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Ansys CERTIFIED ELITE CHANNEL PARTNER

CFturbo

Parametric Turbomachinery Design and Simulations: An Introduction to CFturbo & Ansys CFD

Advanced Modeling & Simulation Seminar (AMS) Series
NASA Ames Research Center, March 18, 2021

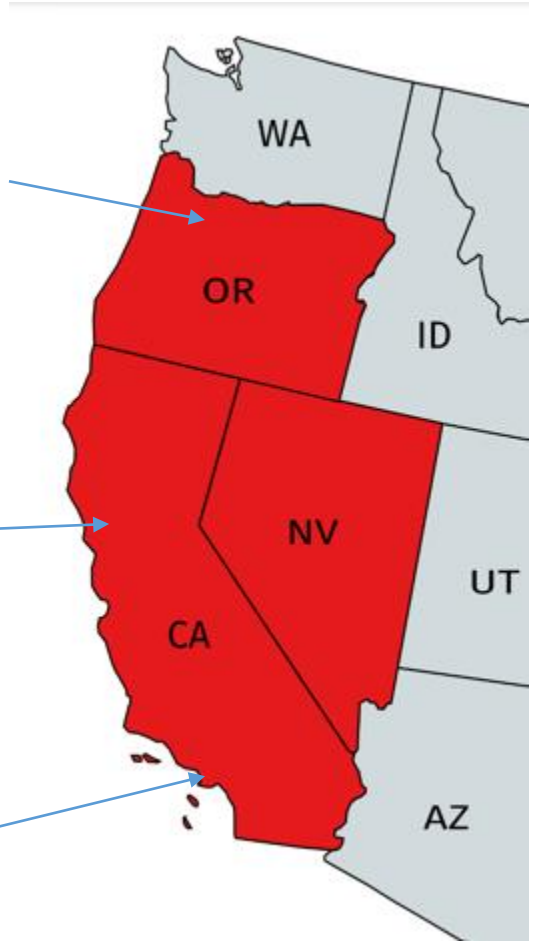
OZEN ENGINEERING

OZEN ENGINEERING, INC.

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Ansys CERTIFIED ELITE CHANNEL PARTNER

- Portland, OR
- Sunnyvale, CA
- Long Beach, CA*



Changing the world through the power of simulation

50 YEARS OF INNOVATION



Leading the simulation market for 50 years

#1 IN ENGINEERING SIMULATION SOFTWARE



The Industry Leader

Simulation is Our Core Business

Uniquely Positioned for Growth

Company

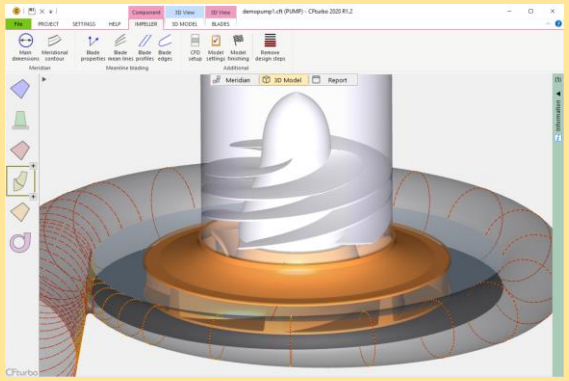
2008 est. CFturbo GmbH
Dresden, Germany

2017 est. CFturbo, Inc.
New York City

CFturbo

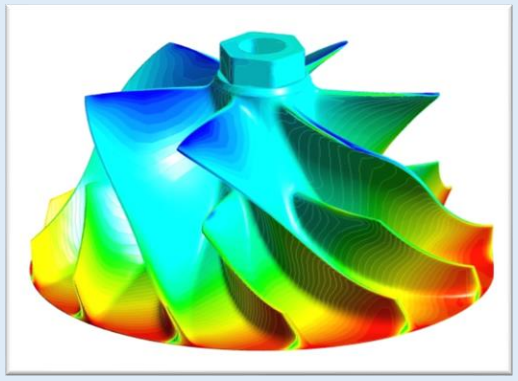
Design Software

- Turbomachinery Design Software
- Automated workflows
- Custom development



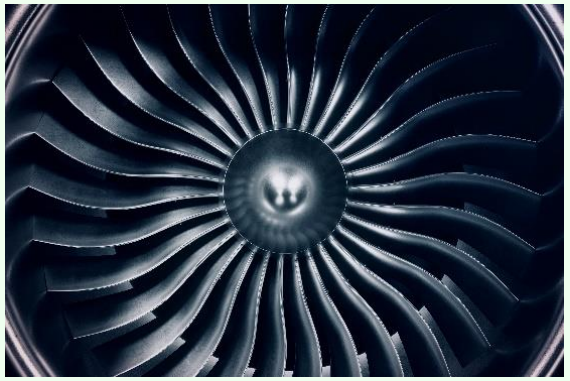
Engineering Services

- CFD/FEA-Simulation
- Digital Design Space Exploration
- Optimization



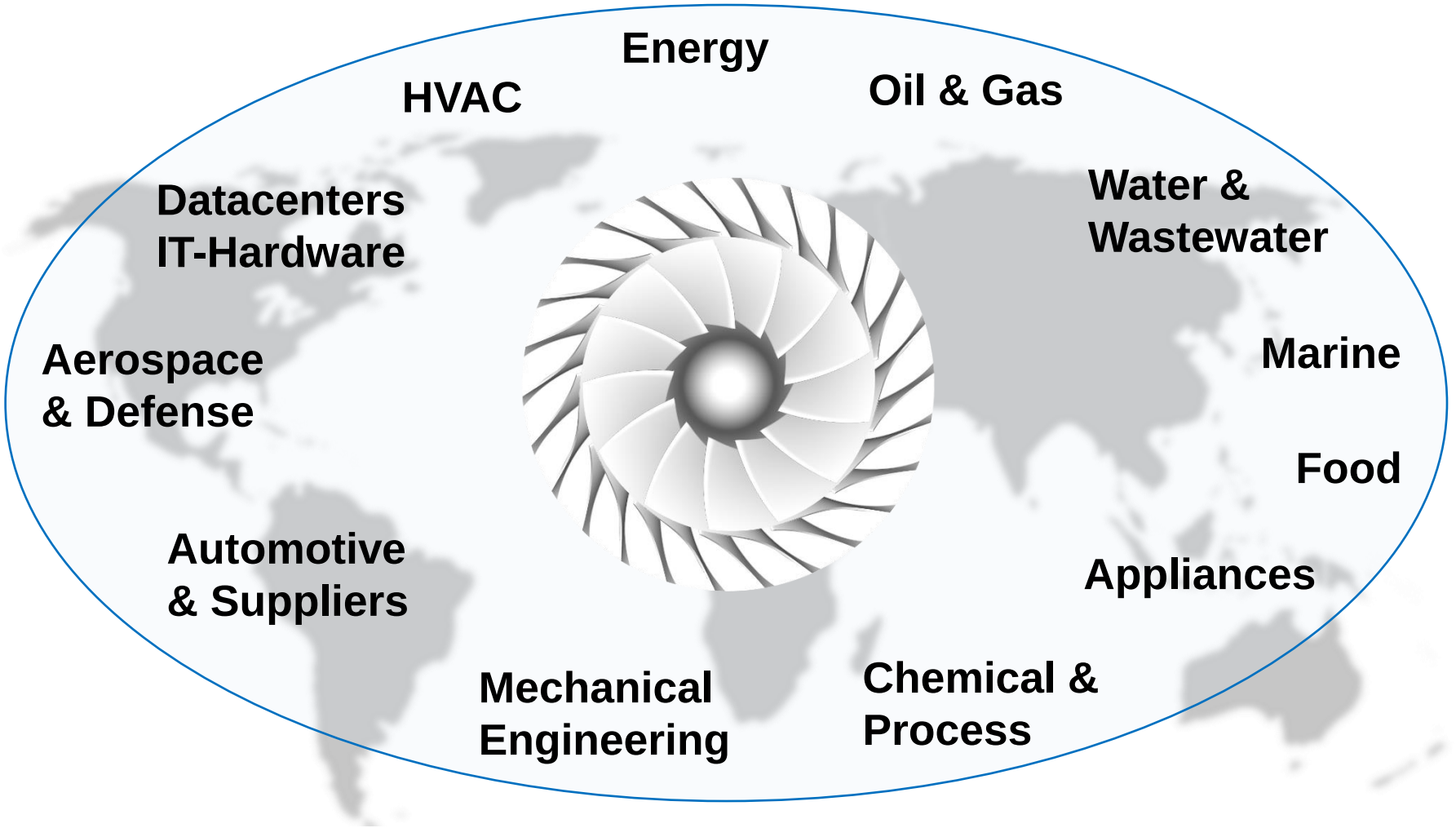
Product Development

- Mechanical Design
- Rapid Prototype Development
- Testing



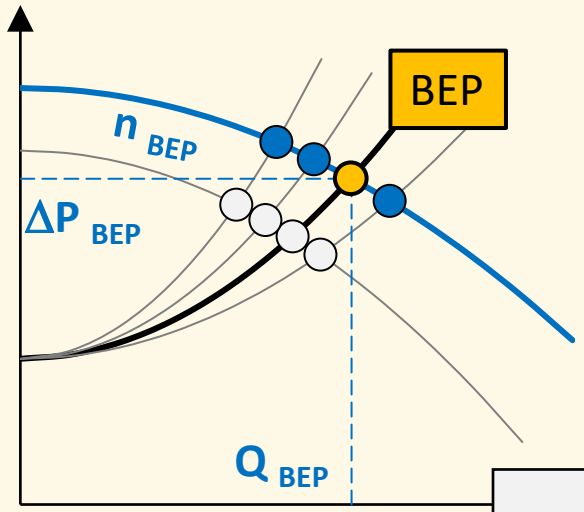
Industries

CFturbo



Various Industries - Large Corporations and SMB - Experts and Beginners

CFturbo Design Methodology



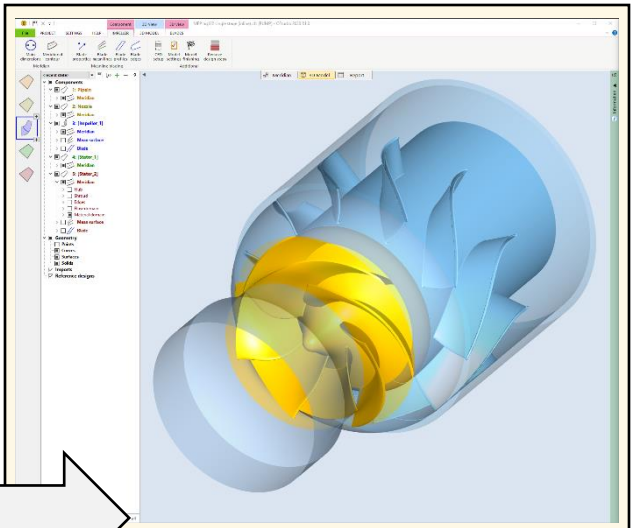
Define operating point
Best Efficiency Point (BEP)

volume flow rate, head or total pressure difference, rotational speed, fluid properties, inlet conditions

