1.0754

Design Parameters

	Units	Ref 1	Ref 2	Design
Outer Diameter	in.	1.066	1.079	1.075
Overall Length	in.	3.430	3.437	3.451
Tangent Diameter	in.	0.7905	0.8341	0.8281
Cup Diameter	in.	0.6781	0.6841	0.6902
Cup Depth	in.	0.5452	0.3913	0.4347
Cup Volume	cu. in.	0.07697	0.05472	0.06898

The Measurements table will indicate the location along the Z-axis of the cursor, as well as the corresponding inner and outer diameters of the reference(s) and your design.

Note that the left-right (i.e. z-axis) movement of the cursor will be limited to the Z-extrema of the reference(s) and your design.

Graph Panning

Activating this button will cause the button to darken (indicating it is latched on) and will cause the cursor to assume the shape of an open hand anytime you float above the graph. Clicking and holding the left mouse button causes the hand to "grasp" the graph, and dragging the mouse will cause the reference(s) to be dragged around the axes correspondingly until the left mouse button is released.

Zoom to Fit

The Zoom to Fit button will cause the reference(s) and your design to fill the graph to the maximum extent allowed by your chosen X-Magnification.

Zoom In and Out

Zooming in and out on the graph is accomplished by locating the mouse cursor above a place on the design that you wish to remain fixed and then turning the mouse scroll wheel forward to zoom in or backward to zoom out.

Edit Points on Graph

The Edit on Graph button only appears when you are in the Cup Editor and are using the CAD tools to edit either cup or outer rim segments. Activating this button will cause the button to darken (indicating it is latched on).

There are two sub-modes available, as shown in the **Graph Edit Mode** radio box:
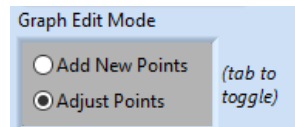
Add New Points allows you to add new graph points in between existing points. Anytime you hover in an allowed location on the graph, a proposed new point will appear. Left-clicking will cause the point to be placed into the design.

Adjust Points allows you to hover over existing points (shown in round purple dots) or control points (shown in green Xs). Left-clicking and dragging allows you to make adjustments.

Reference Models

One of the most powerful features of VennCAD is its ability to display and manipulate reference models. A reference model is a collection of mouthpiece geometry including the <u>cup, inner rim, outer rim, throat,</u> and <u>backbore</u>.
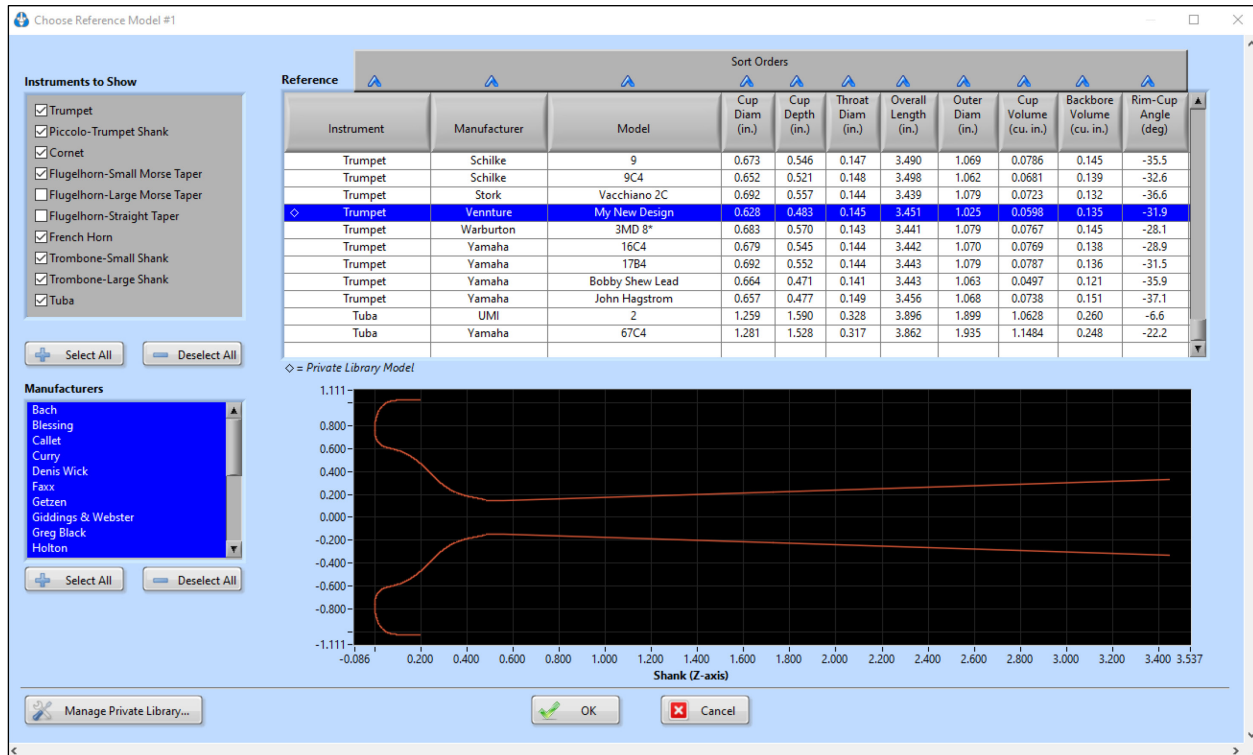
VennCAD features a sizable (and constantly growing, so be sure to keep your software <u>up to date</u>) library of <u>commercially available models</u>, plus any models <u>you have imported</u>.

Opening a Reference Model

You may open up to two reference models anytime in the main design window, cup design window, or backbore design window. These will be displayed alongside <u>your design</u>, if you are working on one.
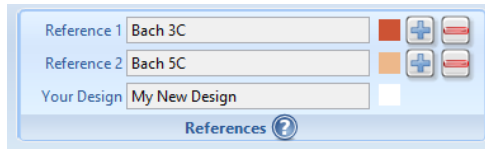
To remove/hide a reference, click the red "-" symbol. To load a new reference model, click the blue "+" symbol to bring up the reference selection dialog box:

The user simply selects a row from the **Reference** listbox and clicks on it to open it. These rows (i.e. reference models) can be sorted in any order using the blue up/down arrow in each column to sort in ascending or descending fashion. Whichever column is clicked reverses sort direction and becomes the primary sort column, and whichever was primary becomes secondary, and so on.

The **Instruments to Show** checkboxes can be checked/unchecked individually, or the **Select All**/**Deselect All** buttons can be used to check or uncheck instruments en masse. Checked instrument types only show up in the **Reference** listbox. Note that you are not prohibited from displaying (and even copying) mouthpieces for different instruments than the instrument you are working on. You may wish, for example, to create a flugelhorn mouthpiece, but may want to display your current trumpet mouthpiece as a template or starting point and then deepen the cup, open the throat, and take other steps to adapt it for flugelhorn use. Note, though, that attempting to copy geometries from different instrument than the one you're designing for may cause the design to fail the checklist, requiring changes before being declared valid.

Likewise, the **Manufacturers** listbox is populated with every manufacturer whose models appear in the **Reference** listbox. You may select or deselect by using shift-click or control click to restrict which manufacturers are represented in the **Reference** list.

Note that there are two sources of reference models: the Public Reference Library and the Private Reference Library. In the listbox above, designs imported into your Private Reference Library will be marked with a diamond icon like the one shown in the figure above.

The Public Reference Library

The Public Reference library is a library of mouthpieces digitized by Vennture and included with VennCAD™. We will be constantly adding new models, so be sure to keep your version of VennCAD™ up to date!

Your Private Reference Library

The Private Reference library allows you to import mouthpiece designs that live on your computer's hard drive. These can be *.mpc files of other designs you have created, or that you receive from other users.

For example, Vennture offers a mouthpiece scanning service. If you own a custom mouthpiece (or a stock one that is not yet in the Public Reference library), you may ship it to Vennture for digitizing. Vennture then ships the mouthpiece back to you and sends a digital *.mpc file.

