HEXAGON

Case Study Brochure

Cradle CFD

Automotive Design and Development

SC/Tetra

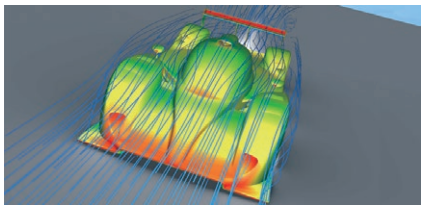
Automating Vehicle Aerodynamics Simulations for Different Height Configurations

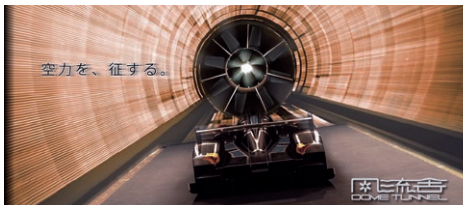
Case study for DOME CO., LTD.

Visual Basic (VB) Interface automates the evaluation of alternative vehicle height configurations

Automatic Adjustment of Simulation Vehicle Heights

Ground vehicle wind tunnel tests often evaluate vehicle aerodynamics for different vehicle height configurations. CFD simulations for such wind tunnel tests require separate computer models for each height configuration.
To simplify this process, DOME used a VB Interface (macro using Windows' COM interface) that automatically makes all the changes to the computer model to properly simulate the height adjustments. It enables steady-state simulations for different height configurations. The VB Interface can also be used for transient simulations where the vehicle height configuration is continuously changing. Vehicle height is adjusted by mesh deformation using the moving element function in SC/Tetra.

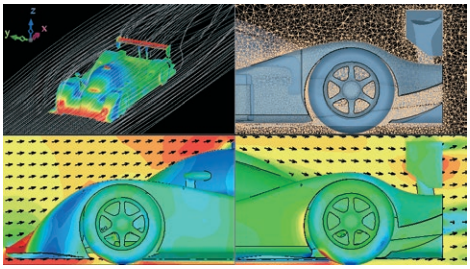




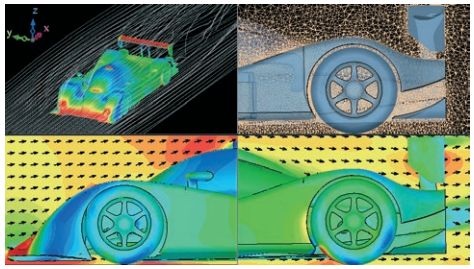
Simulation results

Steady-state analyses were conducted using the automated VB Interface for vehicle height adjustment. The reference height was 50mm at the front of the vehicle and 50mm at the rear. The results reveal the changes in surface pressure and airflow around the vehicle for different vehicle height configurations. A significant change was predicted for the surface pressure around the front under panel.

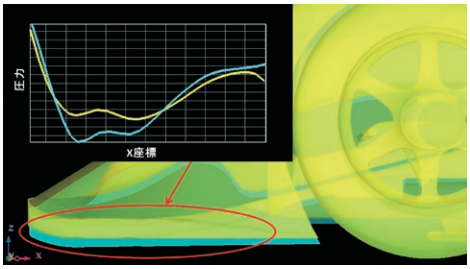
Aerodynamic characteristics at different vehicle heights



Front vehicle height ±0 (mm)
Rear vehicle height ±0 (mm)



Front vehicle height -10 (mm)
Rear vehicle height +30 (mm)

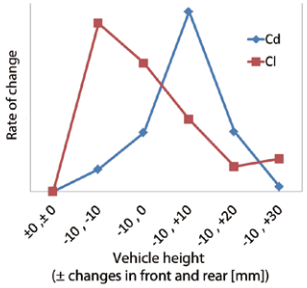


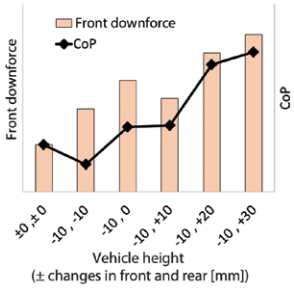
Pressure at front (under)

Changes in aerodynamic characteristics

Comparison of downforce

The simulation results were analyzed to evaluate the relationships of vehicle aerodynamic performance at different vehicle height configuration. The graphs using reference heights are shown on the right. The results show that the front downforce increases as the front vehicle height decreases, relative to the rear height while the proportion of downforce at the front (CoP*) increases.





* Center of Pressure

Customer Comments

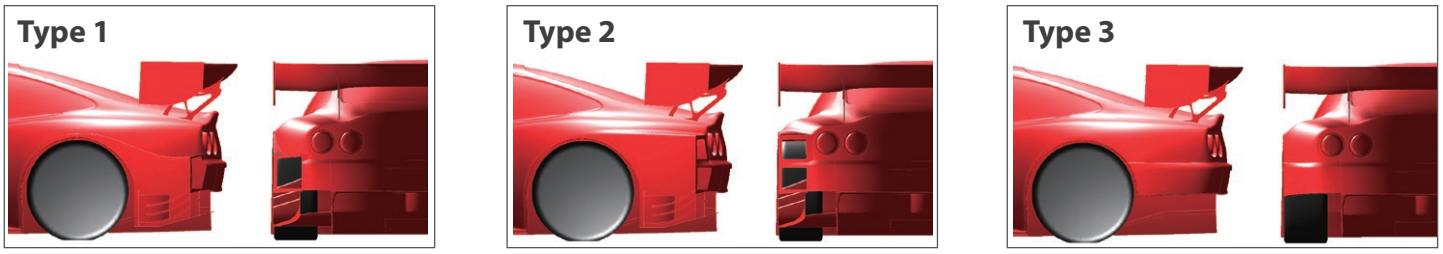
We used SC/Tetra and its VB Interface to automate the changes to the computer models used to simulate the effects of vehicle height adjustments. The computer simulations represented the height configurations tested in the wind tunnel. Using the VB Interface for transient simulations enabled us to successfully evaluate aerodynamics during vehicle acceleration and deceleration.

