SIEMENS
Ingenuity for life

Automotive and transportation

MITSUBISHI MOTORS CORPORATION

Gaining new perspectives with design exploration

Product

Simcenter

Business challenges

Discover better designs faster

Go beyond conventional design methods

Keys to success

Introduce design exploration solution for Simcenter STAR-CCM +

Instill engineering knowledge into design exploration processes

Leverage engineering services from Siemens Digital Industries Software for R&D simulation

Results

Easily implemented design exploration solutions

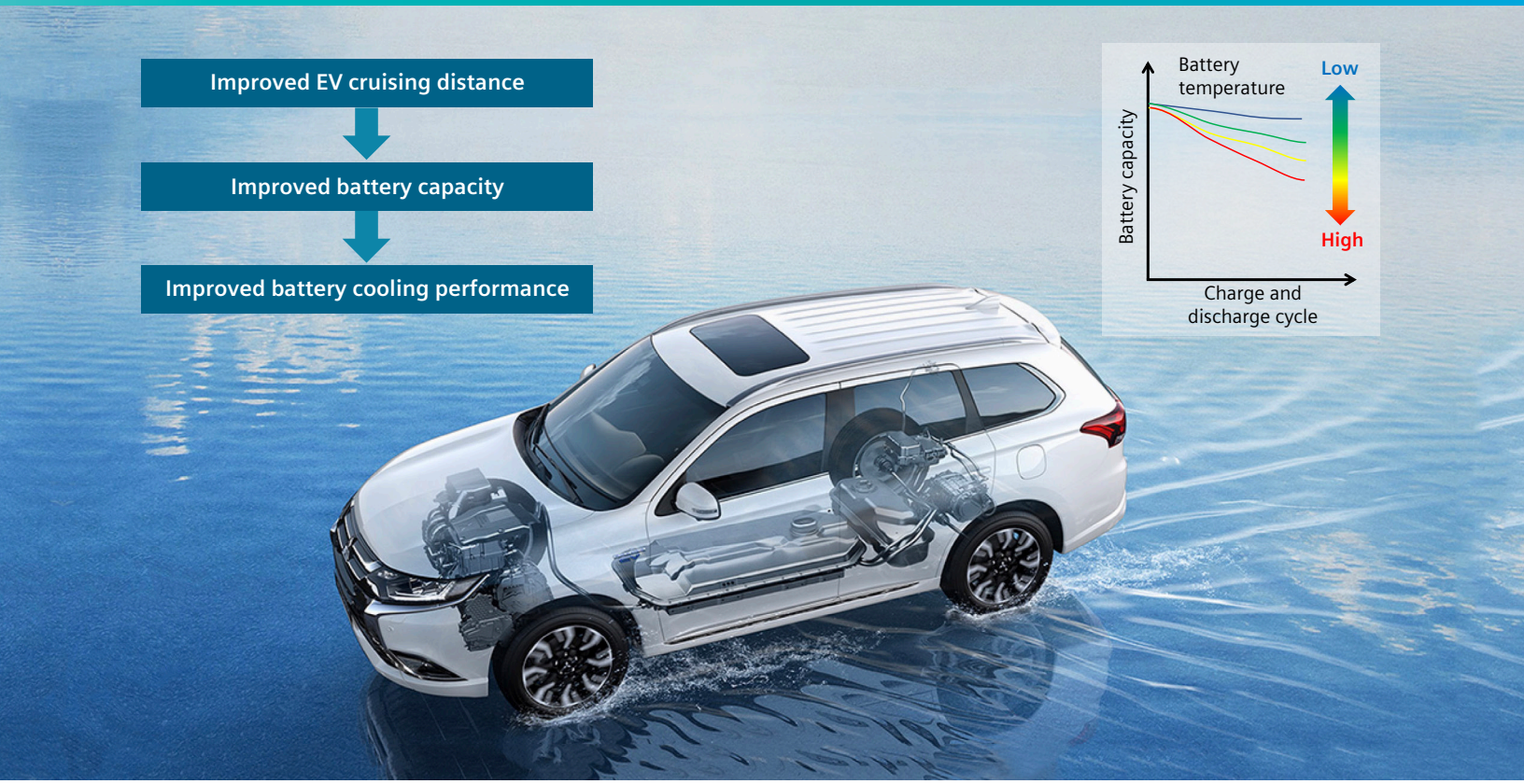
Obtained new and enhanced perspectives on design