You may launch the private library manager (shown below) by clicking the **Manage Private Library…** button in the reference selection dialog (shown above). The following window is then displayed:
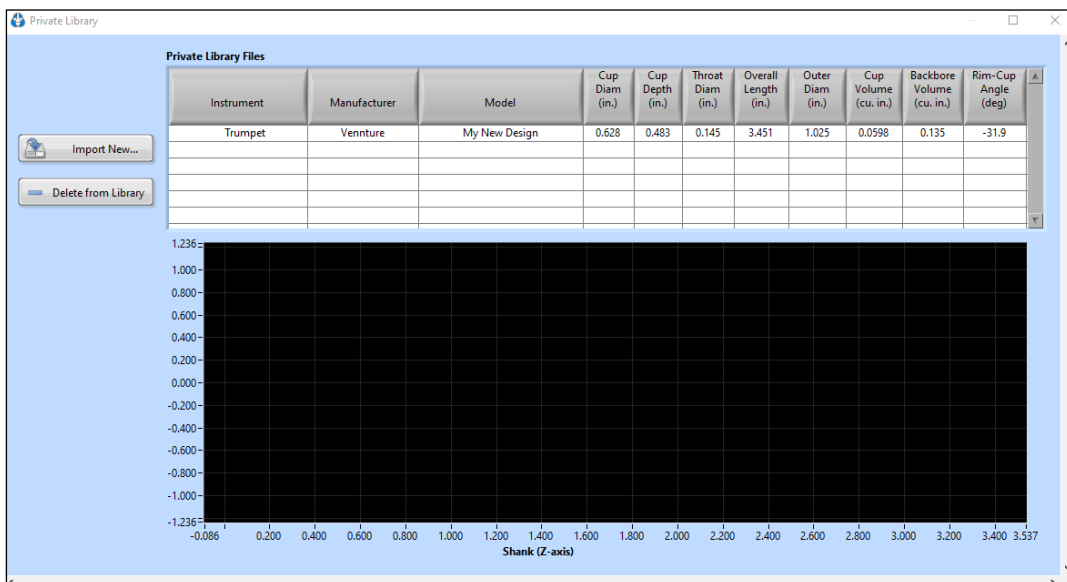
Private library reference models you have previously imported are displayed in the **Private Library Files** listbox. You may delete them by highlighting them and clicking the **Delete from Library** button. You may import new files by clicking the **Import New…** button, which will launch a file selection dialog box.
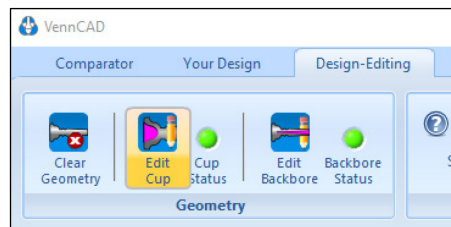
Using Reference Models

There are two major uses for reference models. One is, as the name implies, as a reference. You may compare them, manipulate them, and measure them as a way of understanding geometries of mouthpieces with which you are familiar. For example:

- Why does this rim feel so sharp or flat?
- Why do I experience this cup as wider or narrower than another cup that is listed as having the same diameter?
- What model in another manufacturer's line has a similar cup volume as what I'm using now?

You may also use references as sketching and morphing guides. If you use the CAD Tools or Morph Tools to create or edit your geometry, you may want to open a known model as a reference, knowing you want something that ends up being slightly bigger, slightly smaller, similar in size but different in rim sharpness, slightly deeper but similar in diameter, etc.

The second major use for reference models is as raw material for morphing or CAD editing. For example, you may want to start with the model you have now (either by finding it in the Public Reference Library or by having Vennture scan it and then importing it into your Private Reference Library) and then morph it (to change the rim feel, add or subtract cup volume, change cup diameter or depth, etc.) or edit it with CAD Tools. To accomplish this, you open the reference model, launch the cup editor module:

 and then copy the reference you want to use:
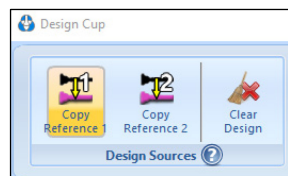
If you have already started your cup/rim design, you will be prompted that copying the chosen reference model will overwrite your work.

Designing Your Own Mouthpiece

VennCAD™ is a powerful tool for visualizing and investigating mouthpieces and their geometries. But the exciting part – and the center of Vennture's business model, since it provides VennCAD™ for free – is when you make the step to designing a custom model by sketching a geometry with CAD tools or tweaking an existing design with morph tools.

The remainder of this manual details how to use these tools to create a *.mpc file, which may be uploaded to Vennture's website (www.vennture.mp/product/custom-mouthpiece) for ordering.

You will create your file, design the cup and rim geometry, design the backbore, and specify the blank weight and engraving text.

Main Design Window

When the user first launches VennCAD™, a splash screen will display briefly:

Then, the main design window will appear:
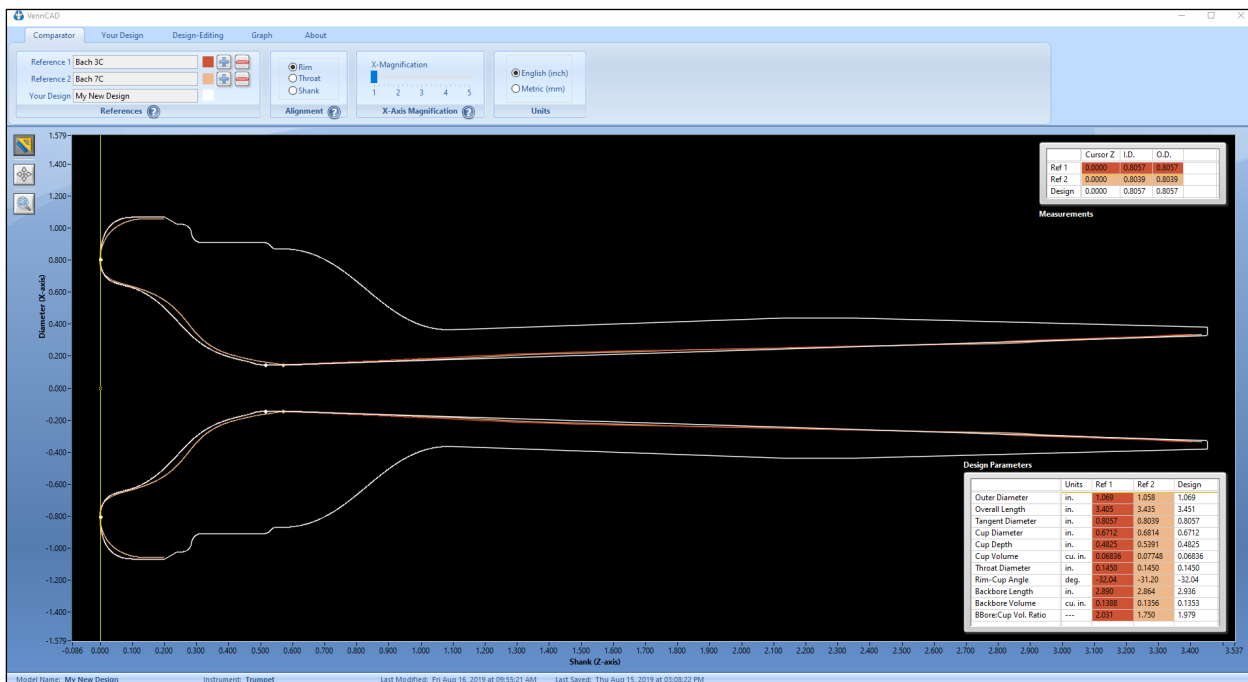
The main design window displays a large graph of your design (if you are working on one) and up to 2 reference models at a time that you are viewing.

It also contains a tab control in the top of the window featuring five tabs:

- **Comparator** tab, which allows you to load new references, change alignment, set X-magnification, or configure units.

- **Your Design** tab, which allows you to specify the filename, design name, and instrument type for your design, and to examine the Design Checklist, which validates that your design meets the requirements for manufacturing.
- **Design-Editing** tab, which allows you to design the cup and backbore geometries, configure the blank weight, set gap adjustment, and specify engraving text for your custom mouthpiece.
- **Graph** tab, which allows you to set graph colors and turn gridlines on and off.
- **About** tab, which allows you to see information about your version of VennCAD, check for new versions, and manage your download preferences.

Your Design Tab

This tab allows you to specify the filename, design name, and instrument type for your design, and to examine the Design Checklist, which validates that your design meets the requirements for manufacturing.

File Handling

These icons allow you to handle the VennCAD™ mouthpiece file (identified by its *.mpc file extension) used to store, archive, and export your design for manufacture.

Note that VennCAD™ automatically saves a copy of the design you are working on each time you exit the software. However, if you want to put one design idea aside for a while, work on another, and then return to the first, you would save your first idea as a *.mpc file in a directory of your choice (such as in My Documents, on your desktop, or in a cloud storage location like Dropbox or Google Drive) and then open it later.

If you decide to order one of your designs from Vennture, you may visit www.vennture.mp and proceed to the mouthpiece order page. In the ordering process, you will be prompted to upload a *.mpc file. The **Order Mouthpiece…** button will launch the product page directly (www.vennture.mp/product/custom-mouthpiece/).

