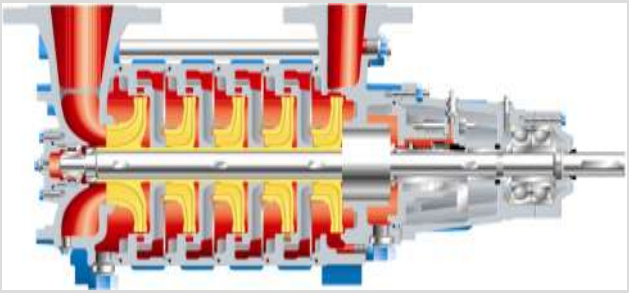
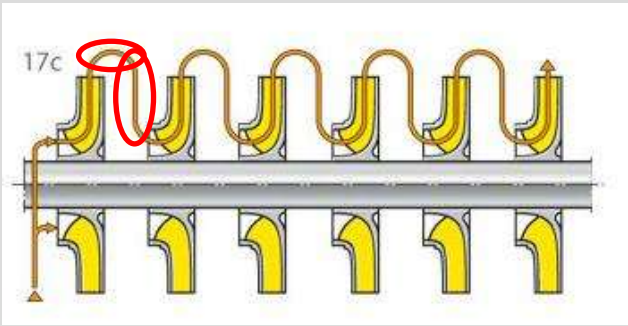
Diffuser design for multistage pumps with *FRIENDSHIP-Framework*

1. Working procedure (framework layout)
2. Design criteria for geometry definition
3. Coupling with CFD-Software
4. Design optimization process



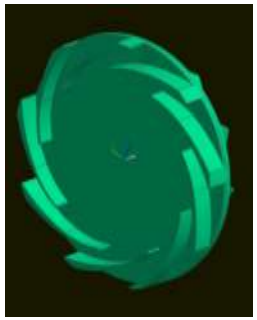


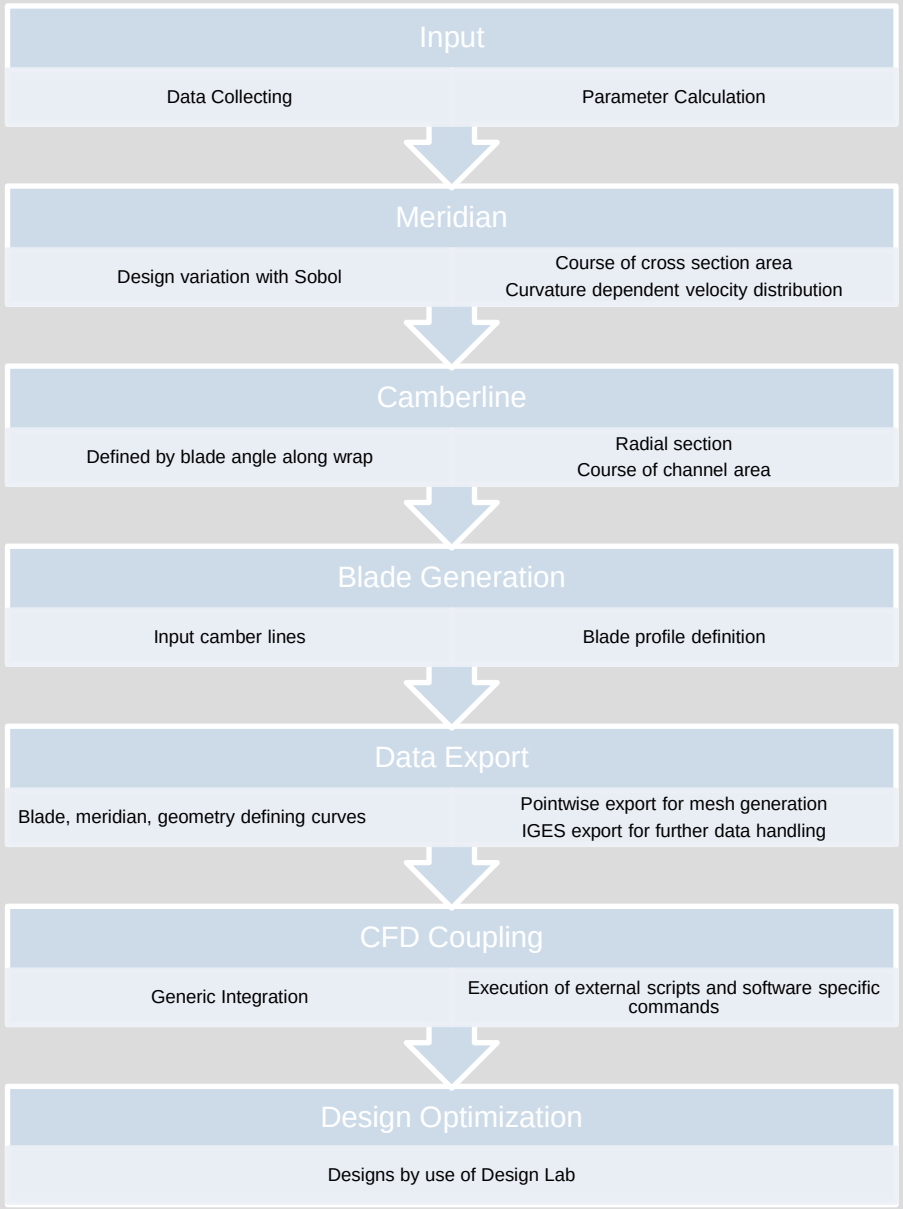
http://www.kreiselpumpenlexikon.de

Overview

Multi Stage Pumps

- Tandem arrangements of impellers with serial throughflow
- Economical increase of pump head
- Typically one stage consists of impeller, diffuser vane and back vane
- At requirement of small outer pump diameter diffuser- and back vane can be combined