Efficiently achieved improvements in design by combining engineers' know-how and design exploration

Siemens CFD solution helps MITSUBISHI MOTORS CORPORATION pursue innovative simulations and improve product performance

MITSUBISHI MOTORS CORPORATION (Mitsubishi Motors) was established when the automotive division of Mitsubishi Heavy Industries, Ltd. became independent in 1970. The company has been involved in automobile production since the pre-war period and is one of Japan's oldest automobile manufacturers. In 1917, the Mitsubishi Model A was developed as the first automobile to be mass-produced in Japan. In recent years, Mitsubishi Motors developed the i-MiEV, the world's first mass-produced electric vehicle, and has been focusing on electric car development since the introduction of its plug-in hybrid EV system.

The Thermal and Fluid Dynamic Engineering Development Group in the Vehicle Function Testing Department at the Mitsubishi Motors research and development center in Okazaki is primarily involved in development related to cooling performance, heat resistance and air conditioning. Development has two dimensions: the first is to predict performance using computer-aided engineering (CAE) at the design stage, before the vehicle is manufactured; the second is to conduct physical testing once a test vehicle has been produced. The group is responsible for developing methods for using CAE technology for environmental and thermal damage-related purposes.



Outlander PHEV battery cooling design exploration.

"The knowledge gained from design exploration has been invaluable, and the project was a success. While the parameter study yielded a two to three degrees Celsius improvement, we were able to achieve an improvement of approximately six to nine degrees by using design exploration. This method is now applied to cooling mechanisms for other parts such as radiators and condensers and contributes greatly to the improved performance of our vehicles."

Wang ZongGuang
Group Manager
Thermal and Fluid Dynamic Engineering Development Group
MITSUBISHI MOTORS CORPORATION

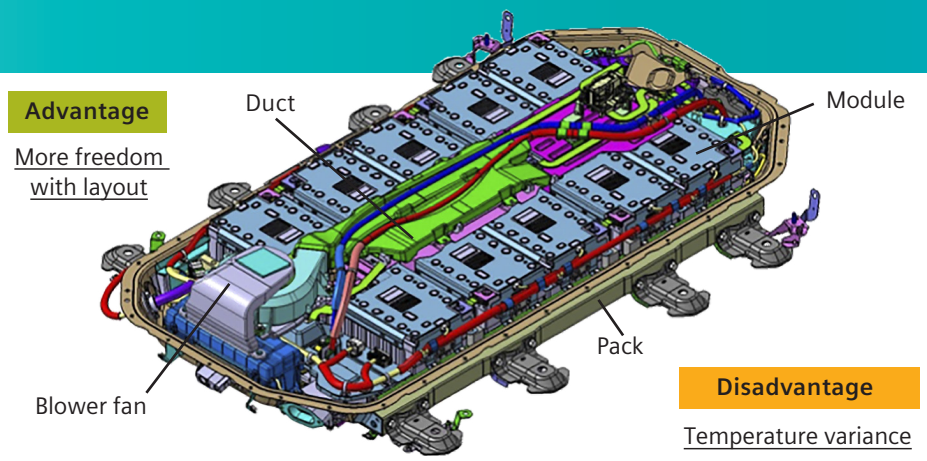
Wang ZongGuang, the group manager, oversees the group and supports its members. Atsushi Itoh, the assistant manager, is responsible for air conditioning and oversees simulations of flow and thermal fields within vehicles, airflow distribution from ducts, and whether the air conditioning reaches the targeted areas. Itoh is also involved in methods development and design exploration (design optimization) related to simulation.

The group runs 3D simulations that predict engine compartment cooling, airflow through the heat exchanger, and thermal damage of parts in the engine compartment, and also simulates coolant, engine oil and transmission temperatures using a 1D tool.