Design Identity

When you create a new design, you will be required to specify which brass instrument the mouthpiece should fit, and to give the design a name. Note that this design name may be different than the filename you use to store the design. It also may be different than what you choose to have engraved on the outside of the mouthpiece cup. This Model Name will be displayed in several locations within VennCAD™. Also, if you import your design into your Private Library to be used as a Reference Model, this name is the model name (with Vennture as the manufacturer) that will come up in the reference selection dialog.
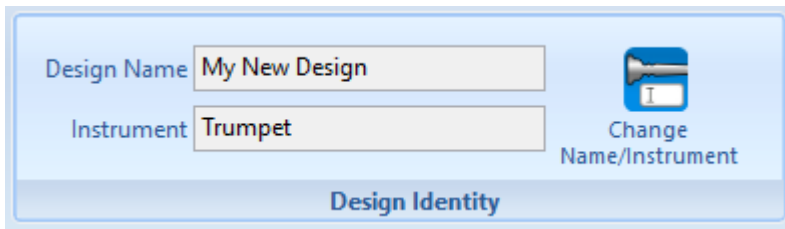
Note that the button above may be used to change the name or instrument type after your have begun your design. While the changing of the design name is straightforward, the changing of instrument type may be a bit more involved. For example, the geometry of the cup/rim or backbore design may be valid for the previous instrument type but invalid for the new instrument type, requiring design modifications.

For your reference, here is a table of the various types of instruments currently supported by VennCAD or in the works for a future software release.

Instrument	Starting Diam. (in)	Min OAL (in)	Max OAL (in)	Manufacturers/Notes
Trumpet	0.3820	2.370	3.570	All
Piccolo (Trumpet Shank)	0.3820	2.370	3.570	All
Cornet	0.3410	2.370	3.570	All cornet; use this choice for piccolo trumpets with cornet shank.
Flugelhorn (small morse taper)	0.3550	2.370	3.570	Also known as Bach Taper. Fits Bach, Courtois, CarolBrass, LeBlanc (including Sandoval), B&S, Taylor, RS Berkeley, and some other European brands, plus Kanstul models 725, 1025, and newer 1525.
Flugelhorn (large morse taper)	0.3940	2.370	3.570	Commonly known as Standard Taper. Fits all Yamaha, Getzen, Callet, Stomvi, Benge, King, Blessing, Conn Vintage One, Weril, Holton, Schilke, older Kanstul 1525 flugelhorns, Austin Custom flugelhorns, Allure, Jupiter, and most other "American" flugelhorns except Bach.
Flugelhorn (straight taper)	0.3930	2.370	3.570	Also known as Couesnon Taper. The French taper is used by original Couesnons, Flip Oakes "Wild Thing," Kanstul CCF 925, and original F. Besson flugelhorns.
French Horn	0.2940	2.370	3.000	All
*Trombone (Small Shank)	0.4220	2.950	3.550	All
*Trombone (Large Shank)	0.4960	2.950	3.550	All
*Tuba	0.5190	3.400	3.950	All

*Not currently available; slated for a future release of VennCAD*

If you have any questions about fitting a mouthpiece to your specific instrument, please do not hesitate to contact us.

Design Checklist

Throughout the design process and then before deciding to order your design, you will want to make sure that VennCAD™ recognizes your design and any changes you might make to it as valid. The Design Checklist area offers a quick and convenient status indicator, as depicted below:
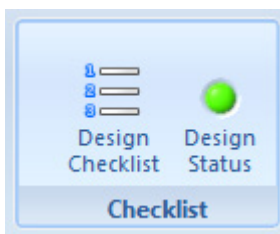
Green light means valid, red light means not valid. Clicking on the **Design Checklist** button will launch a dialog like that pictured below that explains in greater detail any issues with compliance with VennCAD™'s internal design checking and validation algorithm.
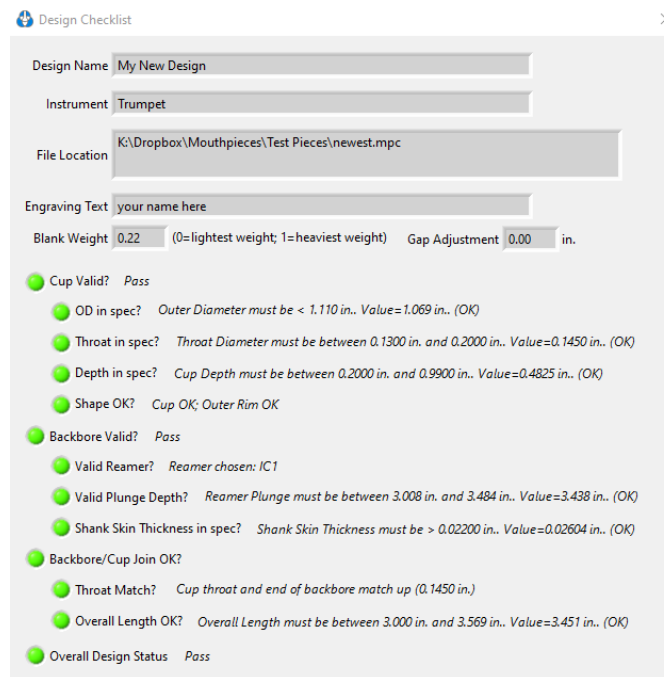
Basically, these checks ensure that your design can be machined using Vennture's materials, tooling, and process. Please feel free to contact us if you have specific questions about the design checklist, Vennture's machining processes, or your design.

Design Editing Tab

This tab allows you to design the cup and backbore geometries, configure the blank weight, set gap adjustment, and specify engraving text for your custom mouthpiece.

Geometry

The geometry of the mouthpiece includes the cup design and the backbore design. In a new mouthpiece design, the cup must be designed first, and the Edit Backbore button will be disabled as shown below:
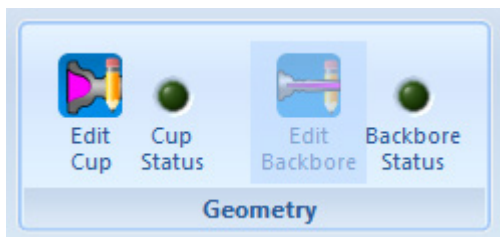
After you create a valid cup design, the Cup Status light will glow green and the Edit Backbore button will be enabled, allowing you to design a backbore that properly mates with the cup design you created:
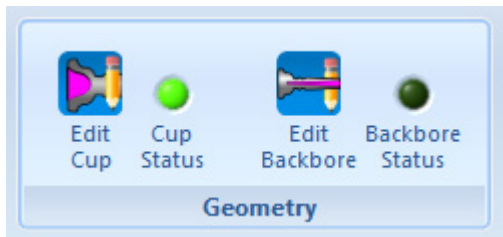
Once you create a valid backbore, both lights will glow green to show you have a valid geometry:
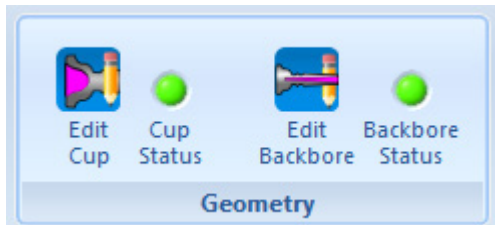
Note that if you then edit the cup design in such a way that it no longer mates with the backbore you designed, the backbore status light will turn off, indicating that a backbore modification must be made to ensure your backbore properly mates with the altered cup design.

Blank

If you have created valid cup and backbore designs, VennCAD™ will automatically draw in the shank and blank that will be created. By adjusting the **Weight** slider/input box from 0.00 (lightest weight) to 1.00 (heaviest weight) in 0.01 unit increments, you can adjust the weight of the blank that will be machined and see it in cross-section.
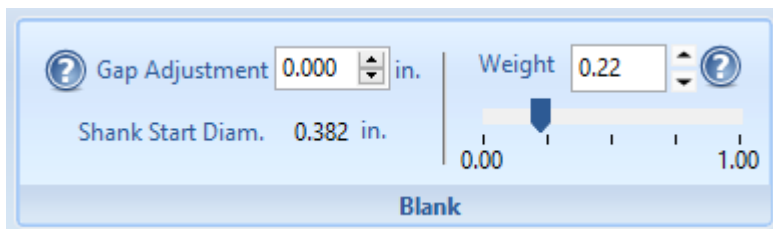
You can also enter a desired Gap Adjustment. The corresponding change in shank diameter will be very small, but may be seen with a high zoom level.

Engraving
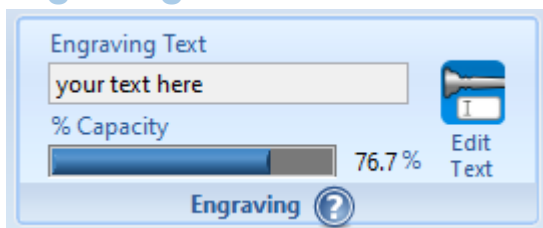
Clicking the **Edit Text** button will bring up a text entry box. Note that the text will be engraved on the exterior of the cup region, opposite the Vennture logo/mark, as shown below:

Note that every Vennture mouthpiece will have a serial number engraved just after the shank taper ends. This 4-digit alphanumeric code will allow Vennture to pull the geometry of the mouthpiece from its records for duplication or modification in VennCAD™.

