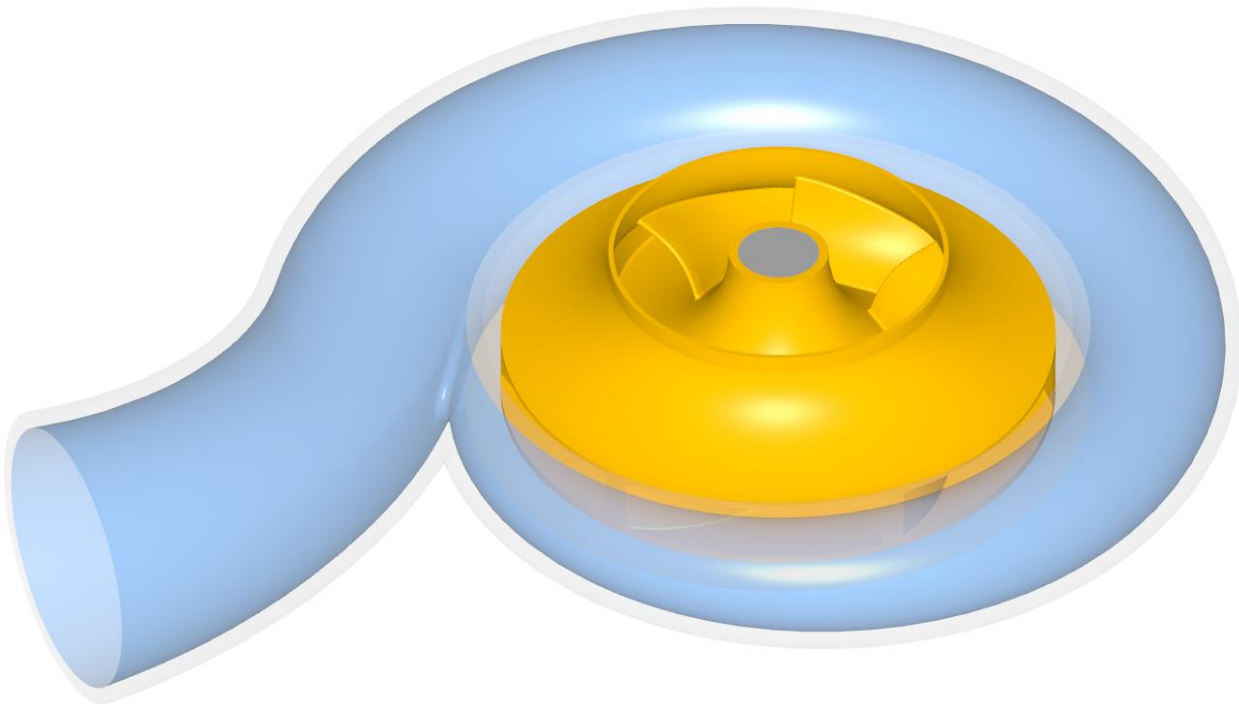


2024 series - Case Study #1

CFturbo BLADERUNNER

Centrifugal End-Suction Pump



CFturbo 2024.R1 model geometry - Centrifugal End-Suction Pump

The CFturbo BLADERUNNER 2024 is a unique and innovative tool that will outperform the known capabilities of an **automated simulation process for Turbomachinery performance maps**. The new CFturbo BLADERUNNER controls the interaction of our conceptual Turbomachinery 3D-CAD system CFturbo with the 3D-CFD software CFturbo SMP (Simerics MP). This combination offers a user-friendly, robust, and affordable solution to predict Turbomachinery performance accurately, making it a tool of great interest to professionals and newcomers in the field.

The actual example will demonstrate the setup and the performance map simulation for a centrifugal end-suction pump model, including the leakage flow path.