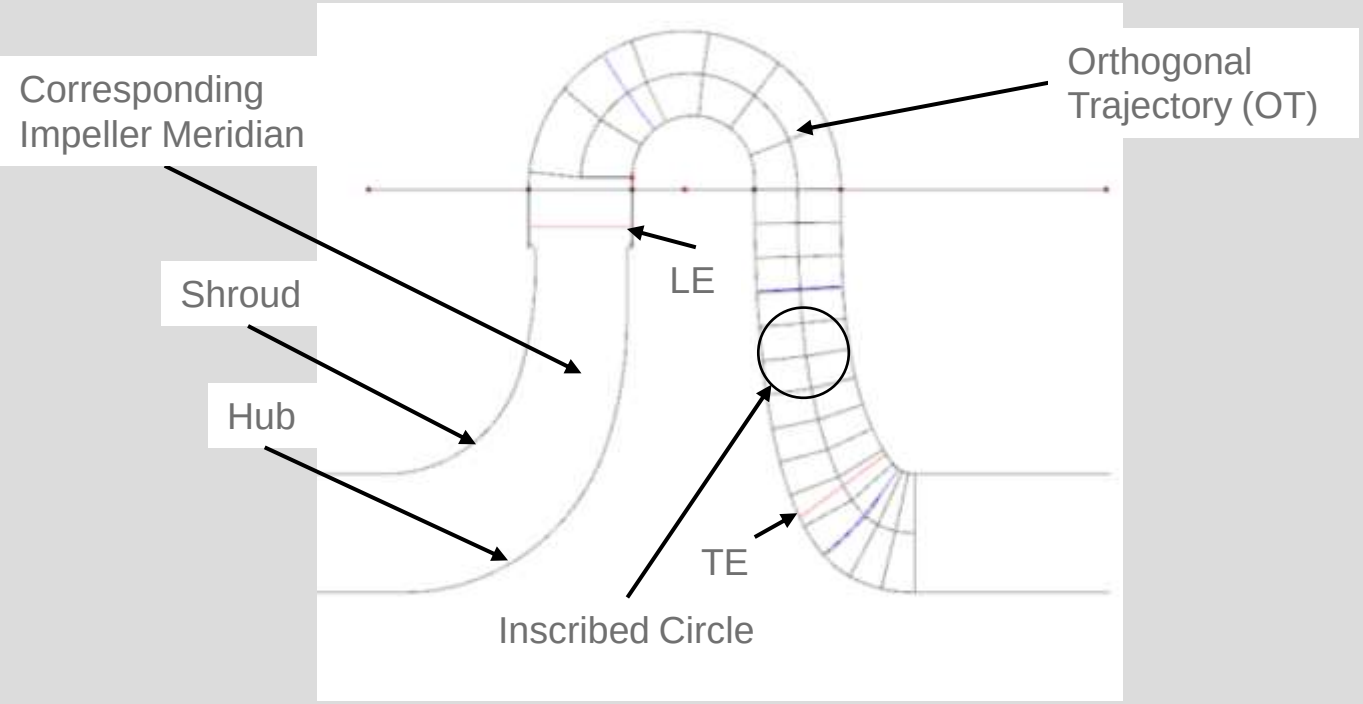


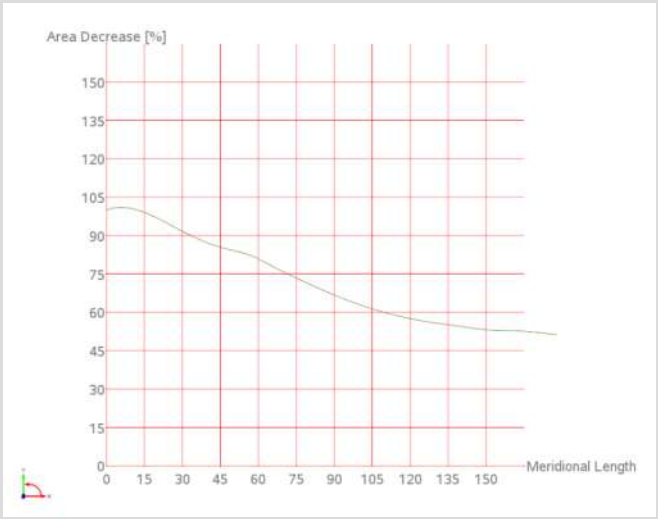


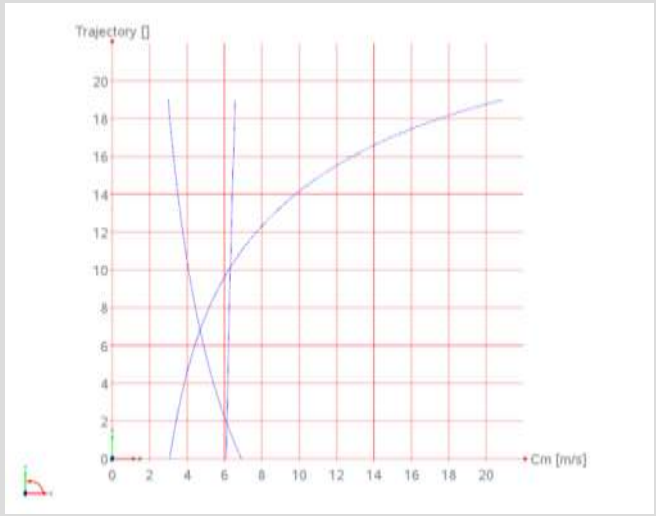
Working Procedure
***Framework* Layout**