Fundamental equations
Bernoulli-, Euler equation, Mass-, Momentum-, Energy conservation, …

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Empirical correlations
Use of publicly available functions, or integrate own proprietary data

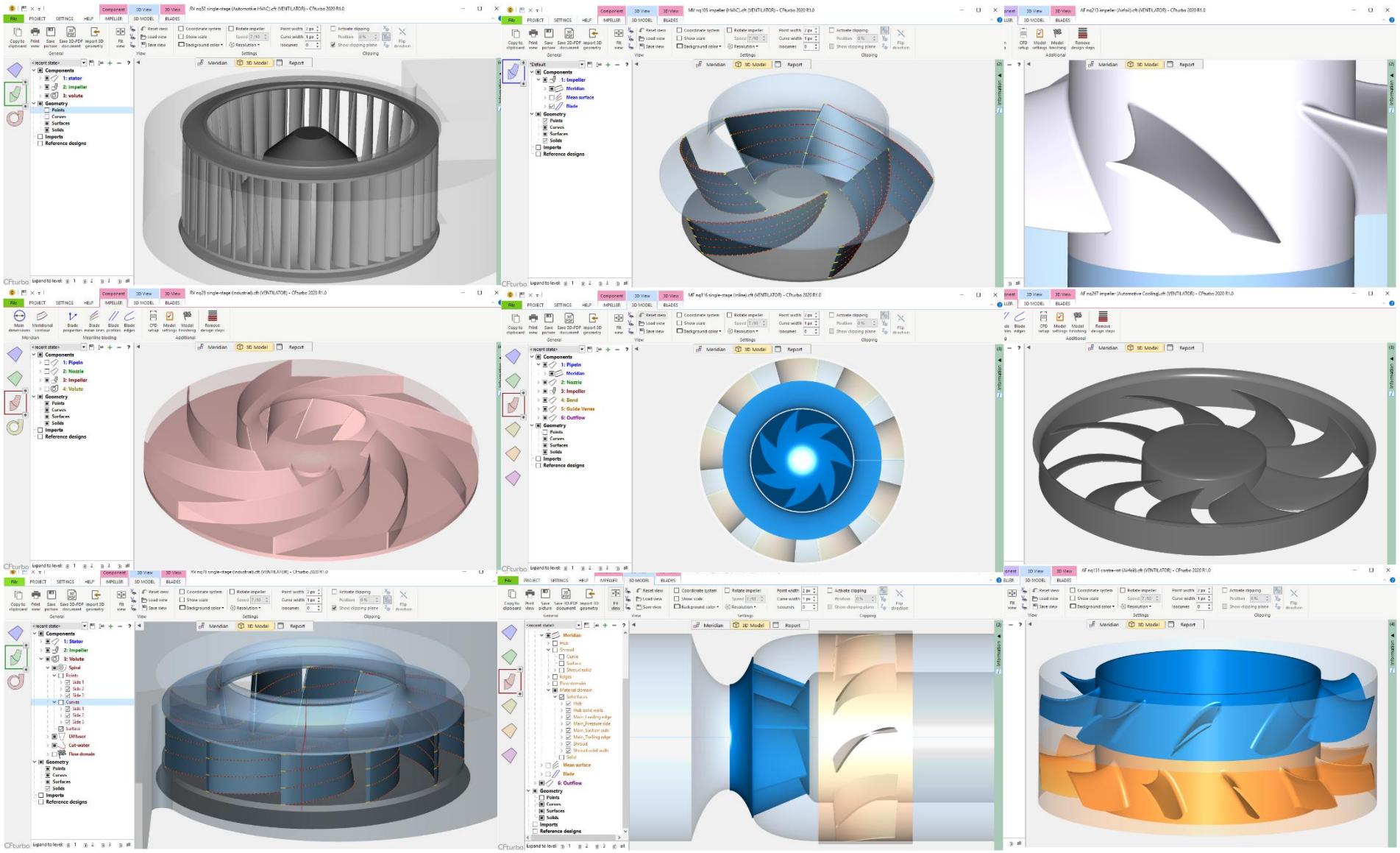


Get 3D-CAD-model
Fluid and solid domains

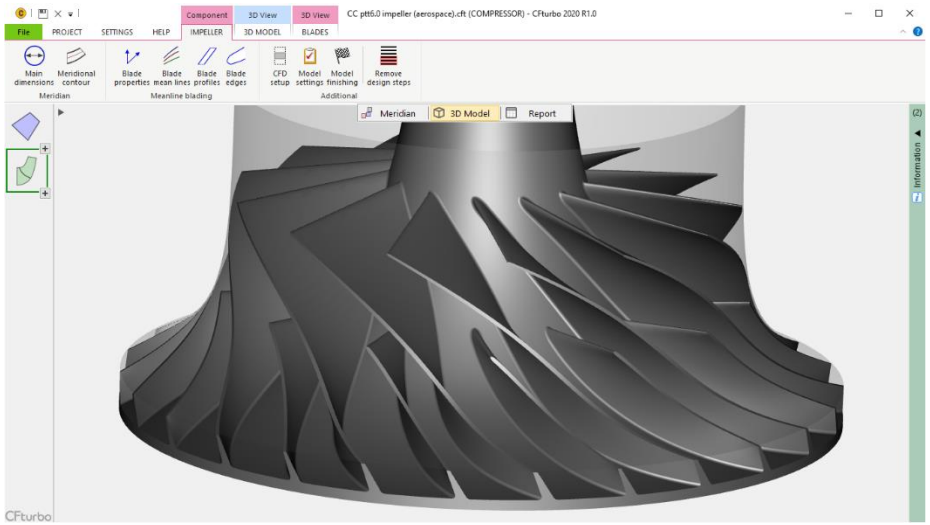
CAD / CFD / FEM - export formats
define batch-mode

