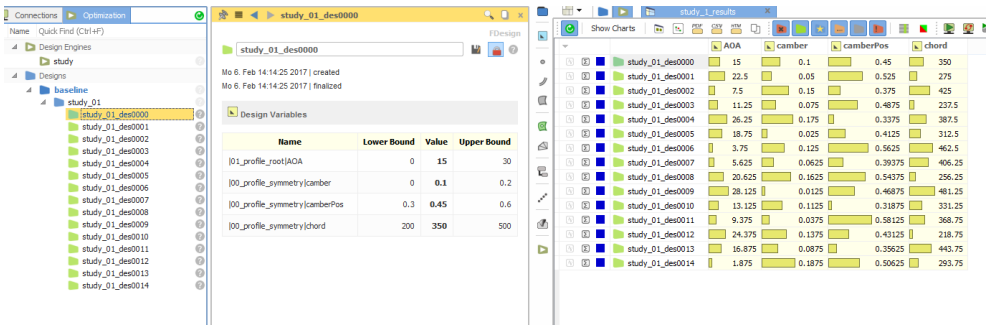
Geometry Variation and Assessment

This tutorial shows you how to automatically vary geometry by using design variables and design engines. In addition, you will be able to browse through created variants and display the different geometries.

Some basic information is also given about the *design results table* and its functionality.

You can check this helpful video giving you a good introduction. For more information about checking bounds of geometry variables, take a look at this video.



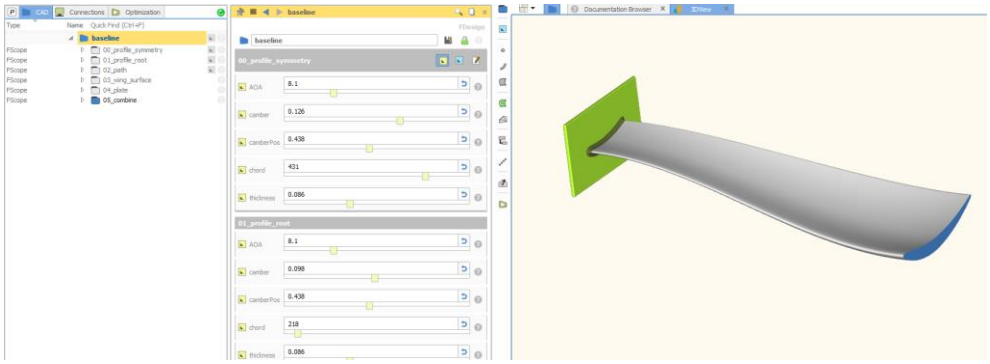
Note that, in this tutorial, geometry gets varied without considering any simulation software (e.g. CFD analysis of the new designs).

Integration of external software for one-click performance analysis is covered in later tutorials.

Initial Geometry

This tutorial is based on the tutorial *first modeling steps* for which a resulting project file is available:

- Choose *file > open sample*.
- Open the project *tutorials > 01_First_Modeling_Steps.fdb.*
- Save this project via *file > save project as* so that we do not modify the original tutorial file.

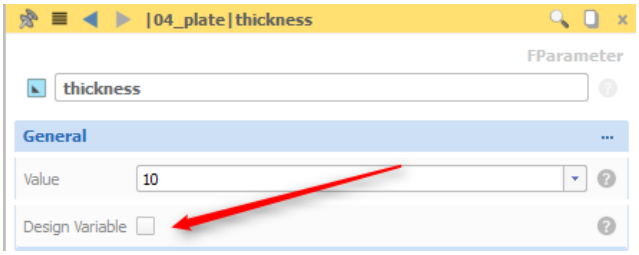


Design Variables

For automated variant generation we need to have *design variables* available. These objects hold discrete numbers and can be controlled by *design engines* as will be shown later.

