SIEMENS
Ingenuity for life

Automotive and transportation

Kawasaki Heavy Industries

Industrial heavyweight uses Simcenter STAR-CCM+ to help reduce CFD time for motorcycles by 75 percent

Product

Simcenter

Business challenges

Reduce time required to get a concept to the model stage

Cut time using CFD to explore options for achieving functional models

Address design challenges in a timely manner

Keys to success

Use the high level of automation in Simcenter STAR-CCM+ for seamless setup of CFD cases

Find that Simcenter STAR-CCM+ results closely align with wind tunnel test data

Results

Used Simcenter STAR-CCM+ and Java macros to cut CFD time by 75 percent

Used Simcenter STAR-CCM+ surface wrapping tools to reduce CAD cleanup time by 85 percent

Improved cross ventilation by about 40 percent in a configuration that satisfied design demands

Siemens PLM Software solution enables Kawasaki to cut CAD cleanup time for Ninja motorcycles

Implementing advanced support operations

The Kawasaki Ninja H2R and H2 motorcycles reflect the full breadth of Kawasaki technologies from across the company's various groups. In addition to the Kawasaki Motorcycle and Engine Company (MC&E), the development of these machines has enlisted the support of the Kawasaki Heavy Industries (KHI) Group Aerospace Company for the supply of aerodynamic devices, the Gas Turbine and Machinery Company for engine superchargers and the Precision Machinery Company for welding expertise.

The motorcycles comprise a grand fusion of cutting-edge know-how reaching across divisional borders at KHI, earning them Kawasaki's special "River Mark" designation – signifying the company's technology, originality and innovation. The Ninja H2 is certified for public roads, while the Ninja H2R is designed exclusively for closed course riding. Based on the power of their supercharged specs and groundbreaking designs, these motorcycles are admired by motorcycle buffs worldwide.

Figure 1: The Kawasaki Ninja H2R (left) and H2 (right).

Eiji Ihara is the manager of the MC&E Development Engineering Section, and Manabu Morikawa is in charge of computational analysis. They provide support for design and testing through simulation during the product development phase. This is an excellent example of so-called development frontloading – a term increasingly used to describe such advanced support operations. The technology adopted in this analysis was developed jointly with the KHI Technical Institute, while MC&E advanced product development.

Reducing turnaround time

"There is no significance in simply developing computational fluid dynamics technology without pursuing the critical need for application in actual product development," says Ihara. "The greatest bottleneck with CFD is the time factor. We used CFD in efforts prior to the Ninja H2R/H2 development as well, but it took so long to achieve functional models that we found it totally impossible to apply the technology in product development. That prompted

"The moment I encountered Simcenter STAR-CCM+, I intuitively realized that it could do the job."

Eiji Ihara
Manager, MC&E Development Engineering Section
Kawasaki Heavy Industries

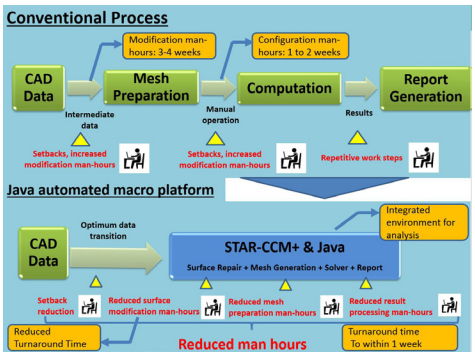

Figure 2: The initiative to reduce turnaround time.

exploration of a wide range of software options, eventually leading us to Simcenter STAR-CCM+ software. The moment I encountered Simcenter STAR-CCM+, I intuitively realized that it could do the job."

The single greatest challenge in developing a new product is the considerable time required to get the concept to the model stage. Prior to discovering the automated aerodynamic analysis macro (VSim) available in Simcenter STAR-CCM+™ software, the analysis required about one month. At the design planning stage leading up to manufacture, designs are liable to undergo adjustments on a day-to-day basis, with new design requirements incorporated into the simulation as a result. Due to using simulation as a design tool, it is essential that analysis be capable of keeping up with the pace of changes.