- Modular design for any kind of blades which are developed by blade angle distribution
- Modules are encapsulated in features

- Input feature gives overview about required data
- Some input data: speed, flow rate, hub- shroud diameter, position of leading and trailing edge
- Some parameter: pump specific speed, hub ratio, stage length

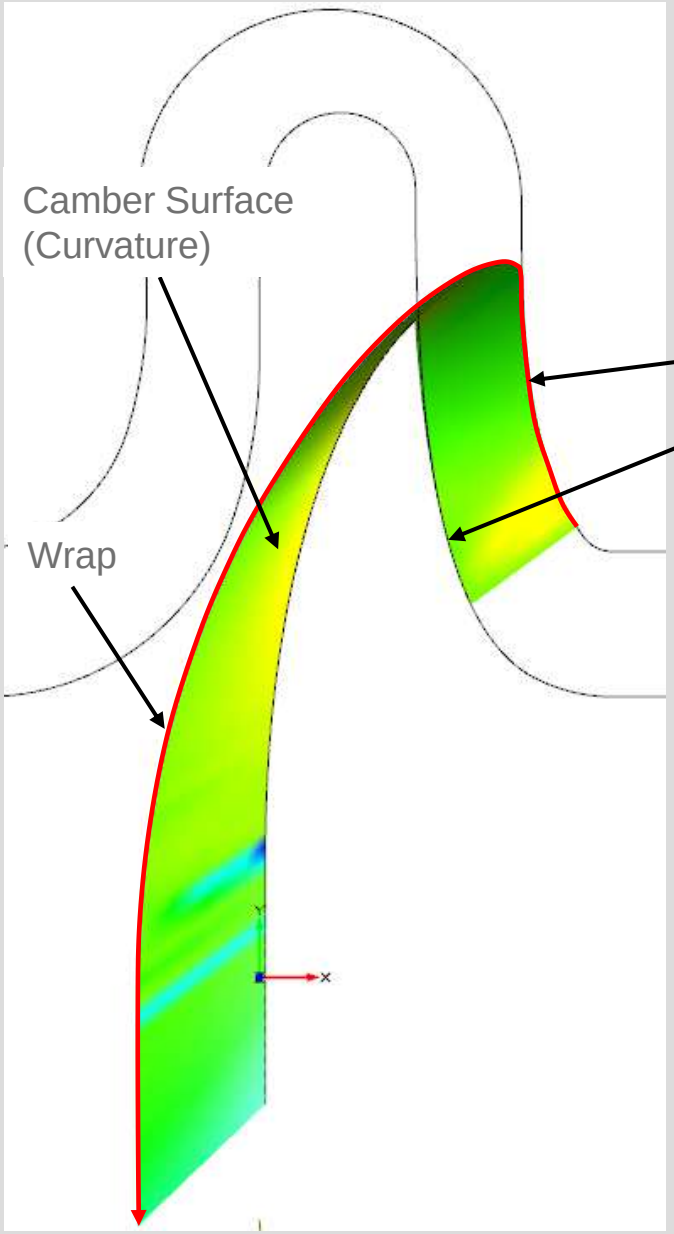


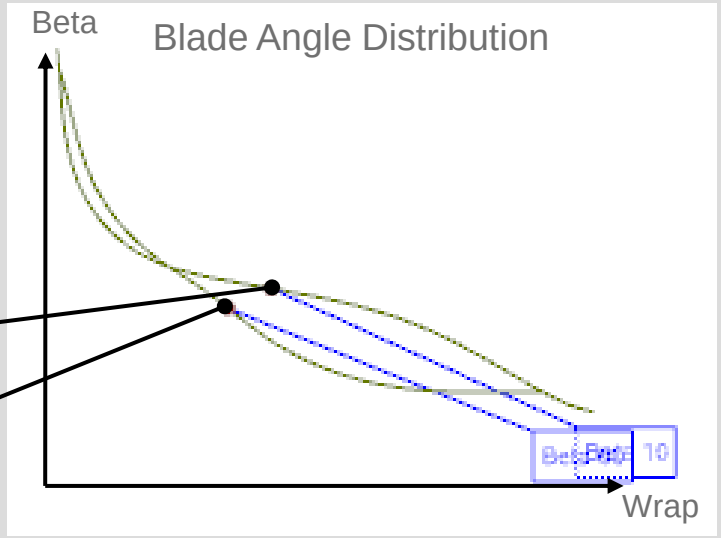




Design criteria
Meridian

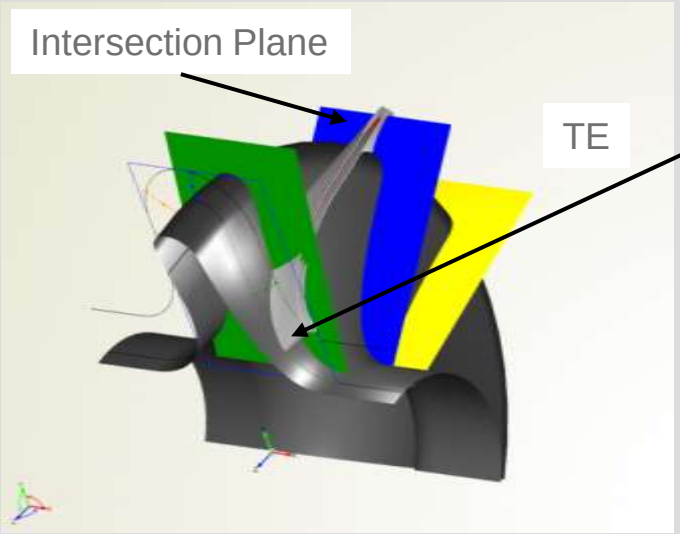
- Smooth course of meridian cross section area
  - Surface of revolution of inscribed circle diameter
- Meridian velocity as constant as possible along OT
  - Curvature dependent velocity distribution