We have design variables in our project already, but:

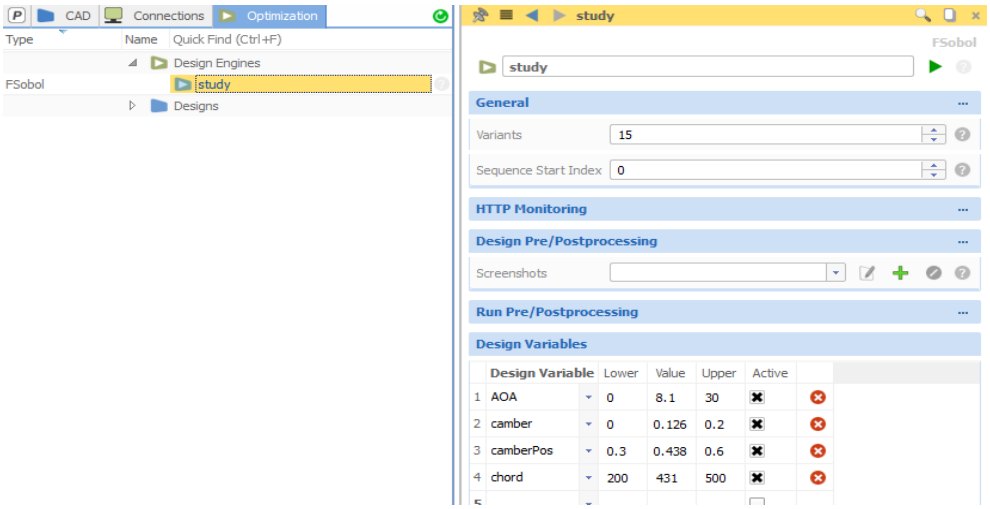
- If you want to switch a *parameter* (which can hold an expression and not just a value) into a design variable, then activate the toggle *Design Variable*.



3 Design Engine

For variation and optimization so-called *design engines* are provided. They can access and modify *design variables* automatically. For each modification they create a variant which is then available to the user.

- Create a *Sobol* engine via *optimization > Sobol*.
  The Sobol will get a node in the object tree under *Design Engines* in the *Optimization* tab.
- Rename it to e.g. “study”.
- As an example, set the number of variants to 15.
- Select the variables from the pull down menu of the category *design variables* and set lower and upper bounds for all variables (see the screenshot for reasonable boundaries).



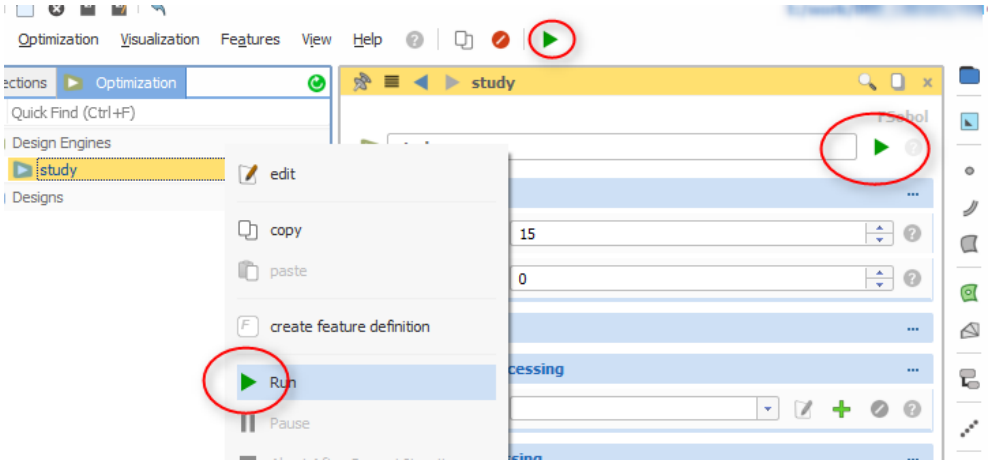
✓ This type of variation strategy is typically used for *Design of Experiments* (DoE). It is a pseudo random-number generator which distributes design variables uniformly in the design space. For single- and multi-objective optimization, the procedure is identical apart from specifying objectives. Note that optimization strategies in CAESES **always minimize** the given objectives. In order to find a maximum you can simply multiply the objective with “-1”.

✓ Remember: Note that only design variables are listed in the pull down menu i.e. parameters that have been switched to be design variables. The full names of the variables incl. scopes are shown in the tool tip (hover with your mouse over the design variable name).

4 Run the Design Engine

The design engine has been configured and is now ready to run. There are three ways available to start engines:

- For the Sobol design engine, choose *Run* from the context menu or click on the green play icon in either the top toolbar or next to the name field.