The full month required for the implementation of computational fluid dynamics (CFD) proved to be too long to make any meaningful contribution to product development in KHI's development span. The first critical issue, therefore, was to reduce CFD turnaround time. The target was set to implement the initial case in one week's time, with Siemens PLM Software's Japanese and overseas offices teaming up to launch a joint project with KHI.

Behind the success in realizing the targeted one-week turnaround time were two important technologies in Simcenter STAR-CCM+: surface wrapping for computer-aided design (CAD) cleanup, and Java macros for powerful automation. Prior to applying these technologies, the following two problems were identified as the key time-consuming factors:

- The time required for CAD repairs (three-to-four weeks), which was resolved with Simcenter STAR-CCM+ surface wrapping and automated CAD repair capabilities

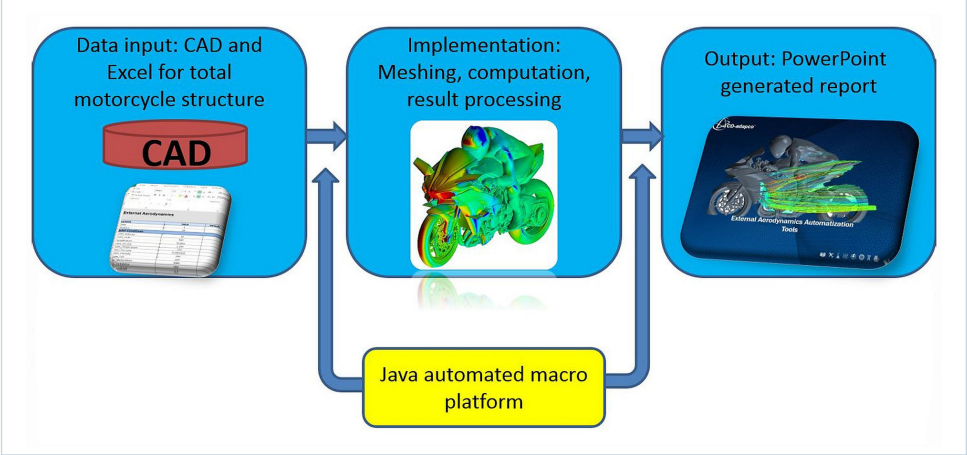

Figure 3: The aerodynamic analysis automated (VSim) macro workflow.

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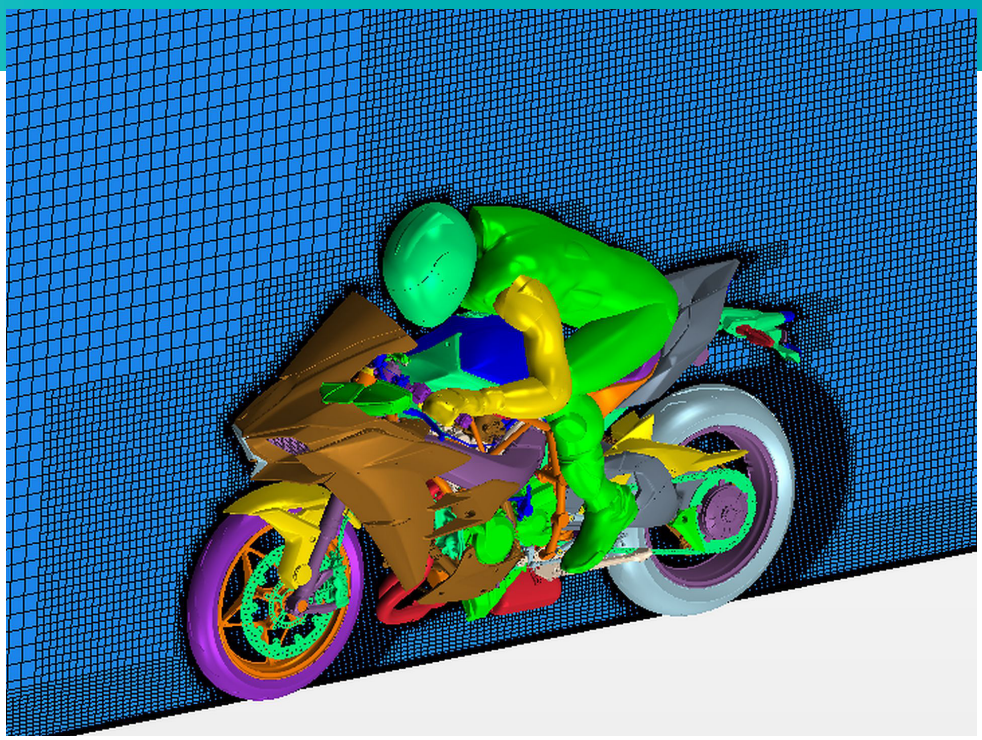