The mandate for simulation

At Mitsubishi Motors, electric vehicles are the present focus of development. The main advantages of electric vehicles over internal combustion engine (ICE) vehicles are primarily environmental – CO_2 reduction via the elimination of harmful emissions, reduced vehicle noise due to the absence of the ICE and better energy efficiency. However, electric vehicles also present challenges such as lower range than ICE vehicles due to battery capacity, limited charging station infrastructure, and safety issues related to their quiet operation.

Improving battery capacity is vital to increasing the cruising distance of electric vehicles. Batteries are susceptible to heat and require temperature control through better cooling. It is difficult to improve cooling performance using only conventional engineering knowledge, and testing is limited by the number of test vehicles that can be produced. For these reasons, computer-aided engineering (CAE) is essential to achieving optimal cooling.



Features of the cooling system.

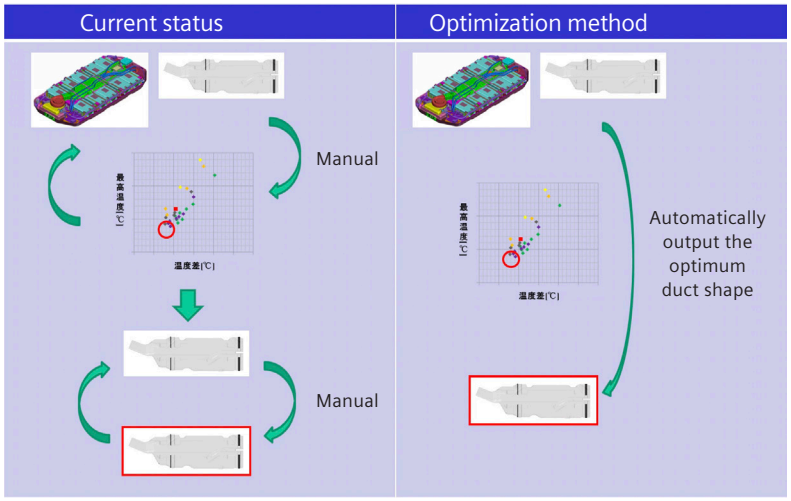
Customization and automation in CFD

Mitsubishi Motors has been a long-time user of Siemens solutions since it introduced STAR-CD™ software, the predecessor of Simcenter™ STAR-CCM+™ software, which is currently used for computational fluid dynamics (CFD) simulations. The company decided to use Simcenter STAR-CCM+, part of the Xcelerator portfolio of software and services from Siemens Digital Industries Software, because of the software's customizability and robust, macro-based automation capabilities. "The advantage of using Simcenter STAR-CCM+ lies in its customizability," Itoh says. "Using macros, we are achieving better and better functionality, and the software makes it possible to improve the effectiveness of methods. Method construction using Simcenter STAR-CCM+ is a breeze."

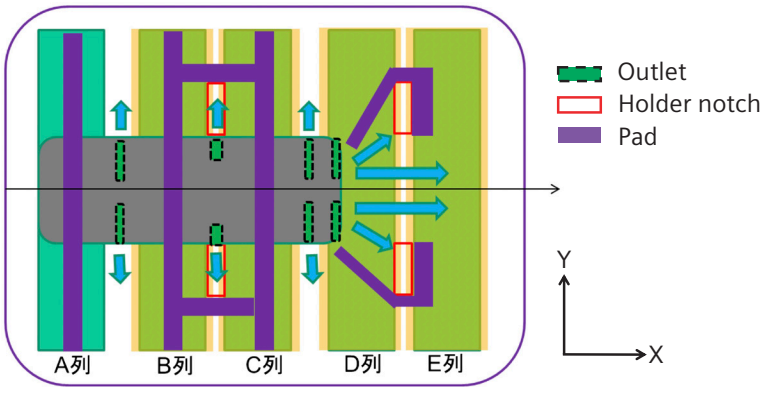
Simcenter STAR-CCM+ includes Design Manager, a capability that helps automate design exploration and optimization. Design Manager uses a blend of optimization algorithms that streamline design exploration studies to help discover better designs faster.