  - $\frac{c}{R} - \frac{\partial c}{\partial n} = 0$
- Brent Design Engine for determination of Orthogonal Trajectories
  - Determination of shortest distance
- Solving differential equation using Brent Design Engine

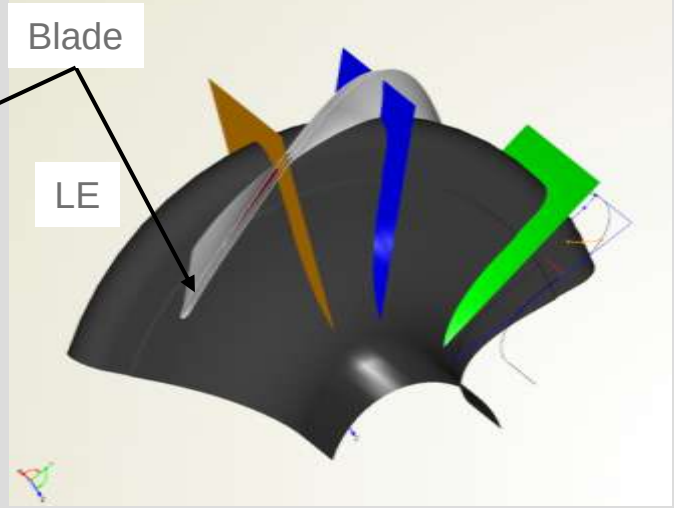


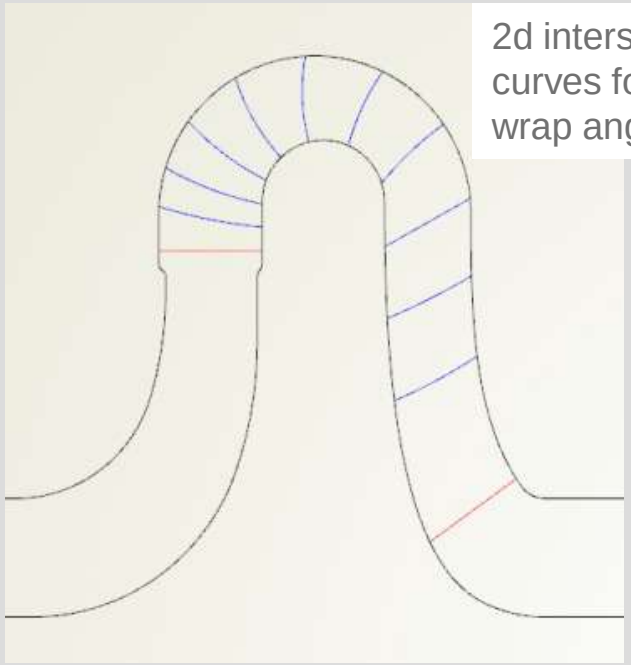


Design criteria
Camber Line

- Definition of camber line which connect leading and trailing edge in an appropriate way
- Pointwise development of the camber line with given meridian and blade angle distribution
- Define blade angle distribution with FSpline
- To meet given leading edge position: Find corresponding area below angle distribution



