Creating the future with Water and Air

Rotating Equipment Development supported by Cradle CFD

Figure 1. TERAL's new Nearly ZEB building

As a specialised pump and fan manufacturer, TERAL offers industry-leading products. TERAL uses high-precision computational fluid dynamics (CFD) to reduce prototyping and investigate design ideas to create better products. In addition, the company also wants to take advantage of the CFD-based research that it has accumulated to develop its design methodology and add value to its products.

Efforts to address energy issues and the challenges of global warming are gaining momentum. Environmentally friendly construction and operation with an energy-conscious approach are in demand for a wide range of buildings, even factories, and initiatives such as Zero-Energy Buildings (ZEBs), also called Net Zero-Energy Buildings, are attracting much attention.

TERAL offers products central to such efforts, with experience in manufacturing and marketing pumps, fans, peripherals, other unit equipment, and related services—headquartered in Fukuyama, Japan. TERAL's roots date back to 1918. Starting with producing pumps for agricultural use, TERAL changed direction in 1956 and began manufacturing fans in response to the growing popularity of centralised air conditioning. In 1974, with the development of fire pumps, the company became a pioneer of unitisation in the industry. Then, in 2018, as the company celebrated its 100th anniversary, TERAL completed a new Nearly ZEB corporate building (a building that reduces net energy consumption by 75% or more) (Fig. 1).

"Triple e" TERAL's concept of product development

High efficiency products realize saving energy and preserving the Earth environment

Triple e

This mindset is directly linked to the thoughts behind the company name TERAL and the slogan "Creating the Future with Water and Air" as our corporate philosophy.

Figure 2. Product development concept "Triple e".

With its expertise in controlling the flow of water and air, TERAL is pursuing the development of higher-efficiency products and reducing energy consumption, based on a product development concept called "Triple e" (Fig. 2), with which the company is pushing the boundaries of advanced manufacturing and contributing to environmental protection on a global scale. "Induction fans (airflow-generating fans)" (Fig. 3), which are used in major stadiums and factories to cope with hot environments, blow air out of nozzles at high speeds to induce airflow in the surrounding air, moving and agitating the air to achieve uniform air conditioning and ventilation with low power consumption. In addition, in recent years, the company has reached the top of the market in Japan with its popular "Disposer" products (Fig. 4), which are used in high-rise condominiums and other buildings to reduce the time and labour required for hygienic garbage disposal.

TERAL uses Hexagon's Cradle CFD to predict the performance of these pumps and fans and to analyse the flow fields (Figs. 5, 6). It is difficult to directly observe the flow fields in pumps and fans to make design improvements because they are inside a casing. Producing prototypes with a transparent case for visualisation, in addition to the need to account for water leakage and deformation, using CFD is essential in terms of time and cost.

Figure 3. Induction fans (airflow-generating fans) "SF". With power consumption as low as that of household lighting fixtures, it's effective for ventilation and heat control.

The company introduced 3D CAD in 2001 and CAE fluid analysis tools in the early 2000s. Back then, several software packages could analyse fluid machinery, including rotors. Of the available options, SC/Tetra was the most satisfactory in terms of speed of analysis and stability of calculations, and it was also easy to use. TERAL adopted SC/Tetra as Software Cradle[1] designed and developed it in Japan with a professional, experienced support system already in place. Software Cradle later updated the software to scFLOW, and the research department is currently using it to predict performance and analyse flow fields based on data for products designed by the development team.

Figure 4. Food waste disposers "DSP-75T". The motor and crushing chamber are smaller than in previous models. It processes 250 g of food waste in approximately 20 seconds.