About Tab

The About tab contains information about the current software version, the latest available version (if applicable), and the following buttons:
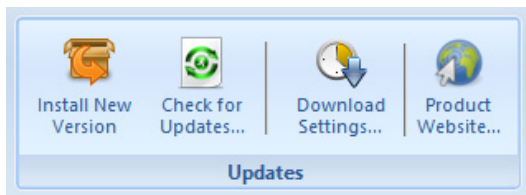
If a newer version is available, the **Install New Version** button will be enabled.

If you have enabled checking for new versions automatically, VennCAD™ will check for a new version once each time it runs. You may also check manually by clicking the **Check for Updates** button. This button will be disabled and greyed out if you have disabled checking for new versions.

The **Download Settings…** button launches a dialog where you can

- enable or disable checking for new versions of the software
- enable or disable the sending of usage and bug reports for the software to assist Vennture in improving the application

The **Product Website** launches VennCAD™'s product website in your default browser. You can manually download the latest version, view documentation and tutorial resources, and learn more about VennCAD™ and Vennture's plans for the future.

Cup Design

The Cup Design is created and modified in the Cup Design Window:
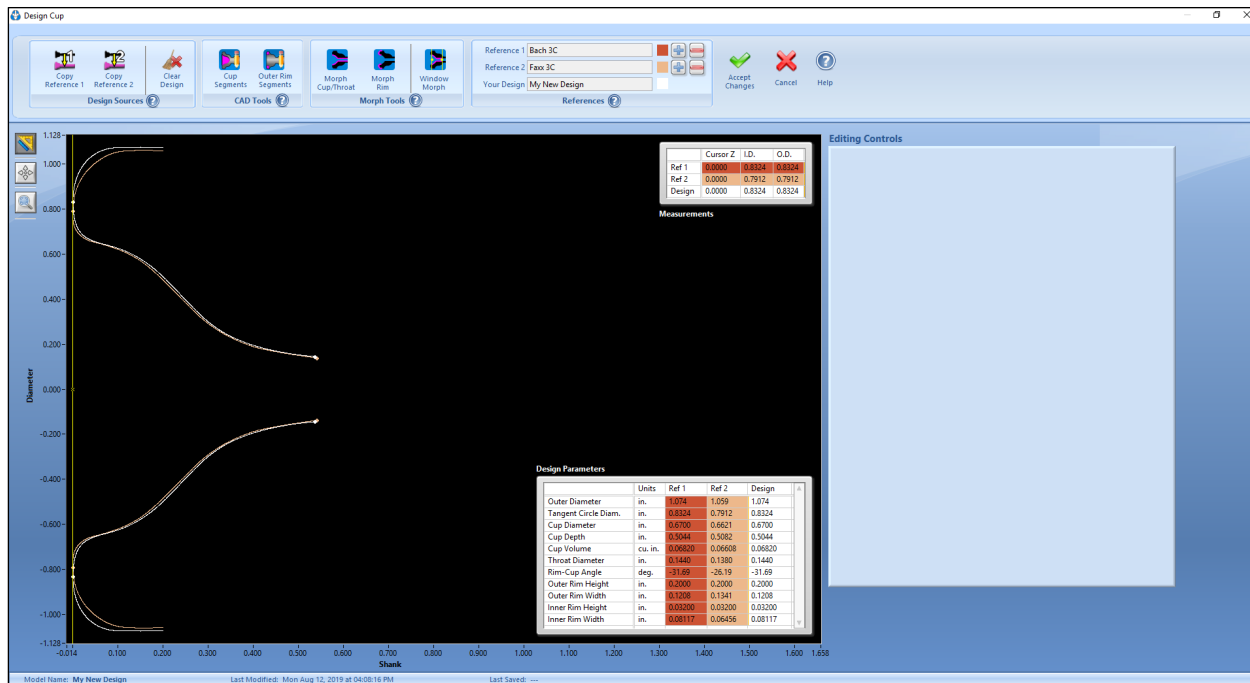
The Cup Design consists of **Cup Segments** and **Outer Rim Segments**.

Cup Segments-a curve or set of curves that defines the geometry from the tangent point to the throat point

Outer Rim Segments-a curve or set of curves that defines the geometry from the tangent point to the OD (outer diameter) point.

Consider the following example:
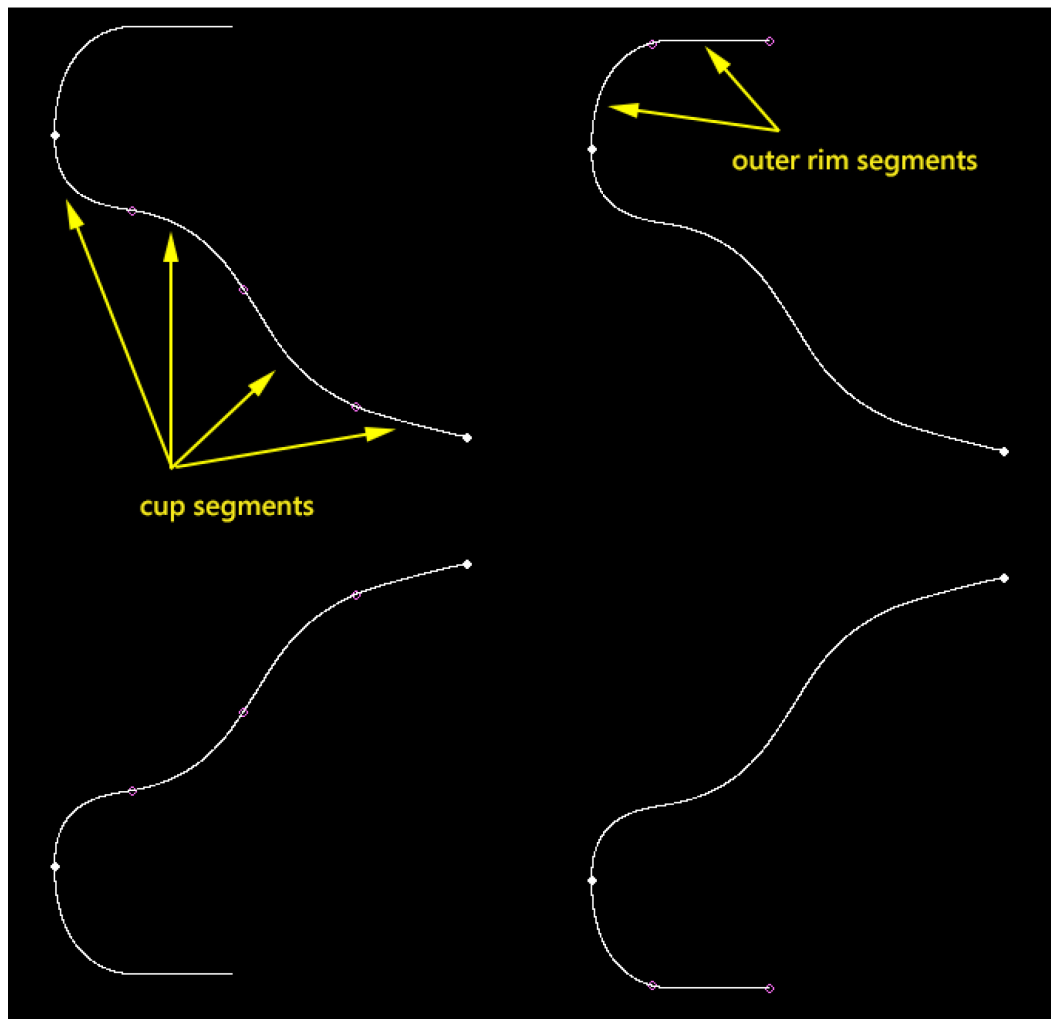
Note that for this particular design, there are four cup segments and two outer rim segments. Other designs may have more or fewer of each depending on the complexity and geometry of the curves in question.

Note that the cup segments and outer rim segments meet at the tangent point.

There are two ways to specify or modify the cup design: CAD Tools and Morph Tools.

CAD tools allow you to draw (from scratch) or modify/manipulate the individual curves that comprise the Cup Design.

Morph Tools allow you to more holistically tweak an existing design but not create a design from scratch.