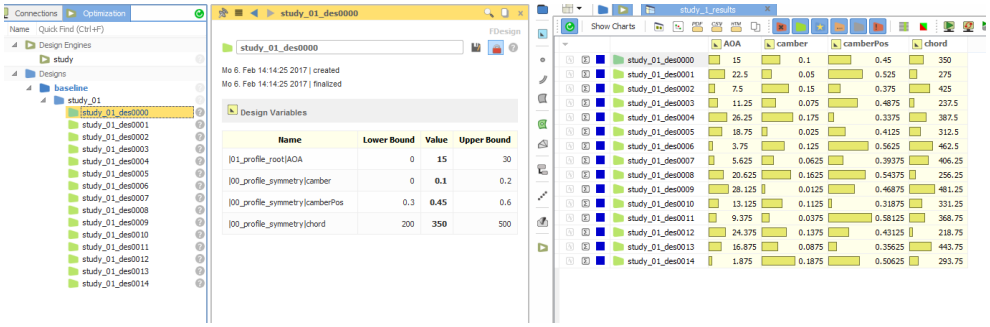


Now, the variants are getting created along with a table which documents them. Wait until the generation process is finished.

5 Browsing through Designs

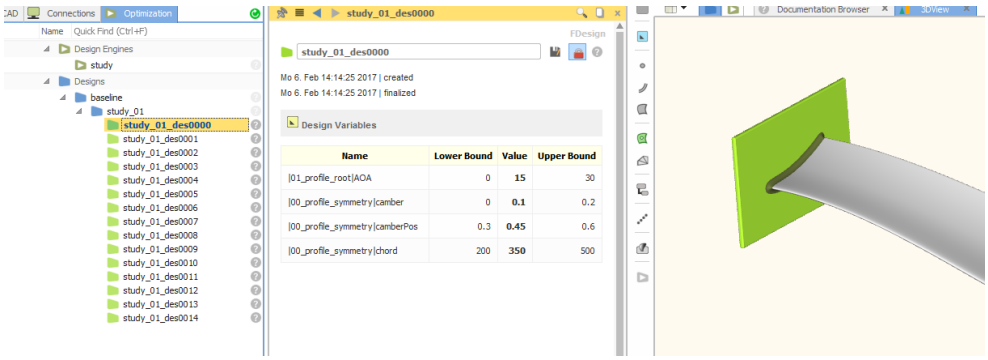
Now we want to browse through the different variants. In particular, we want to look at the individual geometries.

- See the new node *Designs* in the tree with all variants.
- Make a **single mouse click** on a design (either in the tree or the design results table) in order to display the design settings in the object editor.

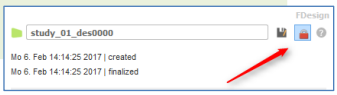


- Click on the *CAD/3DView* tab of the central widget (at the top where the table is given) in order to have a look at the geometry.

- **Double-click** on the first design “study_01_des0000” in the design tree in order to activate it i.e. make it the current design. This updates the variant and shows it in the 3D view.
- Continue browsing via double-click on the other designs in the tree.
- Go back to your initial design via double-click on “baseline” in the design tree.



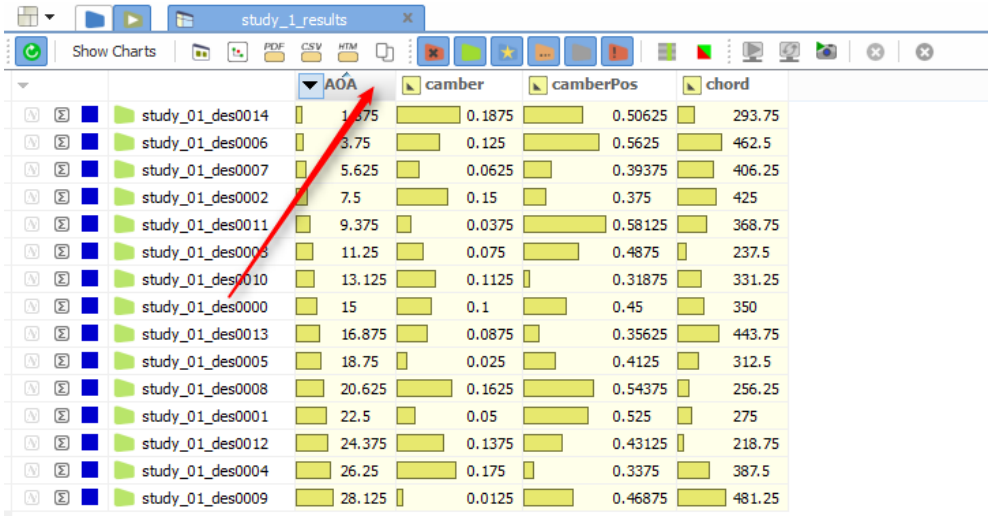
✓ If a design is active, you cannot modify it - to make sure you do not accidentally change designs which have corresponding results already. Click on the upper right lock-icon in the object editor to unlock it. Then you can switch e.g. to the CAD tab and modify objects.



