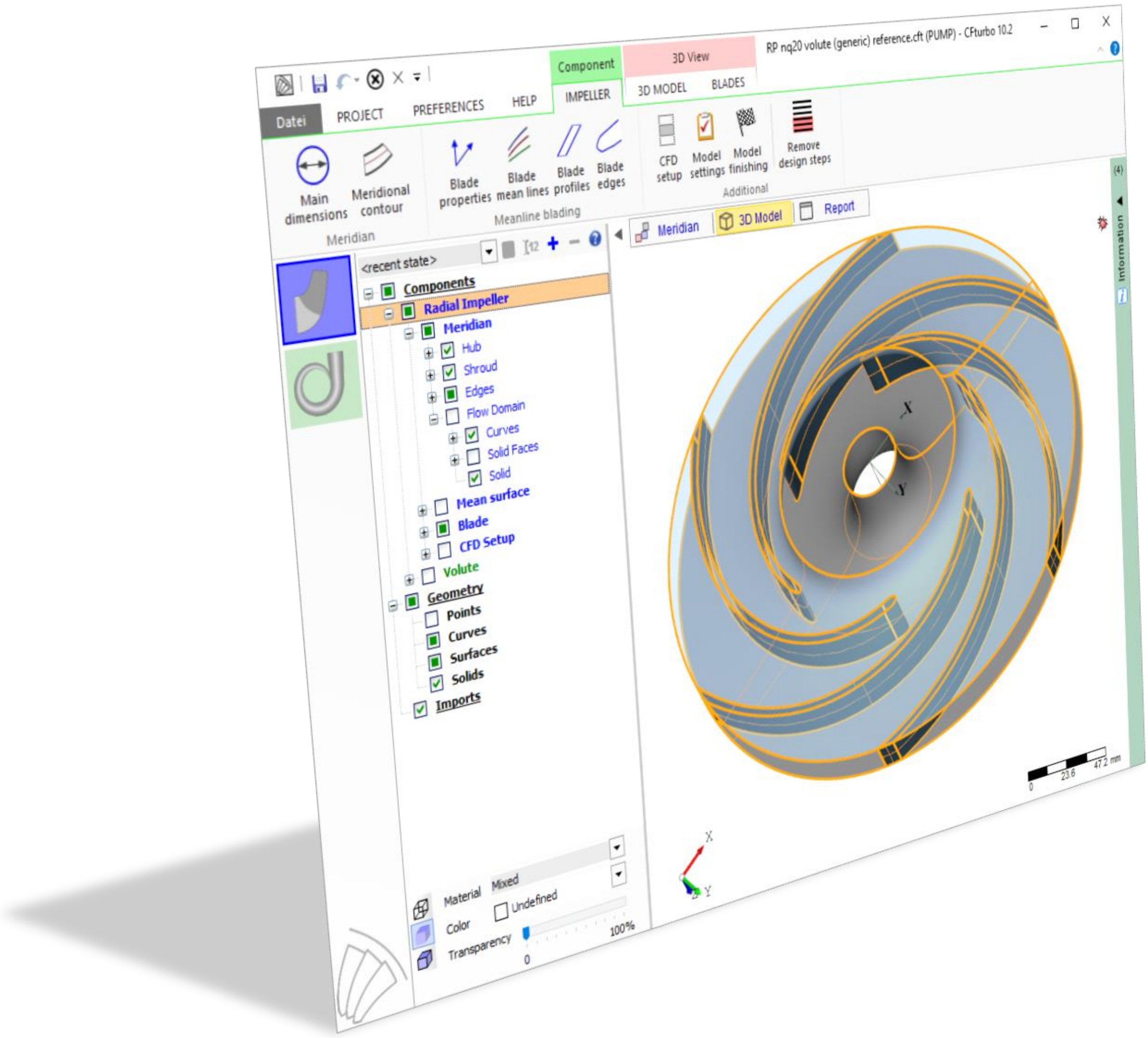
CFturbo®

Trimming a centrifugal pump with CFturbo without losing the parametric description



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1. Introduction

Once a design of a pump has been proven as being efficient and reasonable there is often the need to trim its impeller in order to derive a new model range without going through the entire design process again. This can be done be simply trimming the geometry in any general purpose CAD package. But doing so will result in a model that lacks its original parametric description in turbomachinery terms, that is to say blade angles, mean line description etc. will not be accessible easily anymore. Another aspect is that if there is no CFturbo model of that newly derived model available one cannot make use of the CFturbo interfaces either.