When you first start a new mouthpiece design and open the cup editor, you must either use the CAD Tools to create a design from scratch, or open a reference model and copy its design to give you a starting point to be modified with the CAD or Morph tools.
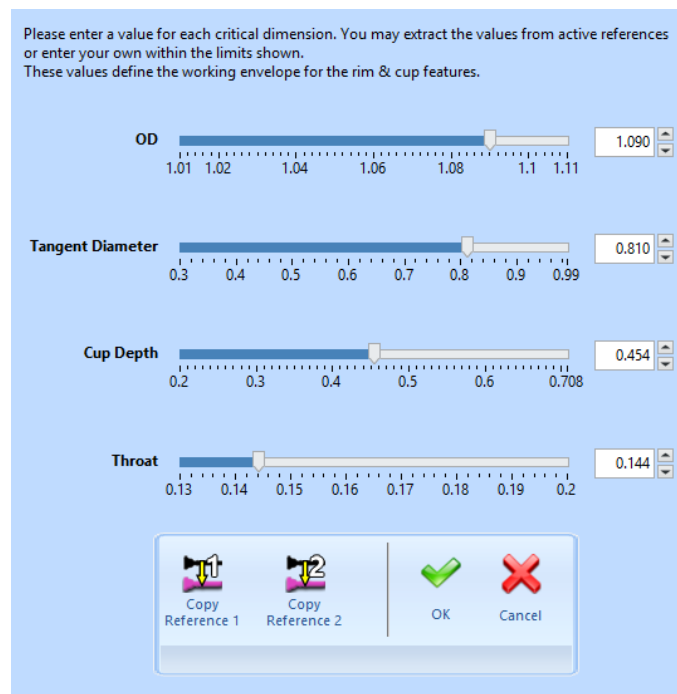
CAD Tools

The CAD Tools allow you to either modify or create cup segments and outer rim segments.
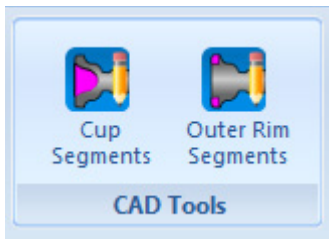
If there are already segments for the region you choose to design, they will be highlighted as shown earlier.

If not, a dialog will pop up inviting you to define the four critical dimensions for your design:

- OD (outer diameter)
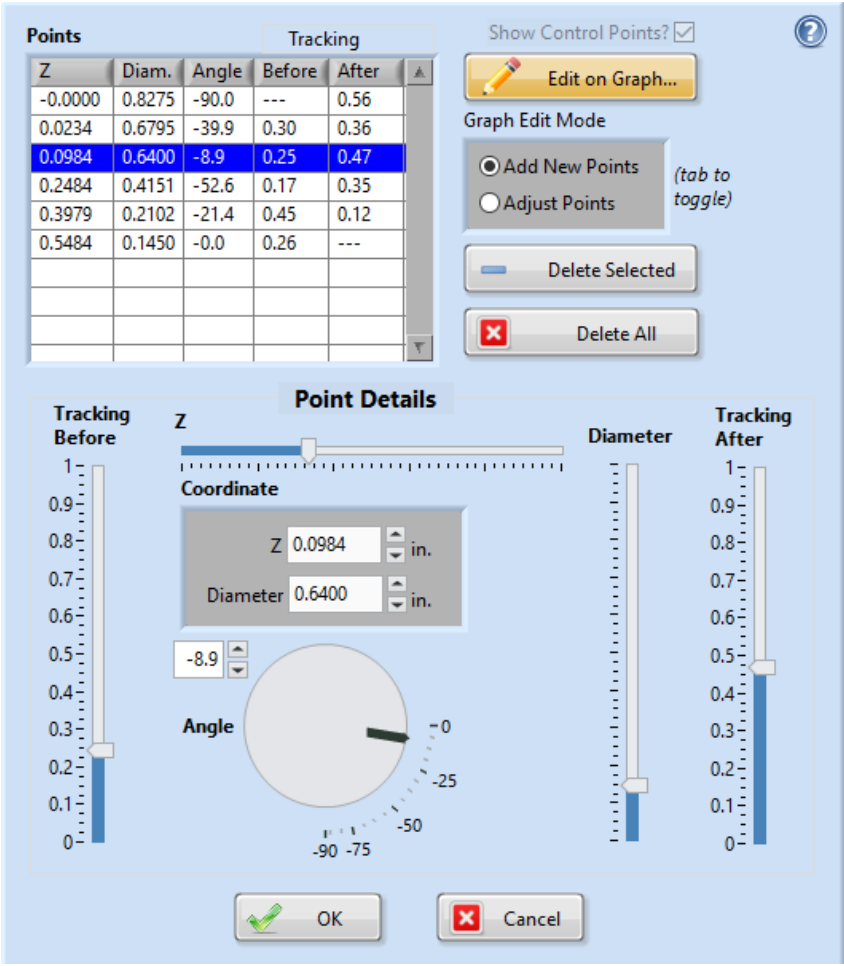- Tangent diameter
- Cup depth
- Throat diameter

These can simply be entered, or can be copied from either of your two references. Armed with these bounding dimensions, VennCAD™ will create a single curve that smoothly connects the tangent point to the outer diameter point as a starting point for the outer rim design, and another single curve connecting the tangent point to the throat point as a starting point for the cup design.

In the example shown here, those bounding dimensions have been copied from Reference #1 (shown in brown), and VennCAD™ has created the initial curve in white connecting those points and forming the starting point for the outer rim and cup designs:
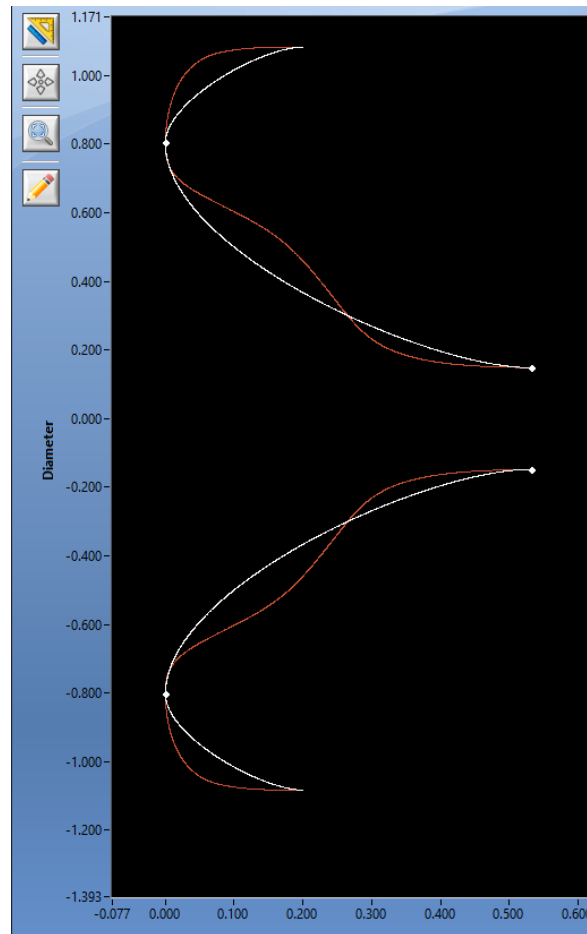
The user can then add additional points using the Edit Points on Graph feature.

Once points are added, or in cases when the user has opened a pre-designed set of segments (such when using a library reference model as a design starting point), the user can use the following editing controls to tweak these points:

The **Points** listbox contains all of the points used to create the design. Each row corresponds to a point. The first is the tangent point, so we see that the tangent diameter is 0.8275". The last point is the throat point, and we see that the throat diameter is 0.1499". The throat point is 0.5484" from the tangent point along the Z-axis, but remember that we measure cup depth from a point 0.032" from the tangent point, so the cup depth of this would be 0.5484-0.032=0.5164".

The **Angle** column of the **Points** listbox tells the slope of the cup geometry at each point. Note that it is -90 degrees at the tangent point, which makes sense. It's the definition of tangent point. If the tangent point is tangent to the table when the mouthpiece is sitting on its cup end, the slope of the mouthpiece surface will be vertical at the tangent point when the mouthpiece is horizontal, as displayed on our graph. Similarly, the slope of the mouthpiece is 0 (i.e. horizontal) when it hits the throat point, which it must be, since the throat is the smallest-diameter point. The throat point is the (global) minimum of the curve.

As mentioned before, the cup and outer rim designs each consist of segments. Each segment has two end points. Thought of a different way, each end point is really the end of one segment and the beginning of the next. The exceptions are of course the tangent point, which is only the beginning of a segment, and the throat point, which is only the end of a segment.