SC/Tetra

Evaluation of Aerodynamic Performance with SC/Tetra

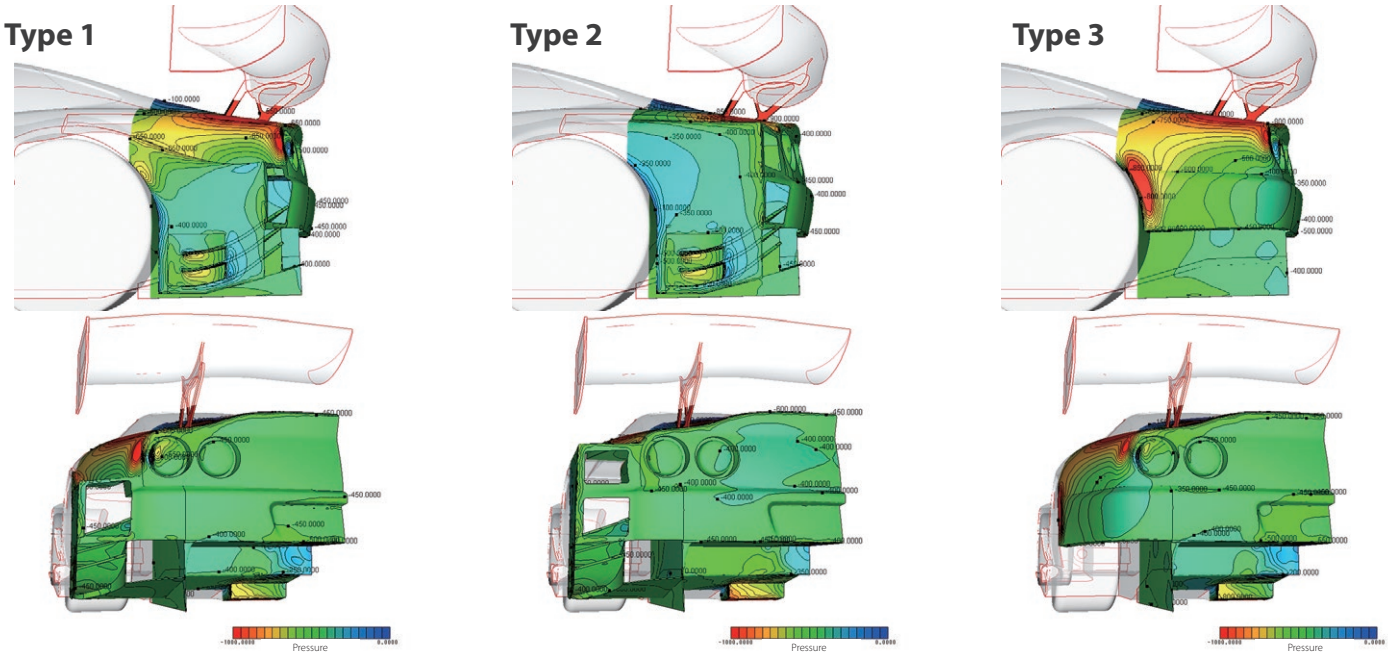
Effect of design change on aerodynamic characteristics of a car

Rear Fender Shape – Analysis Cases –



Pressure Distribution on the Body Surface

Red…Indicates large negative pressure



Comparison of Cd Values

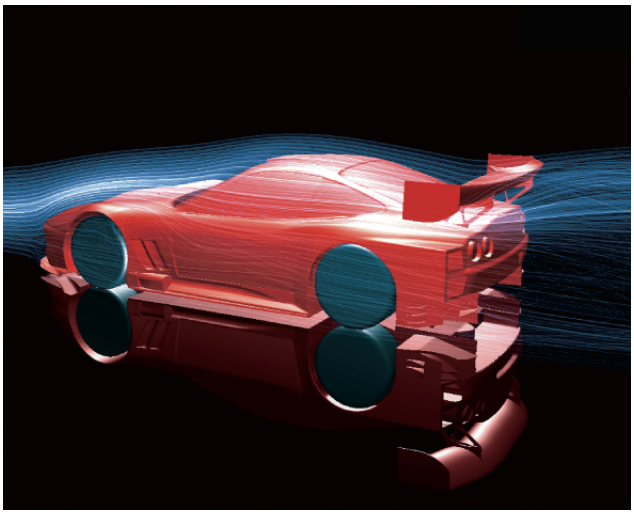
Type 2 < Type 3 < Type 1 Low resistance ➡ Good gasmileage

Cd (drag coefficient) value:
Air resistance coefficient against a moving car
Smaller Cd can be obtained when there are fewer factors that disturb air flow.

Comparison of Down Force at rear part

Type 1 > Type 2 > Type 3

Comparison among the 3 types ▶ "Type2" is the best



Notes

Flow phenomena, which are difficult to be captured in experiments, can be evaluated in detail with numerical simulation and visualization.

SC/Tetra

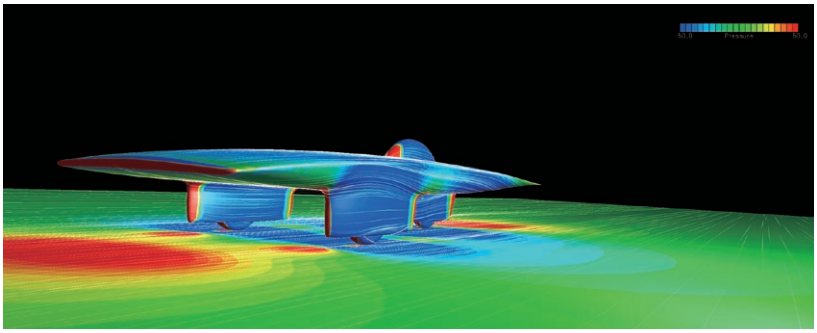
Analysis of a World Solar Challenge Racing Car

SC/Tetra for Effective Aerodynamic Analysis

SC/Tetra is three dimensional thermal fluid analysis software developed by Software Cradle Co., Ltd. that is used by customers all over the world. SC/Tetra is renowned for being a highly practical and accurate analysis tool.

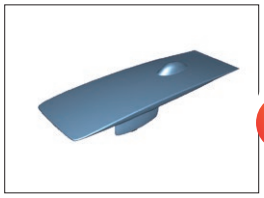
SC/Tetra excels at accurate representation of geometry. Engineers can use the tool to conduct automotive aerodynamic analysis, or evaluate the performance of rotating machinery such as fans and turbines.

2013 Tokai Challenger places the second at the World Solar Challenge

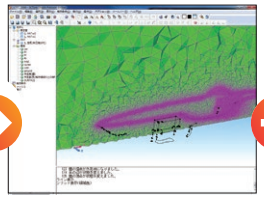


2011 Tokai Challenger places the second at the World Solar Challenge

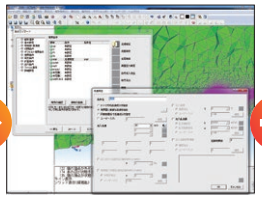
Analysis Process for the Tokai Challenger