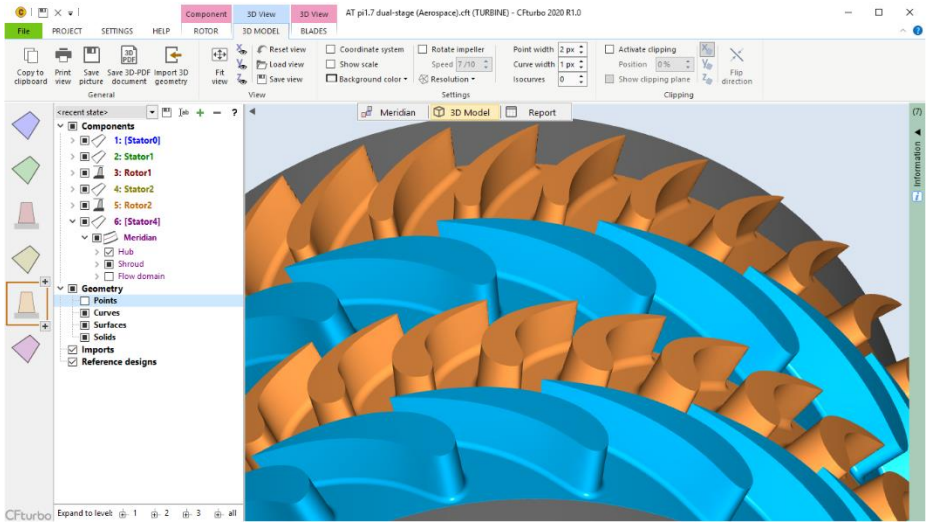
CFturbo examples - Blowers and Fans

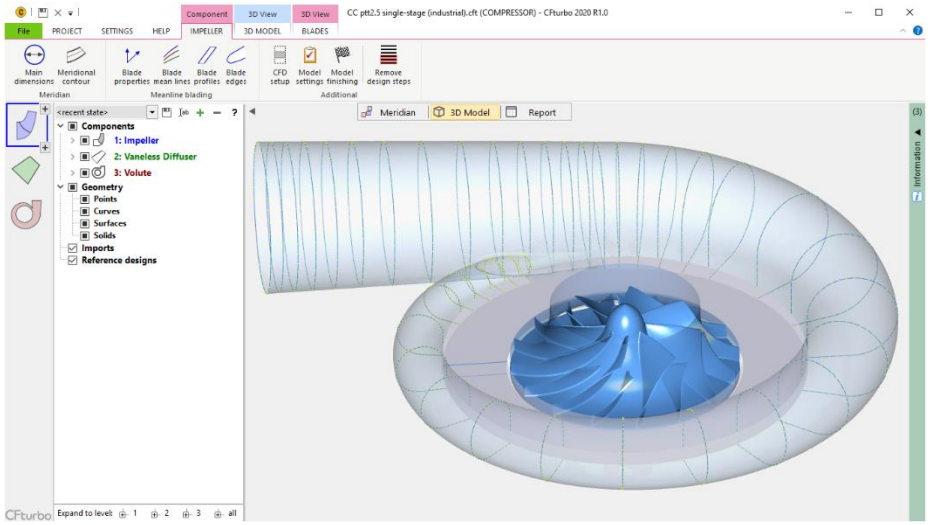
CFturbo

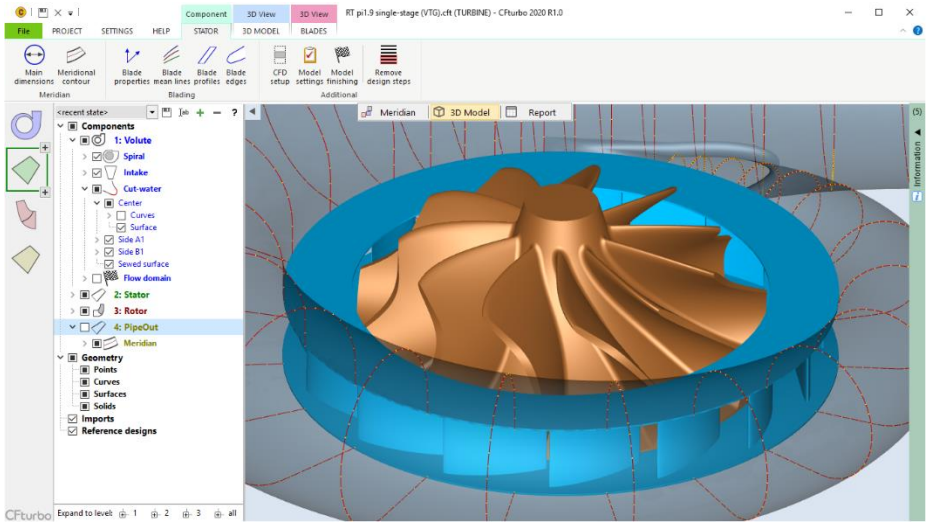


CFturbo examples - Compressors and Turbines

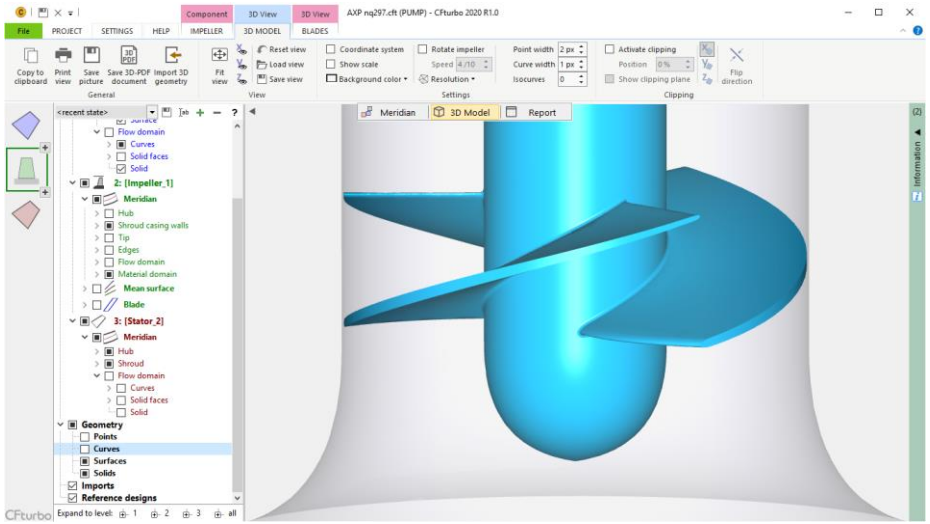


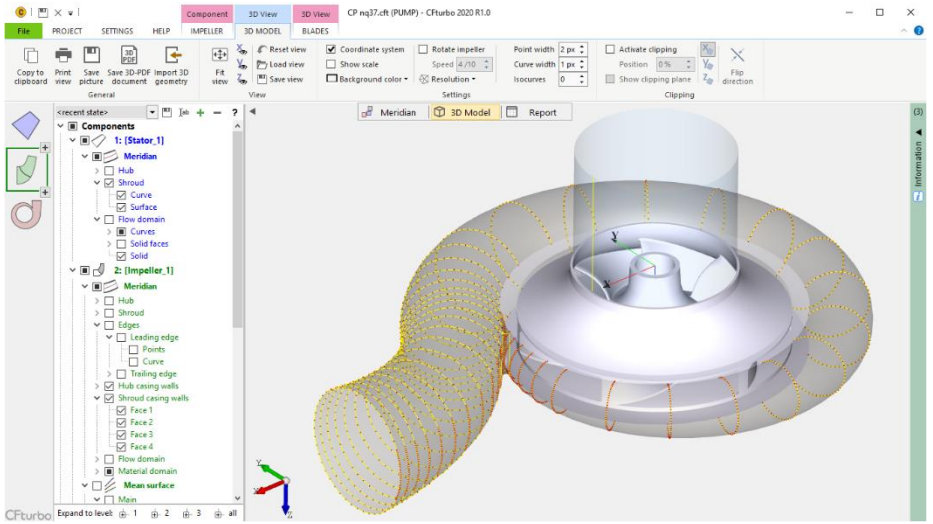


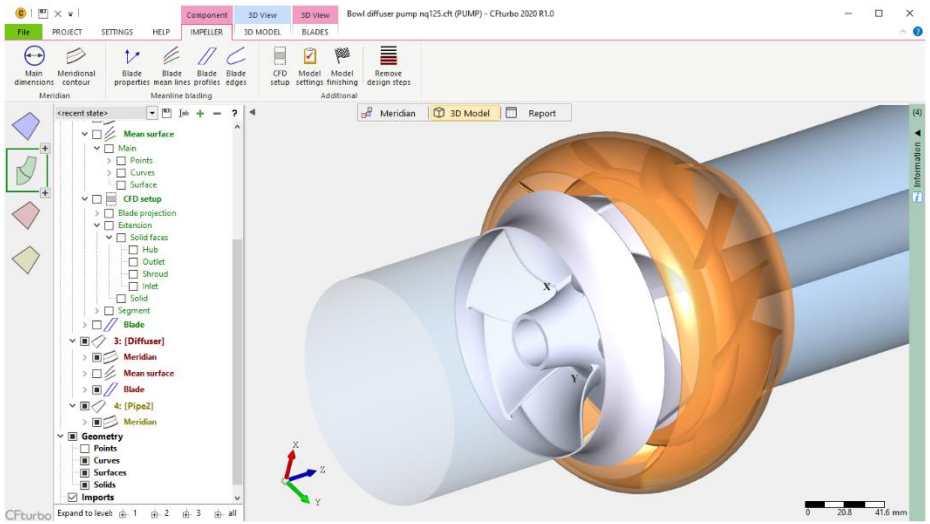


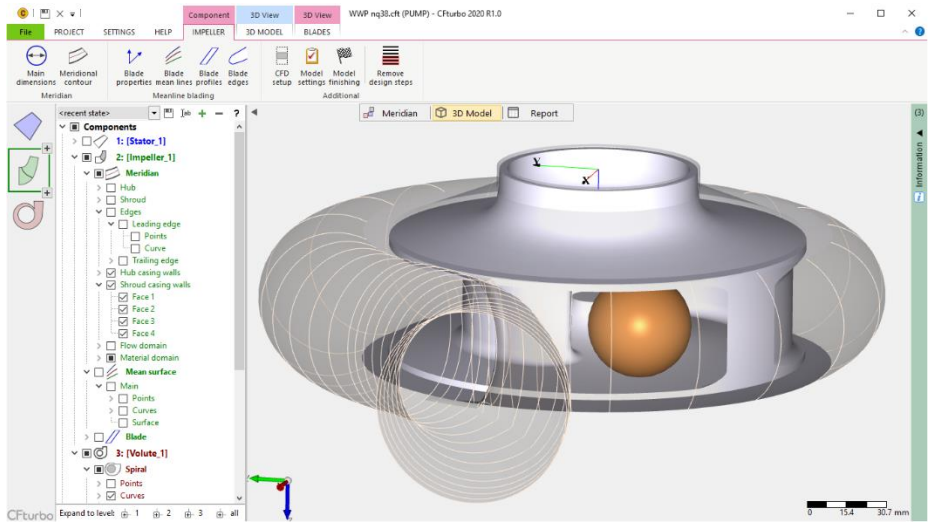


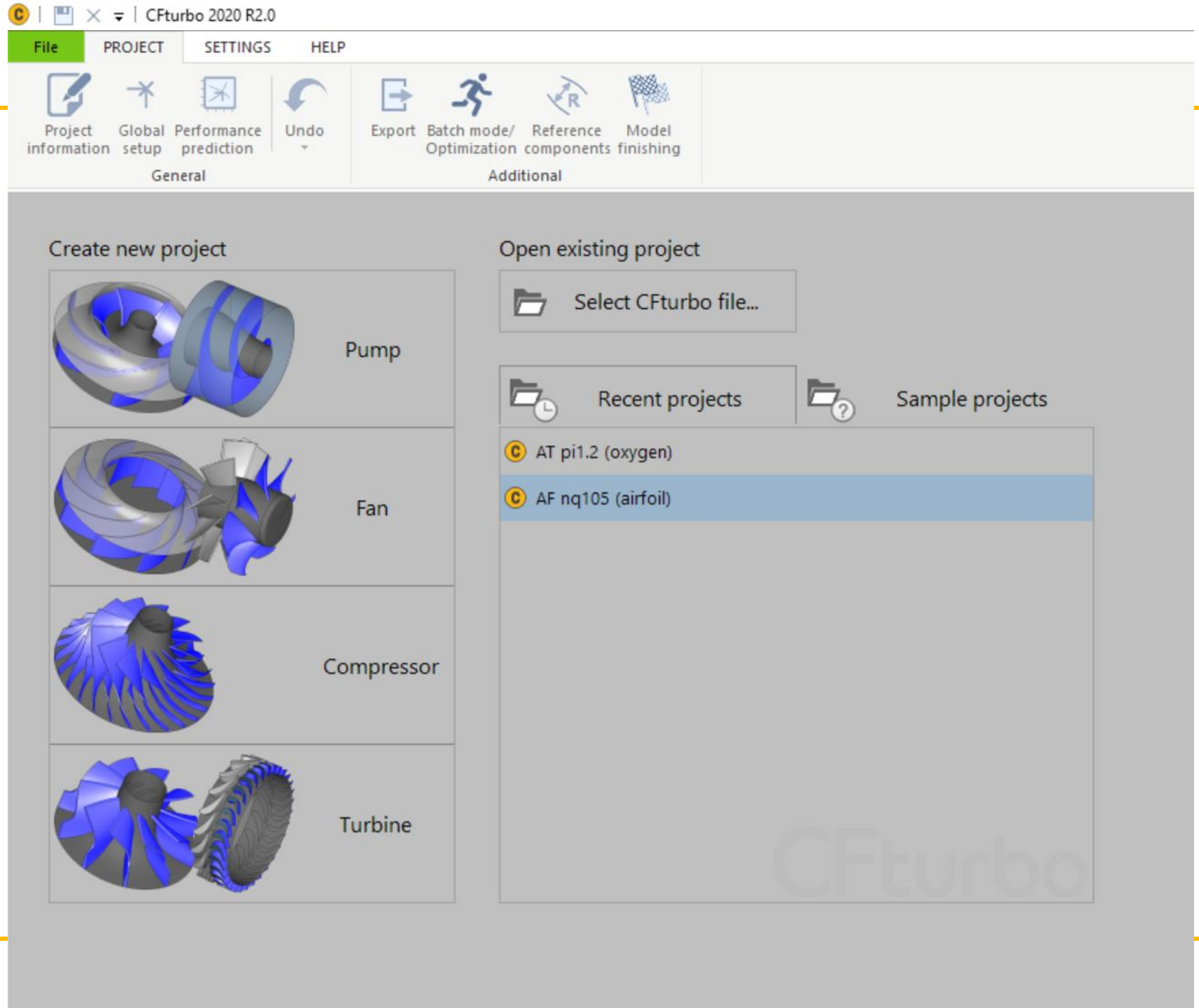
CFturbo examples - Pumps










CFturbo 2020 R2.0
File
PROJECT
SETTINGS
HELP
Project information
Global setup
Performance prediction
Undo
General
Export
Batch mode/ Optimization
Reference components
Model finishing
Additional
Create new project
Pump
Fan
Compressor
Turbine
Open existing project
Select CFturbo file...
Recent projects
Sample projects
AT pi1.2 (oxygen)
AF nq105 (airfoil)
CFturbo

Component | 3D View | 3D View | AT pi1.2 (oxygen).cft (TURBINE) - CFturbo 2020 R2.0

File | PROJECT | SETTINGS | HELP | ROTOR | 3D MODEL | BLADES

Main dimensions | Meridional contour | Blade properties | Blade mean lines | Blade profiles | Blade edges | CFD setup | Model settings | Model finishing | Remove design steps