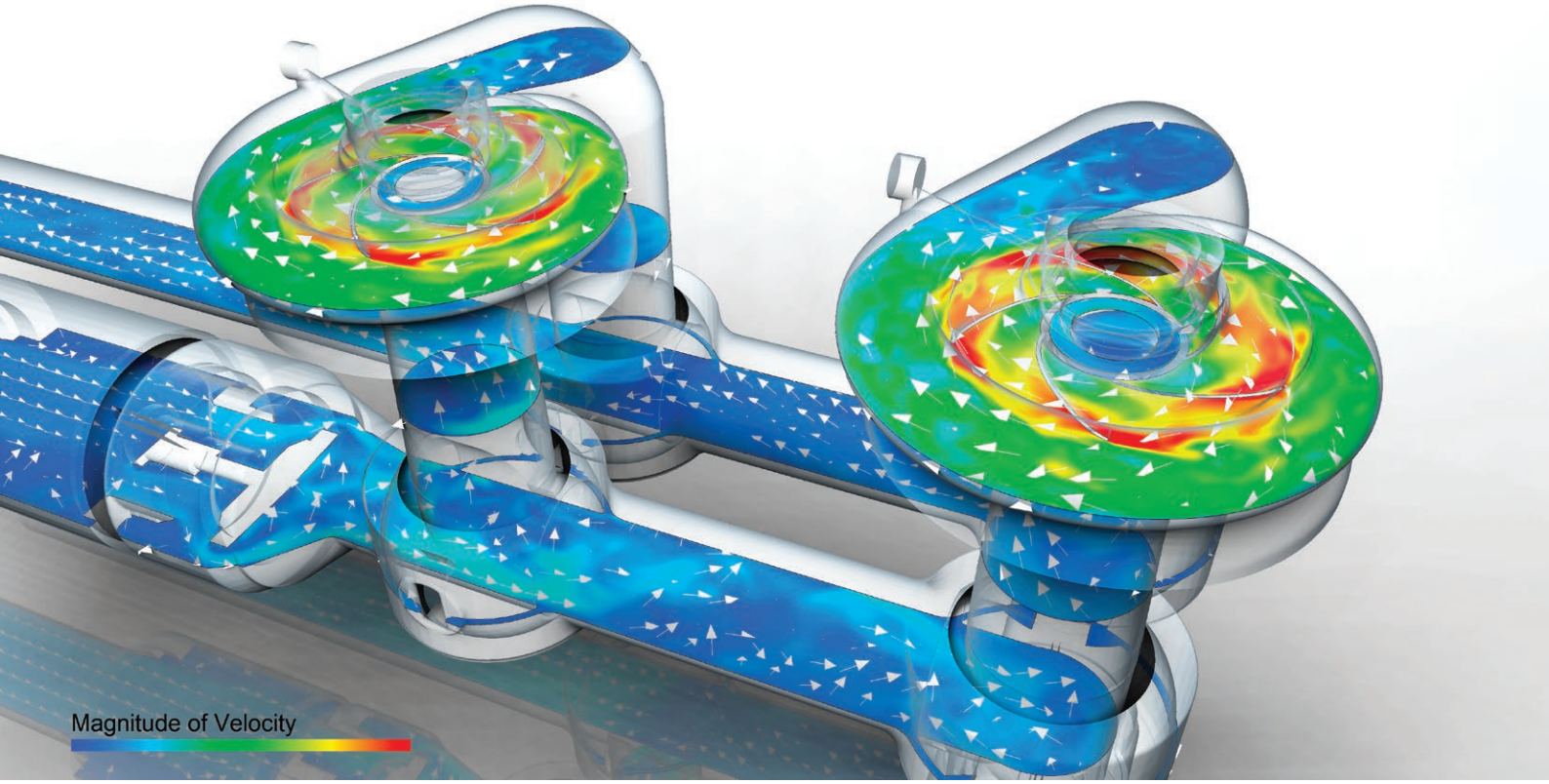

Figure 5. Analysis results showing streamlines and velocity contours for the “MC5S” pump.

Figure 6. Water supply pump unit, direct-coupled booster of the “MC5S” pump.

