

# Simcenter STAR-CCM+ for combustion

## Providing a fast and scalable chemistry solver for efficient, high-fidelity combustion simulations

### Benefits

- Run more solutions in less time with a fast, scalable chemistry solver
- Provide quick, accurate emissions profiles for combustor design with novel automated reactor network approach
- Ensure computational resources are fully used with highly efficient, scalable solvers
- Use model-specific reacting flow mesh adaption method to ensure accurate results with reduced effort structuring the mesh ahead of time, perfect for transient flames
- Get the high-fidelity answer you need for combustion liners with multi-time scale method for conjugate heat simulations with LES

### Summary

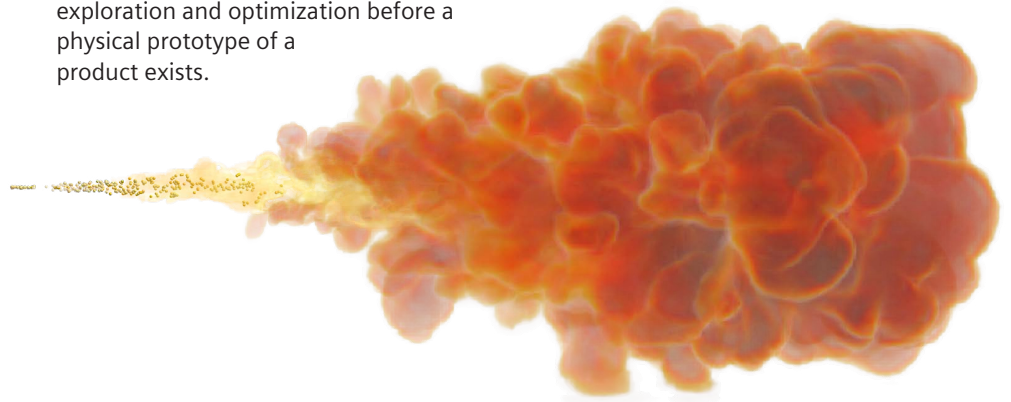
Next-generation combustion systems are under increasingly severe constraints. Tight emissions regulations, a competitive market, new fuels and novel fuel compositions ensure that staying competitive is more challenging than ever.

Additionally, new technologies such as additive manufacturing create limitless possibilities for optimizing combustion chamber geometries. However, without experience in this area it is difficult for engineers to apply these techniques.

A high-fidelity digital twin solves these issues, enabling experimentation, design exploration and optimization before a physical prototype of a product exists.

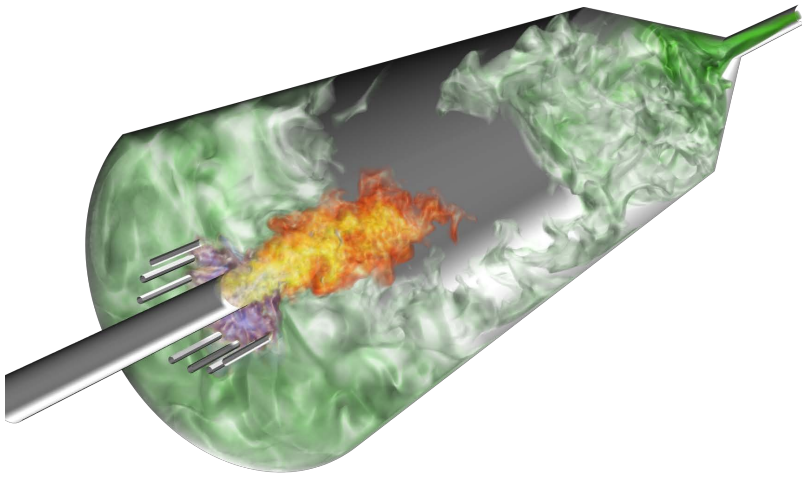
Effectively evaluating combustion system performance is a significant challenge for today's simulation tools. To be effective, these tools must be capable of:

- High-fidelity analysis to get an accurate evaluation of real-world performance. All the physics must be included, such as thermoacoustic noise interactions, multiple time scales, ultra-low-level emissions production and novel fuel chemistries
- Speed and scalability in order to run simulations with sufficient resolution within practical turnaround times
- Design exploration, which is necessary to meet complex design constraints, such as emissions profiles, while getting the best competitive advantage with performance
- Complex geometry handling to cope with novel additive manufacturing techniques



LES simulation of Sandia Flame-G: Temperature field.