Therefore, means are depicted here that can be utilized to get a trimmed CFturbo model without losing the parametric description and but gaining a copy of the reference geometry.

2. Example

A centrifugal pump will be used to demonstrate the above mentioned methodology. This pump is a low n_q-pump and a standard CFturbo example with the name *RP nq20 volute (generic)*. It is shipped with the installation of CFturbo. The design point is defined as displayed in the picture below:

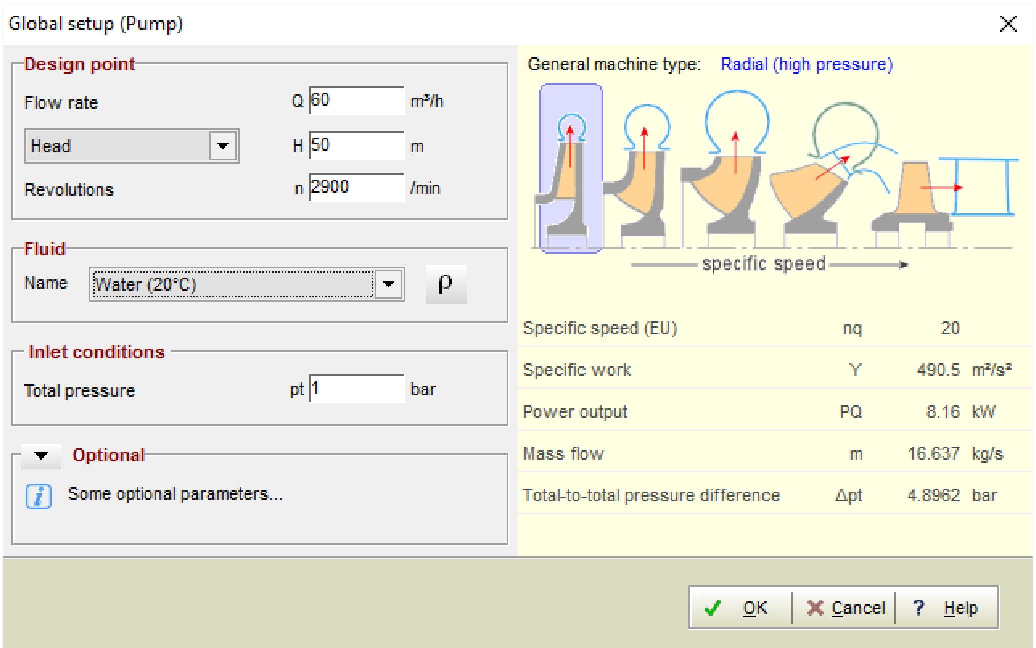

Figure 1: Design point of the example

The low specific speed of $n_q = 20$ suggests a pure radial design with a constant radius trailing edge. The impeller diameter is $d_2 = 220$ mm. It shall be trimmed to a new diameter of $d_{2new} = 200$ mm.

3. Preparation

First at all, the automatic mode has to be deactivated both in the main dimension design step (third tab) and in the blade properties (second tab) if not already done.

