R&T activity

Cenaero is involved in several FP6 and FP7 European Collaborative Research programs related to the development of advanced capabilities for the design of new generation gas turbines:

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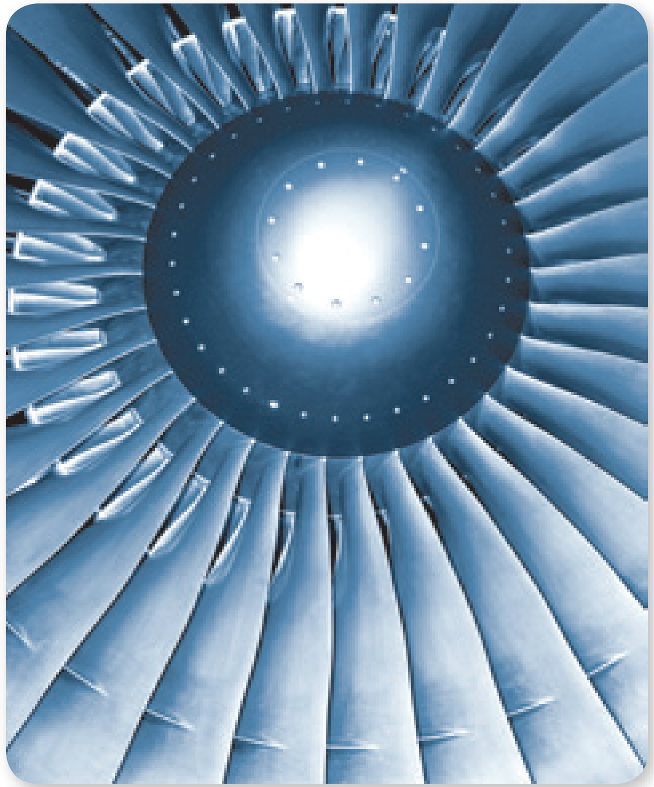
Cenaero



Turbomachinery

Unique engineering services for multi-disciplinary simulation, design and optimization

Our dedicated offer

Turbomachines are found in numerous industry sectors. The complex physics phenomena taking place inside turbomachines and the current trend towards more and more greening in the aeroengine, energy conversion and production sectors pose enormous challenges to the designers.

Cenaero offers its knowledge to the designers by providing dedicated advanced computational workflows to model and optimize turbomachines accounting for multiple disciplines such as aerodynamics, thermal analysis, structure mechanics, acoustics, etc.

For years, Cenaero expertise has been applied to many systems such as oil pumps, heat exchangers, energy gas turbines, turbofans (fan, compressor, turbine), contra-rotating aeroengines, contra-rotating open rotors, etc.

With passion and trust, Cenaero engineers support the designers engaged in a technology innovative process by providing high fidelity numerical simulation services and dedicated software to invent and design more competitive products.

Real geometry effects

- **Seal leakage flows**
  - > Detailed analysis of the flow exchange between the main channel and the cavity underneath the hub surface
  - > Simulations applied to both compressor and turbine stage configurations

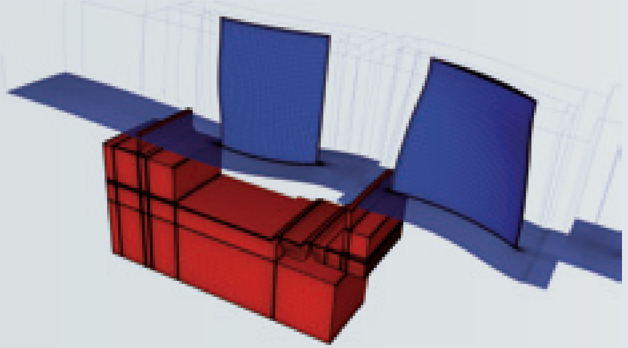


Illustration of the mesh used for a seal leakage flow simulation (courtesy Safran - Techspace Aero)

- **Casing treatments**
  - > Design and analysis of annular recesses (without and with penetration of the rotor blade tip into the casing) or circumferential grooves

- **Manufacturing or engine wear effects**
  - > Simulations including fillet radius or weld beads performed through adequate meshing (either through appropriate blocking for structured meshes or through unstructured meshing)
  - > Wall roughness effects

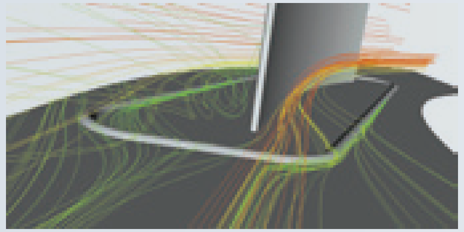


Illustration of the deviation due to the weld bead (courtesy Safran - Techspace Aero)