1. Define the duty point (Best Efficiency Point BEP) and create a conceptual pump design

Global setup

Design point

Flow rate * $Q = 1000$ gpm

Head * $H = 70$ m

Revolutions $n = 3600$ /min

Fluid Name: Water (20°C)

Model: Constant

General machine type: Centrifugal (medium pressure)

Specific speed (EU) $n_q = 37.4$

Specific work $Y = 686$ m²/s²

Specific speed numbers

n_q (EU) = 37

N_s (US) = 1930

Component: CP_nq37.cft • PUMP - CFturbo 2024 R1.0

Pressure (tot)

Temperature

Options: Project information, Global setup, Performance prediction, Undo, Export, Batch mode / optimization, CFturbo, Reference designs, Model finishing

Component: CP_nq37.cft • PUMP - CFturbo 2024 R1.0

3D View

Reset view, Load view, Save view, Fit view, View

Coordinate system, Show scale, Background color

Rotate impeller, Speed 5/10, Display quality

Point width 2 px, Curve width 1 px, Isocurves 0

Activate clipping, Position 0%, Show clipping plane, Clipping

2. Start CFturbo BLADERUNNER - set up meshing parameters and CFD solver settings

The screenshot shows the 'Settings' tab in CFturbo BLADERUNNER. The left sidebar displays a tree view of the workspace with various flow rate and speed settings. The main panel is divided into several sections:

- Variant description:** Original file name: CPnq37.cft
- GEOMETRY EXPORT SETTINGS:** Includes 'Edit settings', 'GLOBAL MESH PARAMETERS' (Presetting: Fine, Cell size on surfaces: 0.004, Maximum cell size: 0.008, Minimum cell size: 0.0001), and 'LOCAL MESH PARAMETERS' (Co1_InletPipe, Co2_Impeller).
- CFturbo:** Project type: Pump, File version: 2024.1.0.104.
- Design point information:** Rotational speed: 3600 [1/min], Volumetric flow: 1000 [gpm], Head: 70.104 [m].
- Fluid properties:** Name: Water (20°C), Density: 998.2 [kg/m³], Kinematic viscosity: 1 [mm²/s], Vapor pressure: 2340 [Pa].

A 3D model of a pump assembly is shown on the right, with a blue inlet pipe and a green impeller.

The screenshot shows the 'Settings' tab in CFturbo BLADERUNNER, focusing on the 'Steady' simulation settings. The left sidebar is the same as in the previous screenshot. The main panel displays the following settings:

Category	Parameter	Value	Units	Use for caption
ROTATIONAL SPEEDS	Co2_Impeller	Clockwise	3000 /min	<input checked="" type="checkbox"/>
	Co1_InletPipe-Inflow	Specified total pressure	100000 Pa	<input type="checkbox"/>
FLOW BOUNDARY CONDITIONS	Co3_VoluteExtension-Outflow	Specified volumetric flux	gpm	<input type="checkbox"/>
	Co1_InletPipe-Inflow	Specified total pressure	100000 Pa	<input type="checkbox"/>
FLUID PROPERTIES	Name	Water (20°C)		
	Density	998.2	kg/m³	
	Dynamic viscosity	0.0009982	kg/m·s	
	Vapor pressure	2340	Pa	
SOLVER SETTINGS	Run type	Steady		
	Parallel simulation	Running on all cores		
	Cavitation	Enabled		
	Gravity force	Disabled		
CONVERGENCE SETTINGS	Residuals criterion (Flow)	0.0005		
	Residuals criterion (Turbulence)	0.001		
	Residuals criterion (Cavitation)	0.001		
	Min. iterations	300		
	Max. iterations	1000		
	Saving frequency	500		
	NUMERIC SETTINGS	Schema	Relaxation	

A yellow callout box highlights the convergence settings, stating: "Meshing parameters, CFD solver settings, and convergence criteria are crucial. Standard settings are available but can be modified."