TERAL has achieved high confidence in its analyses based on the wealth of analytical experience it has accumulated. When performing an investigation, it is essential to understand the factors that cause errors, such as disturbances. More recently, when there are differences between experimental and analytical results in performance curves, “it seems that more and more often we find that the problem isn’t on the analytical side at all, for example, that there are differences between the design model and the actually produced components. At this point, I feel that the precision of manufacturing, measurement and analysis are equally matched”, says Dr. Ikeda.

Figure 7. Multistage pump line-up.

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>
> Mr. Haotian Han

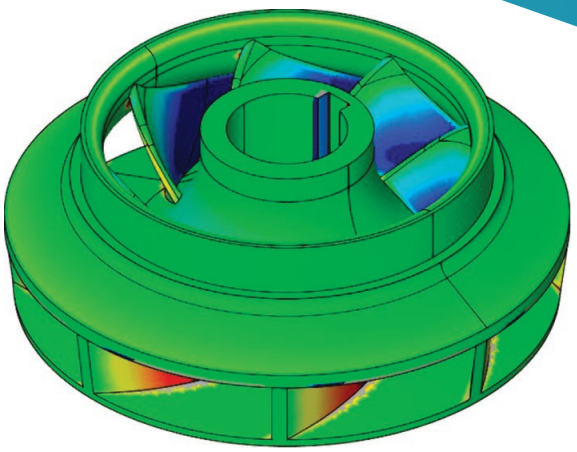

Figure 8. Shape discrepancies between the design model and the reverse-engineered model of an impeller. Dark red or blue areas indicate where differences of 2 mm or more were found

To investigate the cause of discrepancies between analytical and experimental results, TERAL is more involved in reverse engineering than ever before. One example that illustrates the importance of this approach is in the analysis of multistage pumps (Fig. 7). During the prototype evaluation phase for these products, a situation arose where there were significant differences between the values predicted in advance by CFD using design (CAD) models and the experimental values. After measuring the impeller prototypes with a 3D scanner and comparing the results with the design models, it was found that the blade shape deviations of 2 mm or more had occurred in the manufacturing process (Fig. 8). When the actual shape data from these measurements were re-used for the CFD analysis (Fig. 9), it was confirmed that there was good agreement between the experimental and analytical values (Fig. 10). In this way, TERAL skillfully uses the data obtained from product design, manufacturing, testing, and the other processes as feedback for design and manufacturing to reduce the number of prototypes and tests.

The scFLOW Visual Basic (VB)[2] interface has also helped eliminate errors introduced during analysis. For example, when running multiple analyses while making minor geometric changes to the blade shape, various engineers working on the project need to ensure they all use the same boundary conditions and setup details. scFLOW automatically enters the relevant information into Microsoft Excel[2] using the VB interface, so there are no omissions. This is also useful for standardising analysis within the company so that there are no differences in analysis conditions, even if a project is passed on to someone else before completion.