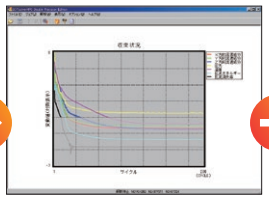
CAD data



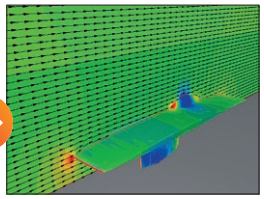
Automatic mesh generation



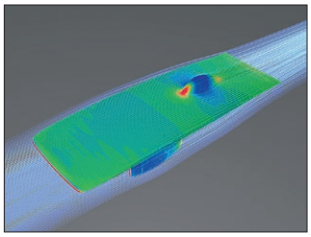
Condition setting wizard setup



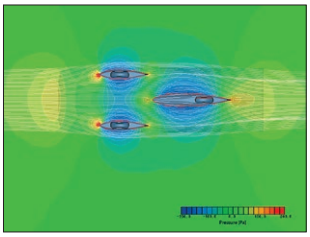
Calculation



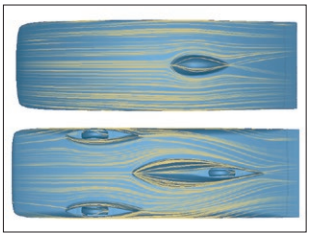
Display results



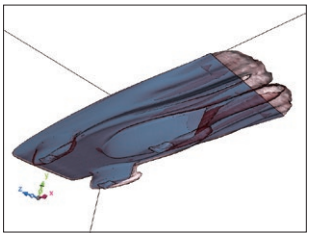
Pressure and flow of vehicle body surface



Pressure and airflow around the lower part of the vehicle body



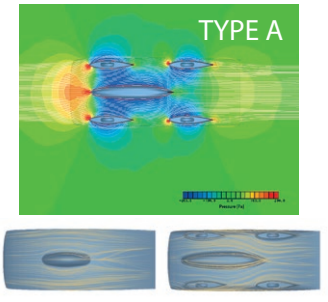
Airflow around the vehicle body surface (using oil flow view)



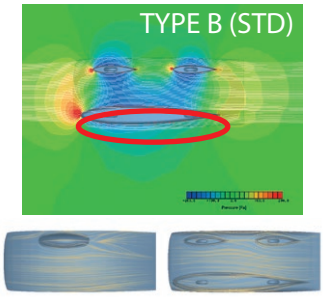
Distribution of turbulence energy

SC/Tetra helps engineers to visualize the invisible airflow and identify the pressure distribution

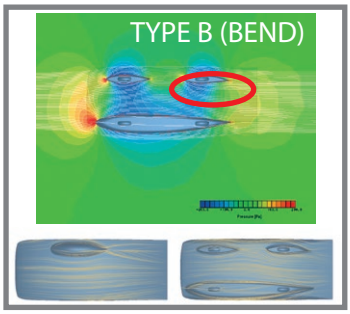
Analysis of the Tokai Challenger (Pressure and Airflow Around the Lower Part of the Vehicle)



Converted the previous model into a four wheeler



Changed the size and position of the cockpit



Modified the geometry of the wheel fairings

SC/Tetra

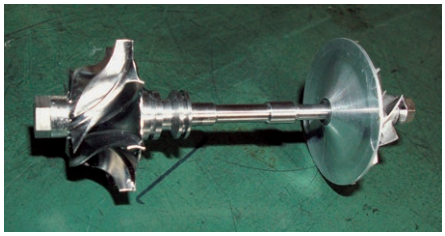
Turbocharger Analysis

Case Study for ACR Co., Ltd.

Minimize prototyping by analyzing turbocharger vane geometry using SC/Tetra

Analysis Objective

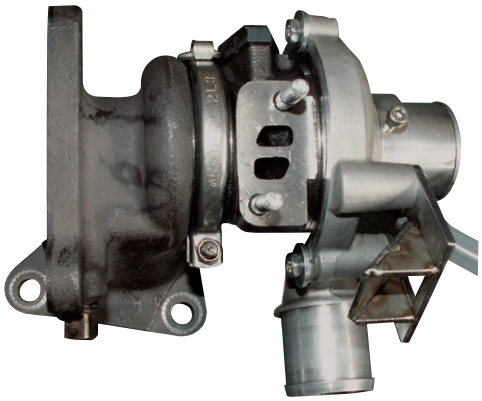
Improve efficiency by reducing the turbocharger gas flow rate to one third the value used in the world's smallest turbocharger found in Japanese Kei minicars.



Turbine rotor

Product

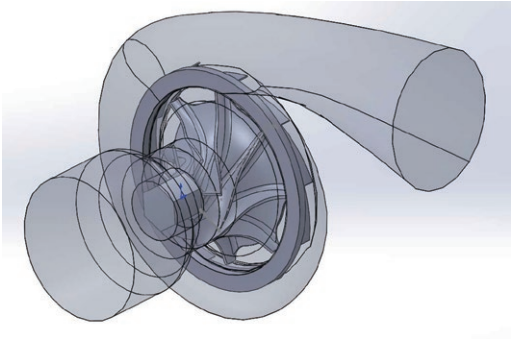
A mini turbocharger for a small, single-cylinder auxiliary power generation diesel engine used to extend the range of electric vehicles.



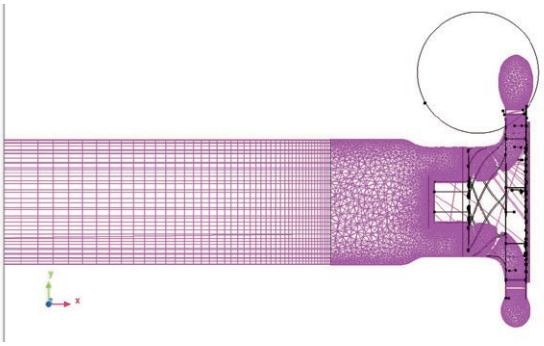
Turbocharger exterior

Analysis model

Geometry A



Meshing

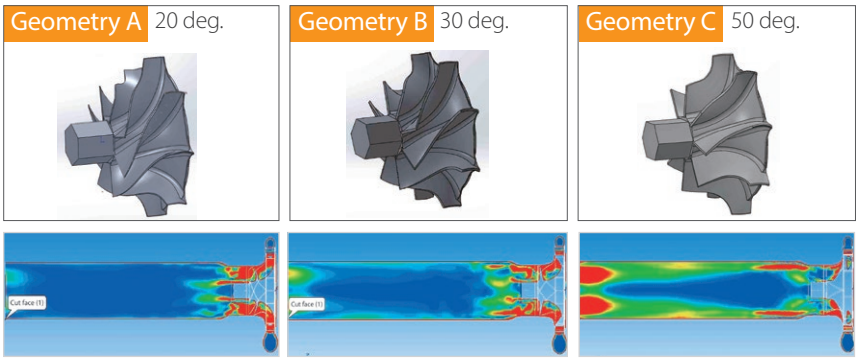


Total number of elements: 6,143,065

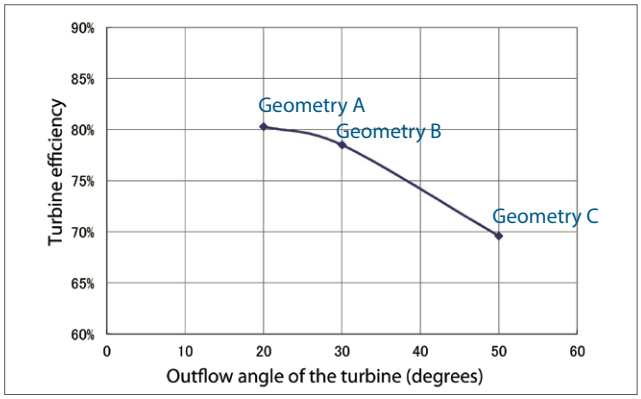
Analysis results

Rotational speed: 200,000 rpm

CFD analysis was used to optimize the rotor vane outflow angle.