The **Tracking** columns (**Before** and **After**) represent how well the mouthpiece design "tracks" the slope just before and just after it hits the point. That is, the segment before the point in question hits the designated slope precisely as it hits that point, and the next segment begins with exactly that slope. But tracking is a

relative measure of how far to the left of the point the (preceding) segment begins to approach that slope, and how long after the point the (next) segment maintains that slope. Consider the following example:
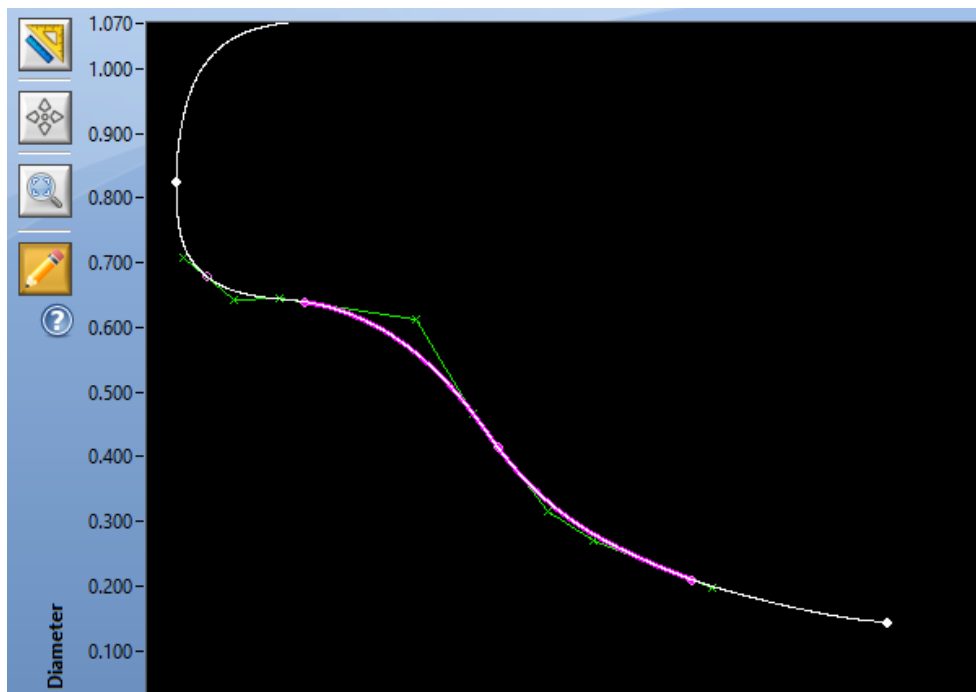
There are two purple-highlighted segments. The point in the middle of them is the point we are editing in the **Points** list. Its slope happens to be -52.6 degrees. No matter what we do to the Tracking Before and Tracking After settings, the design will have a slope of precisely -52.6 degrees as it passes through the point. The thick pink line, which overlies the white line, shows the original design, when both **Tracking Before** and **Tracking After** are set to moderate/intermediate values.

In the example below, we increase the **Tracking Before** value to a higher number. The thin pink line show what happens to the segment to the left of the point in question.
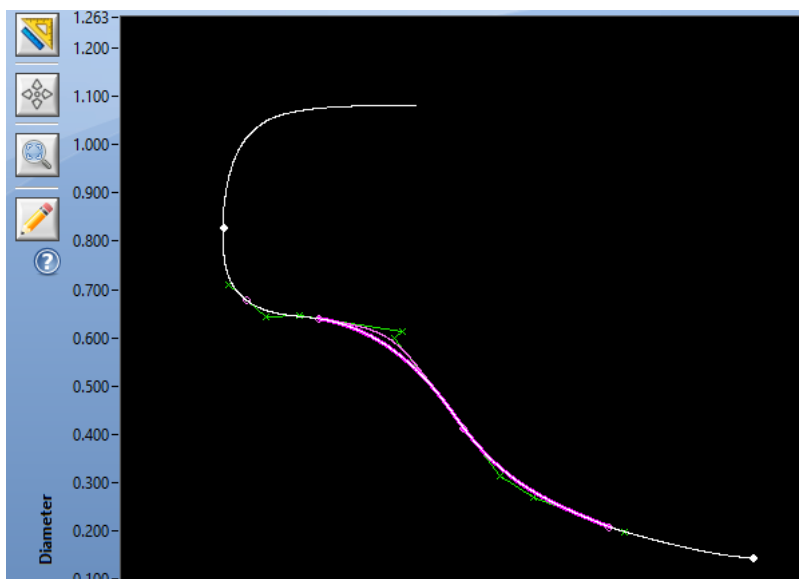
Prior to the change in **Tracking Before**, it slowly turns and hits the slope at our point. By *increasing* **Tracking Before**, we force it to approach that slope farther away and come in on more of a straight approach through our point.

The controls under **Point Details** allow you to adjust the position (i.e. **Z** and **Diameter**), **Angle**, and **Tracking** (both **Before** and **After**) of whichever point you have highlighted in the **Points** listbox. In addition, you may delete the highlighted point by clicking the **Delete Selected** button.

Note the green Xs on the graph above. These can be shown or hidden using the **Show Control Points** option. They are visual representations of the tracking. You will note that they form a straight line through the graph point, indicating the slope of the mouthpiece curve through the graph point. The closer the left-hand control point is to the graph point, the smaller the **Tracking Before** value is. The closer the right hand control point (green X) is to the graph point, the smaller the **Tracking After** value is.

Morph Tools

The morph tools allow you to make more holistic modifications to valid cup and outer designs without manually modifying individual segments.
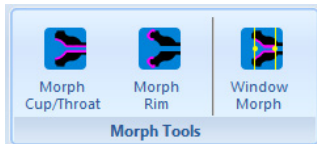
As shown above, the outer rim and cup are defined as a series of segments, each with a start and end point and several curve parameters. The morph operations do not pay attention to these curve boundaries, morphing one, several, or all of the curves smoothly to create a new geometry. After the morph operation is complete, VennCAD™ will refit curves to the new morphed geometry, altering the endpoints and parameters of existing curves and perhaps even combining or subdividing previous curves to reflect the changed geometry.

Morph Cup/Throat

The Morph Cup/Throat function brings up the following suite of controls:
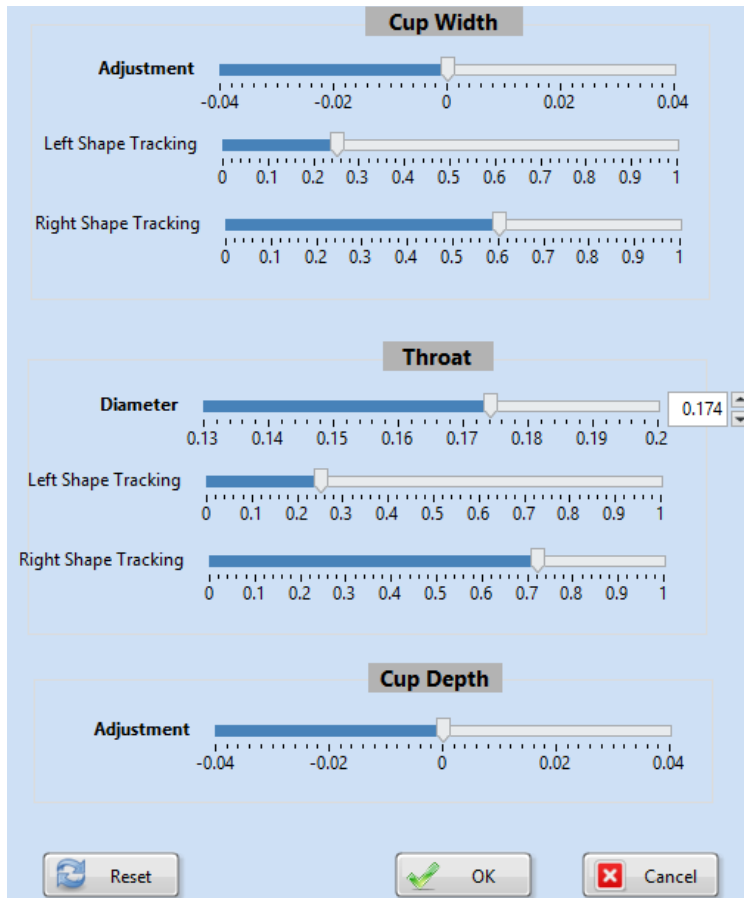
The **Adjustment** slider under **Cup Width** will adjust the tangent diameter by the amount indicated. (Note that this doesn't directly adjust the measured cup width, since cup width is not measured at the tangent point. Increasing the **Adjustment** value for a given setting of **Left Shape Tracking** and **Right Shape Tracking** will inevitably increase cup width, just as decreasing the **Adjustment** value will inevitably decrease cup width.)

The **Diameter** slider under **Throat** will set the throat diameter to the indicated value. You may also enter it precisely in the supplied number control.

The **Left Shape Tracking** and **Right Shape Tracking** sliders under both **Cup Width** and **Throat** adjust how much the shape of the morphed (shifted) design *tracks the original design's shape*.