6

Design Results Table

The design results table provides sorting mechanisms with regard to its entries. Sorting can be done by clicking on the header of the parameter or design variable once or twice for increasing or decreasing order.



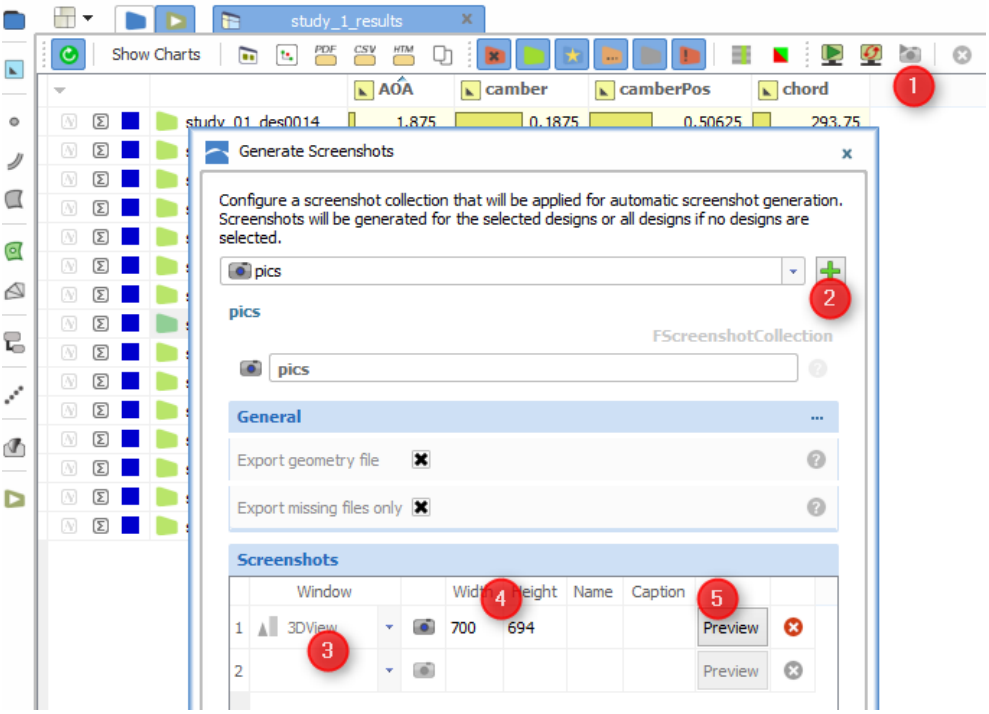
✓ Sorting is more exciting if objectives are involved e.g. sorting for minimum pressure loss or minimum resistance coefficient etc. ☺

✓ Result tables can also be customized. New tables can be created via *view > new > viewer > design results table*. Parameters, design variables, constraints from the model and even designs from the design tree can be inserted via drag & drop to an empty table widget. Also, designs can be dragged into a generated result table like the one above e.g. to compare designs from different engine runs.

7 Screenshot Collection

Generate screenshots of each design, e.g. in a fixed perspective to compare them. This can be done before a run is started (in the design engine), or afterwards at the design results table.