Figure 4: Trimmed mesh on a plane section around the motorcycle, showing refinement in the wake region, automatically generated with Simcenter STAR-CCM+.

- The time required for analysis settings (one-to-two weeks), which was resolved with preprocessing automation using a Java macro

With the VSim macro supplied by Siemens PLM software, all analysis settings and data were entered in a Microsoft Excel spreadsheet software that was read by Simcenter STAR-CCM+. The macro automated the entire process: CAD import, boundary organization, boundary conditions; and preparing wind tunnel configurations, analysis, postprocessing settings, batch submissions and generating written reports using Microsoft PowerPoint presentation software.

Siemens PLM Software ran benchmark tests, leading to a one-week turnaround time. By implementing this benchmarked process, MC&E also realized a turnaround time of one week, as well as output in only one-to-two days when geometry modifications were needed to address minor changes.

"Compared to before, now we can simulate several dozen cases in reduced time," says Morikawa. "Thanks to this, the number of prototypes being turned out has also been reduced, making an extremely valuable contribution to lowering cost and man-hours. We feel that the application of Simcenter STAR-CCM+ has proved highly effective on this front as well."

In terms of computational resources, the initial application of CFD in product development was conducted through dozens of parallel computations. With the success of the Ninja H2R/H2, the computational

	Conventional method	Post-automation
CAD corrections	3 to 4 weeks	2 to 4 days
Analysis condition settings	1 to 2 weeks	Within 1 day
Work hours	4 or 6 weeks	Within 1 week
Turnaround time	1 to 1.5 months	Within 1 week

Table 1: The reduced turnaround time results.

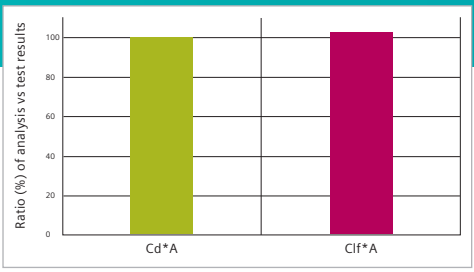

Figure 5: Results of CFD analysis accuracy verification.

approach earned high marks in the company, leading to an increase in clusters and subsequent applications of CFD in the development of wide-ranging models.

Improving simulation reliability and accuracy

With the principal products at MC&E characterized by high speed and power, the key areas of application for CFD were in the evaluation of aerodynamic performance and thermal management of onboard electronic components. In the past, CFD was only adopted for products involving both high engine displacement and price. Today, the application of this tool has been expanded to analyzing small engine displacement models as well.