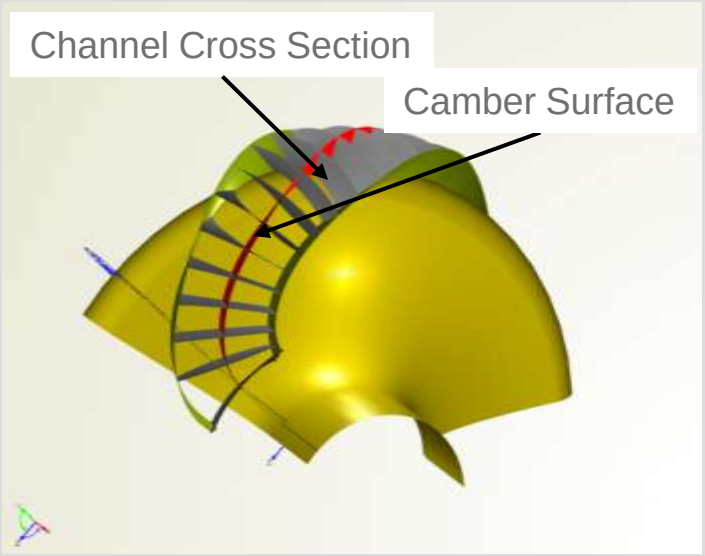


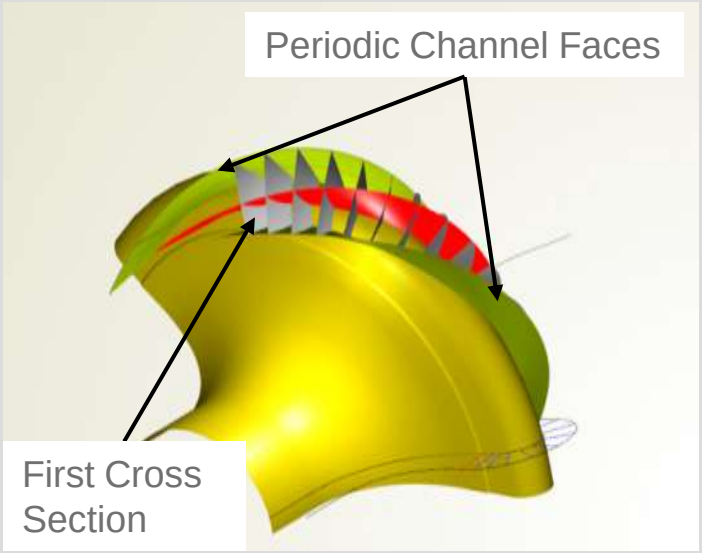


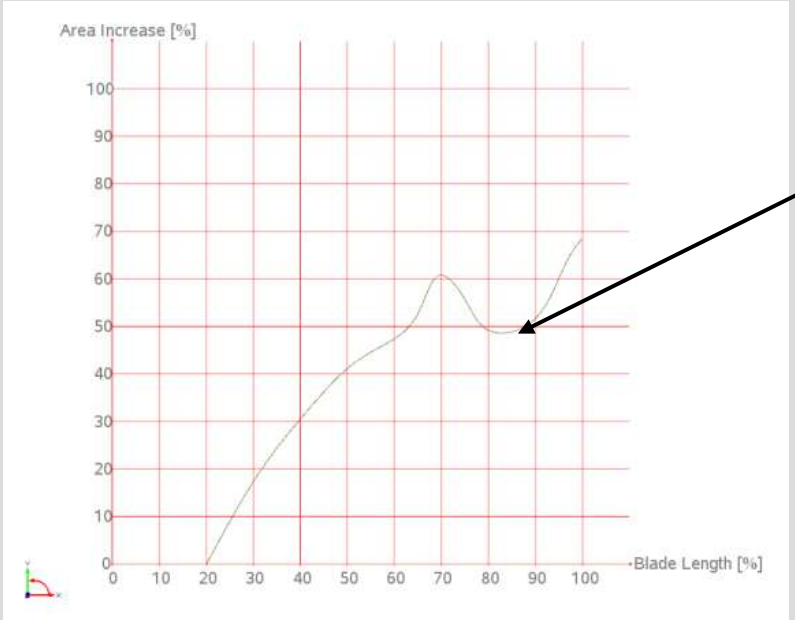
2d intersection curves for different wrap angles

Design criteria
Radial Section

- Blade should intersect hub and shroud by angle of 90°
- Procedure:
  - Intersection curves of radial plane with camber surface
  - Projection of intersection curves onto meridian plane to generate 2d radial section curves
- Repetition for different wrap angles realized in feature definition