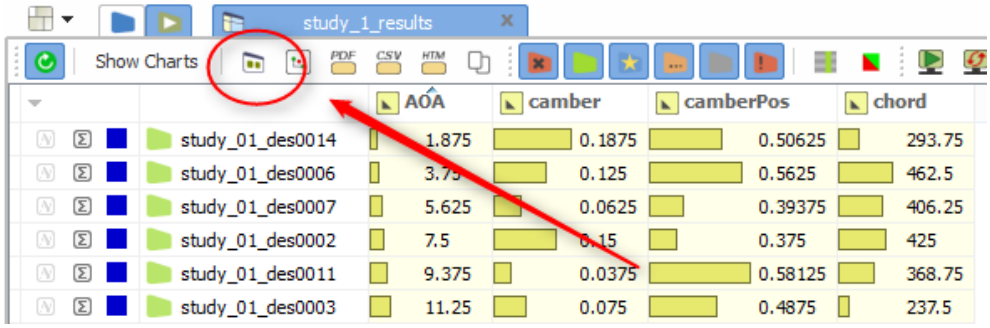
- Click on the camera symbol in the top right of the design results table. (1)
- Click on the green plus icon to generate a new screenshot collection. (2)
- In the drop down menu "window" select the *3DView.* (3)
- You can now adjust the height and width of the screenshot, as well as add a caption. To control the result you can check the preview. (5)
- Finally, click on "Generate", CAESES will then step through the designs to create the pictures for you. These ones can now be visualized in the design viewer (next page).



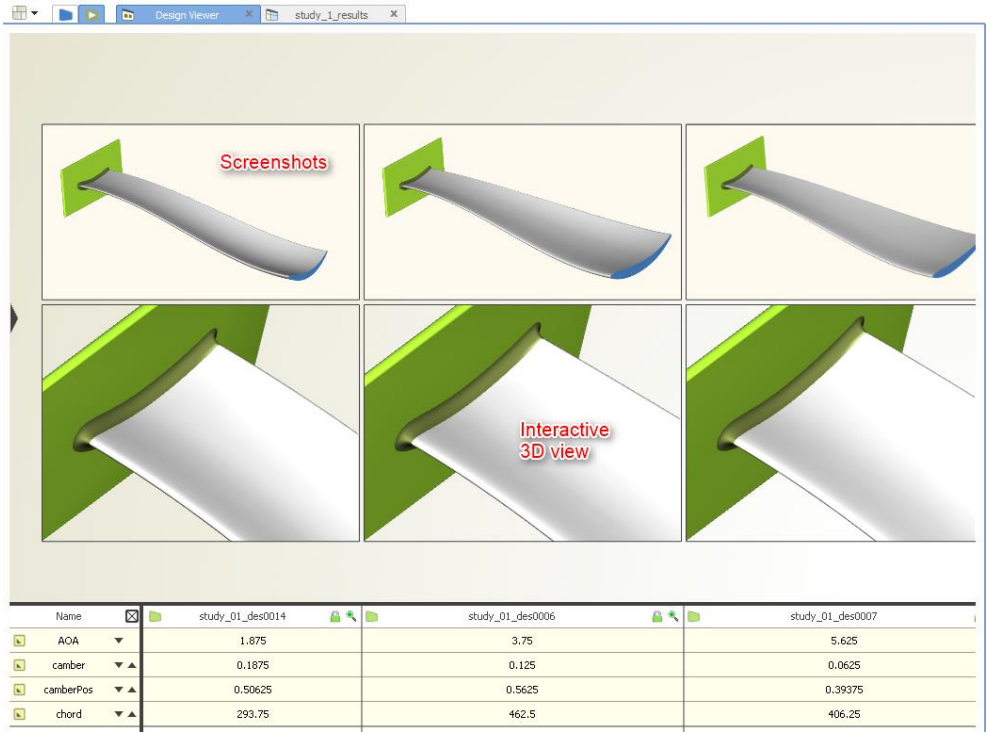
8 Design Viewer

If you created a *screenshot collection* it is easy to compare these within the *design viewer*.

- Click on the *design viewer* icon in the top left of the *design results table*.