Implementing design exploration

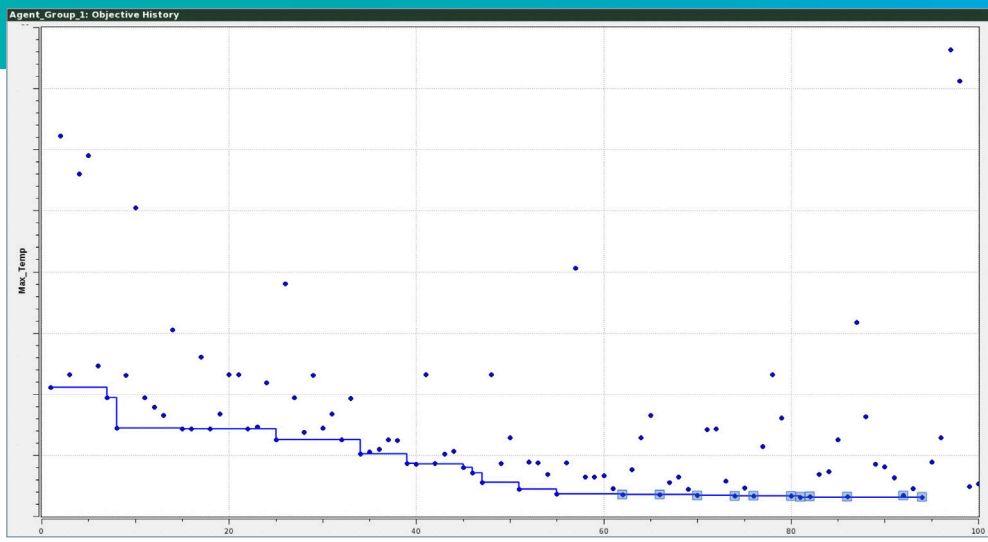
To improve battery cooling performance, Mitsubishi Motors conducted a design study using the airflow distribution from the duct as a parameter. When they were unable to achieve the desired cooling performance, the engineers concluded that they could not reach their targets by only reviewing simulation results or using conventional knowledge and methods. The company recognized the need to explore the design space with multiple parameters, including the outlet duct, holder notch and pad attachments. This led to the launch of a virtual project that aimed to develop simulation methods using design exploration with a focus on improving battery cooling performance and reducing design time. The virtual project focused on the cooling performance of the battery used in the Outlander PHEV plug-in hybrid vehicle.



CFD process in design.



Parametric study of duct air distribution rate.



Design exploration history.

Developing design exploration methods

The development of a design exploration method was accomplished in two stages. In the first, Mitsubishi Motors conducted a review of whether it could improve the performance of the air-cooling system, which was considered fully optimized. In the second phase, the company held a brainstorming meeting that included the design staff, CAE engineers, managers and others. Based on the discussions, the team used design exploration after making improvements to the base model.

In the first stage, the team identified the objectives of the study: reducing maximum cell temperature and homogenizing battery cell temperatures. The exploration study used 22 design parameters, including the duct outlet (position, width, height, and angle), holder notch (position and width), and pad position. In the study, a steady-state analysis calculation was done using a 56-core processor, and the number of designs was set at 100, which required 4.5 days for a complete analysis. The number of meshes used in the analysis model was approximately 11 million.

"While the parameter study yielded a two to three degrees Celsius improvement, Mitsubishi Motors was able to achieve an improvement of approximately six to nine degrees by using design exploration.

In the second stage, a new design was chosen as the base model, building on the engineers' know-how from the brainstorming meeting. A single objective of reducing the maximum temperature was set, using the same design parameters as the first study.