For comparison reasons a copy of the reference geometry as STEP or IGES should be taken. To this end the blades as well as the hub surface have to be selected in the 3D view of CFturbo. Afterwards the appropriate format must be chosen in the export panel and the data can be saved, see next figure:

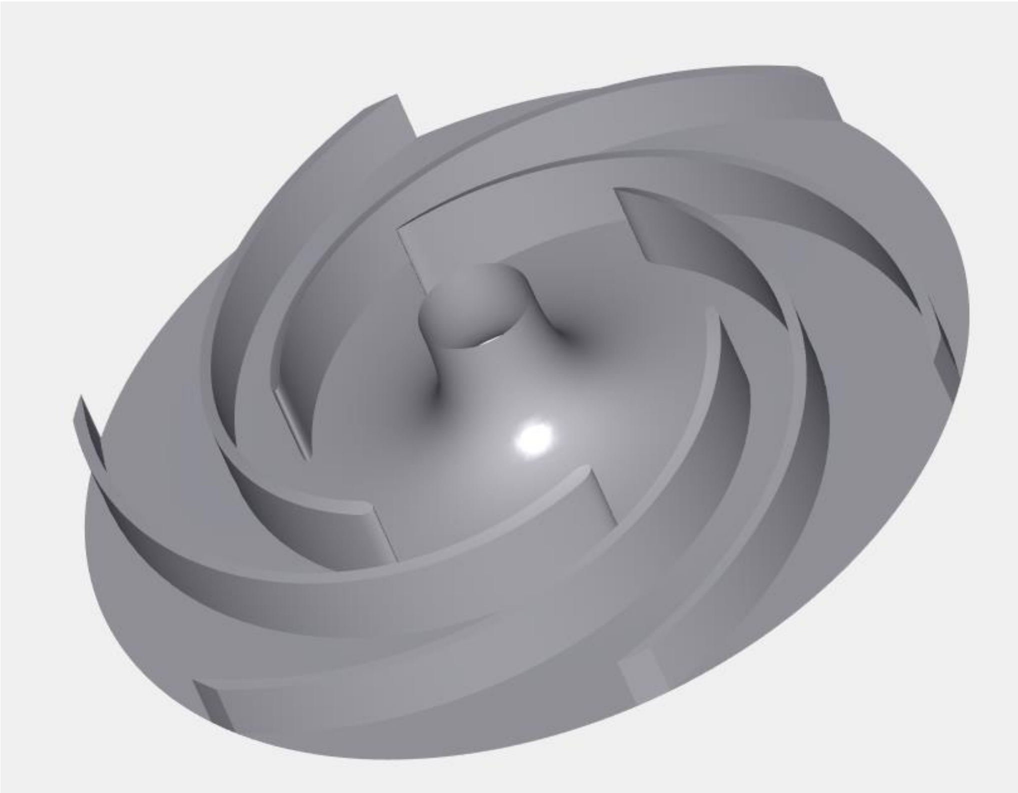

Figure 2: Reference geometry

From the meridian the reference hub and shroud contour has to be saved as z-r-table by right clicking on its respective representation in the meridional contour design step dialog, see Figure 3. This data will have to be used later on for the approximation of the new Bezier-control-points of the trimmed meridional contour. Therefore, they have to be trimmed too by deleting all z-r-co-ordinates with a radius bigger than 100 mm. The data close to the trim radius will possibly have to be adjusted by interpolation in order to gain a smooth meridional contour:

Hub

…			
39.605089	83.672241		
39.622952	86.302404		
39.636969	89.003538		
39.647583	91.776836		
39.655245	94.6235		
39.660419	97.544741		
39.663581	100.54178	→ 39.662359	100
~~39.665216~~	~~103.61584~~		
~~39.665823~~	~~106.76817~~		
~~39.66591~~	~~110~~		

Shroud

…			
23.793584	99.565166		
23.888728	100.64418	→ 23.831617	100
~~23.981891~~	~~101.7181~~		
~~24.073154~~	~~102.78591~~		
~~24.1626~~	~~103.84657~~		
~~24.250314~~	~~104.89903~~		
~~24.336381~~	~~105.94222~~		
~~24.420887~~	~~106.97504~~		
~~24.503918~~	~~107.99637~~		
~~24.585563~~	~~109.00508~~		
~~24.66591~~	~~110~~		

The leading edge contour and position needs to be determined too. In the current example the leading edge is a straight one with a constant radius of r_1 = 54.11 mm. Hence, this parameter is sufficient to restore the leading edge position after the trimming.