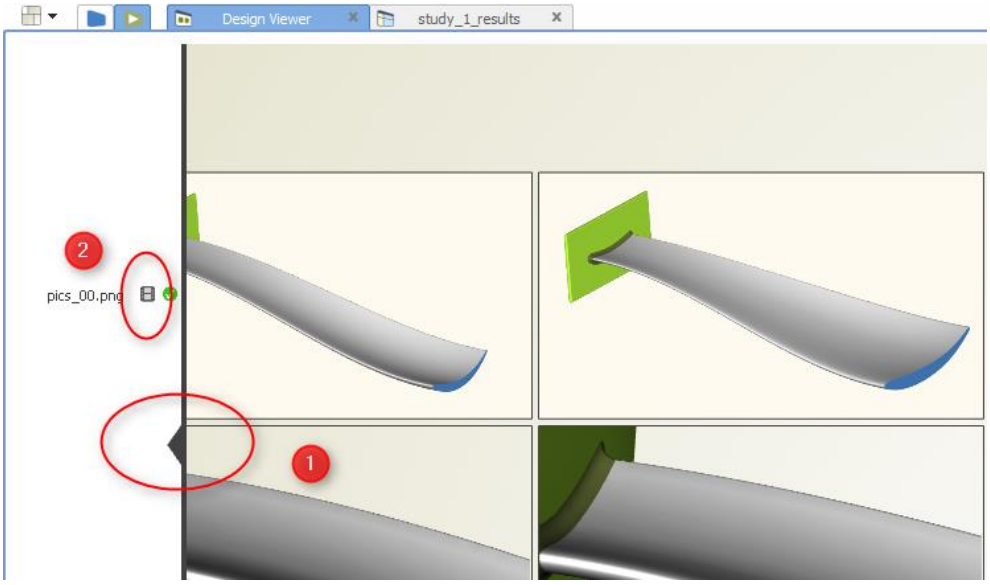
- In the *design viewer* scroll with the middle mouse button to zoom in and out.
- The first row (right above the table values) contains an interactive 3D window. Keep the CTRL key pressed while using your other mouse buttons to rotate or zoom in.



9 Create a Gif Animation

In the *design viewer* you can directly create a gif animation of the available screenshots.

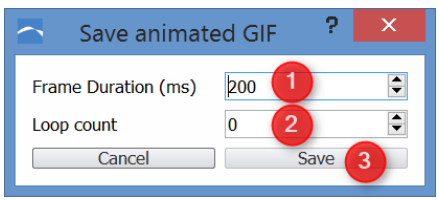
- Click on the black arrow in the middle on the left side of the design viewer in order to expand the side bar.
- Click on to create a gif animation for the selected row of screenshots.



A *Save Dialog* window is opened

- Choose a folder location to save your gif file.
- Click on *save*.
- Choose the *frame duration* (1).
- Choose *loop count* (2). How often should the loop of screenshots be shown when you open the gif file (0 means continiously playing the gif, 1 the gif will stop after one loop.).
- Click on *Save*.

Now you can find and open the saved gif file in your choosen folder location.



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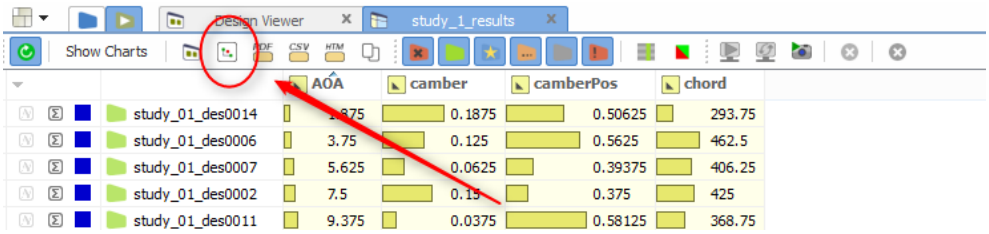
Diagrams and Charts

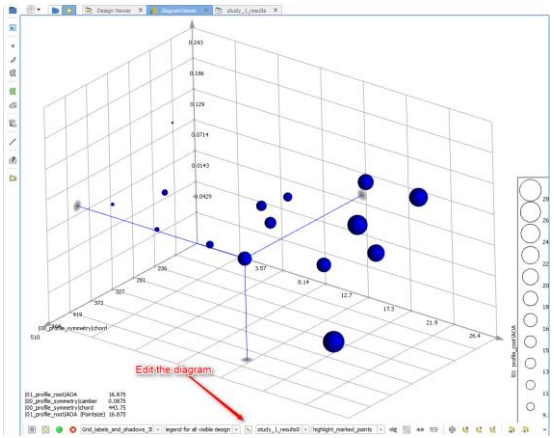
CAESES allows you to create various 2D charts and diagrams. See also the tutorial about Dakota in the "Learn More" tutorial section.