The merits of the automated VSim macro are not limited to simply reducing turnaround time, with the following advantages also available:

- Elimination of analysis setting errors
- Elimination of disparities in results when different engineers run the analysis

The streamlined, automated process ensured that even personnel with limited experience can perform the CFD analysis with ease. More recently, an in-house thermal management analysis evaluation macro has also been developed, enabling cuts in turnaround time for that work as well. In addition to reducing the development turnaround time through simulation, it is also vital for the analysis to be accurate. KHI has a wind tunnel facility where testing is conducted on a full-scale motorcycle model. Wind tunnel characteristics are employed in the boundary conditions of the analysis. Analysis accuracy is calculated by comparing coefficient of drag (C_d) and coefficient of lift/front (C_{lf}) with the test results for the six major aerodynamic components. Verification of analysis accuracy is also performed by comparing computational flow visualization with flow field test data using smoke and other techniques. The results from the automated VSim process in Simcenter STAR-CCM+ showed excellent agreement with test data for the overall motorcycle as seen in figure 5.

"Both of these areas were first-time challenges for KHI, and there is no doubt that without CFD onboard, we would never have succeeded in the development."

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Figure 6: Full cowling type (left) and naked type (right).

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Manabu Morikawa
Head of Computational Analysis, MC&E Development Engineering Section
Kawasaki Heavy Industries

Ninja H2R/H2 design challenges

The development of the Ninja H2R/H2 models encountered two major design challenges:

- Ensuring radiator ventilation flow capable of cooling the engine
- Aerodynamic devices to lower lift

The Ninja H2R/H2 models are mounted with supercharger-assisted engines. The Ninja H2R is a "monster machine" with an engine output of 321.4 horsepower (hp) (at ram air pressure), giving rise to extremely high engine heat generation compared to previous models. Based on this, one principal design goal was to provide ample radiator ventilation flow to cool the engine.

The motorcycles are the fastest from the Kawasaki stable, while also being extremely lightweight, leading to potential floating of the front wheel. Due to this, the key aerodynamic challenge was to lower lift on the front wheel. These two points were treated as key CFD themes as the development progressed.

Radiator cross-ventilation studies

Motorcycles come in the conventional full cowling and naked types, with each offering its own benefits and issues. A full cowling offers improved airflow at the front of the radiator, but wind ventilation is poor since the cowling stretches over the back of the radiator. With a naked type motorcycle (no cowling), the ventilation at the rear of the radiator is excellent, but is countered by the inability to collect air flow at the front of the radiator.

To develop these Ninja H2R/H2 models, a design capable of incorporating the benefits of both types was required. To address that need, Simcenter STAR-CCM+ simulations were used to identify a design capable of collecting wind at the front and enhancing ventilation out the back. Specifically, different cowling configurations were analyzed numerically until the required flow volume was eventually obtained. Compared to the initial design, CFD results showed that cross ventilation was improved by approximately 40 percent in a configuration that satisfied the design demands.

Aerodynamic device studies

The next phase comprised studies of aerodynamic devices that would lower front-wheel lift, an important design consideration for realizing safe driving on the Ninja H2R/H2. The KHI Group Aerospace Company used around 100 years of aerodynamic know-how to assist