Contour of shear heat



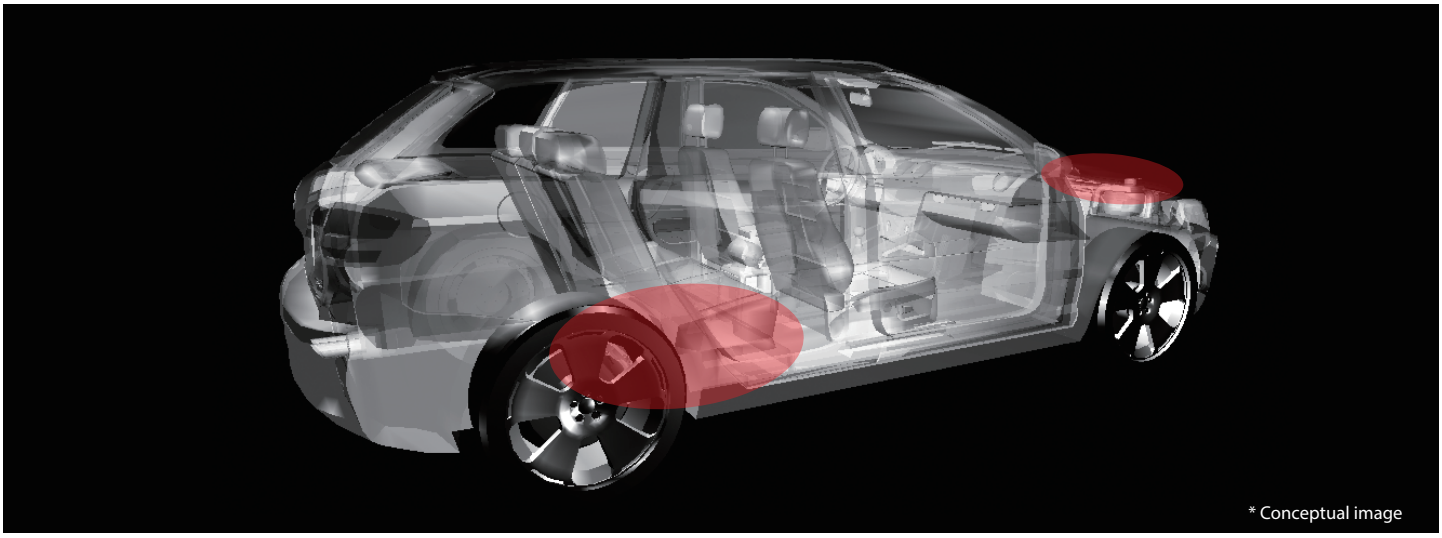
Efficiency as a function of rotor vane outflow angle

Customer Comments

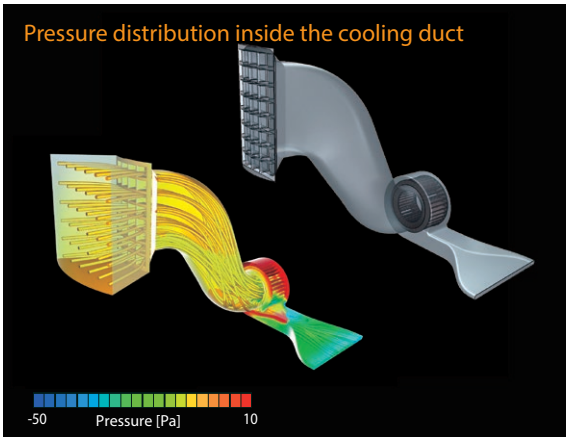
Prototyping new geometry for a turbocharger is costly and time intensive. We were able to optimize the vane geometry for maximum efficiency by using CFD analysis. SC/Tetra was used for the CFD calculations. We will make prototypes based on the analysis results and test them to assess performance. Perhaps additional efficiency improvement will be possible. Ultimately we will match this turbocharger with an engine to boost the flow rate and extend range. This product will be ready to market very soon.

SC/Tetra

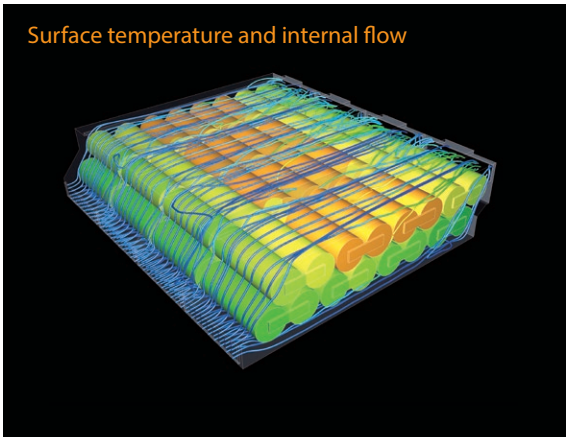
Analysis of Cooling Systems for Hybrid and Electric Vehicles (HEV/EV)



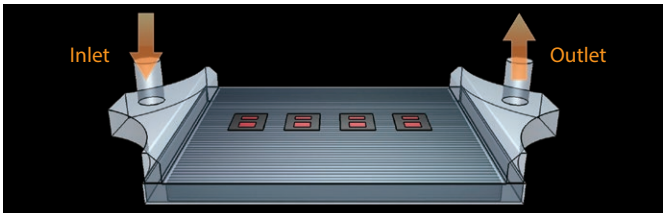
Battery Cooling Fan Module



Battery Packs

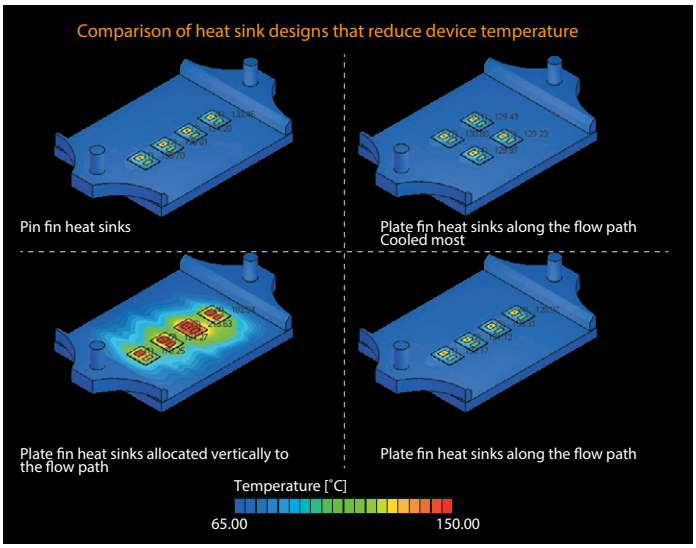


Direct Liquid Cooled IGBT Module



The IGBT (Insulated Gate Bipolar Transistors) plays an essential role in activating the inverter within the PCU (Power Control Unit), the main HEV/EV control module, to generate three-phase electric power.

