Nuclear Energy

1 Automatic Design System Using Artificial Intelligence to Design Piping, Air Conditioning Ducts, and Cable Trays

Due to current reductions in the cost of renewable energy, nuclear power generation is faced with a demand for improvements in various areas of competitiveness. In addition to the approximately 100 km of piping used for each advanced boiling water reactor (ABWR) plant, this automatic design system using artificial intelligence (AI) was also developed to support high-speed route plans and mutual arrangement adjustment for air conditioning ducts and cable trays. By utilizing this system, it is possible to shorten processes, reduce amounts of materials, and dramatically reduce the cost of plant construction. This system uses a hybrid method that combines a route search program employing genetic algorithms with deep learning in order to learn the three-dimensional computer-aided design (3D-CAD) data of existing plants, thereby enabling the design of piping routes while taking advantage of previous design know-how.

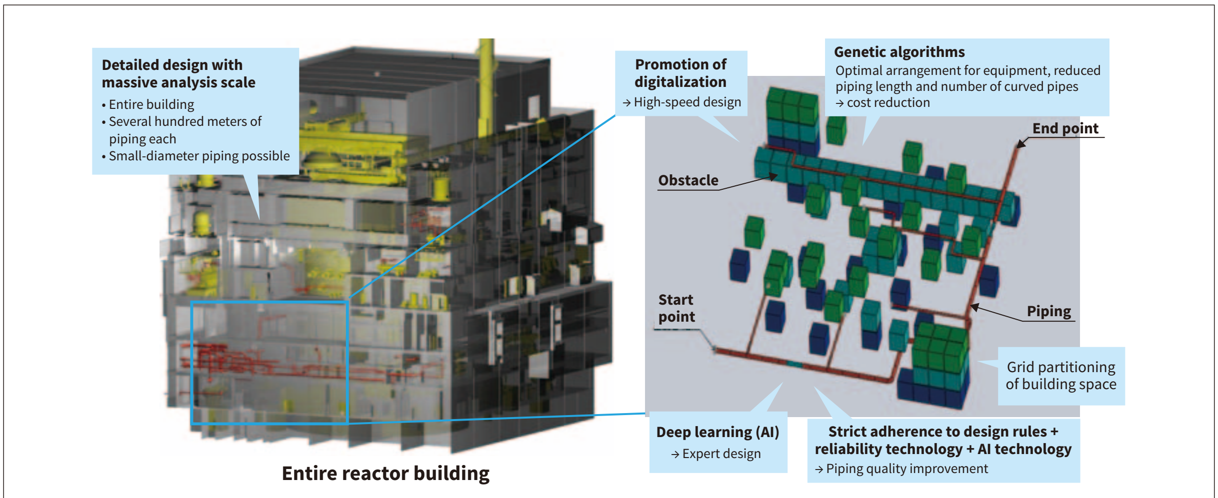
Another one of this system's features is its ability to plan piping routes while giving consideration to thermal expansion, vibrations, and the fluid phenomena that previous design processes had particular trouble dealing with, such as turbulence and swirling flow. As described in the example of the article "[3] Design Rationalization through the Application of Measurement Accuracy Evaluation Technology Using Fluid Analysis within Piping" below, by teaching this system with the input conditions (fluid conditions and route shapes) and output results (swirl intensity) analyzed using this technology, it is now possible to create piping route plans that reduce the occurrence of flow rate measurement flaws caused by swirling flow.

(Hitachi-GE Nuclear Energy, Ltd.)

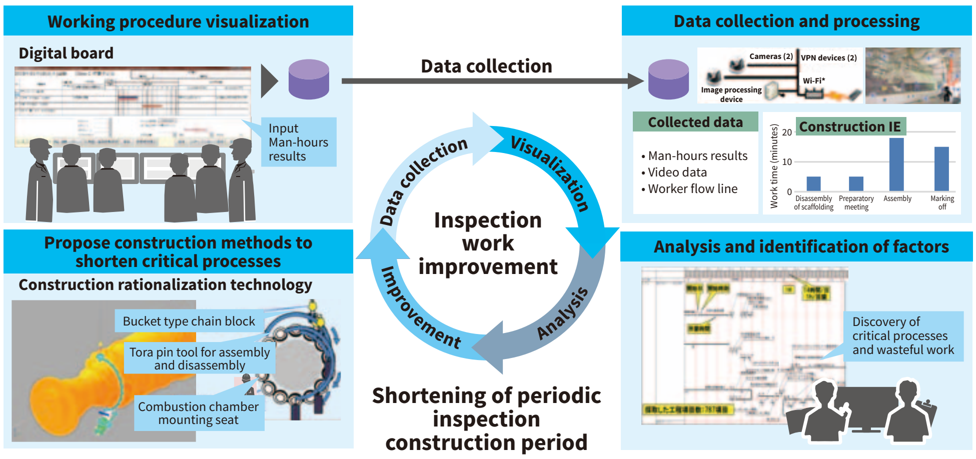
2 Business Expansion Effort through Digitalization of Construction