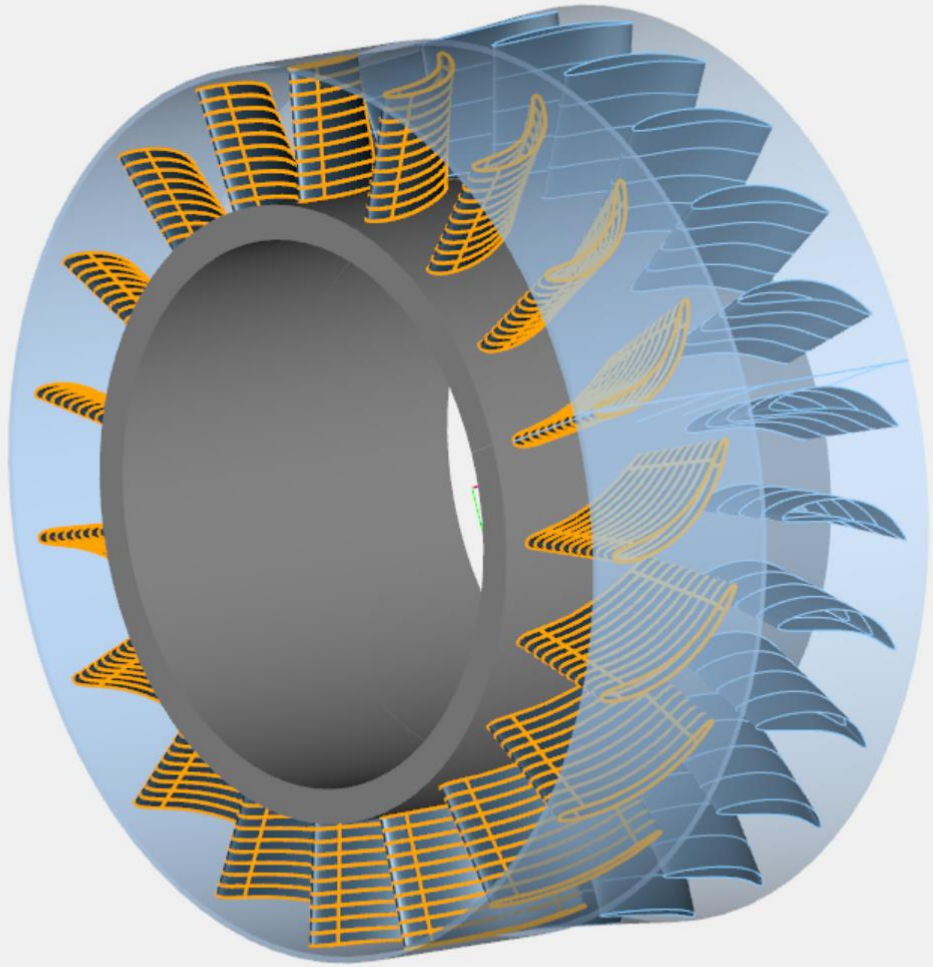
Meridian | Meanline blading | Additional

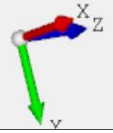
<recent state>

- Components
  - 1: Nozzle
    - Meridian
    - Mean surface
    - Blade
  - 2: Rotor
    - Meridian
    - Mean surface
    - Blade
- Geometry
  - Points
  - Curves
  - Surfaces
  - Solids
- Imports
- Reference designs

Expand to level: 1 2 3 all

Meridian | 3D Model | Report





0 10.1 20.2 mm

4 | 0 | 0 | (4)

Information

Global setup

With given total pressure at inlet only axial rotors can be designed.

1: Nozzle

Automated blade angles are NOT active. Values are fixed but may not reflect input parameters.

2: Rotor

Automated Main dimensions are NOT active. Dimensions are fixed, but may not reflect input parameters.

Automated blade angles are NOT active. Values are fixed but may not reflect input parameters.

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Main dimensions

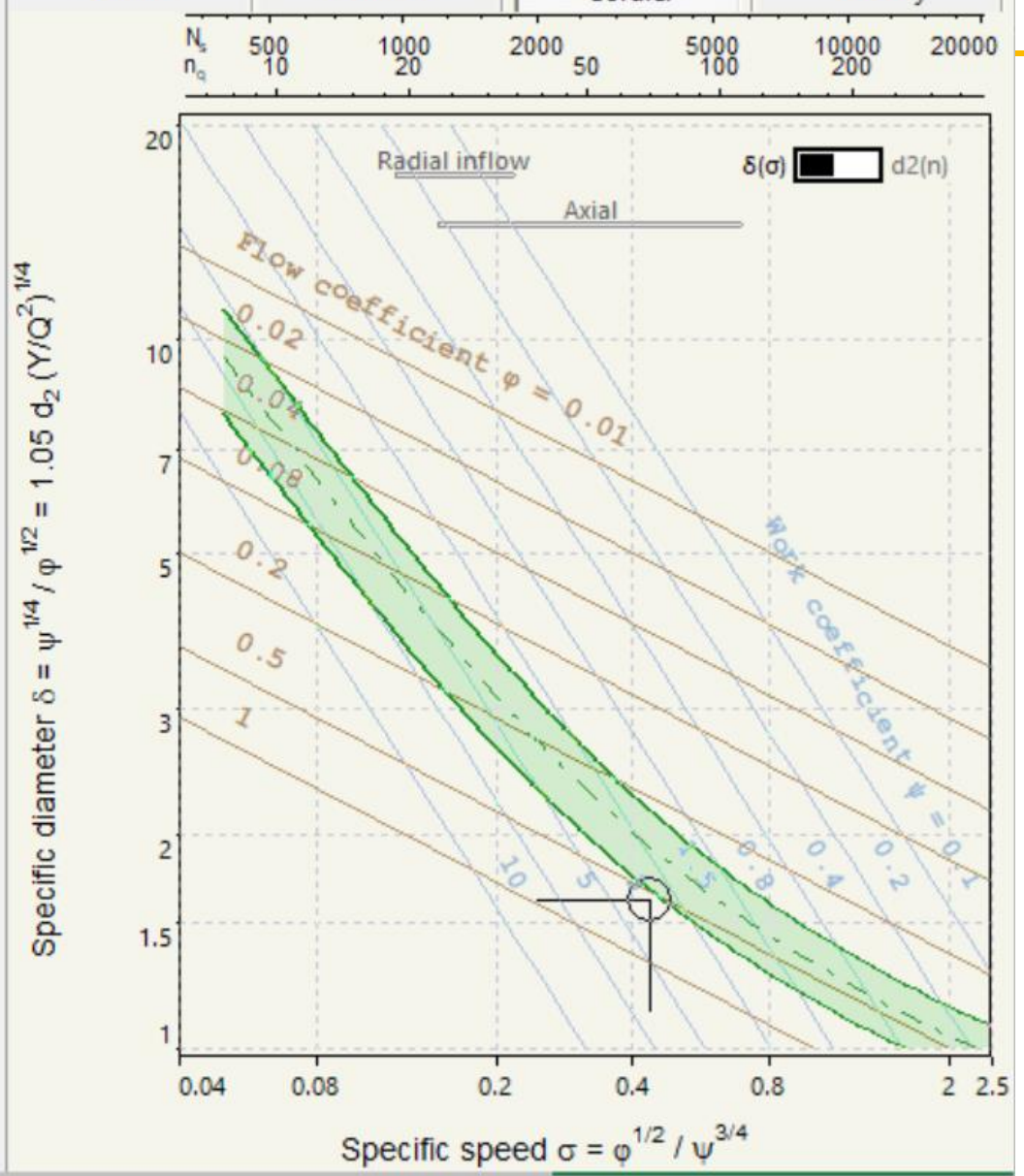
1 Setup | 2 Parameters | 3 Dimensions

General

- [ ] Manual dimensioning
- [x] Unshrouded Tip clearance xIn 0.16 xOut 0.16 mm
- Material density ρ 7750 kg/m³
- Impeller type: Standard
- [ ] Consider upstream swirl
- Blade design mode: Mean Line — using Euler equation on mean lines