The IGBT output must be adjusted depending on the vehicle size class. With a larger output, more heat will be generated from the IGBT, which makes cooling performance a crucial factor when designing IGBT modules. Simulation enables engineers to visually evaluate the impact of heat sink shape, observe the effect of heat dissipation, the difference in heat distribution, and other temperature critical patterns. This helps engineers to understand the thermal contributions from each component and determine the optimal design.

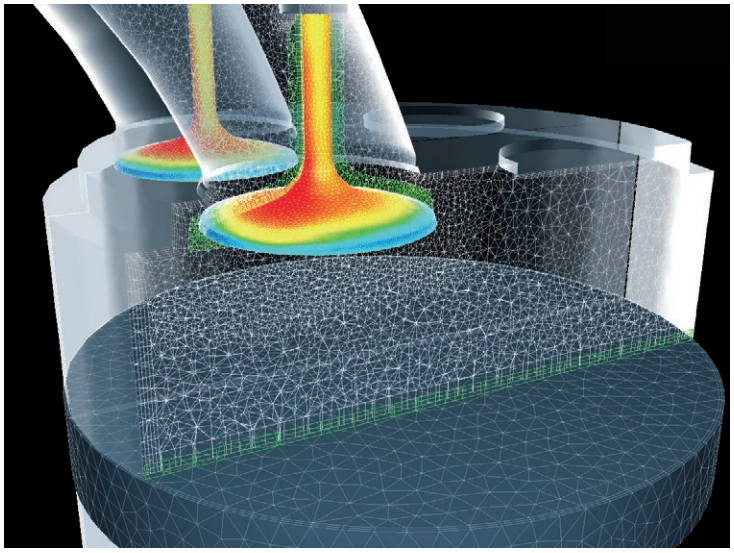


SC/Tetra

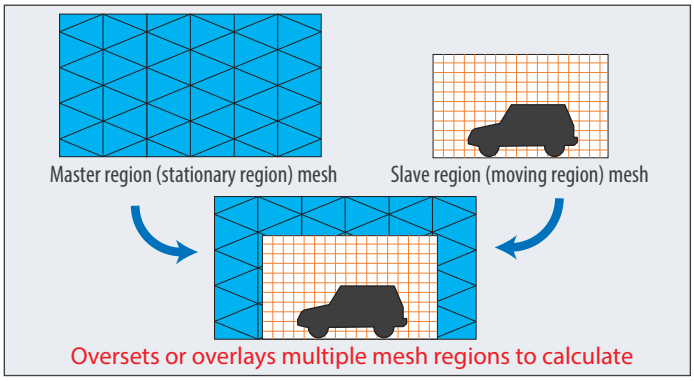
Overset Mesh - Overset Method

Enables simulation of moving objects with complex movements and/or rigid-body collision with walls - by overlapping multiple mesh regions

What is Overset Mesh?

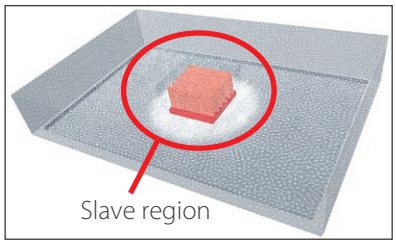


Simulates one analysis space by oversetting multiple computational grid (mesh) regions. Requires users to create a domain and mesh that surrounds a moving object separately from the other domain. A moving condition can be applied to each moving region.

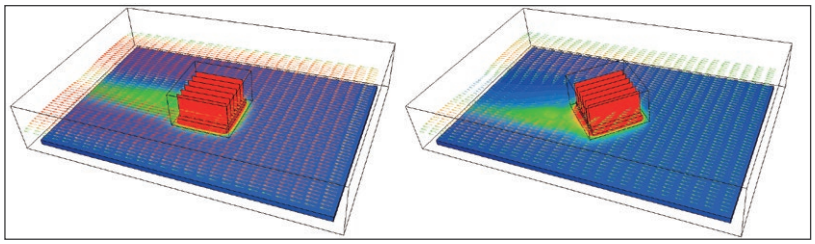


Application 1: Slave Region Can be Replaced Arbitrarily to Compare Multiple Cases

• Heat sink



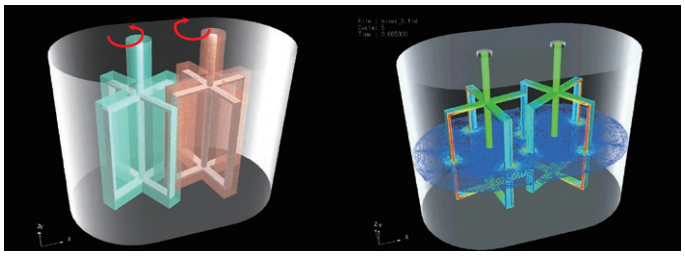
Mesh created per part



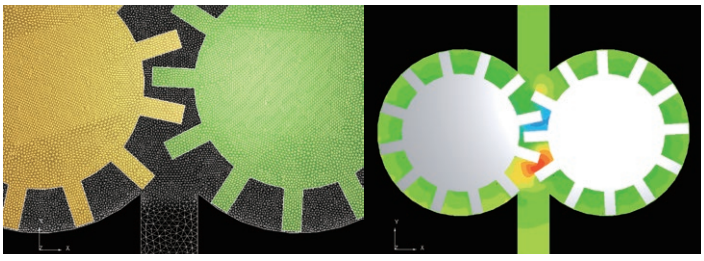
Analysis model can be modified just by moving a part or by replacing it and merging it back to the master region

Application 2: Multiple Rotating Regions Overlapping One Another

• Mixer

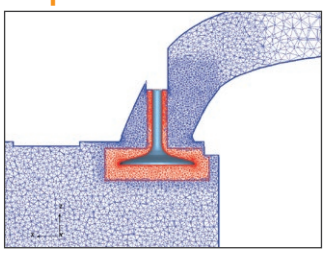


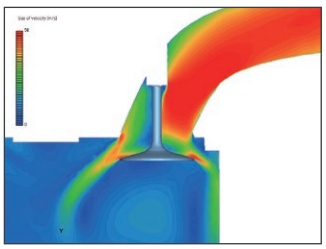
• Gears



Application 3: Moving Object with Contact

• Open-close Valve





The overset method helps execute the analysis that requires a complex movement or contact of objects, which cannot be simulated with a single mesh.

Other Applications

- Ball valve
- Rotation of scroll pump
- Piston movement
- Open/close motion of flaps, etc.