Expectations have been on the rise in recent years for utilizing digital technology as a way to improve safety, quality, and productivity at construction sites, while also solving problems such as the inability to pass down knowledge as the number of skilled workers and supervisors decreases.

Hitachi Plant Construction, Ltd. has been providing customers with high-value construction services by proposing and developing construction methods, procedures, jigs and tools, etc. that can shorten critical processes, by registering efforts to shorten the schedules of periodic inspection work at power plants as Lumada use cases as well as by fusing on-site status visualization (IT) and expert knowledge [operational technology (OT)]. In order to promote collaborative creation with customers in the construction field, a platform for sharing the details



1 Result of piping route plan created by automatic design system



IE: industrial engineering VPN: virtual private network
* See "Trademarks" on page 150.

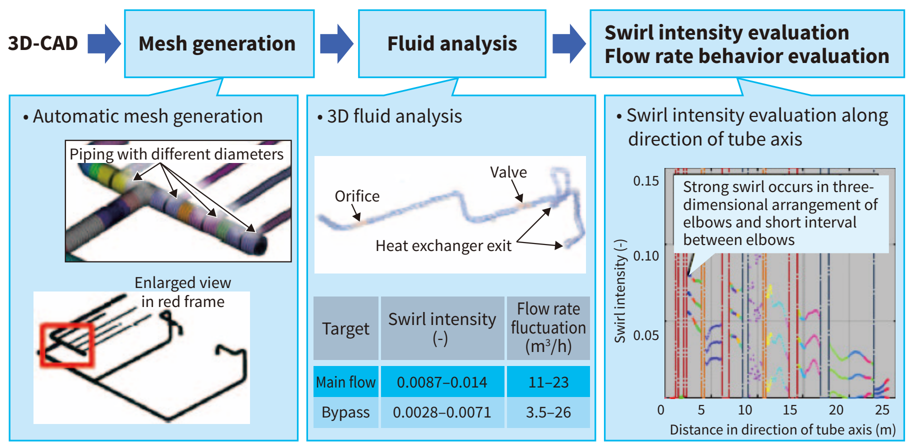
2 Periodic inspection work process visualization and construction period shortening technology (Lumada UC-01382)

of construction plans and the state of progress with the customer is necessary. By linking reality with digital information from engineering to construction, including maintenance and periodic inspection after completion, and by visualizing this with "digital twins" that are shared with the customer, it is possible to achieve highly efficient design, construction, and optimal operations. As core solutions, Hitachi Plant Construction is promoting a wide range of digitalization efforts and methods of collaborative creation with the customer, including laser point cloud measurement technology to enable an understanding of site status that is both fast and highly accurate, construction plan simulations through point cloud data combined with 3D models, construction visualization networks that allow the site status to be monitored together with the customer, and the handing down of technology for operation and maintenance.
(Hitachi Plant Construction, Ltd.)

3 Design Rationalization through the Application of Measurement Accuracy Evaluation Technology Using Fluid Analysis within Piping

In order to rationally evaluate the effects of flow rate characteristics within piping on a flowmeter at the design stage, Hitachi has developed technology to visualize the swirl intensity of flows inside piping that affect the indicated values of flowmeters, using the evaluation method that automatically generates meshes for 3D fluid analysis from a piping system's 3D-CAD data, then partially segments the region in an appropriate manner and performs continuous 3D fluid analysis.

Furthermore, since analysis that uses a great deal of intricate 3D fluid analysis takes time, and there is the risk that it might not be possible to use flowmeters to evaluate all plants at the design stage, Hitachi has created



Target	Swirl intensity (-)	Flow rate fluctuation (m^3/h)
Main flow	0.0087–0.014	11–23
Bypass	0.0028–0.0071	3.5–26

3 Measurement accuracy evaluation technology using fluid analysis within piping system screening technology that automatically performs simple calculations of swirl intensity from 3D-CAD data by constructing a swirl intensity prediction model for 3D elbows and other major piping configuration elements, and by performing sensitivity analysis with a focus on elbows, valves, and other key parts of the piping system configuration.