Suppose you want to increase the cup width but do not wish to change the throat diameter. If you set **Adjustment** to +.02", the tangent diameter will increase by precisely .02". Obviously, the point just to the right of this on the Z-axis (say, Z=0.001) has to shift very nearly .02" as well in order to not wildly distort the shape. And so too the point just to the right of that must shift by nearly 0.02". But, if *all* of these points shifted *exactly* .02", yes, the cup diameter (measured at the stipulated point) would increase by exactly .02". But carrying this logic all the way down, the throat diameter would also increase by .02", which we decidedly do NOT want. So VennCAD™ must shift points farther on the positive Z-axis (i.e. farther from the tangent point and closer to the throat point) less and less until, at or before the throat point, the shift becomes zero and the morphed design lies atop the old design. The tracking controls influence the algorithm that determines this rate of divergence from the chosen adjustment (of .02" in this case) to the tangent diameter to the diameter adjustment of zero made at the throat point.

In general, *increasing* **Left Shape Tracking** makes the *shape* of the morphed design more similar to the original shape toward the left (i.e. closer to the tangent point) of the design. *Decreasing* **Left Shape Tracking** allows the morphed shape to return more quickly and approach the old shape, making the shape of the left portion of the morphed design less similar to the original. Conversely, **Right Shape Tracking** affects the right portion of the design (nearer the throat point) more strongly. However, both affect the entire design, gradually rolling off at points farther from their zone of influence. They interact and, if set to extreme values, can create kinks or bends that the software (or the final machining process) may even disallow. In all cases, though, the adjustment to the tangent diameter and/or throat diameter. Rest assured, a little bit of experimentation will be an excellent guide here. In a few moments you will start to get a feel for how to use these controls to create smooth, graceful modifications to reference models or other previous designs.

Morph Rim

The Morph Rim function allows you to morph the inner and outer rim with one convenient tool. You may edit either one or both, making them relatively sharper or flatter as you desire. Note that morphing the outer rim will affect the outer rim segments. After you approve the morph operation, VennCAD™ will re-fit curves to match the new morphed design. Morphing the inner rim will affect the cup segments (since the inner rim is simply the segments or parts of segments that lie to the left of the 0.032" cup-measuring Z-depth). Again, after you approve the morph operation, VennCAD™ will re-fit the cup curves to match the new morphed design.

Activating the Morph Rim function brings up the following suite of controls:
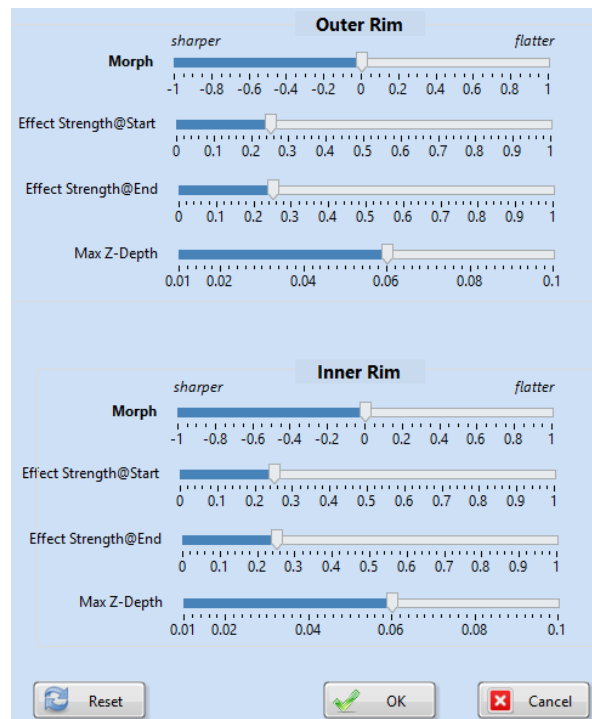
The **Morph** sliders allow you to make either the inner or outer rim flatter or sharper.

The operation affects the rim from the tangent point (which is itself unaffected by the operation) all the way to the Z-depth specified by **Max Z-Depth**, at which point the morphed curve will precisely rejoin the original outer rim design or cup design (of which the inner rim is a subset).

The Effect Strength sliders increase or decrease the chosen flattening or sharpening effect more in the beginning of the curve (closer to the tangent point) or the end of the morph's zone of influence specified by **Max Z-Depth**. Note that both the **Effect Strength@Start** and Effect **Strength@End** sliders affect the entire curve, and interact with each other; they just have a more pronounced effect on the start or end regions respectively.

Just as with the Morph Cup/Throat functions, extreme settings can cause kinks or bends which are undesirable or which may be disallowed by the software or machining process. And just as before, a little bit of experimentation with the four sliders for the inner or outer rim will allow you to develop a feel for creating the contour you want. Using reference models whose rim feel you are familiar with may be helpful here to allow a basis for comparison. Also, if you have a difficult time obtaining the contours you're envisioning, getting close and then using the CAD Tools to fine-tune may be a good strategy.

Window Morph

The Window Morph tool is similar to the Morph Cup/Throat tool, except the user can set the zone over which it acts. By contrast, the cup morph acts most strongly at the tangent point and tapers off completely by the throat point, and the throat morph does the opposite.

Activating the Window Morph function brings up the following suite of controls:
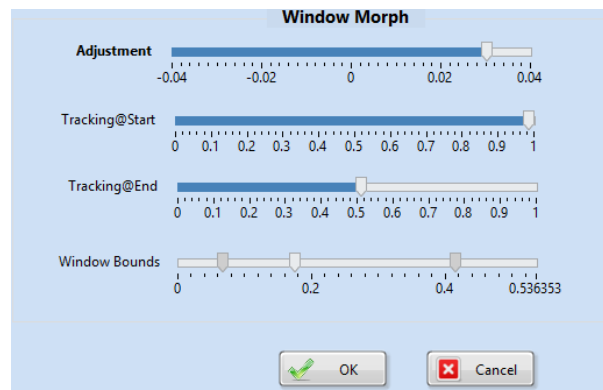
A positive value of **Adjustment** moves the curve outward, increasing cup volume; a negative value moves the curve inward, decreasing cup volume.

The three sliders on the **Window Bounds** control set the beginning, maximal point, and end of the zone of operation, respectively, along the Z-axis. That central location – the maximal point of operation – sets the Z-point at which the morphed curve is farthest from the original curve. At this point, the morphed curve will be the precise distance (in inches) from the original curve that is specified on the **Adjustment** slider. In the example above, this means that the curve has been translated by 0.03" (which increase the diameter of the design as displayed on the graph by twice that, or 0.06"). At the beginning and end of the zone of operation, as specified by the first and last cursors respectively on the **Window Bounds** slider, the morphed curve converges with the previous curve.

Note that the beginning, maximal point, and end of the zone operation specified by the **Window Bounds** slider may also be adjusted by clicking on and dragging the vertical line cursors that appear on the graph as shown below:
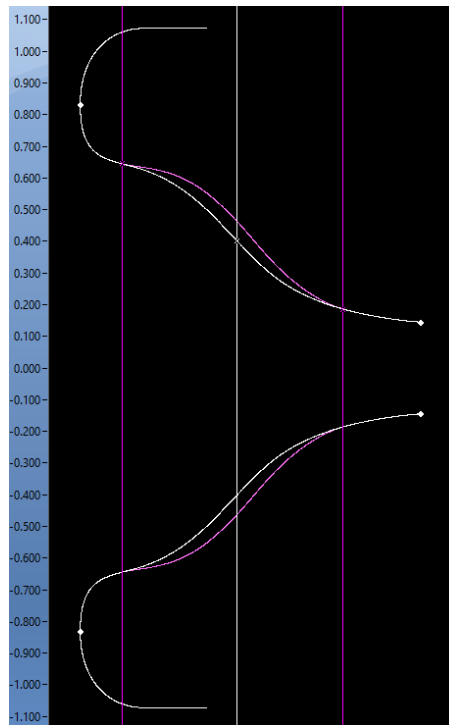
The white line is the maximal point of operation, and the left and right purple lines define the beginning and ending of the zone of operation. Dragging these cursors will move the cursors on the **Window Bounds** slider, and vice versa.

Tracking@Start adjusts how closely the morphed curve follows the original curve near the start of the zone of operation. **Tracking@End** adjusts how closely the morphed curve follows the original curve near the end of the zone of operation.

Just as with the Morph Cup/Throat functions, extreme settings can cause kinks or bends which are undesirable or which may be disallowed by the software or machining process. And just as before, a little bit of experimentation with the four sliders that define the **Window Morph** function will make you proficient in creating smooth, useful modifications to existing geometries.