SC/Tetra

JOS (Joint System Thermoregulation-Model)

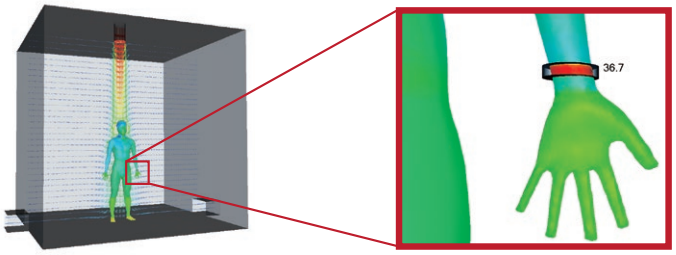
Perform thermoregulation analysis using CFD and JOS

What is JOS?

JOS computes the temperature and quantity of perspiration of a human body. JOS models a human body by dividing it into seventeen body segments to simulate the morphological and physiological characteristics and thermoregulation function of each segment by solving heat balance equations.

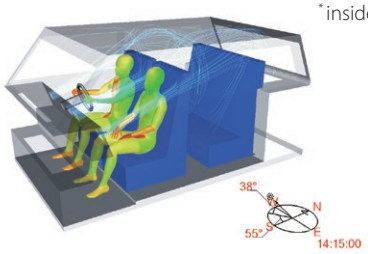
Seventeen body segments:
A more detailed prediction of temperature distribution within the human body is made possible by modeling each body segment. JOS and its revised version, JOS-2, are available.