Multi stage options

Values | Meridian | Cordier | Velocity



Information

✔ OK | ✖ Cancel | ? Help

Main dimensions

1 Setup | 2 Parameters | 3 Dimensions

Automatic | Set default

Parameters

Used for ave. diameter dM1

Isen. vel. ratio total-total — vstt 0.52

Used for inlet diameters dH1, dS1

Diameter ratio dH/dS — v1 70 %

Meridional expansion/ contraction — Coaxial @Hub

Used for hub diameter dH2

Meridional velocity ratio — cm2/cm1 1

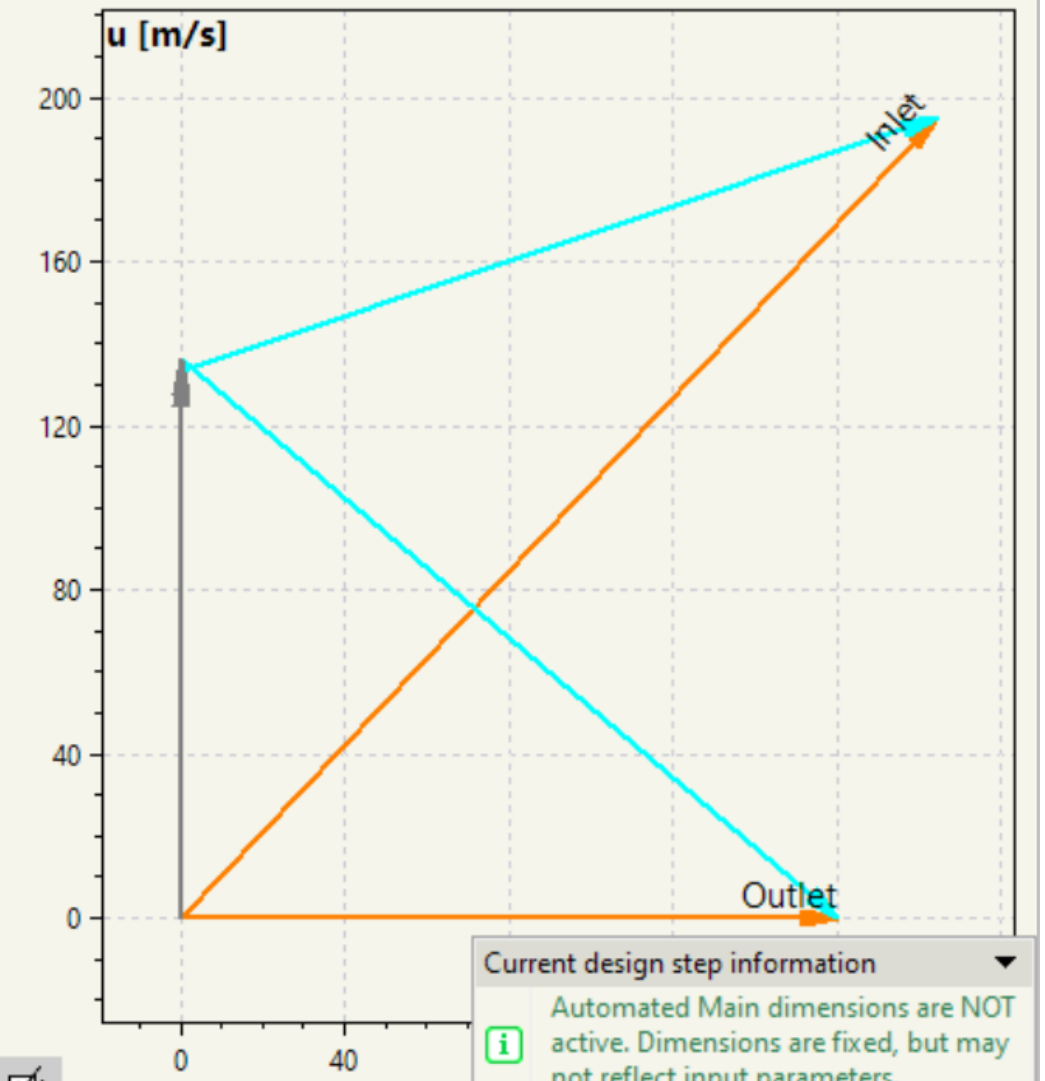
Efficiencies

Design relevant | Information only

Total-to-static efficiency — ηts 72.5 %

Values | Meridian | Cordier | Velocity

absolute (c) | relative (w) | velocity @ mid-span

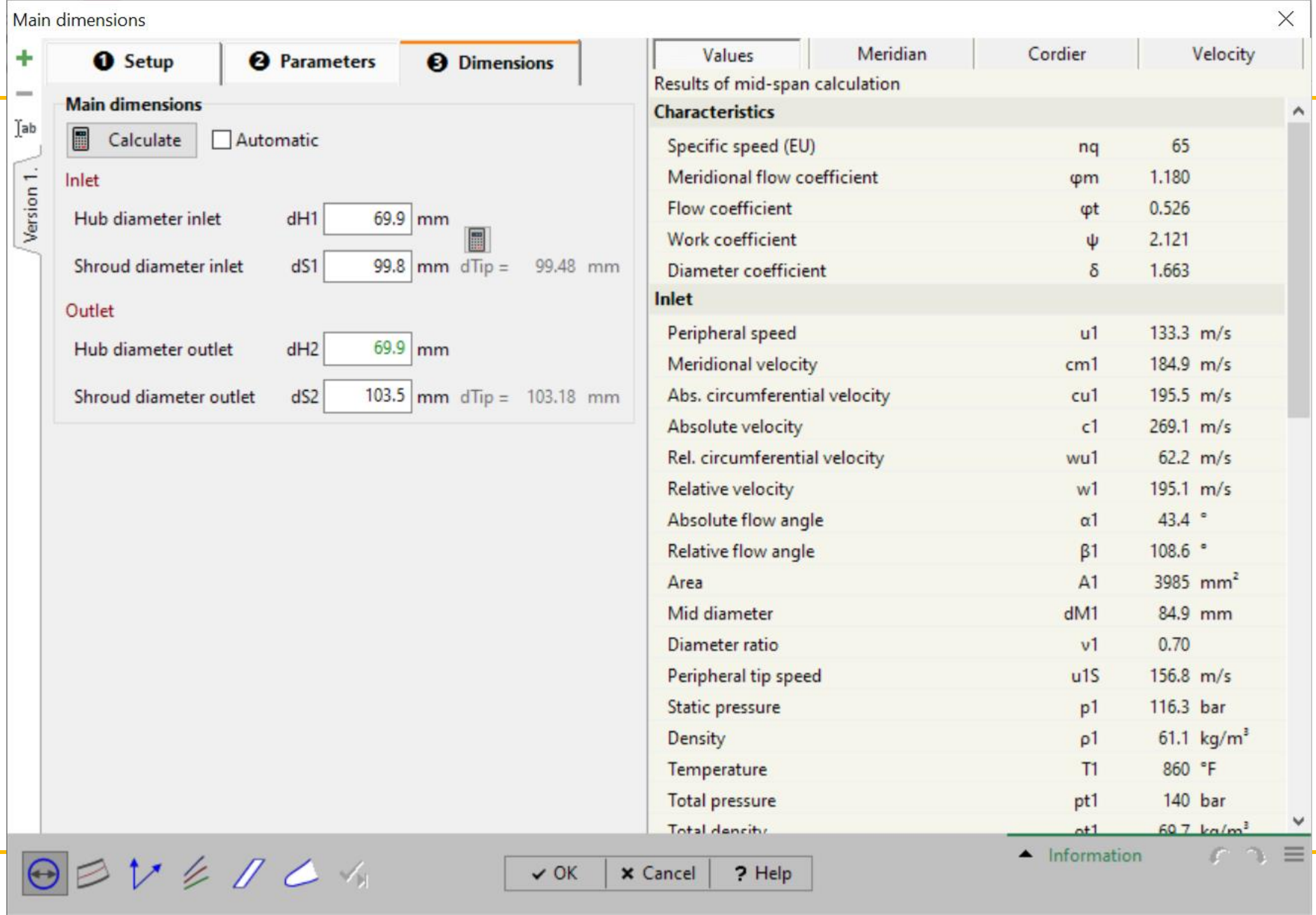


Current design step information

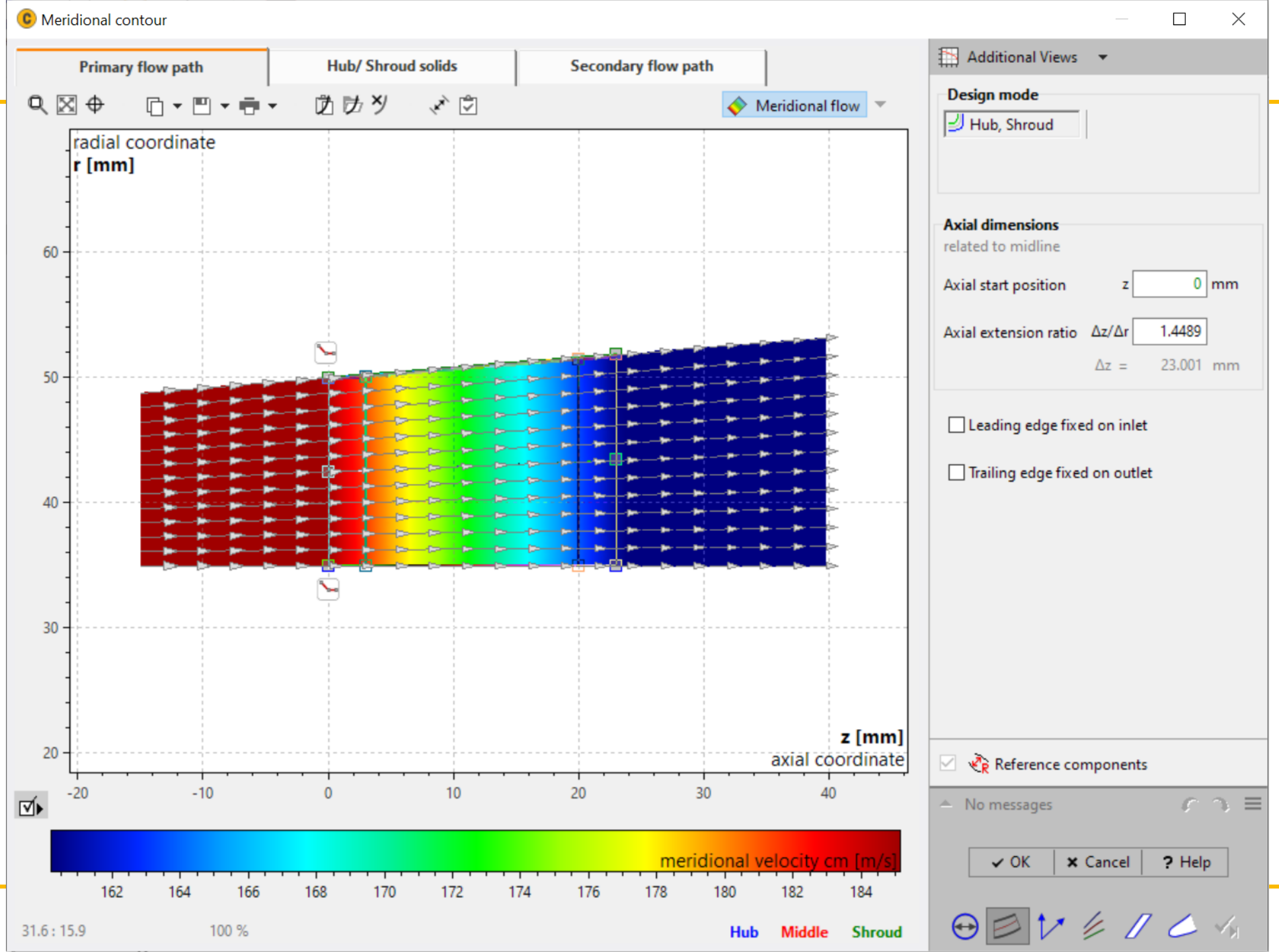
Automated Main dimensions are NOT active. Dimensions are fixed, but may not reflect input parameters.