True physics

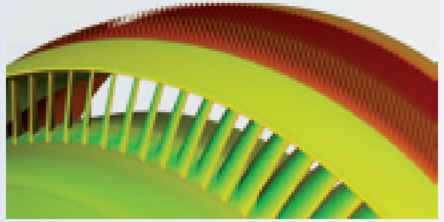


Illustration of a surface air cooled oil cooling system (courtesy Safran - Techspace Aero)

- **Aerothermal simulations**
  - > 3-D numerical model for surface air cooled oil cooling (ACOC): fins optimization to determine the best compromise between heat power and aerodynamic losses
  - > Complex simulations and optimization of engine cooling systems combining internal convection cooling with external film cooling

- **Multi-phase flows**
  - > Numerical model for Gerotor pumps based on a deforming mesh approach coupled to a remeshing strategy enabling to cope with the permanently deforming cavities located between the inner and outer gears
  - > Scavenge systems simulation

Illustration of the flow within a Gerotor pump (courtesy Safran - Techspace Aero)

- **Unsteady flows**
  - > Sliding mesh or phase-lagged approaches to model non-axisymmetric casing treatments, aeroelastic effects such as flutter and forced response as well as real geometry or condition effects
  - > State-of-the-art research activities investigating the feasibility of hybrid RANS-LES approaches for a better modeling of turbulence

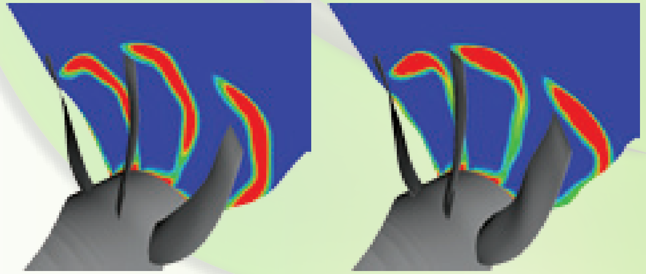
Innovative design

- **Multi-physics multi-criteria design tackling over a hundred parameters within a heavily constrained setting**
  - > Aerodynamic shaping of non axisymmetric end walls for compressors and turbines
  - > Aero-mechanical shape optimization of composite fan blades accounting for fluid-structure interaction
  - > Aero-acoustic design and optimization of CROR propellers with severe mechanical constraints
  - > Etc.

- **Tailored design methodologies including shape parameterization, robust mesh generation, integration of real geometry/technological effects, cost functions definition, etc.**

- **Associated computational workflow setup for multi-physics data exchanges, coupling, etc.**

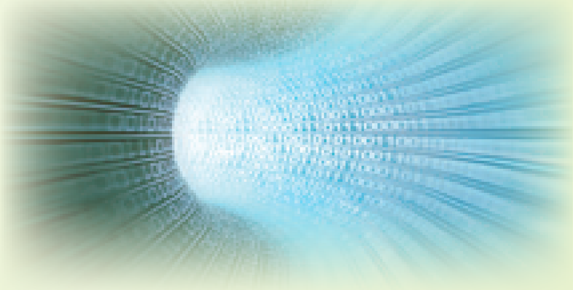
Contra-Rotating Open Rotor aeroacoustic design with mechanical constraints (102 propellers shape parameters including restaggering at take-off and top-of-climb)(courtesy Safran - Snecma). Entropy distribution upstream the mixing plane at take-off illustrating the impact [baseline (left) vs selected optimized case (right)] of the acoustic cost function on the front propeller wake (courtesy Safran - Snecma)



Powerful computing

- **In-house optimization platform Minamo**
  - > State-of-the-art mono- and multi-objective evolutionary algorithms
  - > Efficient coupling to surrogate models through a trust-region management framework
  - > Direct and neutral access to the CAD master model through CAPRI
  - > Design of Experiments and powerful surrogate modeling techniques used in a fully integrated manner to minimize the number of function calls
  - > True insight to the design space, quantitative identification of the key factors and trades leading to innovative design options

- **Software capabilities**
  - > Pre- and post-processing tools
  - > CFD software (Argo, elsA and other commercial software)
  - > FEA software (Morfeo and other commercial software)
  - > MDO platform (Minamo)
  - > Scripting (Python, etc.)
  - > Developpement of fully customized computational chains



- **World-class HPC system ranked in the Top500 list of the world's most powerful supercomputers**
  - > Advanced services to help designers leverage the power of parallel HPC architectures, also via remote access
  - > Good knowledge of scientific applications and their requirements in terms of computing environment