Analysis of Human Body Temperature While Wearing a Wearable Device



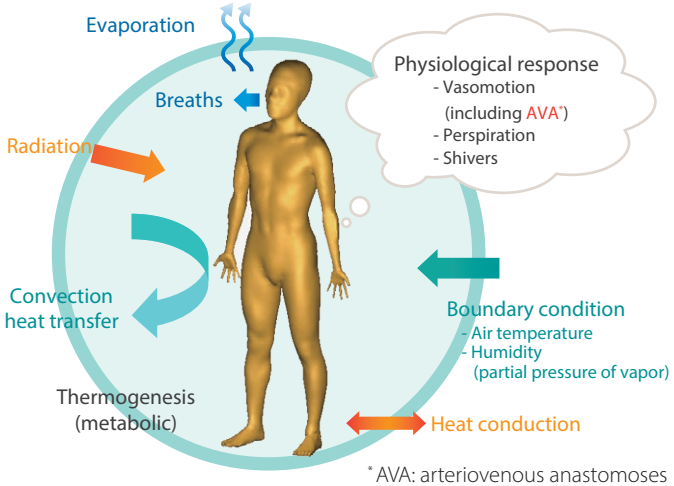
*indoor

Analysis of Human Body Temperature



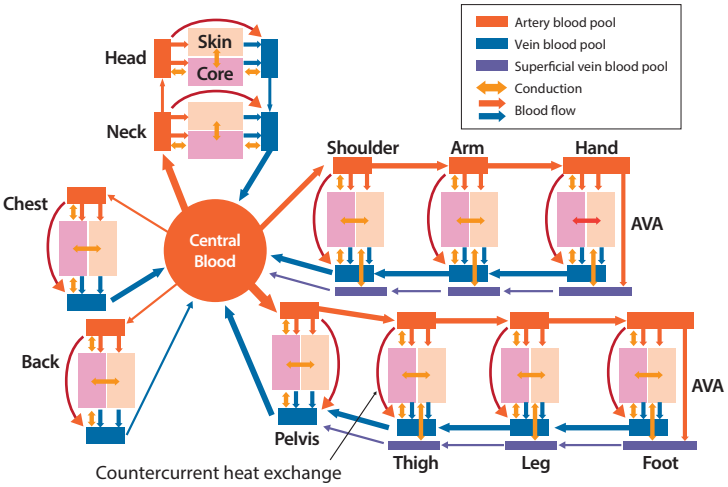
*inside vehicle

Factors Considered in the JOS Model



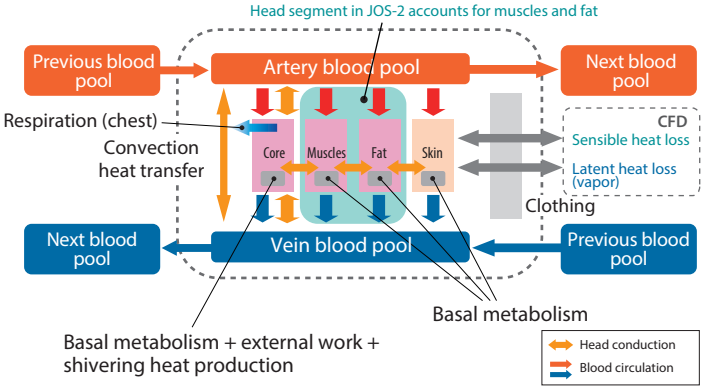
*AVA: arteriovenous anastomoses

Heat Exchange Within a Body

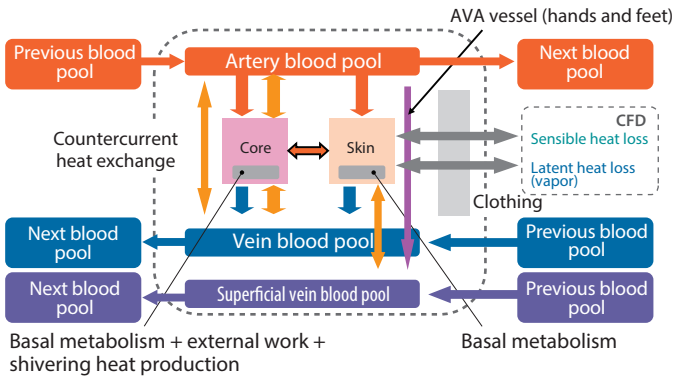


Heat Exchange Within a Body Segment

• Segments other than the limb



• Limb segment



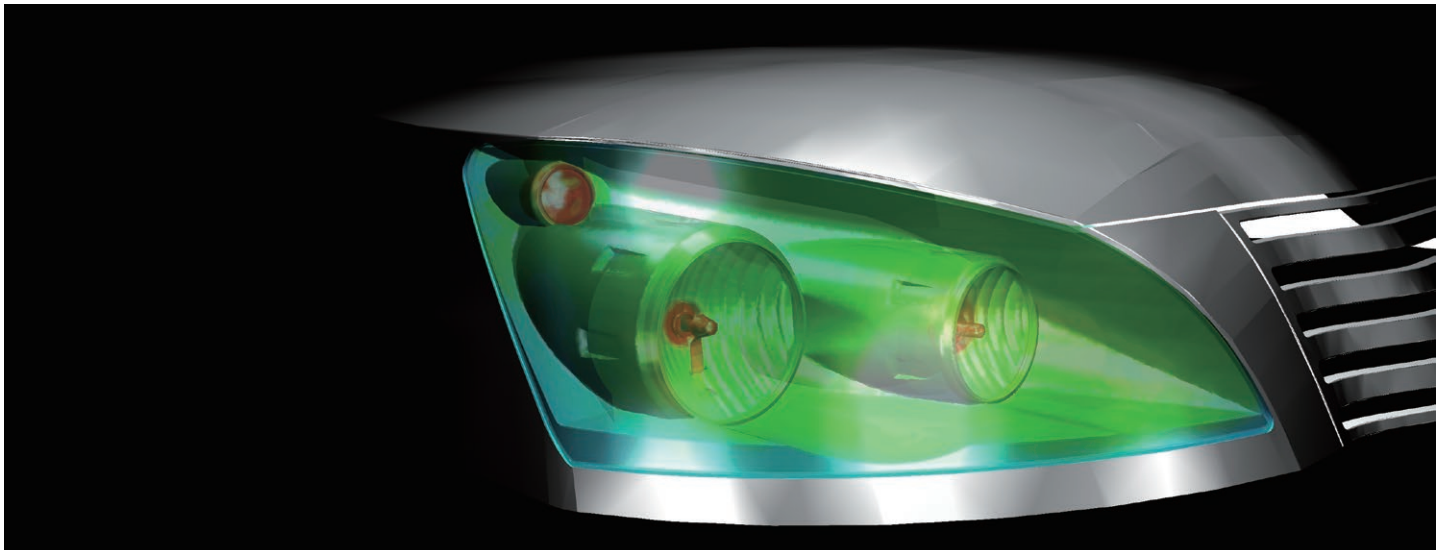
Notes

The JOS function can be used to perform human body thermoregulation analysis in non-uniform thermal environments such as a vehicle interior or a semi-enclosed outdoor space. These are difficult scenarios to evaluate using traditional thermoregulation indices. They are also difficult to experimentally evaluate when the human subject is wearing wearable devices. JOS-2 uses a head segment consisting of four layers to account for the head's high heat capacity. Using JOS-2 engineers can conduct faster analyses with improved accuracy.

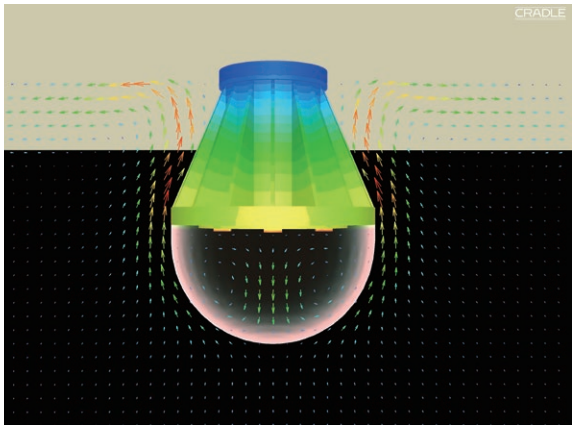
SC/Tetra HeatDesigner scSTREAM

Heat Release Analysis of Lighting Equipment

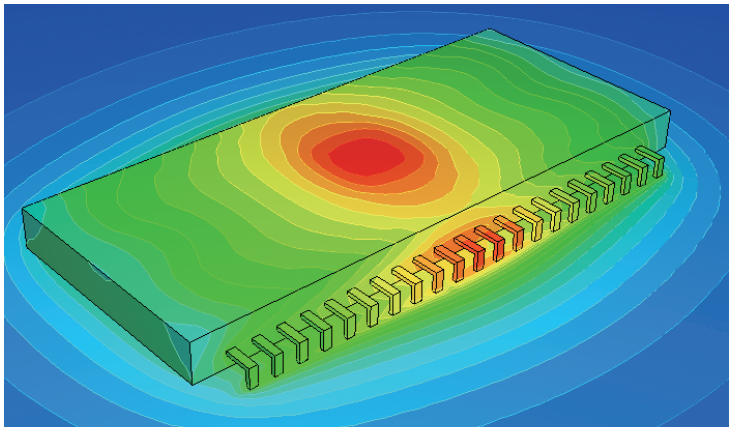
Case Studies of SC/Tetra, HeatDesigner, and scSTREAM



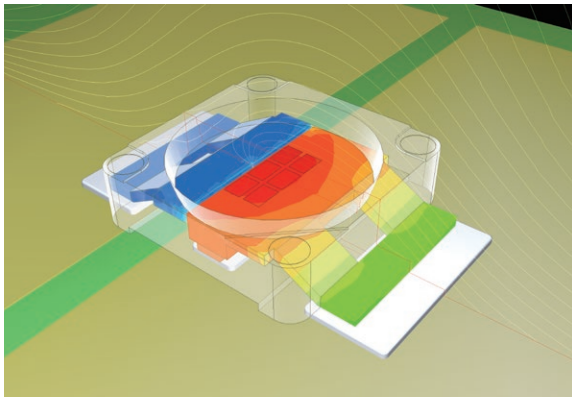
LED Bulb



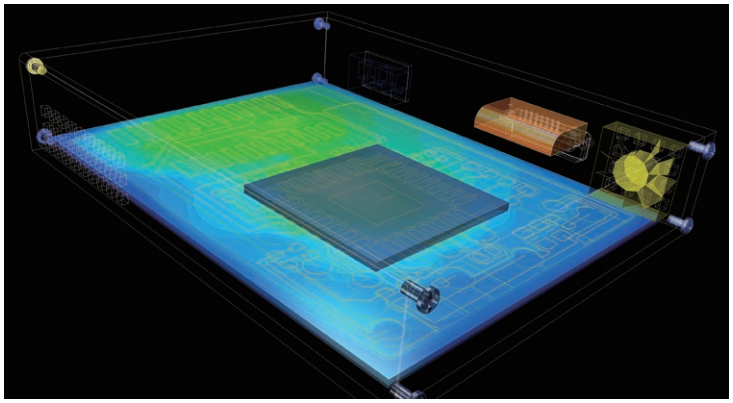
Semiconductor Devices



LED Devices



Heat Release Analysis Considering Gerber Data



Notes

It is a big challenge to effectively promote heat release from electronics components such as highly integrated LSI and LED, which is miniaturized further.
Thermal design is vital to develop high-quality products with more energy saving capability and longer duration.
Simulation helps examine new ideas for thermal design specifically and clearly with visual insights.