Information

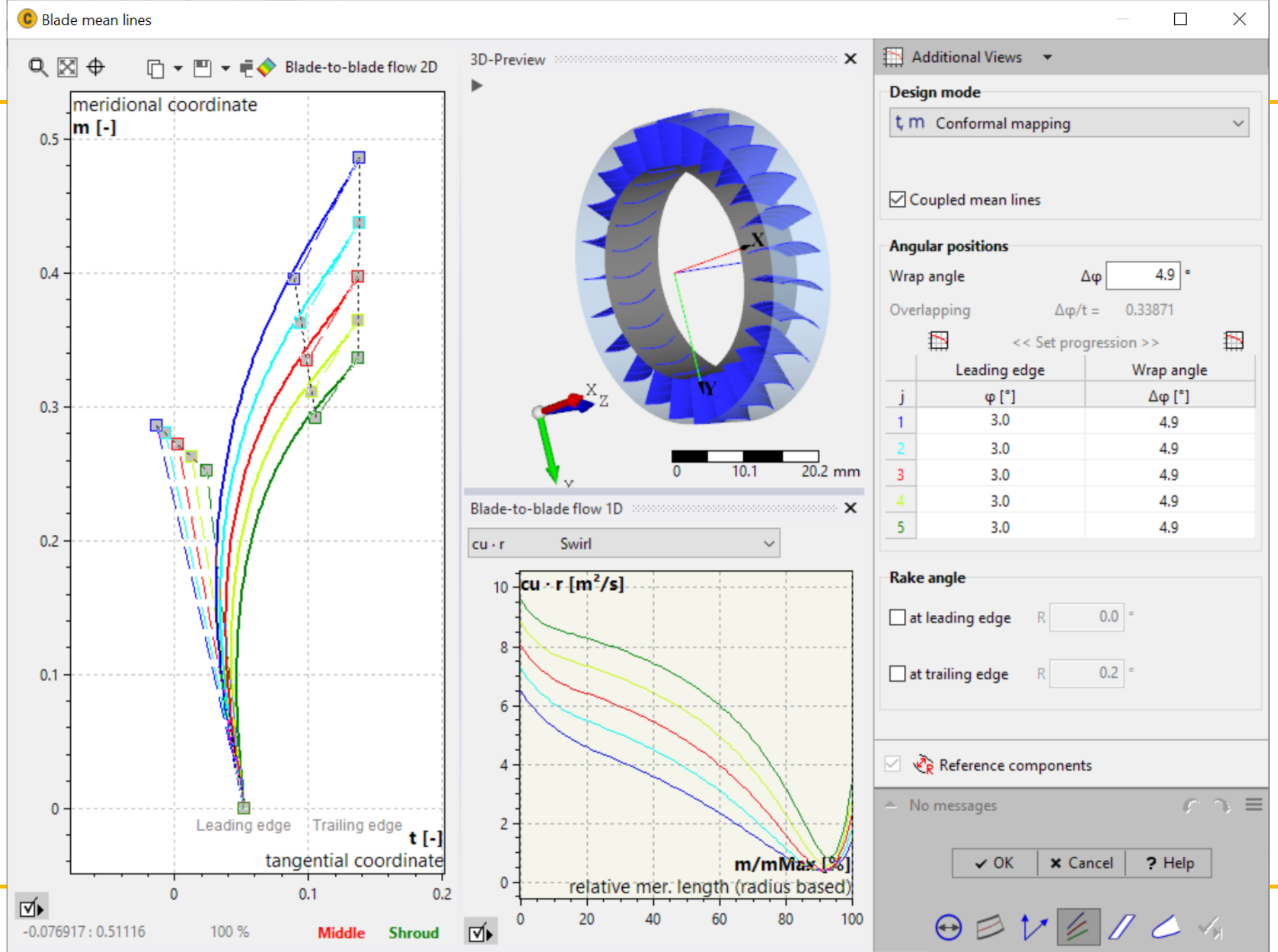
OK | Cancel | Help


Main dimensions
1 Setup
2 Parameters
3 Dimensions
Main dimensions
Calculate
Automatic
Inlet
Hub diameter inlet dH1 69.9 mm
Shroud diameter inlet dS1 99.8 mm dTip = 99.48 mm
Outlet
Hub diameter outlet dH2 69.9 mm
Shroud diameter outlet dS2 103.5 mm dTip = 103.18 mm
Values
Meridian
Cordier
Velocity
Results of mid-span calculation
Characteristics
Specific speed (EU) nq 65
Meridional flow coefficient φm 1.180
Flow coefficient φt 0.526
Work coefficient ψ 2.121
Diameter coefficient δ 1.663
Inlet
Peripheral speed u1 133.3 m/s
Meridional velocity cm1 184.9 m/s
Abs. circumferential velocity cu1 195.5 m/s
Absolute velocity c1 269.1 m/s
Rel. circumferential velocity wu1 62.2 m/s
Relative velocity w1 195.1 m/s
Absolute flow angle α1 43.4 °
Relative flow angle β1 108.6 °
Area A1 3985 mm²
Mid diameter dM1 84.9 mm
Diameter ratio v1 0.70
Peripheral tip speed u1S 156.8 m/s
Static pressure p1 116.3 bar
Density ρ1 61.1 kg/m³
Temperature T1 860 °F
Total pressure pt1 140 bar
OK
Cancel
Help
Information

CFturbo


Meridional contour
Primary flow path
Hub/ Shroud solids
Secondary flow path
Meridional flow
radial coordinate
r [mm]
60
50
40
30
20
-20
-10
0
10
20
30
40
z [mm]
axial coordinate
meridional velocity cm [m/s]
162
164
166
168
170
172
174
176
178
180
182
184
31.6 : 15.9
100 %
Hub
Middle
Shroud
Additional Views
Design mode
Hub, Shroud
Axial dimensions
related to midline
Axial start position
z
0
mm
Axial extension ratio
Δz/Δr
1.4489
Δz =
23.001
mm
Leading edge fixed on inlet
Trailing edge fixed on outlet
Reference components
No messages
OK
Cancel
Help

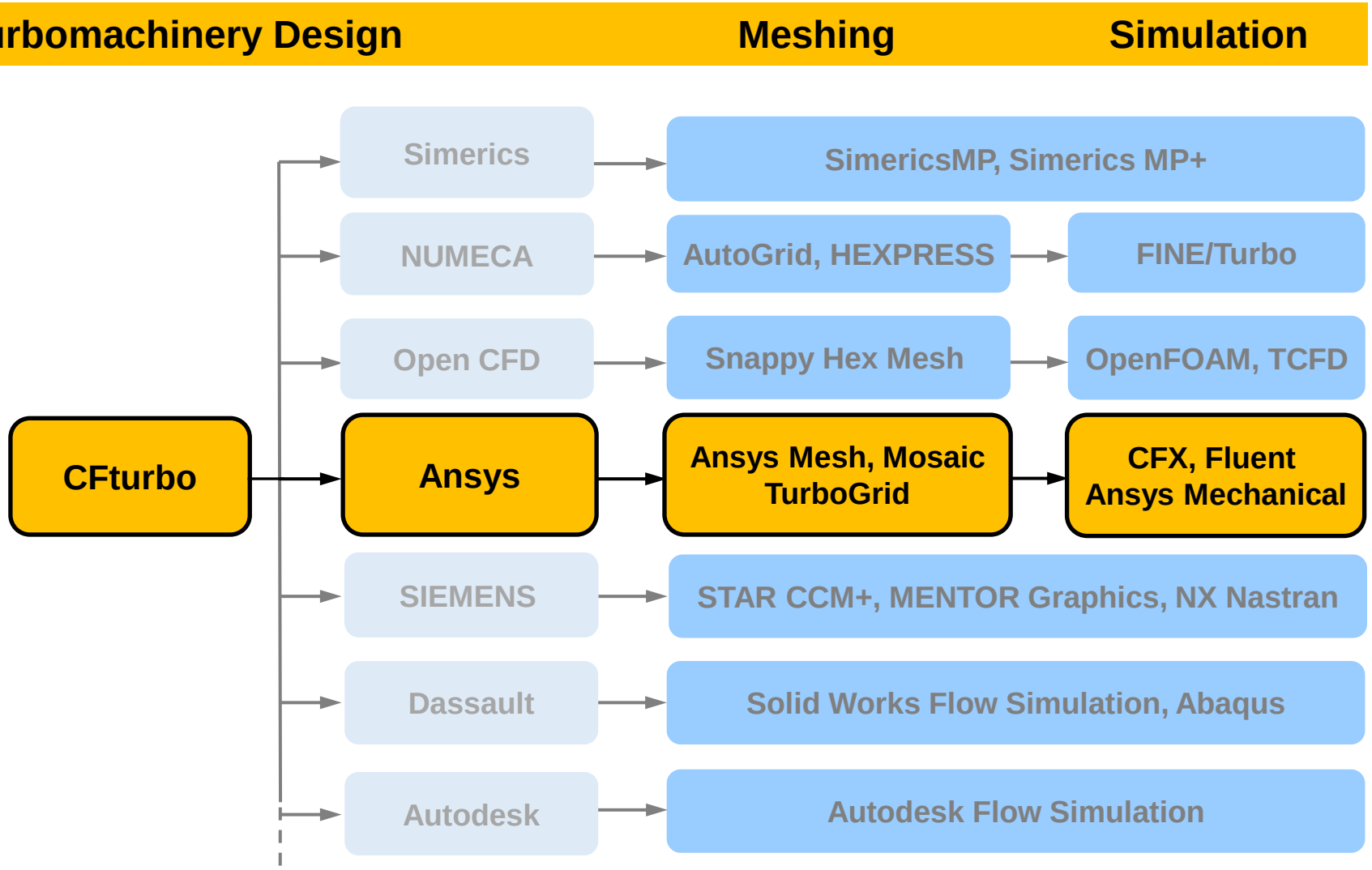
CFturbo


Blade mean lines
Blade-to-blade flow 2D
meridional coordinate
m [-]
0.5
0.4
0.3
0.2
0.1
0
Leading edge
Trailing edge
t [-]
tangential coordinate
0
0.1
0.2
-0.076917 : 0.51116
100 %
Middle
Shroud
3D-Preview
X
Z
Y
0
10.1
20.2 mm
Blade-to-blade flow 1D
cu · r
Swirl
cu · r [m²/s]
10
8
6
4
2
0
m/mMax [%]
relative mer. length (radius based)
0
20
40
60
80
100
Additional Views
Design mode
t, m Conformal mapping
Coupled mean lines
Angular positions
Wrap angle
Δφ
4.9
°
Overlapping
Δφ/t =
0.33871
<< Set progression >>
Leading edge
Wrap angle
j
φ [°]
Δφ [°]
1 3.0 4.9
2 3.0 4.9
3 3.0 4.9
4 3.0 4.9
5 3.0 4.9
Rake angle
at leading edge
R
0.0
°
at trailing edge
R
0.2
°
Reference components
No messages
OK
Cancel
Help