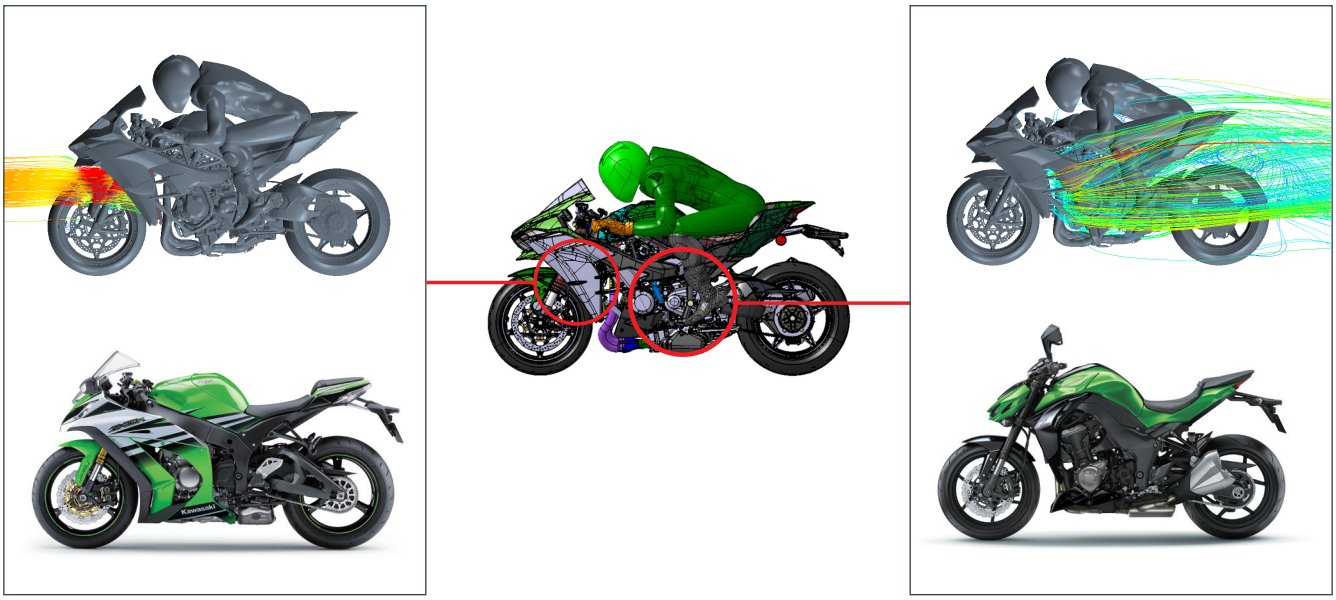

Figure 7: Cowling configuration studies to secure radiator cross ventilation: The frontal wind flow collection is equivalent to the cowling type (left). The rear cross ventilation is equivalent to naked type (right).

in analyzing multiple mirror configurations and other devices to help lower front-wheel lift.

"Both of these areas were first-time challenges for KHI, and there is no doubt that without CFD onboard, we would never have succeeded in the development," says Ihara. "From the design stage, we realized that it would be exceptionally tough to achieve effective heat balance while reaching extremely high speeds.

"Then again, because this was a machine styled for customers who demand just such performance, there was no choice but to achieve that goal. We sifted through many ideas, eventually uniting our focus in a single direction to advance the product development. KHI offers the advantages of being an integrated heavy industrial power with a wealth of technologies to draw from. The resulting collaboration across divisional lines provides a core strength as a company."

In a very real sense, this project was a rich embodiment of the "All Kawasaki" spirit.

"One of the company's premier success stories"

Using Simcenter STAR-CCM+ surface wrapping and the automated macro platform enabled KHI to drastically reduce turnaround time. This cleared the way for applying CFD in the development work,

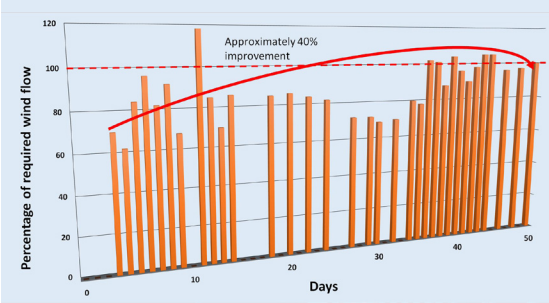

Figure 8: Radiator cross-ventilation transition during Ninja H2R/H2 development.