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Transient LES simulation of flameless methane combustor from Verissimo et al. The fuel / air mixture is shown in blue with areas of NO<sub>x</sub> formation formed in green.

- In-built design exploration to balance the complex tradeoffs needed for modern combustor design when the operating envelope is highly constrained
- Innovative data analysis tools, including capabilities such as data focus to answer questions, such as where is soot formation most likely to occur?, as well as collaborative virtual reality (VR) to allow all combustor design stakeholders (heat transfer team, combustion team, mechanical integrity team) to review, discuss and critique in real-time as a team

## Simcenter STAR-CCM+ offers the solution

Simcenter™ STAR-CCM+™ software is a multi-purpose computational fluid dynamics (CFD) tool with comprehensive multiphysics capabilities. With a single integrated user interface (UI), you can use a full suite of coupled physical models to build a high-fidelity digital performance twin of a real-life application.

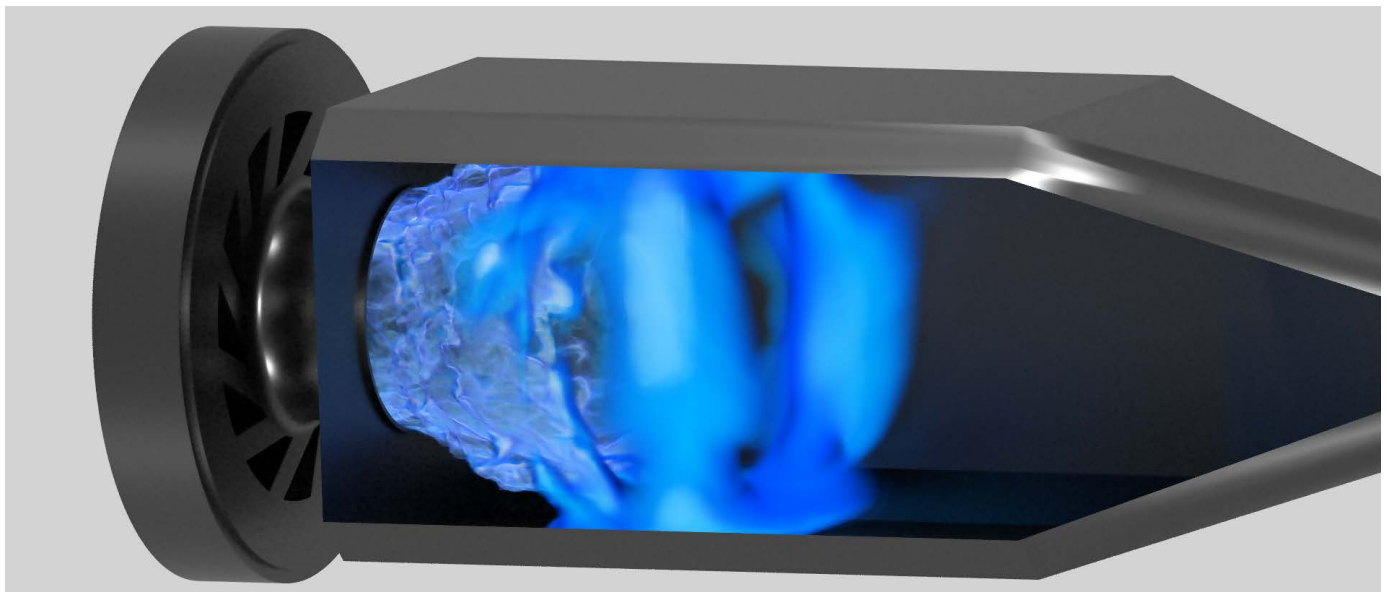
With Simcenter STAR-CCM+ the combustion simulation user benefits from improved workflows and functionalities such as:

- A pipelined automated computer-aided design (CAD) to solution workflow for complex and novel combustion chamber geometry simulation
- Automated flamelet workflow including flamelet table generation from mechanism import to table building, integration and analysis