Advantages of design exploration

With conventional design processes for improving battery cooling performance, the solution in most cases is simply opening as many holes in the duct outlet as structurally possible. With this approach, the staff in

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Assistant Manager
Thermal and Fluid Dynamic Engineering Development Group
MITSUBISHI MOTORS CORPORATION

Solutions/Services

Simcenter STAR-CCM+
siemens.com/simcenter

Customer's primary business

MITSUBISHI MOTORS CORPORATION is a Japanese multinational automotive manufacturer headquartered in Tokyo, Japan. In 2011, Mitsubishi Motors was the sixth-biggest Japanese automaker and the nineteenth-biggest worldwide by production.
www.mitsubishi-motors.com

Customer location

Tokyo
Japan

charge of battery design and testing viewed the current design as optimal, leaving little opportunity for improved performance. Design exploration offered an enhanced perspective throughout the project.

Key role of Siemens engineering services

Mitsubishi Motors used Siemens Digital Industries Software's engineering services to develop methods for the design exploration project. With a wealth of knowledge related to computational fluid dynamics (CFD) and design exploration, as well as its insights as a software developer, Siemens helped Mitsubishi Motors gain proficiency with the software and understand the simulation results in preparation for developing the design exploration methodology.

Further development

The battery cooling project combined the knowledge and expertise of engineers with STAR-CCM+ design exploration technology.

"The knowledge gained from design exploration has been invaluable, and the project was a success," says Wang. "This method is now applied to cooling mechanisms for other parts such as radiators and condensers, and contributes greatly to the improved performance of our vehicles."

Beyond the Thermal and Fluid Dynamic Engineering Development Group, Mitsubishi Motors has implemented Simcenter STAR-CCM+ at its Aerodynamics Group. The Simcenter portfolio includes not only CFD, but also a wide range of solutions including structural analysis, acoustics, 1D simulation, and advanced driver assistance systems (ADAS), integrated in a comprehensive solution that no other CAE vendor can offer.

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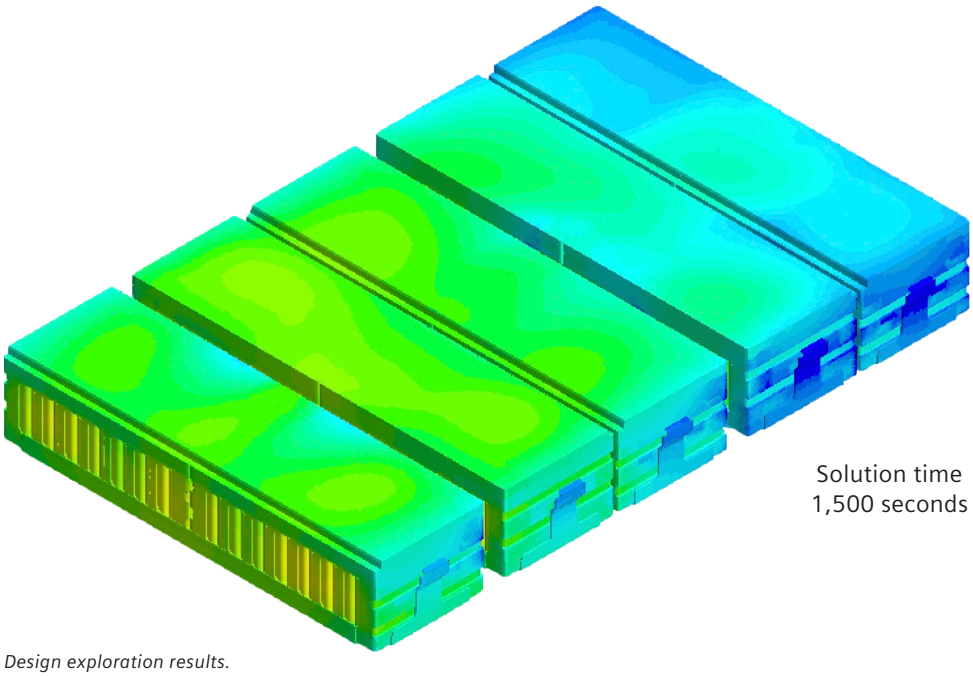

Design exploration results.

Siemens Digital Industries Software

Americas +1 314 264 8499
Europe +44 (0) 1276 413200
Asia-Pacific +852 2230 3333

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