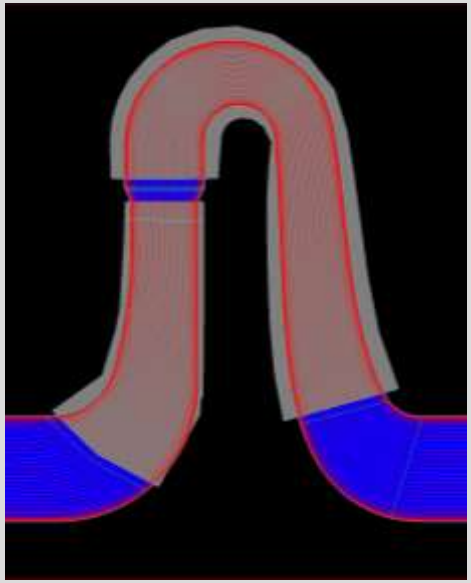




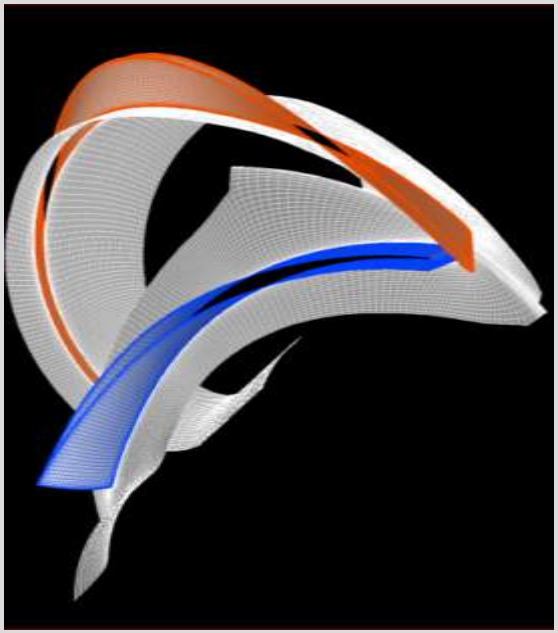
Design criteria
Channel Area

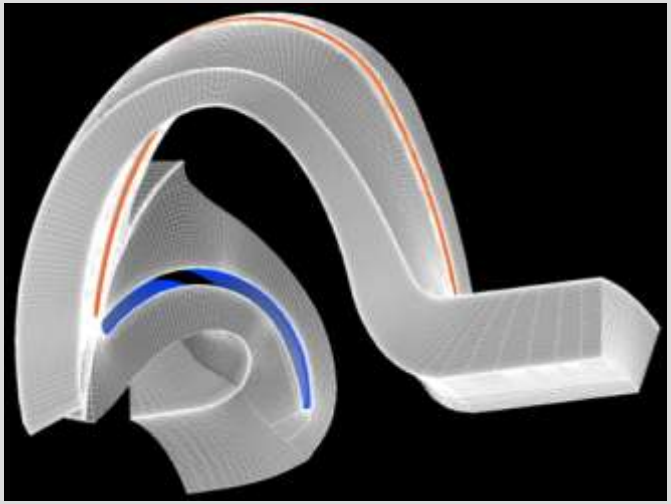
- Course of channel area should be smooth
- Procedure:
  - Generation of periodic channel faces by camber surface rotation by half of pitch angle
  - Channel area surface generation by estimation of shortest distances to hub, shroud and periodic surfaces starting from camber surface
- Repetition and preparation of course by feature definition

Geometry read in



Mesh generation finished





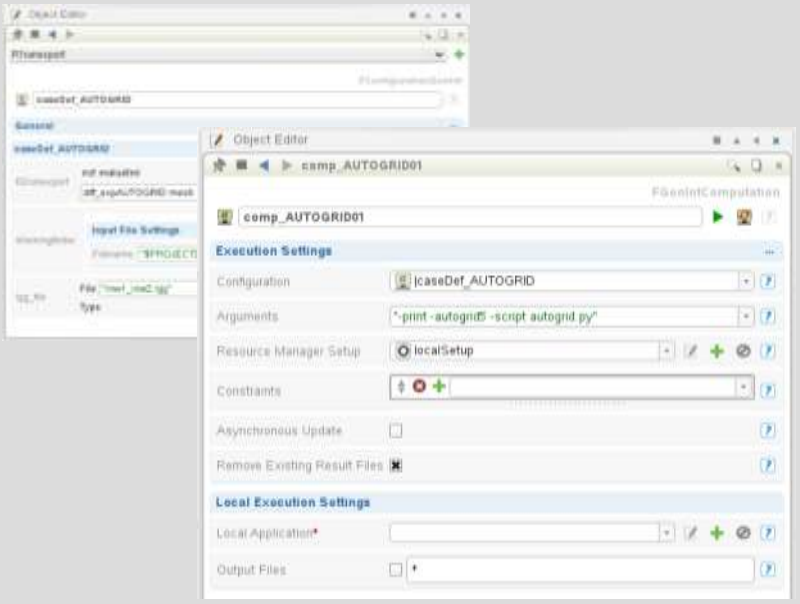
Python Script

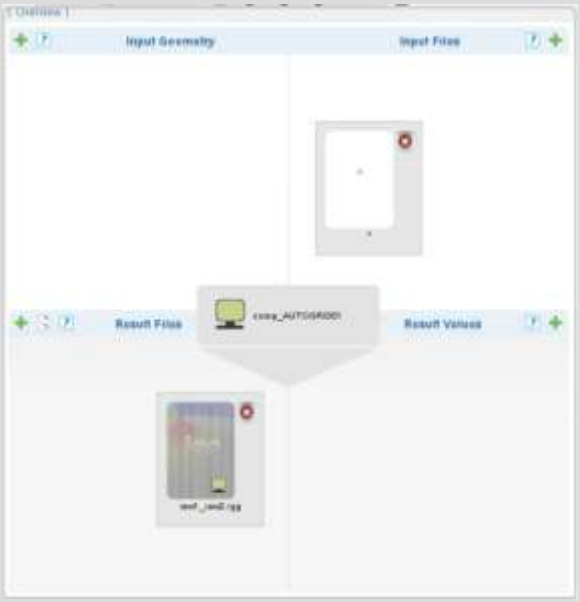
```
# -*- coding: utf-8 -*-
# igg810_2 -print -autogrid5
a5_open_project('./row1_row2.trb')
select_all()
#row(1).select()
a5_import_and_replace_geometry_file('./row2.geomTurbo')
unselect_all()
#row(2).select()
#row(1).load_geometry('./imp_blade.geomTurbo')
#a5_import_geometry_file('./diff_blade.geomTurbo')
select_all()
set_active_control_layer_index(50)
a5_start_3d_generation()
a5_save_project('./row1_row2.trb')
```