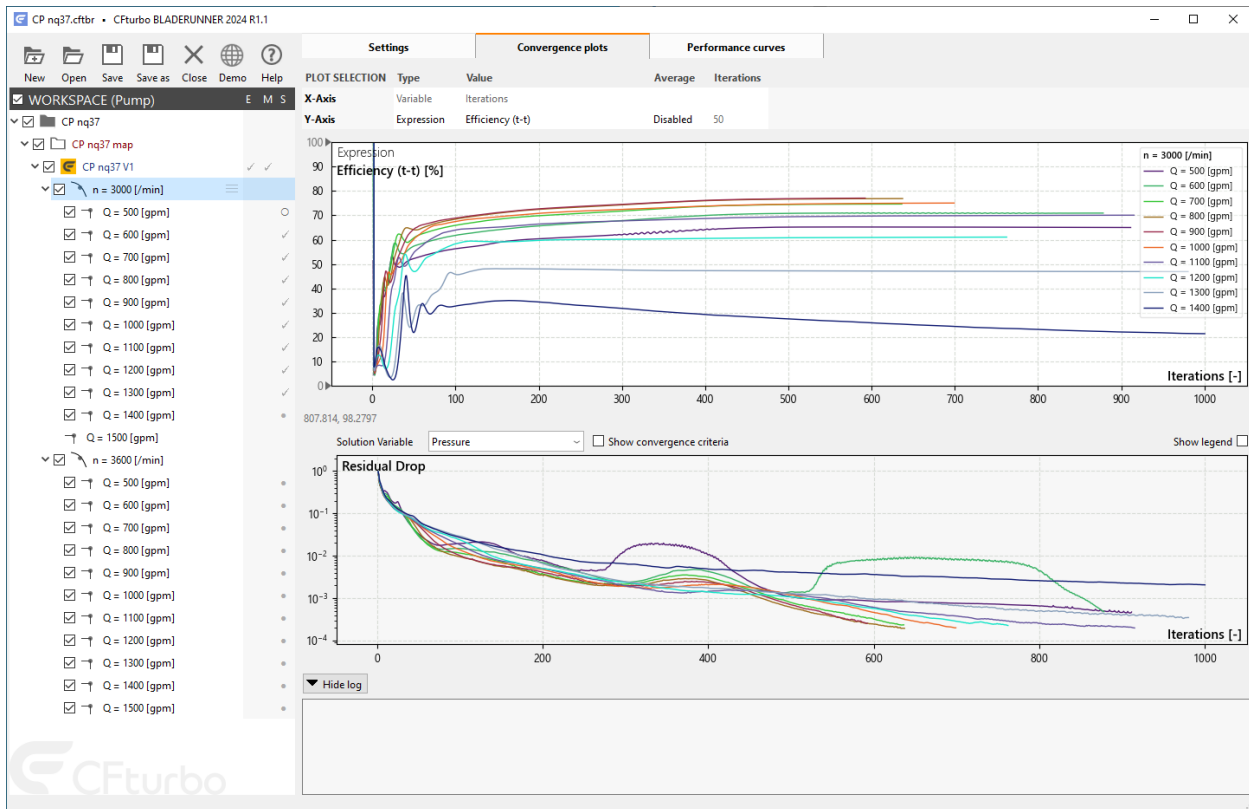
3. Review the computational grid, start CFD simulations, and check convergence

The screenshot shows the CFTURBO software interface. On the left, a tree view displays the workspace structure: WORKSPACE (Pump) > CP nq37 > CP nq37 map > CP nq37 V1. Under CP nq37 V1, there are two sets of flow conditions: one for n = 3000 [1/min] and another for n = 3600 [1/min]. Each set includes flow rates from Q = 500 [gpm] to Q = 1500 [gpm].