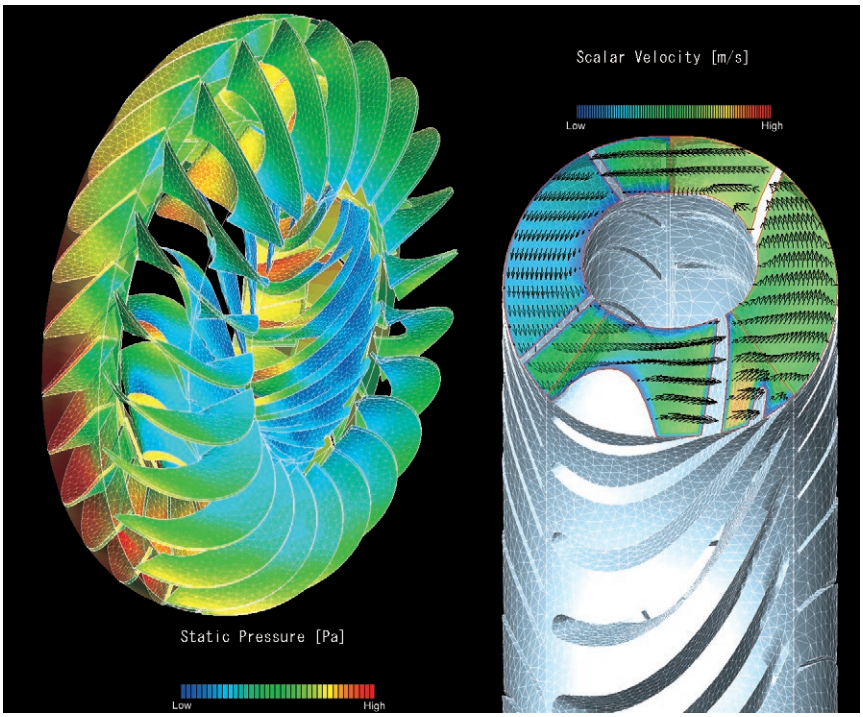
SC/Tetra

Other Cases Studies

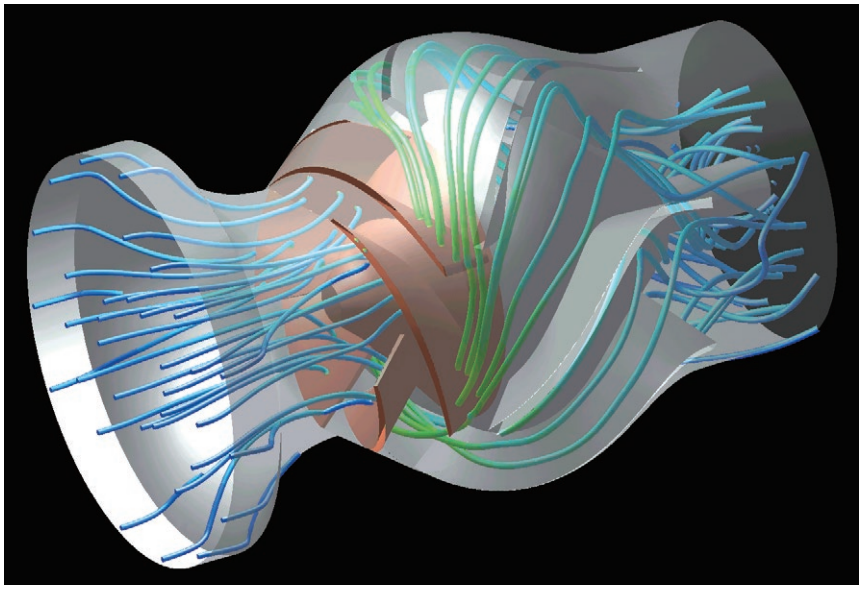
Case Study of SC/Tetra

Torque Converter

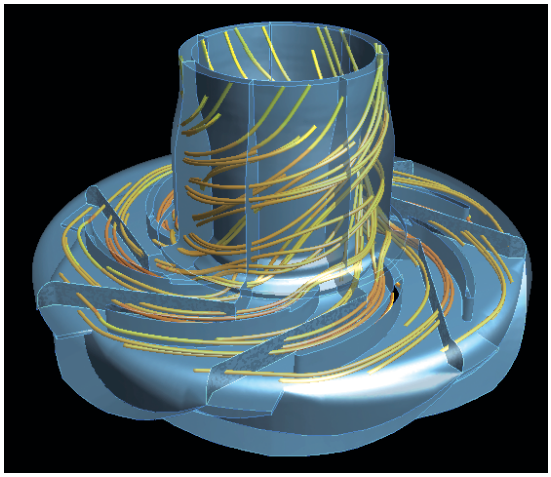
Torque converter is a turbomachinery that transmits rotating power with fluid. It is often used for automatic transmissions on automobiles. Rotation of pump blades directs the oil in a torque converter to the turbine blades, then the inertia force of the oil rotates the blades and transmits the torque. Fluid analysis reveals complex flow dynamics in a torque converter and enables performance evaluation by calculating pressure and torque values.



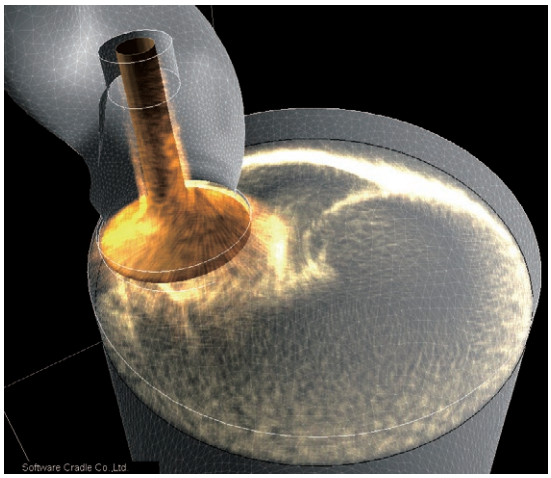
Mixed flow pump



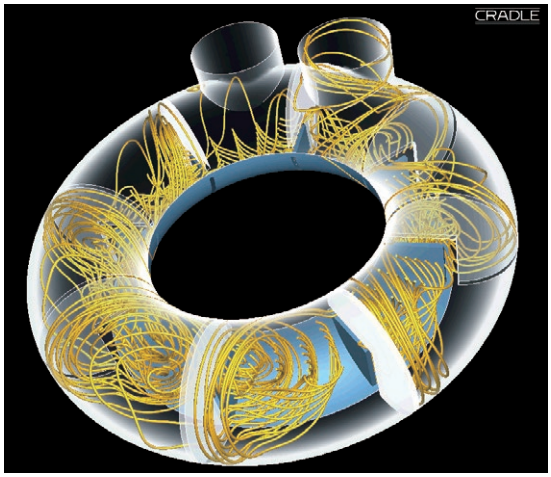
Multistage pump



Engine port



Vortex blower



Pump internal flow analysis for high-efficiency impeller and casing.
Computation of swirl ratio and/or tumble ratio of engine port.

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Our technologies are shaping production and people-related ecosystems to become increasingly connected and autonomous – ensuring a scalable, sustainable future.

Hexagon's Manufacturing Intelligence division provides solutions that use data from design and engineering, production and metrology to make manufacturing smarter. For more information, visit hexagonmi.com.

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