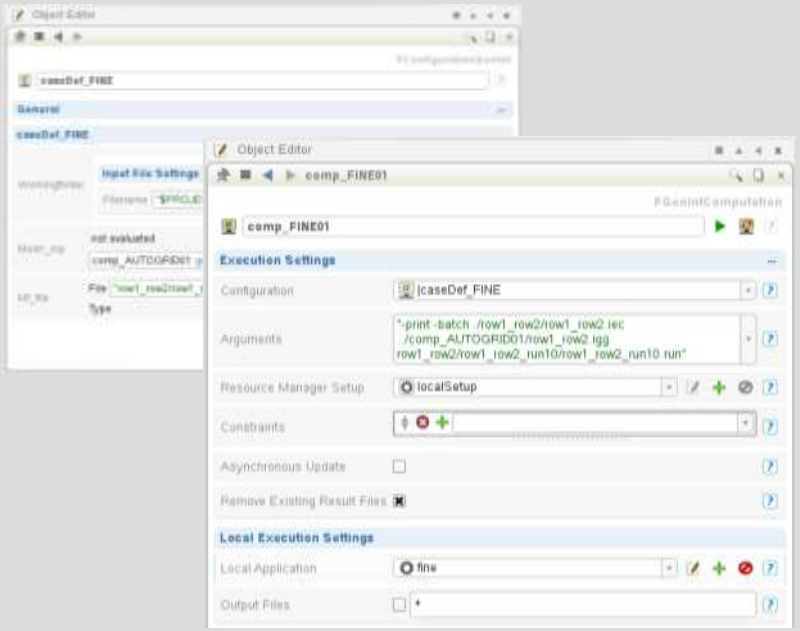
CFD-Coupling

Export AutoGrid5™ / Mesh generation

- Feature for pointwise export of meridian and blade geometry in geomTurbo format
- Very short python script for automatic mesh generation
- Automatic mesh generation for impeller and diffuser







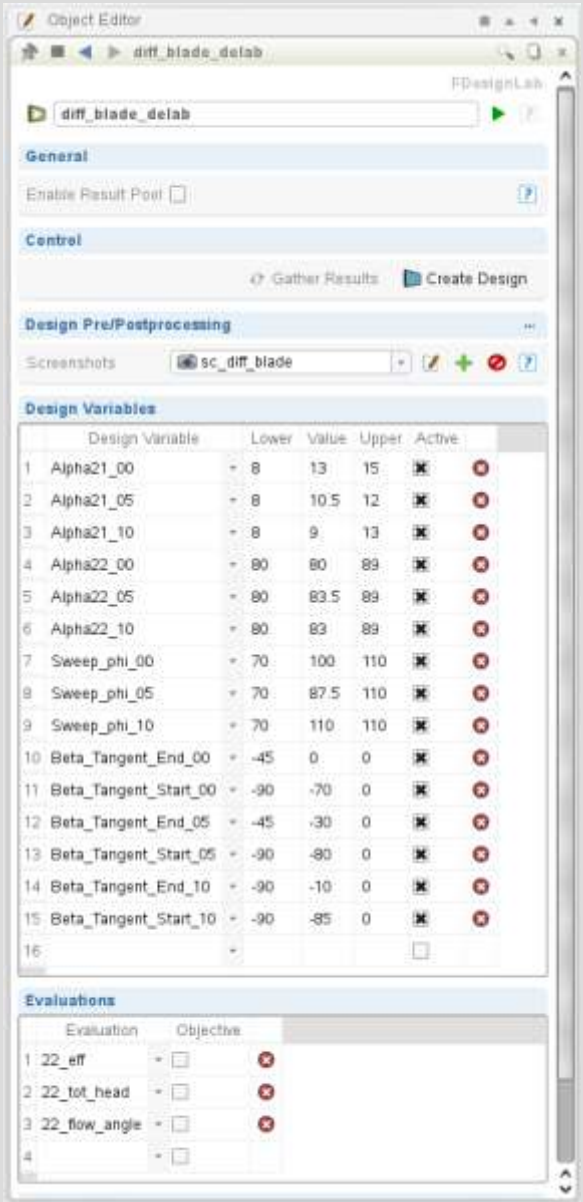
CFD-Coupling

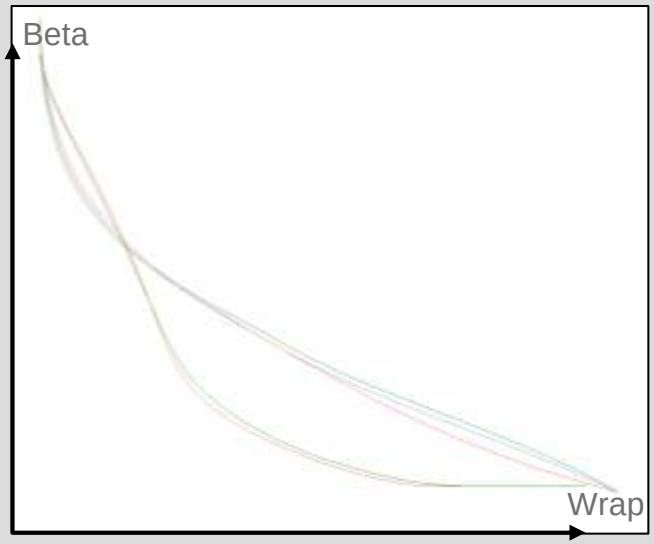
Simulation Process

- Generic Integration
- Automatic mesh generation via system command
- Automatic CFD setup by FINE™/Turbo system command
- Only diffuser design point evaluating in the Framework (Reread)