In the future, by adding flowmeters to the design of new plants and to existing plants, this technology can be used to evaluate effects on the indicated values of flow rates in advance for installed piping systems, thereby eliminating reworking at the on-site testing stage.
(Hitachi-GE Nuclear Energy, Ltd.)

4 Creation of System for Handing Down Nuclear Power Technologies and Promotion of Technology Transfer Activities

As handing down nuclear power technologies to the next generation has become a major issue, Hitachi has been conducting activities aimed at transferring technologies[*1] through knowledge management (KM). Major activities conducted so far include (1) listing owned technologies and creating knowledge maps, (2) creating a catalog of transferred technologies that summarizes effective transfer methods, and (3) holding forums to revitalize KM activities.

In creating its knowledge map, the company identified 16,000 transfer items while taking inventory of knowledge assets, mainly in the design department. Considering each transfer item, it clearly defined the experts who possess each technology, the "nexperts" (a word coined by combining "next" and "expert") who will inherit the technology, transfer priority, deadline, details, and methods, and based on all of this, constructed a technology transfer system [knowledge transfer system (KNOTS[*2])]. The creation of this system allows for the unified management of the state of transfer for technologies owned by all departments, and visualizes the number of technologies owned and the amount of time that is required to transfer them at the individual level, thereby enabling the organized management of technology transfer while avoiding the risk of technology loss.

In the future, Hitachi plans to formulate capability management and education plans linked with KNOTS, while considering ways to apply KNOTS to new areas of technological development, and seeking to build an organization where employees spontaneously and continuously engage in transfer activities while sustaining KM activities.
(Hitachi-GE Nuclear Energy, Ltd.)

*1 T. Yagi, et al. "Knowledge Management for Transferring Nuclear Industry Technical Knowledge to Next Generation," *Hitachi Review*, 69, pp. 571–575 (Jul. 2020).
*2 Means "knots, links, groups"

The creation of KNOTS allows for the visualization of technologies owned by the organization and the state of transfer, and supports efficient technology transfer activities

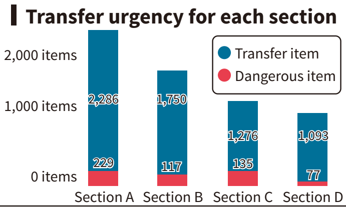
Digitalized knowledge map

Knowledge transfer system (KNOTS)

(1) Identification of transfer items and details				(2) Responsible person/person in charge, priority determination						(3) Clear definition of transferred documents and deadlines			
Technological area: Major item	Technological area: Medium item	Technological area: Small item	Transfer details	Responsible person	Expert	Nexpert	Influence	Urgency	Priority	Technological transfer reference documents	Transfer methods	Status	Deadline
System	Basic plant plan	Individual system specifications	• Off-gas system (equipment development, system specifications)	Ichiro Hitachi	Ichiro Hitachi	Shiro Hitachi	2	3	6	Document 1	Document creation	Completed	FY2021 2Q
			• Hydrogen injection equipment (hydrogen handling, reactor chemistry foundation)	Ichiro Hitachi	Ichiro Hitachi Jiro Hitachi	Saburo Hitachi	1	2	2	Document 3	Holding of study groups	Incomplete	FY2023 2Q
			• Heating steam system (equipment characteristics, sizing)	Ichiro Hitachi	Jiro Hitachi	Shiro Hitachi	3	3	9	Document 4	Simulated experiences	In progress	FY2021 2Q
			• Compressed air system (equipment characteristics, sizing)	Ichiro Hitachi	Jiro Hitachi	Saburo Hitachi	1	3	3	Document 5	Company-wide training	Incomplete	FY2023 2Q

Various support machines utilizing KNOTS data

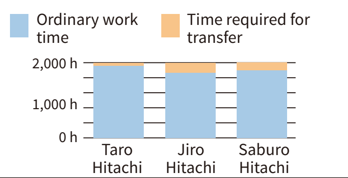
Transfer urgency for each section



State of technology ownership

	Expert	Expert	Nexpert
Position	Section chief	Senior	Specialist
Name	Ichiro Hitachi	Jiro Hitachi	Saburo Hitachi
Age	45	64	27
Priority 9	3	14	10
Priority 6	6	0	28

Time required for transfer



4 Overview of KNOTS technology transfer system