Backbore Design

After a valid cup design is created or modified, the backbore must be specified to create a complete and valid mouthpiece design.
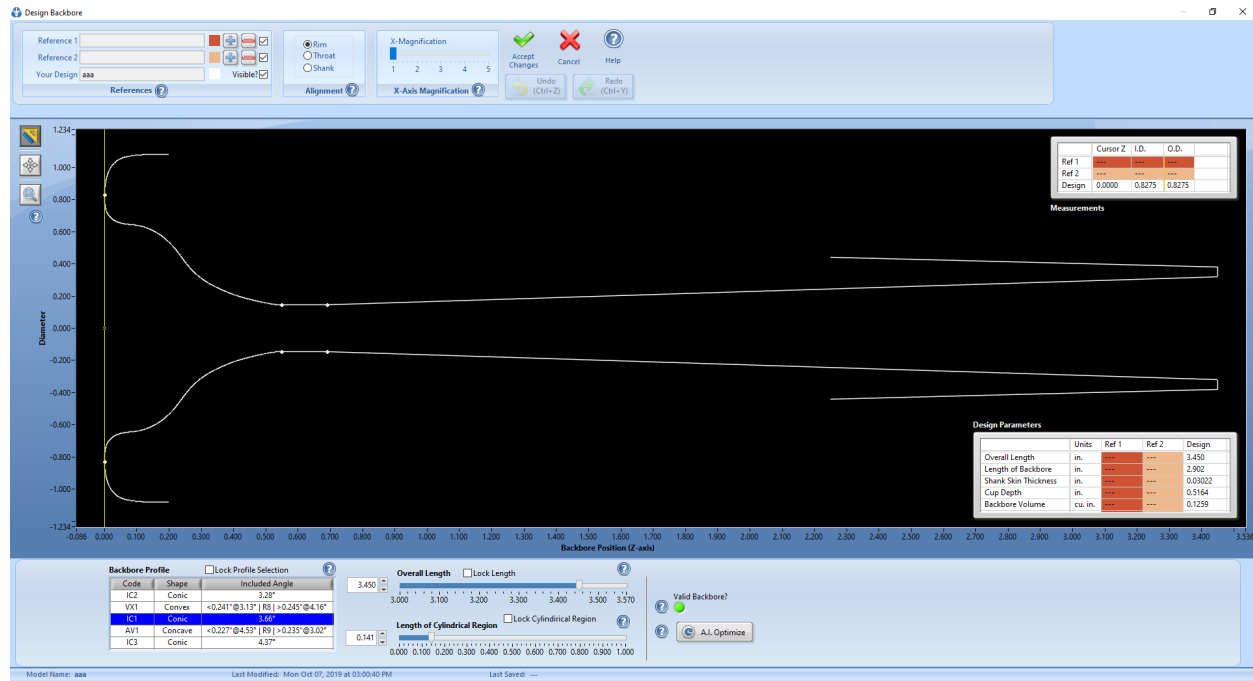
This consists of selecting a backbore profile, setting the overall length of the mouthpiece, and determining the length of the backbore that should be conical. This can all be accomplished automatically by using VennCAD™'s Backbore Optimizer AI tool.

Backbore Profile Selection

The backbore profile is basically a shaped drill bit. It creates a tapered shape in the mouthpiece. Its smallest diameter is the throat diameter; its largest diameter, the starting inner diameter, occurs at the shank end of the mouthpiece.

The profile to be used is chosen in the **Backbore Profile Selection** listbox:

The **Code** column shows short 3-character codes used to identify each profile.

The **Shape** column characterizes the profile as convex, conic, or concave. For the time being, all of Vennture's backbore designs are either conic (i.e. tapering at a constant linear rate), or made up of two conic sections connected smoothly by a radius.

- **Conic** means that the profile is shaped precisely as a cone (that is, a frustum, since a cone starts at a point, but, in the context of a mouthpiece, it begins at the throat diameter and continues until the starting inner diameter of the backbore). It tapers at a constant linear rate.
- **Convex** means the conic section closer to the throat has a *smaller* included angle than the section near the shank of the mouthpiece.
- **Concave** means the conic section closer to the throat has a *larger* included angle than the section near the shank of the mouthpiece.

Generally speaking, for a given throat diameter (i.e. smallest diameter of the backbore) and starting inner diameter (i.e. largest diameter if the backbore), a convex profile will produce a tighter (i.e. less volume) backbore than a conical profile, and a concave profile will produce a more open (i.e. more volume) backbore than a conical profile. The player may experience the more open backbore as freer-blowing, and the less open backbore as tighter/more efficient. Also, again *speaking generally*, the tighter backbore will tend to produce a smaller octave spread and the more open backbore a larger octave spread. That is, if a mouthpiece tends to go sharp while jumping up an octave, it may help to tighten the backbore (i.e. opting for a conic backbore instead of concave, or convex instead of conic).

The Included Angle column specifies the included angle(s) for the profile. The conic profiles have a single angle listed; the convex and concave profiles have two taper angles listed, with the radius that connects them in between. For example, for convex profile VX1, <0.241"@3.13° means "the profile tapers at 3.13° included angle up to diameter=0.241"." R8 means that there is an 8" radius that blends the two conical tapers together. And >0.245"@4.16° means "the profile tapers at 4.16° include angle for all diameters greater than 0.245"."

You may wonder how these were designed, and why there are only five. Most mouthpiece manufacturers only offer a handful of backbore designs. Vennture analyzed hundreds or trumpet, cornet, and flugelhorn mouthpiece backbores, and then ran optimization algorithms to test potential designs against these many current mouthpiece designs. This rather small handful of profiles allowed a very close recreation (i.e. differing by only a few thousandths of an inch in diameter all the way down and matching volumes to within a percent or two) of nearly every commercial model out there.

We realize that backbore design is an area of great interest which spurs much discussion and a wide variety of opinions. Please feel free to contact us if you have more questions about backbores, how to design one for your application, and how Vennture approaches them in general.

In future, more designs may be released as necessary, and fully customizable backbores may be explored. However, for now, this selection offers excellent flexibility and performance.

This flexibility is fully realized by varying not only the selection of profile, but the overall length of the mouthpiece and the length of the cylindrical region joining the cup at the throat point to the backbore profile.

Overall Length of Mouthpiece

The user will directly set the overall length of the mouthpiece using the slider or data entry box:
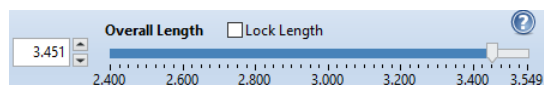
This will indirectly determine the backbore length of the mouthpiece. Note that the overall length of the mouthpiece obeys this equation:

$$O.A.L. = Inner\ Rim\ Height + Cup\ Depth + Backbore\ Length$$

Recall that inner rim height is arbitrarily set at:

- 0.032" for trumpet/cornet/flugelhorn/French horn
- 0.064" for trombone
- 0.072" for tuba

Cup depth is determined during the cup design process.

Thus, backbore length is driven by the setting for overall length.

The allowed range of overall length is constrained by VennCAD™ automatically depending on the instrument type, cup design, and profile selection.

Length of Cylindrical Region

The user will set the length of the cylindrical region used to create the backbore in the slider or data entry box:
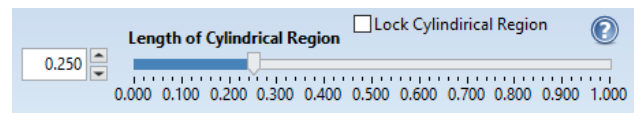
The throat diameter will be continued from the throat point, creating a cylindrical throat point, for the stipulated length, at which point it will begin to taper ever wider according to the profile selected. *This is a very important concept.* This cylindrical throat region can be any length greater than or equal to 0.

As the length of the cylindrical region is adjusted, the graph and calculated design parameters will update to reflect the change.

Backbore Design Validity

The Valid Backbore? Indicator will turn bright green to indicate that the design is valid:
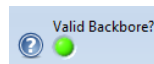
A backbore design is valid if the following criteria are satisfied:

- One of the five available profiles is selected
- Overall length is within the acceptable range for mouthpieces of that type (e.g. trumpet, cornet, etc.)
- The shank skin thickness is greater than or equal to the limit for that mouthpiece type. (too short of a cylindrical region coupled with too long of an overall length will cause the shank skin to become thinner and eventually disappear entirely)

Backbore Optimizer AI

To simplify the backbore design process, Vennture has analyzed the geometry of hundreds of commercially-available mouthpieces to develop algorithms for choosing a backbore profile and determining overall length and cylindrical region length in order to create backbore designs in line with industry best practices.

Note that is can determine all three parameters automatically (i.e. **Profile Selection**, **Overall Length**, and **Length of Cylindrical Region**), or any sub-set of those. The user can use the **Lock** checkboxes to force the algorithm to accept the user's chosen value for that parameter and optimize the other two.

For example, if the user wants to set a particular **Overall Length** but would like the input of the algorithm to choose a profile and length of cylindrical region depth, the user would enter the desired **Overall Length** and then check the **Lock Length** checkbox. Then the user would ensure the **Lock Profile Selection** and **Lock Cylindrical Region** checkboxes were unchecked. Finally, the user would click the A.I. Optimize button to run the backbore optimizer algorithm:

An error message saying "No solution found!" will be displayed if no valid backbore design can be determined. Please do not hesitate to contact Vennture if you have any difficulty with the Backbore Optimizer algorithm or any aspect of the backbore or mouthpiece design process.