Two other parameters have to be extracted from the meridional contour: the new impeller width b_{2new} at the trim diameter as well as the axial position of the mid line at this new diameter. This can be done by using both the zooming feature and measure distance feature of CFturbo respectively.

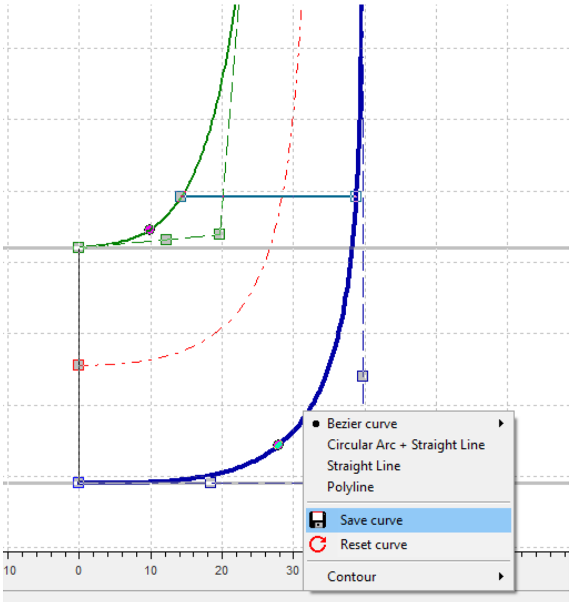

Figure 3: Saving of hub contour

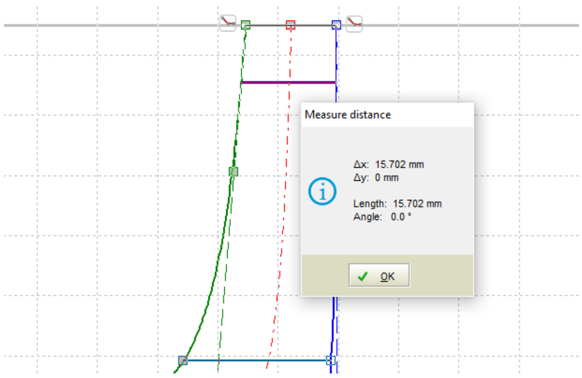

Figure 4: Measure new b_2 and axial position

Using this procedure, the new impeller width becomes b_{2new} = 15.7 mm and the new axial position of the mid line becomes z_{new} = 31.85 mm.

Now the new blade angle at the trailing edge has to be determined. Before this is accomplished one should change the x-Axis definition to radius for the mean line design step.