CFturbo

Interfaces to 3D-CFD/FEA

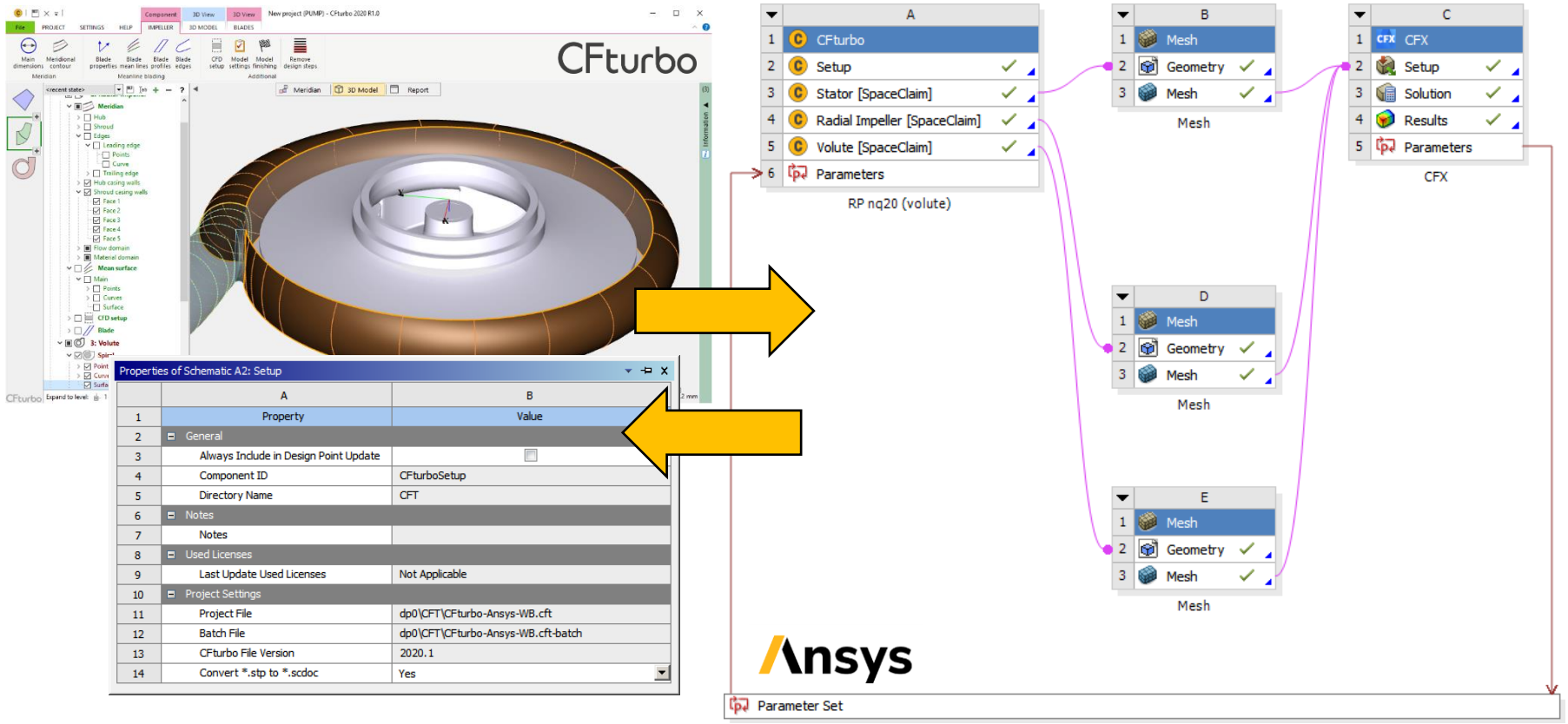
CFturbo



CFturbo in Ansys Workbench

CFturbo

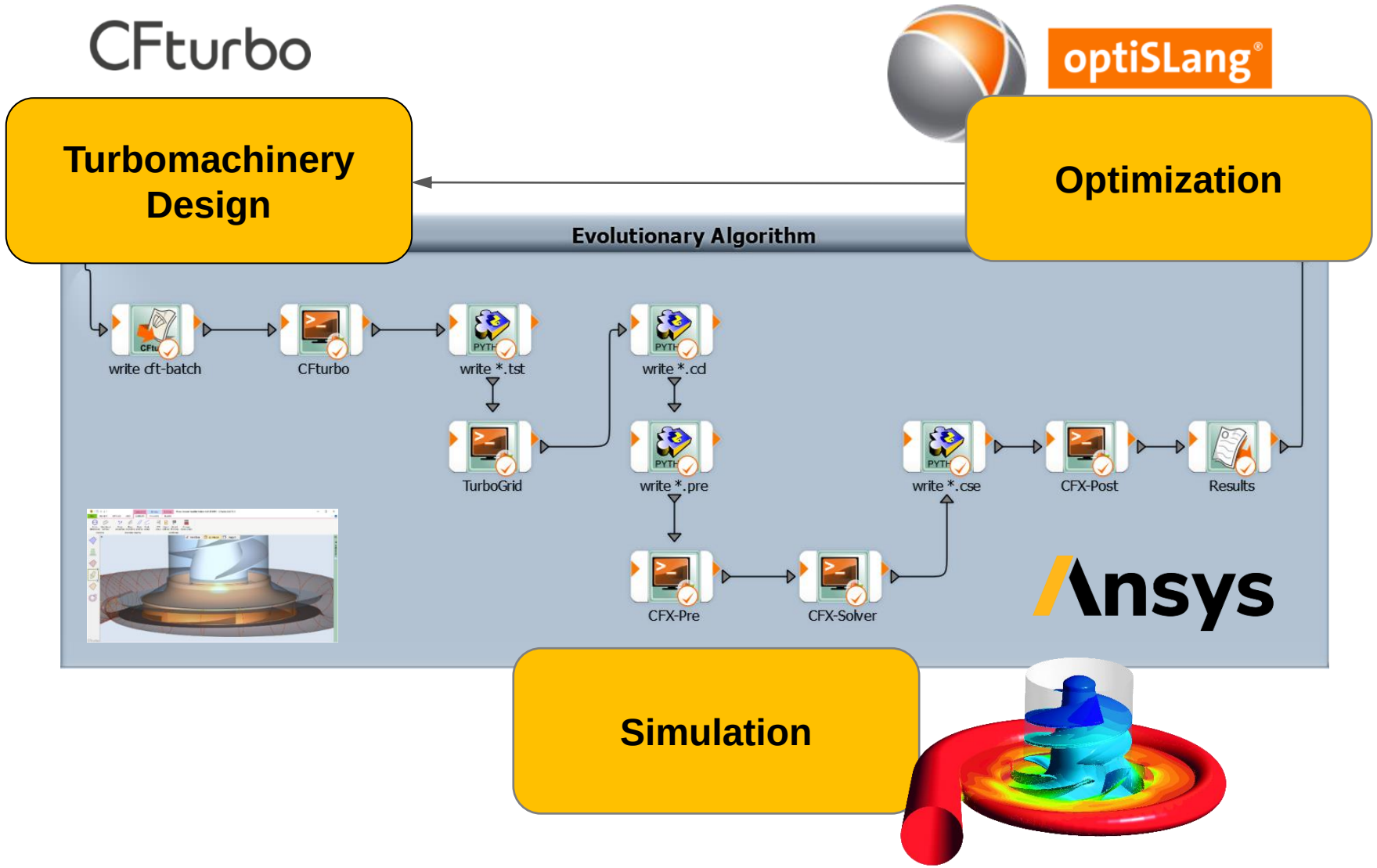
Bi-directional Integration



Interactive or Automated Design Space Exploration

Optimization Workflow

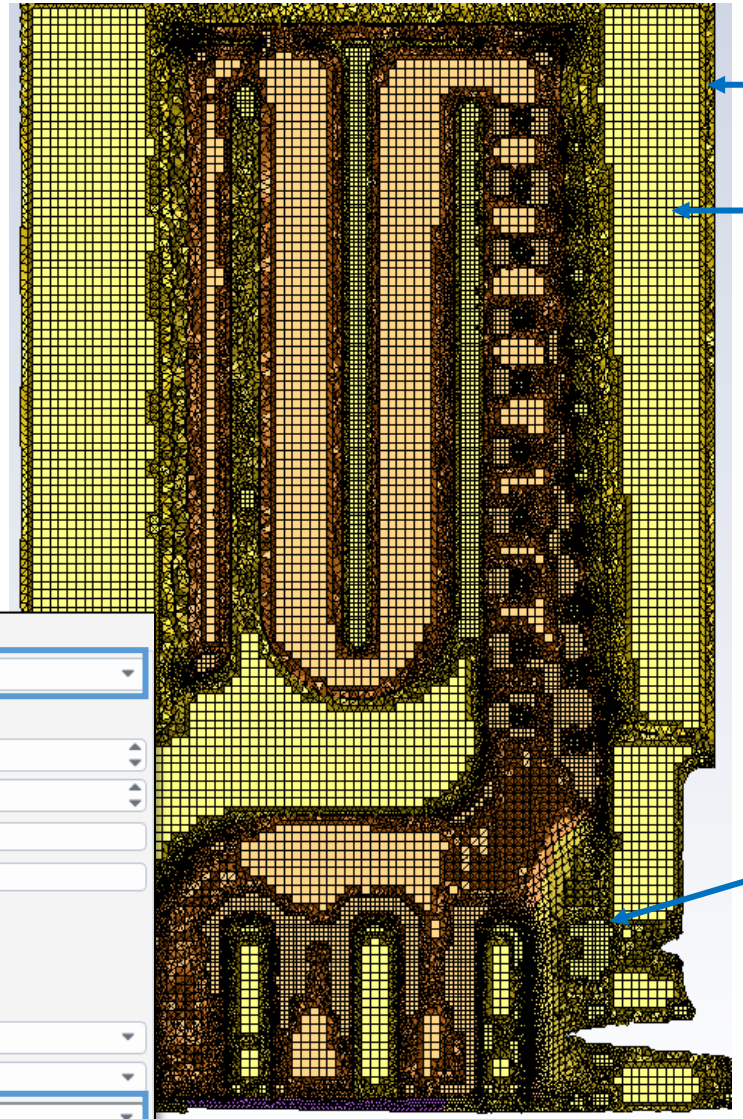
CFturbo

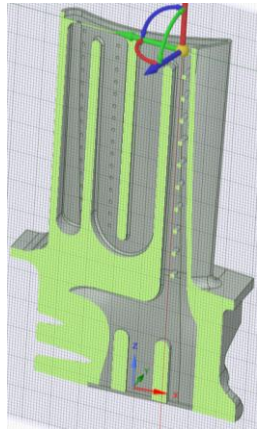


Hexcore meshes in Fluent Meshing

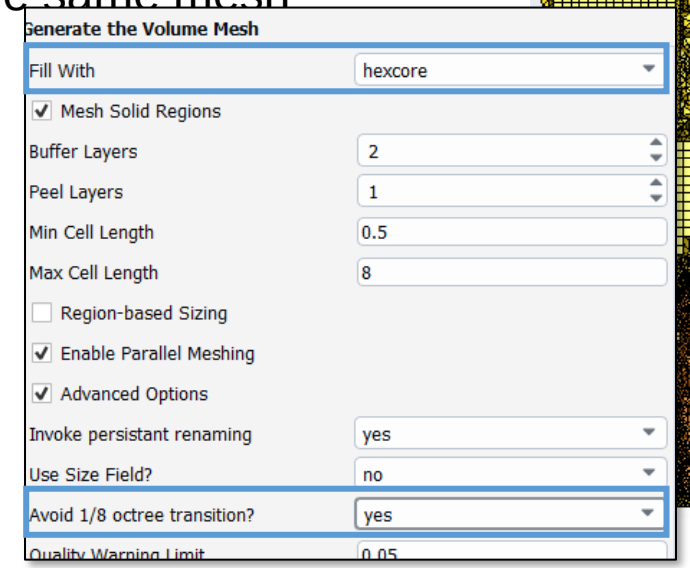
Hexcore meshes from Fluent Meshing now provide efficient meshes for the CFX solver

- Hexcore meshing in the Fluent Meshing Watertight Meshing workflow has a new option to avoid hanging nodes (1-to-8 transition avoidance), producing meshes that are compatible with the CFX solver
- Produces reduced cell counts for the same mesh resolution compared to tet/prism meshes
  - 30% faster solve times are typical
  - Improved convergence observed