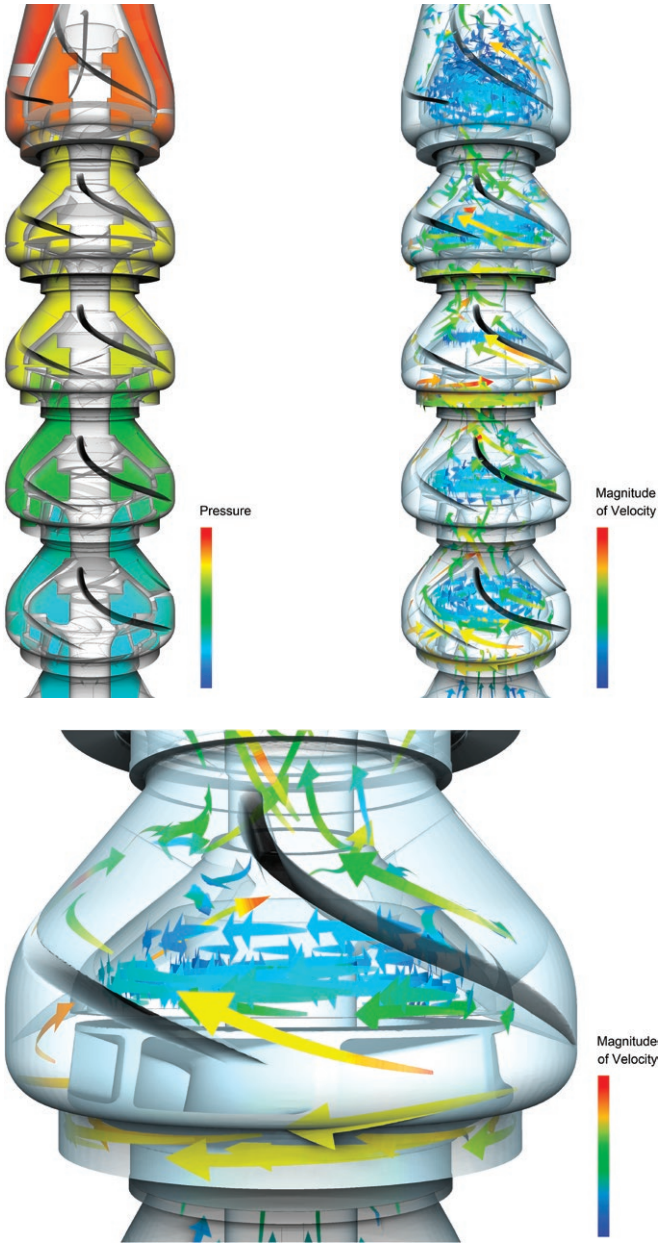

Figure 9. Overall analysis results (Upper left: static pressure distribution, Upper right: streamlines, bottom: streamlines / enlarged).

> **scFLOW has more stable analysis results than other tools. While the mesh refinement can sometimes affect the results with CFD, we rarely see that with scFLOW. This makes it possible to entrust the analysis even with the less experienced engineers."**
>
> **Dr. Eng. Teruaki Ikeda**

In addition, the scFLOW VB interface has also helped to reduce working time. Previously, it took an hour to set up an analysis, but with the VB interface, this has been reduced to 20 minutes, including setup and running checks. This is particularly effective when a large number of analyses need to be run with minor changes in conditions.

The introduction of scFLOW has been a success for TERAL in drastically reducing costs and shortening the prototyping phase. Previously, the company used to make a lot of impeller prototypes and benchmark them. If the performance were lacking, the geometric shapes would be adjusted and prototyped again, repeating the trial and error process. More recently, however, because scFLOW allows the performance to be validated in advance, performance targets can sometimes be met after just one prototype, allowing the company to move on to the production process.

Mr. Han praises scFLOW for being "beginner-friendly software". "SC/Tetra also had good usability, but scFLOW has the operations lined up on the screen, so it's even easier to understand how to use it". He adds that "even a beginner can learn all the operations in a month or two. scFLOW also has fewer output file types than SC/Tetra". He says new users get confused if there are too many files, so he appreciates that the number of outputs is low by the default and can be changed in the settings.

Dr. Ikeda says "scFLOW has more stable analysis results than other tools". He says confidently "While the mesh refinement can sometimes affect the results with CFD, we rarely see that with scFLOW. This makes it possible to entrust the analysis even with the less experienced engineers."