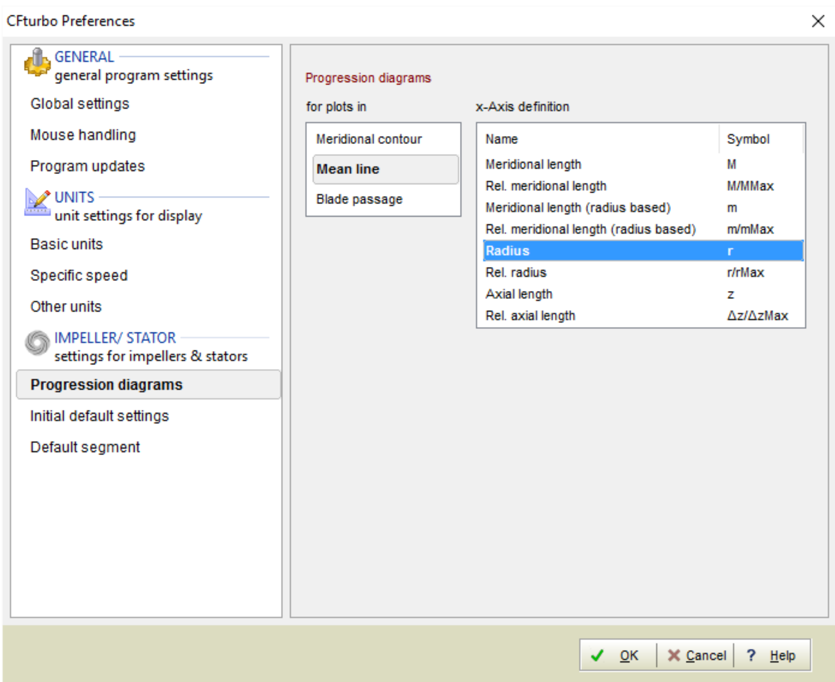

Figure 5: Change preferences

Now the new blade angle at the leading edge β_{B2new} can be determined within the mean line design step, this time by using the zoom feature in the β-progression diagram. It has to be done for the hub only since this CFturbo model has blades with a freeform 2D blade shape. In this case the hub mean line is the master mean line and determines the shape of all other mean lines. The new blade angle is β_{B2new} = 20°.

Another important feature is the hub mean line in t-m-co-ordinates. Again these have to be saved by right clicking on the appropriate curve in the mean line design step. They have to be trimmed too, see next section. Once this is accomplished all the necessary data has been saved.

4. Trimming

The trimming starts at the main dimensions design step. Here the earlier defined and derived trim diameter d_{2new} = 200 mm, see section 1, and the new impeller width b_{2new} = 15.7 mm, see section 3, have to be set.

The second step is to set the new axial position of the mid line in the meridional contour. This is best done by right clicking on the control point and typing in z = 31.85 mm.

In the meridional contour design step both the hub and shroud Bezier curves have to be adjusted in accordance to reference contours. It is recommended to use the built in approximation feature by choosing the polyline to Bezier method. If this is called one has to specify the polyline, which is the trimmed hub meridional contour derived according to section 3. After pressing start and OK the new hub representation is set up.

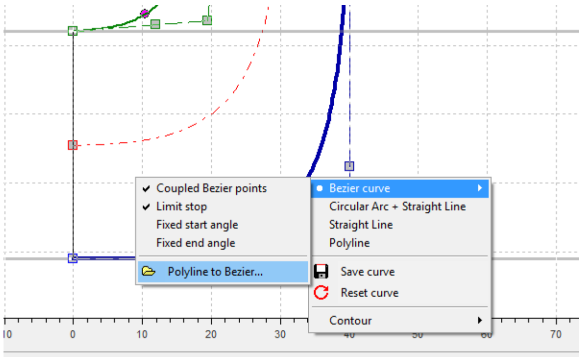

Figure 6: Context menu

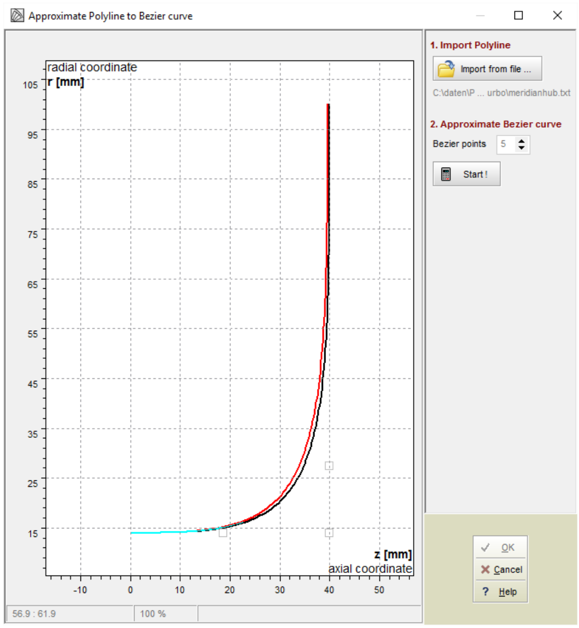

Figure 7: Bezier control point fitting

The same has to be done for the shroud contour. The final adjustment is the setting of the leading edge radius r_1 by right clicking on the appropriate control point and typing in the earlier derived value (see section 3). Now the meridional contour is a trimmed copy of the reference.

Within the blade property design step only the blade angle of the hub has to be set to β_{B2new} = 20°.