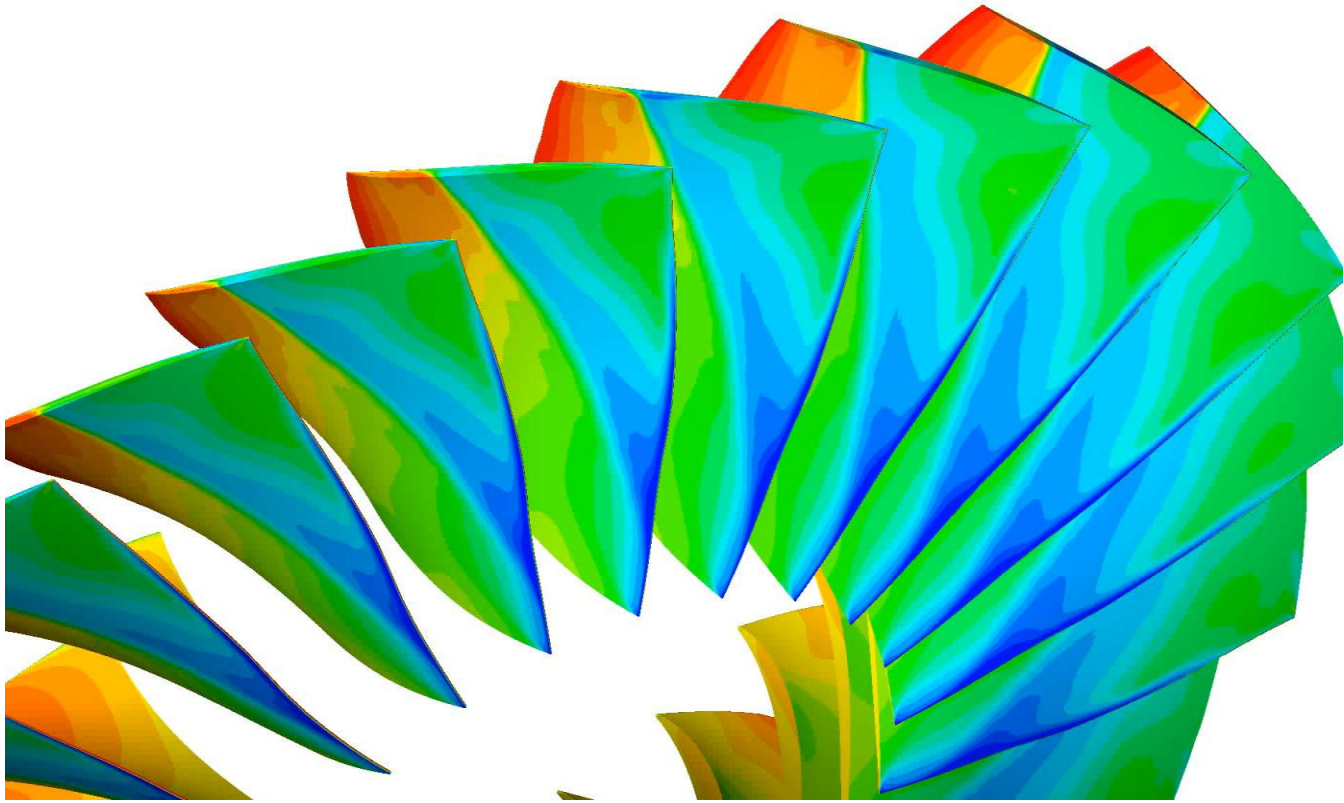
Hexcore mesh for a cooled turbine blade



GPU Accelerated Animations for Transient Blade Row Results

Animate Transient Blade Row results live using GPU accelerated animations in CFD Post

- No need to wait for transient files to load or animation encoding
- True 3D interactive animations – adjust the view during the animation
- New for 2021 R1:
  - Support for multi-disturbance TBR cases
  - Mesh motion from blade flutter now part of the animations
  - Contour support added
  - Videos can be exported as well as viewed live in CFD Post

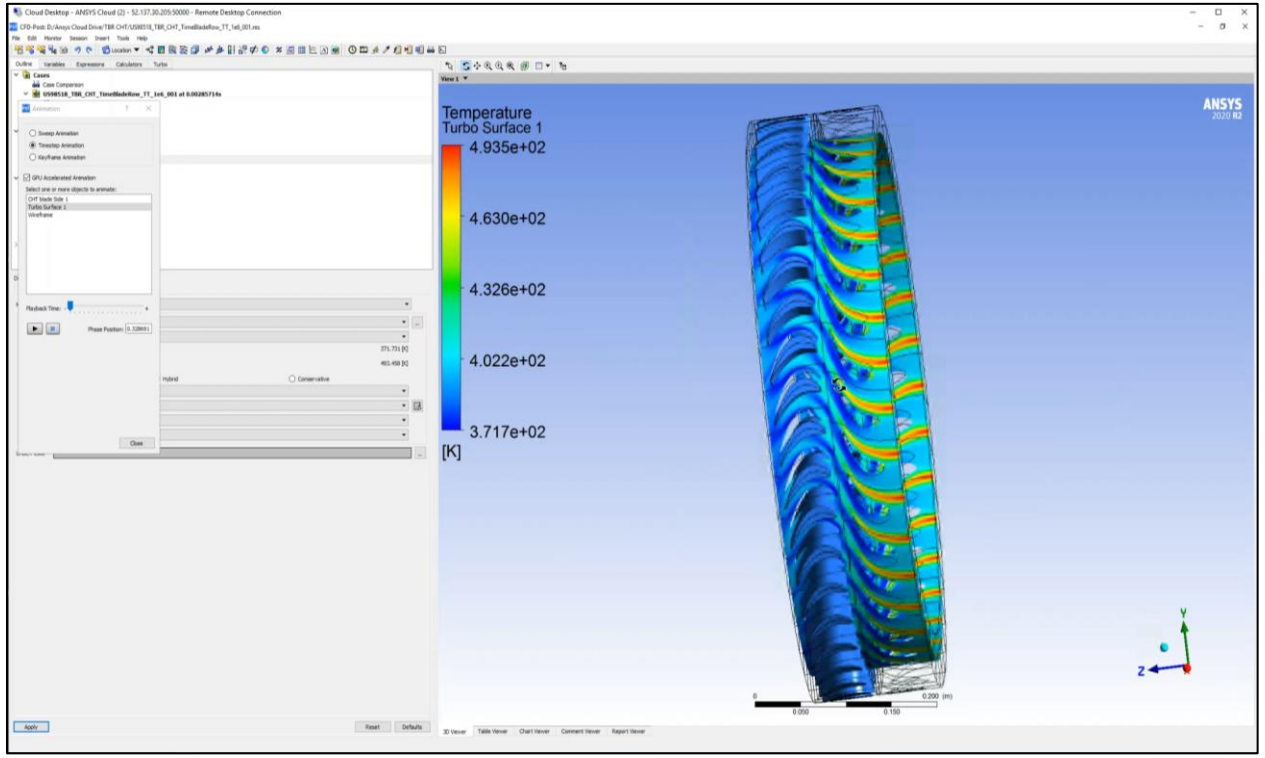


Pressure variations and blade flutter for Rotor 67 with GPU accelerated animations

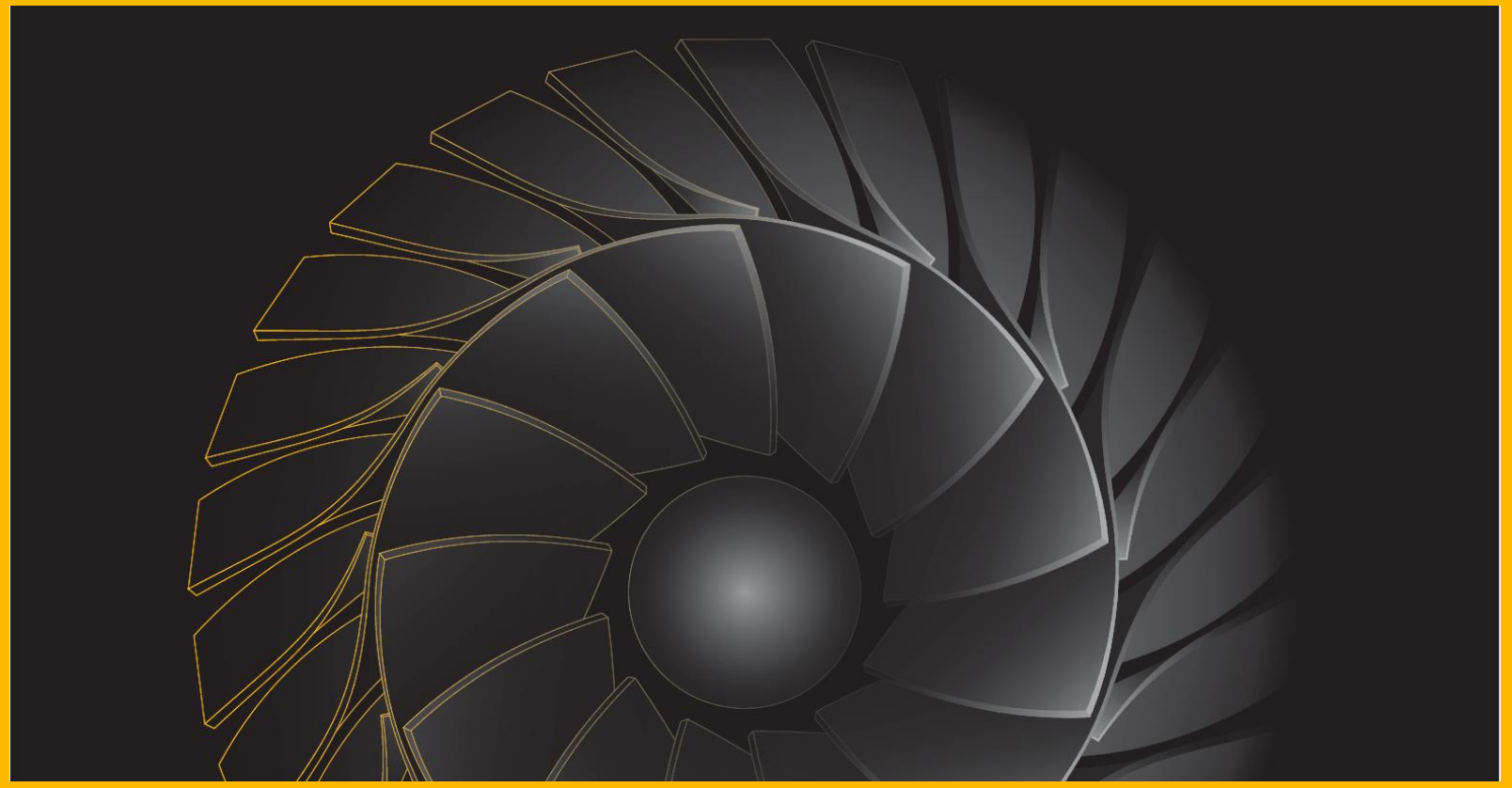
Ansys Cloud with CFX

Run CFX and the Turbo Tools interactively via Remote Desktop or in-browser

- Perform Pre or Post-processing, or run end-to-end workflows using a cloud-based Virtual Desktop Interface
  - Remote Desktop Protocol (RDP) provides optimal performance where firewalls allow
  - In-browser provides access via a web browser where firewalls do not allow RDP
- Hardware configurations from 16 to 120 cores
- See *Ansys Cloud What's New* for more info



CFD Post running on the Ansys Cloud via Remote Desktop



To get more information, or to
register for a free trial contact
info@ozeninc.com