Further process outside *Framework*

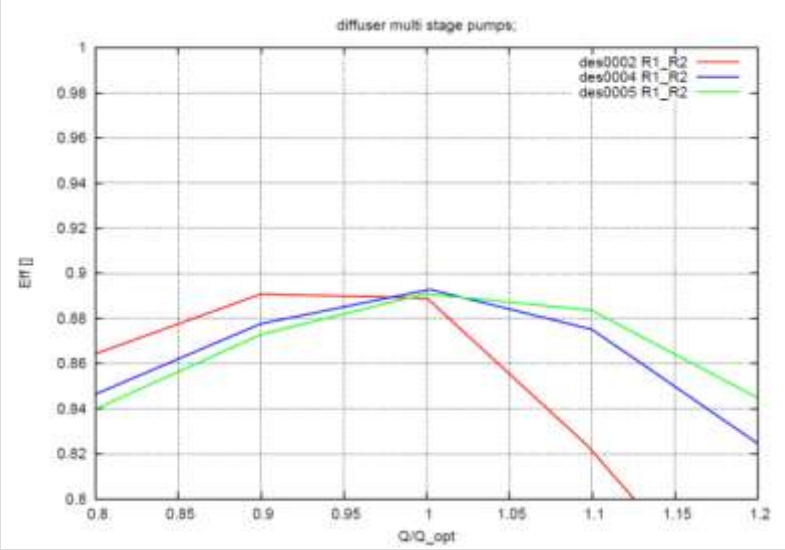
- Simulation of different flow rates
- Pearl script for reading FINE™/Turbo result files and data plotting with Gnuplot

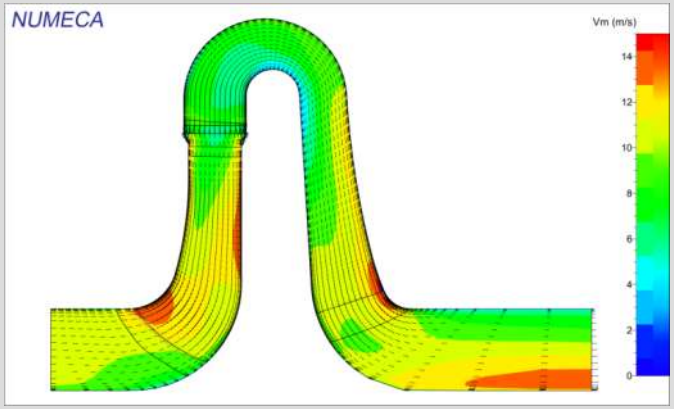


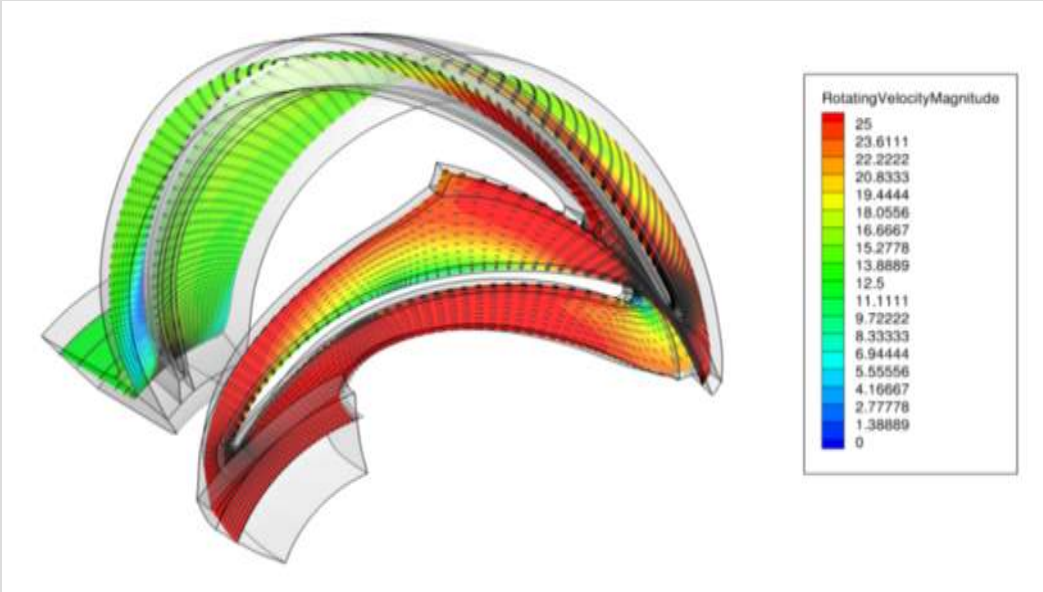


Design Optimization Process
Example

- FDesignLab
- IGES Export of promising geometry data to CAD for integration into PLM







Design Optimization Process
Results

- Post Processing with CFView and Tecplot possible

Prospect and

Conclusion

Conclusion

- Modeling of high quality multi stage pump diffusers with special consideration of design criteria
- Coupling of *Framework* with Numeca´s FINE^{TM}/Turbo CFD tools

Prospect

Extension of

Framework

application range