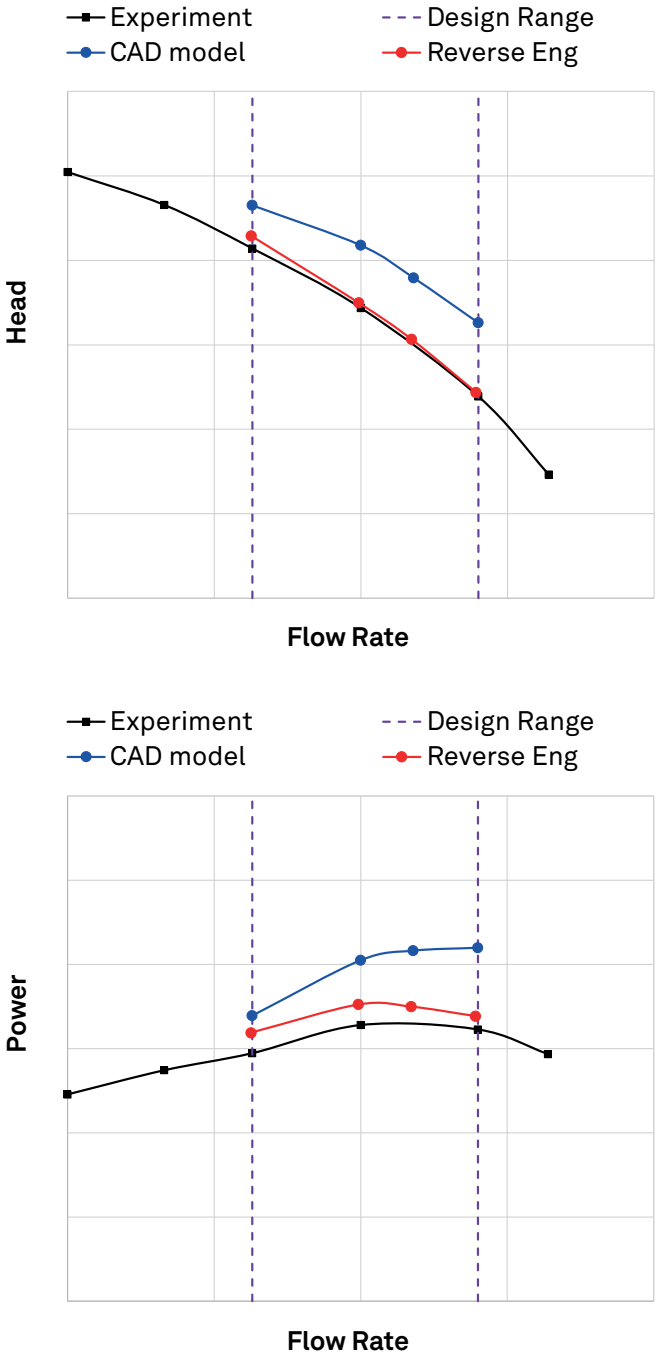

Figure 10. Comparison of performance curves.

On the other hand, Dr. Ikeda points out that the most important role of CFD is “to numerically ‘investigate’ the effect in the performance by the shape change and to pass these findings on to the designers”. Without CFD, even if we came up with a new shape, we would have limited ability to verify that the flow was as intended. When designers can get feedback based on the analysis results, they gain experience that leads to the generation of new ideas for better designs in the future.

“We expect that the 3D design and CFD exchanges the impossible designs, which were based on the conventional methods and experience, to the possible designs”, says Mr. Takuno. Until now, for example, the design parameters for impellers have been fixed in specific ways, such as the blade-to-blade width, the inlet angle, and the outlet angle. But now, it is also possible to design and analyse new parameters for the areas in between. “As we gather more data, we may find parameters that have a greater effect on the performance. Eventually, I think we can create our own empirical formulas”, adds Mr. Takuno.

Currently, TERAL is working on fluid and strength analysis, but at the same time, there is a growing demand for noise and vibration analysis for fans. Noise and vibration analysis is becoming increasingly important because the quiet operation and low-vibration performance are value-added product features. Noise and vibration can only be determined at the prototyping stage, but simulations would reduce the number of prototypes and generate new design ideas. For pumps, however, there is a strong demand for simulations considering the cavitation and contamination, and the company plans to tackle these areas next. TERAL is taking a new step towards more advanced product development for high-performance, highly efficient, and more comfortable products.

(1) Software Cradle is part of Hexagon’s Manufacturing Intelligence division.

(2) Visual Basic and Microsoft Excel are trademarks, or registered trademarks of Microsoft Corporation in the United States and other countries.

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