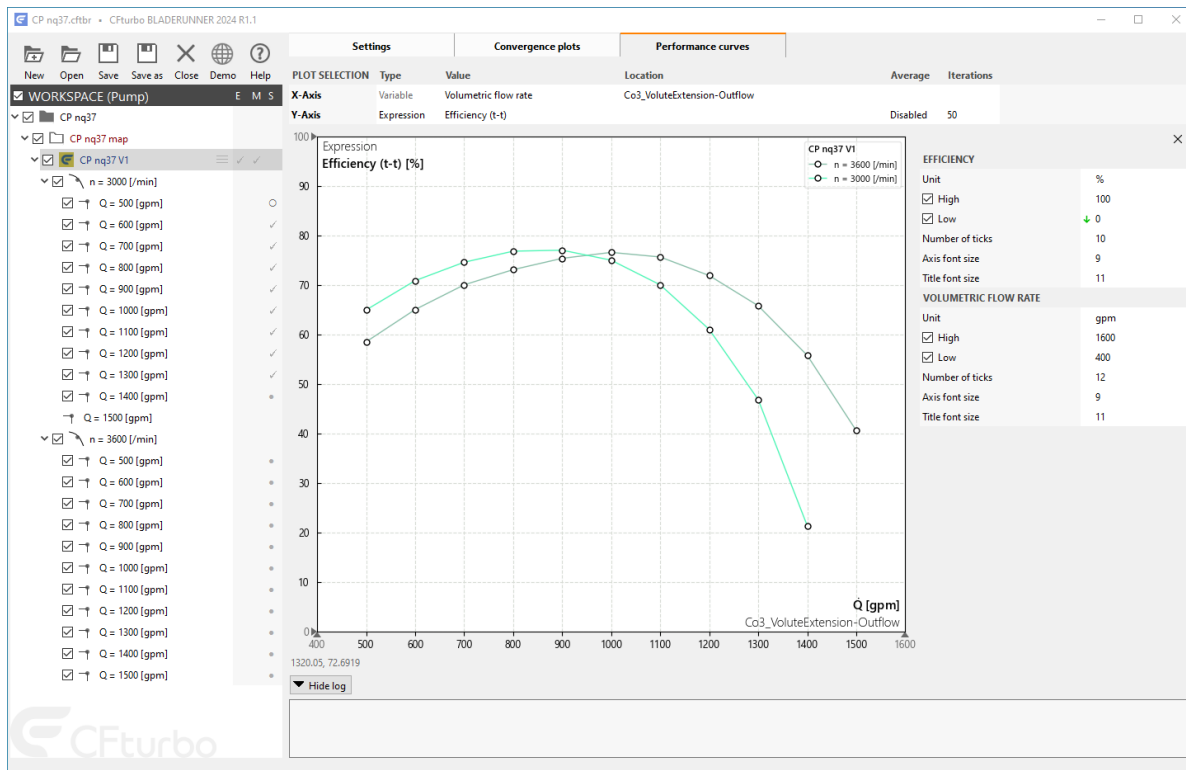
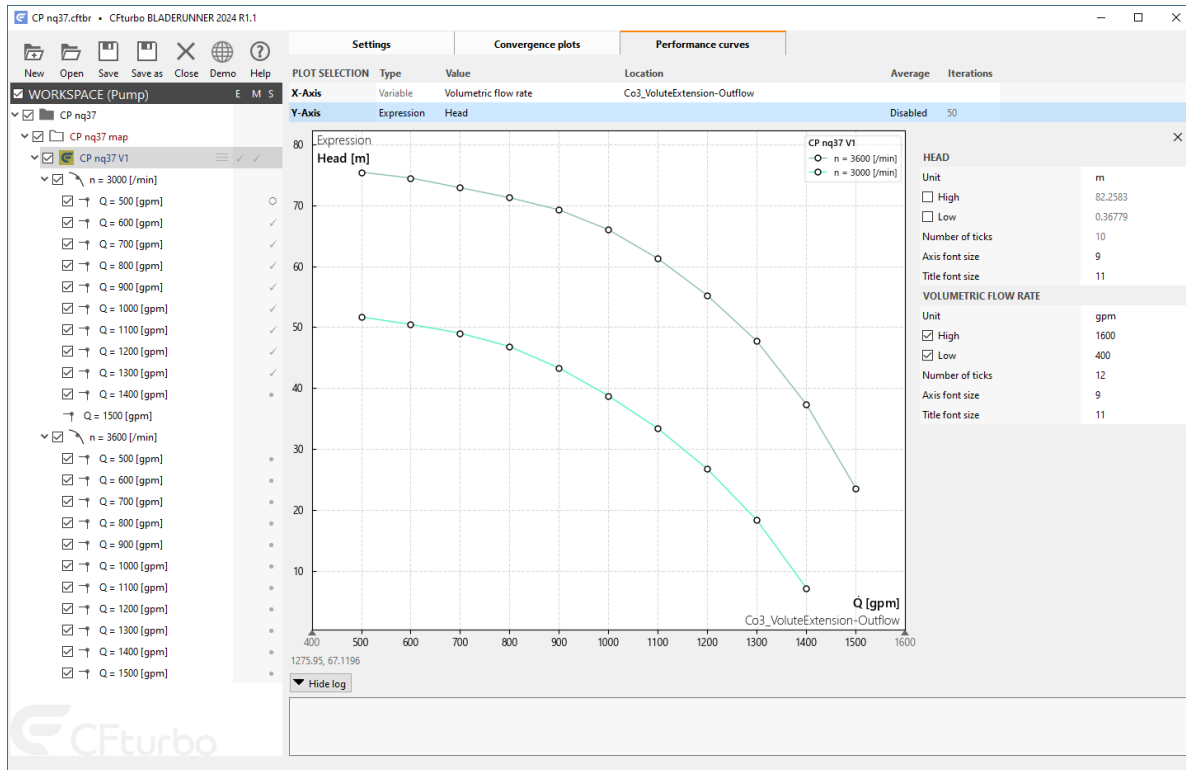
The main panel is divided into several sections:

- Variant description:** Original file name: CPnq37.cft
- GEOMETRY EXPORT SETTINGS:** Includes options for Edit settings, GLOBAL MESH PARAMETERS (Value: Fine), Presetting (Value: Fine), Specific length calculation (Using all CAD surfaces), Cell size on surfaces (0.004), Maximum cell size (0.008), Minimum cell size (0.0001), and Refine cells next to boundaries (checked).
- LOCAL MESH PARAMETERS:** Lists various mesh regions with their types and maximum sizes. For example, Co1_InletPipe is a Domain with a max size of 0.008.
- Mesh statistics:** A bar chart showing the number of cells for different components: Co1_InletPipe (22885), Co2_Impeller (176296), Co3_Volute (77810), Co3_VoluteExtension (77621), and a TOTAL of 1941277.

A yellow callout box with the text "Checking the initial computational grid directly in Simerics MP and adjusting the meshing parameters can be done quickly." is overlaid on the mesh statistics section.



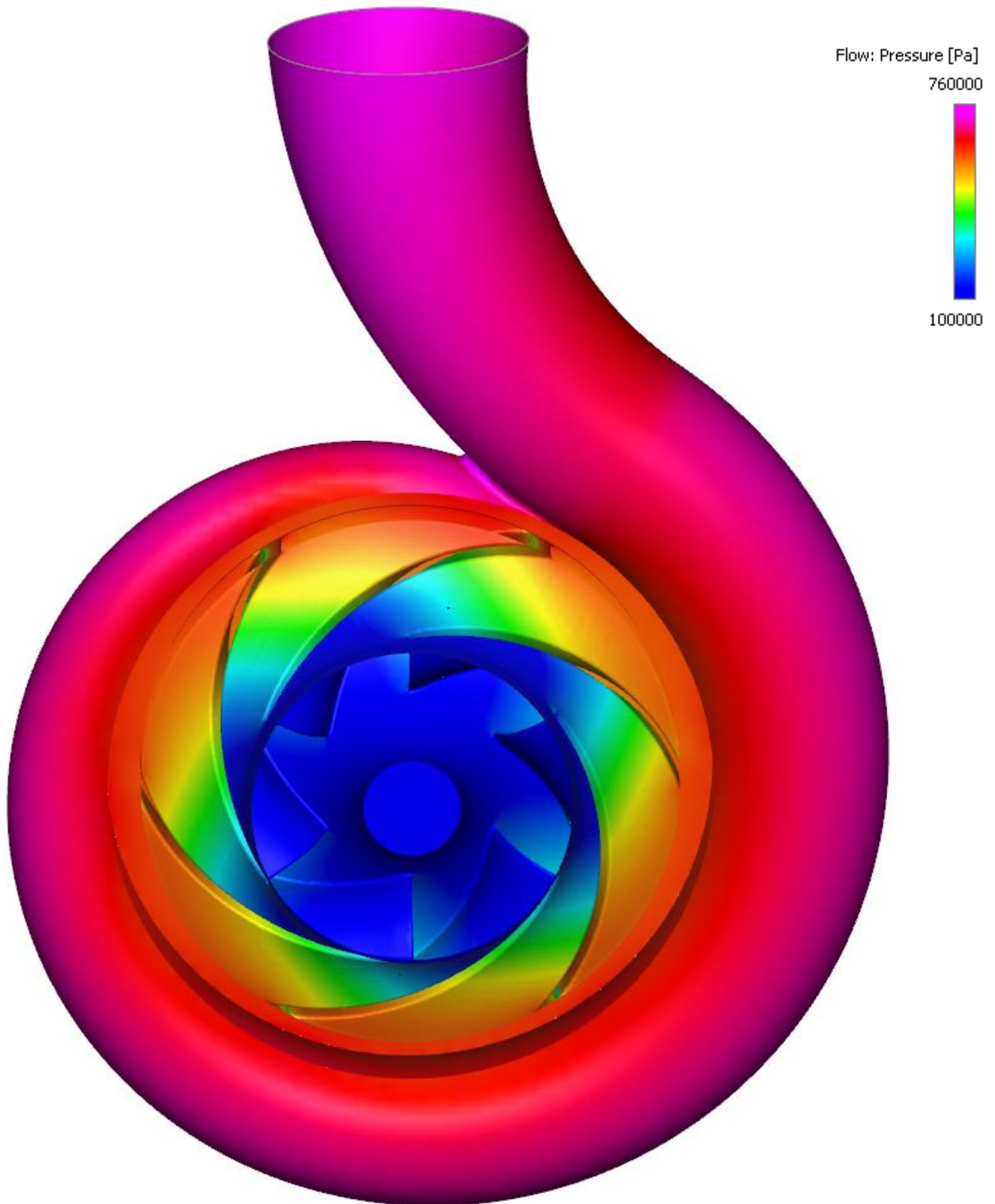
4. Plotting results - automatically during simulation runs