The hub mean line derived from the reference geometry is still untrimmed and contains m-values that corresponds to radii bigger than the trim radius of 100 mm. Therefore, this data has to be trimmed with the new maximum m-value of the new meridional contour. The maximum value can be determined in the m-t-diagram within the mean line design step for the hub with m_{max} = 0.615.

Now the t-m-representation of the hub can be trimmed in a similar way as the hub and shroud meridional contour have been trimmed, see section 3. Again interpolation can be used to get a smooth distribution close to the new maximum m -value.

…
1.9712834 0.60205991
1.9942299 0.61039761
2.0171587 0.61873050 → 2.006893 0.615
~~2.0400692 0.62705736~~
~~2.0629607 0.63537699~~
~~2.0858326 0.64368816~~
…

The final step is to apply the polyline to Bezier method again by using the adjusted t-m-data. This has to be done similarly to the meridional contour adjustments (see Figure 6 and Figure 7) on the hub t-m-mean line in the mean line design step.

5. Test

A simple test is the import of the exported reference geometry and display together with the trimmed one. Both geometries should be identical within the tolerances involved in this kind of trimming procedure.

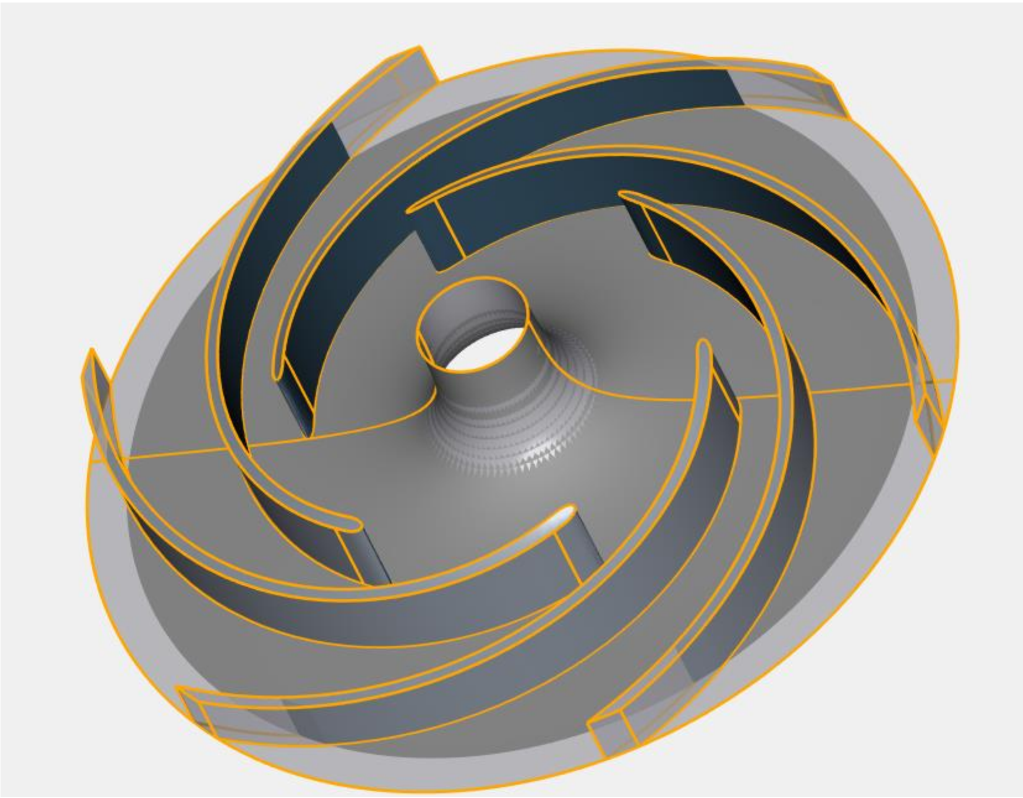

Figure 8: Comparison of trimmed and reference geometry

6. Annotation

In case the blade thickness is not constant at a span some means have to be applied to gain a well-trimmed impeller with respect to the blade thickness.