► Click on the second icon in the top left corner of the *design results table* to create a diagram.



► Select the type of diagramm you want to create and then select the mapping tab to insert the variables.

► Set the inputs and click ok to see the diagram.

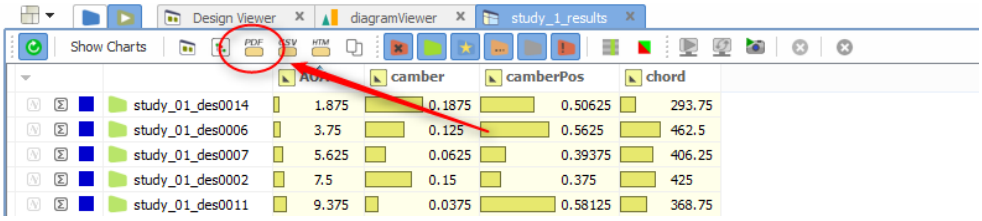


✓ Ok, since there is no evaluation in this project, the diagram isn't that helpful. However, if you are evaluating an objective and set the objective as e.g. point size and/or point color, the diagram can enable you to see connections between single parameters and the results.

11 PDF Reports

In order to exchange and present the data of a variation, it is possible to create PDF reports with information about the design exploration or your shape optimization run. Once again, switch back to the table:

- Click on the PDF icon in the top left corner of the *design results table* and select whether you want to export a report with diagrams based on the displayed columns in the *design results table*, or if you want to export a report with tables showing *design variables*, *parameters* and *contraints* as well as screenshots.



- If you need *.csv or *.html data, choose the buttons next to the PDF button.

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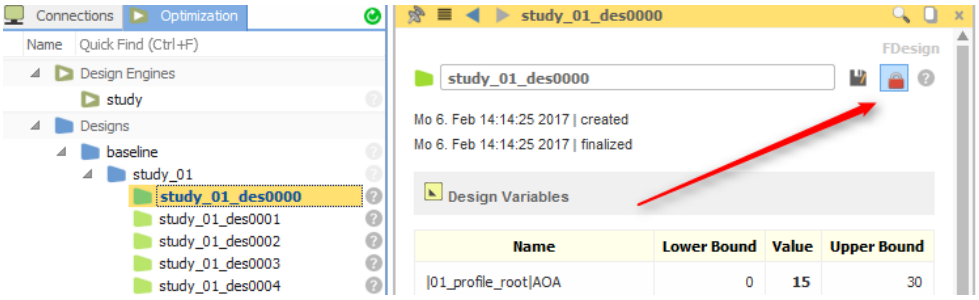
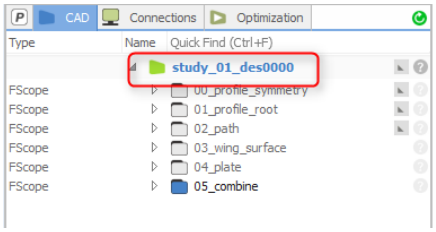
Editing Variants

If you browse through variants (by double-clicking on a design) note again that they are in a read-only mode by default for protection purposes. If you want to edit, modify or continue design work on such variants deactivate the lock next to the name field:



- In the design tree, **double-click** on a variant to select it as current design.
- Click on the red lock icon in order to remove the modification protection. The icon will turn green to indicate that the variant can now be edited.
- Change to the *CAD* tab: The read-only mode has disappeared and the variant can be edited. Note that the name of the current variant is always on the top of the model tree.



✓ A typical optimization process might start with a simple variation (exploration). After that, a good variant is picked and activated with double-click. Now you can create a new design from the current design (in order not to modify the existing variant for which results exist already). For an activated design, choose ***optimization > create new design from current design.***

Alternatively, you can save the current design into a new project, to get rid of all the other content. For an activated design, choose ***file > save current design as ...***