A user can switch and plot any available flow field variables or integral values, such as head, static, or total pressure differences, impeller or stage efficiency, shaft power, torque, etc.



5. Flow field post-processing in CFturbo SMP (Simerics MP)



6. Computational resources

- **Meshing** Simerics MP, hexahedral, binary tree mesh, ~ **2m nodes**
- **CFD code** Simerics MP, k- ϵ -turbulence model
- **Run time** 1 operating point, Steady-state (MFR) simulation ~ **6 ... 9 minutes**
 1 operating point, Transient, 3 revolutions ~ 20 minutes*
- **Processor** Intel® Xeon® Gold 6438Y+, 2 GHz, 32 Cores, 32 Logical Processors

* Automated transient flow simulation and DoE/optimization technology are currently under development and will be integrated into the subsequent releases, CFturbo 2025.R1, and R2.

7. Summary

“An accurate pump performance curve over the lunch break ...”, anticipated for a long time, has become a reality! Predicting reliable Turbomachinery performance maps has always been a challenge, mainly when one must deal with limited resources. The all-new CFturbo BLADERUNNER, combining the conceptual 3D Turbomachinery design software CFturbo with the 3D fluid flow solver Simerics MP, delivers CFD results fast using a standard 32-core Windows workstation.

Compared to simplistic inviscid flow calculations or loss-model-based performance estimations, here we have a practical solution based on detailed Turbomachinery geometry components and 3D-CFD that provides fast and reliable performance data and will open an excellent path to affordable and accurate design exploration and optimization.

8. About CFturbo

CFturbo (est. 2008) is headquartered in Dresden, Germany, with a major office in Brooklyn, NY. CFturbo is dedicated to Turbomachinery design and engineering services in designing rotating machinery components and solving fluid flow and heat transfer problems. The company has gained worldwide respect within the Turbomachinery community.

Our conceptual design software, CFturbo, is the most user-friendly system available on the market. Through its unrivaled, intuitive, and user-friendly design process, CFturbo software empowers every user, regardless of experience. The software can be used to design various turbomachinery-related devices, including pumps, fans, blowers, compressors, turbines, stators, and volutes.

CFturbo, Inc. offers various Turbomachinery engineering services, including aerodynamic and hydraulic designs, CFD and FEA simulation, rotating machinery optimization, mechanical design, prototyping, and testing. For more information, visit cfturbo.com.