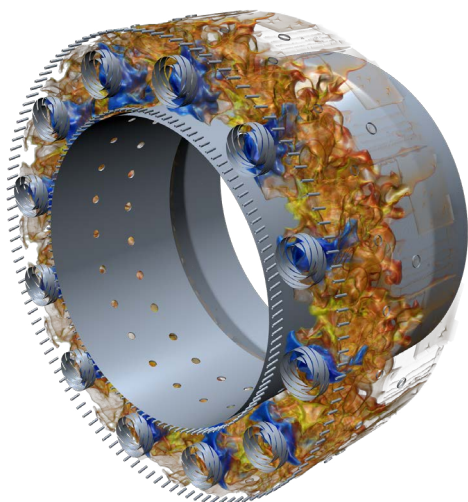
## Cutting-edge combustion

Simcenter STAR-CCM+ provides state-of-the-art combustion models from the latest proven research to ensure users have the best capabilities at their fingertips, such as:

- Complex chemistry with turbulent flame closure for accurate emission prediction with flame propagation and positioning
- Thickened flame model for accurate combustion without the need for excessively large meshes

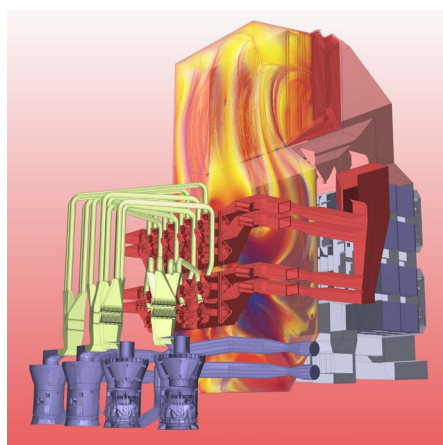


Siemens Industrial Turbomachinery LTD DLE SGT-100. Mixture fraction distribution.

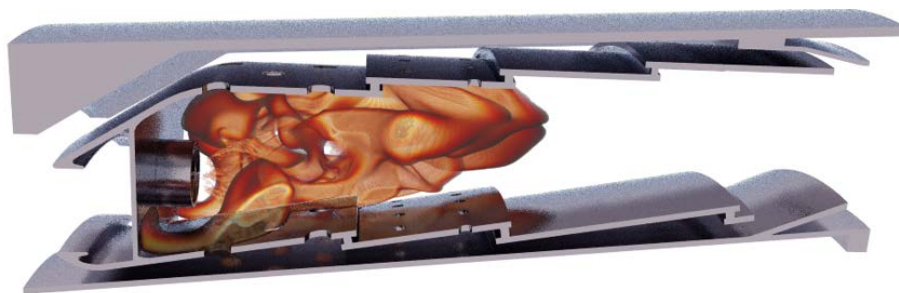


Transient LES combustion in annular gas turbine combustor showing the fuel-air mixture fraction.

- Reactor network model for quick emissions studies
- Complex ignition models such as imposed stretch spark ignition model (ISSIM) and sub-grid spark to correctly capture ignition events



Coal combustion simulation.



Temperature on flame front in the sector model of a gas turbine combustor liner.

### Speed and performance

To meet the severe constraints of the combustion market it is necessary to perform more design iterations early in the design cycle to prevent costly problems from arising in production. Simcenter STAR-CCM+ enables this by ensuring combustion simulations work efficiently with our technologies:

- A state-of-the-art, proprietary ordinary differential equation (ODE) chemistry solver that makes all simulations faster, regardless of mechanism size. For large mechanisms with more than 100 transported species, we automatically use the Simcenter STAR-CCM+ sparse solver, significantly speeding up calculations
- Linear scaling, proven to high core counts in benchmarks
- Powerful chemistry acceleration techniques to further reduce run time
- Clustering for large mesh counts to reduce the number of chemistry calculations
- Dynamic mechanism reduction for large mechanisms to reduce the number of chemical paths that are considered
- In-situ adaptive tabulation (ISAT) for small mechanisms reduce the number of chemistry calculations, optimizing runtime
- Our unique pressure-implicit with splitting of operators (PISO) solver formulation gives efficient performance for high-fidelity large eddy simulation (LES) combustion runs
- Minimizing cell count to achieve fast runtime with our specific reacting flow mesh adaption model to ensure that cells are only placed where the reacting flow needs it
- Multi-timescale modeling approach to couple conjugate heat transfer with LES combustion for highly accurate combustor liner simulations

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