Solutions/Services

Simcenter STAR-CCM+
www.mdx.plm.automation.siemens.com/star-ccm-plus

Customer's primary business

Kawasaki Heavy Industries, Ltd. (KHI) is one of the three major heavy industrial companies in Japan, starting as a shipyard in 1896. The company's current lineup covers a broad range of products, including motorcycles, precision machines, plants and environmental systems, gas turbines, ships, railroad vehicles, aircraft and spacecraft.

www.global.kawasaki.com/en/

Customer location

Minato, Tokyo
Japan

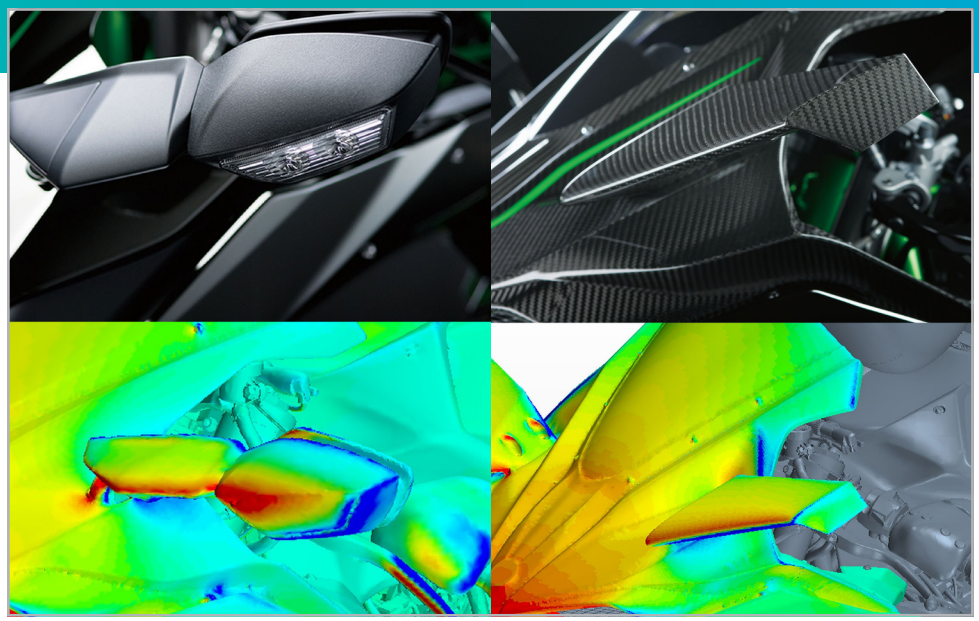

Figure 9: Aerodynamic device study results for Ninja H2 (left) and H2R (right), delivering a minimum rise in drag and a major reduction in lift.

with the resulting cross-sectional use of CFD within the KHI organization emerging as one of the company's premiere success stories in recent years. Another highlight in this project was Siemens PLM Software's Power Session license – a creative licensing approach unique to Simcenter STAR-CCM+. This licensing format can be applied to augmentation of hardware resources, facilitating flexible use of hardware geared to the specific development cycles at hand.

To further improve product performance, Morikawa is studying the potential application of HEEDS™ software, Siemens PLM Software's multidisciplinary design exploration (MDX) tool that is used in product development.

This interview was held in 2015. Names, titles and divisions mentioned were correct at the time. Kawasaki Ninja H2R/H2 written about in this article is the 2015 model.

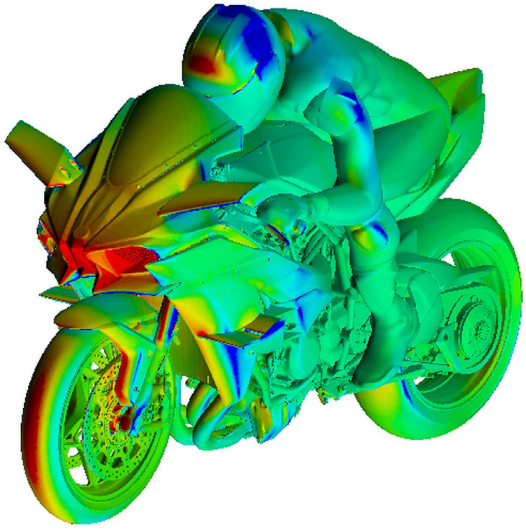

Figure 10: Pressure contours on the motorcycle and rider as pictured in Simcenter STAR-CCM+.

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