(b) "S-FORMER Mini" (Rectifier and related equipment)

Delivery of Rectifier Equipment for Train-6 Chlor-Alkali Electrolysis Plant of AGC Inc.

Fuji Electric has provided thyristor-type DC power conversion equipment (S-FORMER Mini), and related equipment such as the voltage regulating transformers and the harmonic filters for the Kashima Plant operated by AGC Inc. The plant started operation in November 2021.

The main features of this system are as follows:

(1) The system can satisfy harmonic regulation at 66-kV receiving power point since harmonic current flowing into the grid system is mitigated by applying multi-pulse rectification (36-pulse rectification) and employing both voltage regulating transformer and harmonic filters.

(2) High power factor operation has been achieved among wide DC output range (221 to 670 V DC, 5 to 24 kA) thanks to thyristor firing angle control and load tap changer installed in the voltage regulating transformer.

"PVI1400CJ-3/2600" PCS for Large Capacity Storage Batteries for the Real Time Market

Demand for large-scale storage battery systems for stabilizing the grid is increasing to allow renewable energy, such as solar and wind power, to be the main source of power. Fuji Electric developed the "PVI1400CJ-3/2600," a 2,600-kVA outdoor PCS for large-capacity storage batteries. This system is the first central PCS from Fuji Electric that conforms to the certification standard of high-voltage grid Interconnection protection devices by the Japan Electrical Safety & Environment Technology Laboratories.

The main features are as follows:

(1) Thermal loss reduction in the cable between the battery and PCS (36% lower in current at the same capacity) with high voltage DC input.

(2) High conversion efficiency (98.2%) through the use of highly efficient power semiconductors

(3) The world's smallest class footprint [dimensions: W2,516 × D1,545 × H2,653 (mm)]

(4) Standby loss reduction with an idling function (390W or less)

Industry's Smallest Class Switchgear That Complies with IEC Standard

Recent switchgear used as substation equipment is required to have both large capacity and small size due to the increase in load capacity. Fuji Electric has developed switchgear with an expanded rated current range despite the reduced depth dimension of the busbar compartment and acquired its third-party certification in accordance with IEC standards (IEC 62271-200). The main features are as follows:

(1) The installation area has been reduced (20% smaller than the previous model, the smallest class in the industry*1) through the use of a round shape conductive busbar structure to reduce the depth dimension.

(2) Its loss of service continuity category is LSC-2B-PM*2, and therefore the circuit breakers can be removed for inspection even while the bus bar is energized during equipment operation.

(3) It achieves AFLR*2 of the internal arc classification, which indicates that the entire surrounding area of the product is safe. Its internal cooling system can rapidly cool the hot gases generated in the event of an accident to safely discharge upward, eliminating the need for exhaust ducts.

*1 Comparison based on specifications of a rated voltage of 24 kV, breaking capacity of 25 kA and rated current of 1,250 A

*2 LSC-2B-PM, AFLR: Terms for specifications used in IEC standards specifications

"SPH5000EC" (Controller configuration example)

"SPH5000EC" CPU Module of "MICREX-SX Series"

Packaging machines, printing machines, semiconductor manufacturing equipment and other machine equipment require high-speed and high-precision motion control. At the same time, easy connectivity with devices in the machines also required to improve design flexibility and to reduce system start-up person-hours. In response to these requirements, Fuji Electric has developed the "SPH5000EC."

The main features are as follows:

(1) Equipped with the open network EtherCAT master function, the module can be easily connected to slave devices such as servo systems and remote I/Os.

(2) Up to 32 axes of servo motors can be synchronously controlled in a control cycle of 1 ms.

(3) A multi-CPU module system with up to three units of the SPH5000EC can be configured, allowing easy system expansion to accommodate additional customer equipment functions.

(a) Pressure transmitter (L-type)

(d) Differential pressure transmitter

(c) Absolute pressure transmitter (T-type)

(d) Level transmitter

"FCX-AIV Series" Pressure Transmitters

Since the pressure transmitter "FCX Series" was launched in 1989, they have accumulated over 1 million sales results worldwide. Fuji Electric has developed the "FCX-AIV Series" as the latest model to respond to requests for higher performance and new functions such as functional safety compliance.

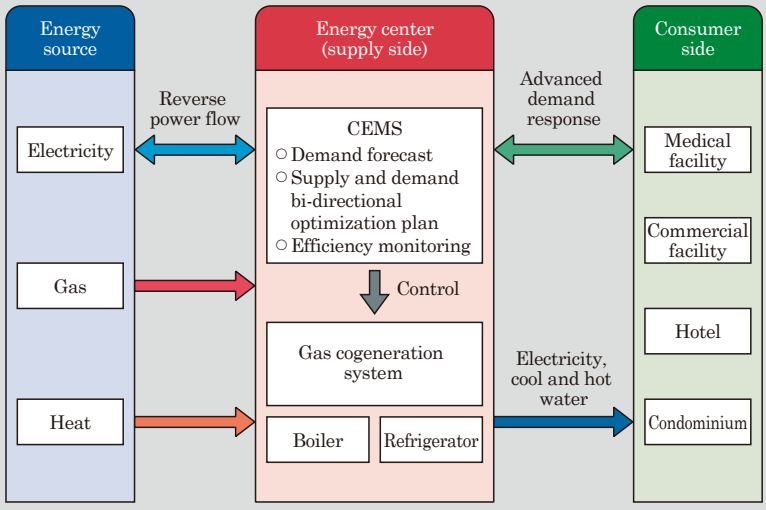
The main features are as follows:

(1) Improved measurement accuracy, responsiveness and long-term stability
- ○ High accuracy: ±0.065% (standard)
- ○ Response time (dead time): 40 ms
- ○ Zero shift for maximum span: ±0.1%/5 years

(2) Certified to IEC 61508 (SIL2), the functional safety standard, the transmitters can be used for an emergency stop system for plants, which requires high reliability.

(3) Field configurator allows non-contact setting of transmitter parameters even in explosion-proof areas.

(4) Revision7, the latest version of HART communication, is supported.



CEMS for a Shin-Sapporo Station Area Development Project by Hokkaido Gas Co., Ltd.

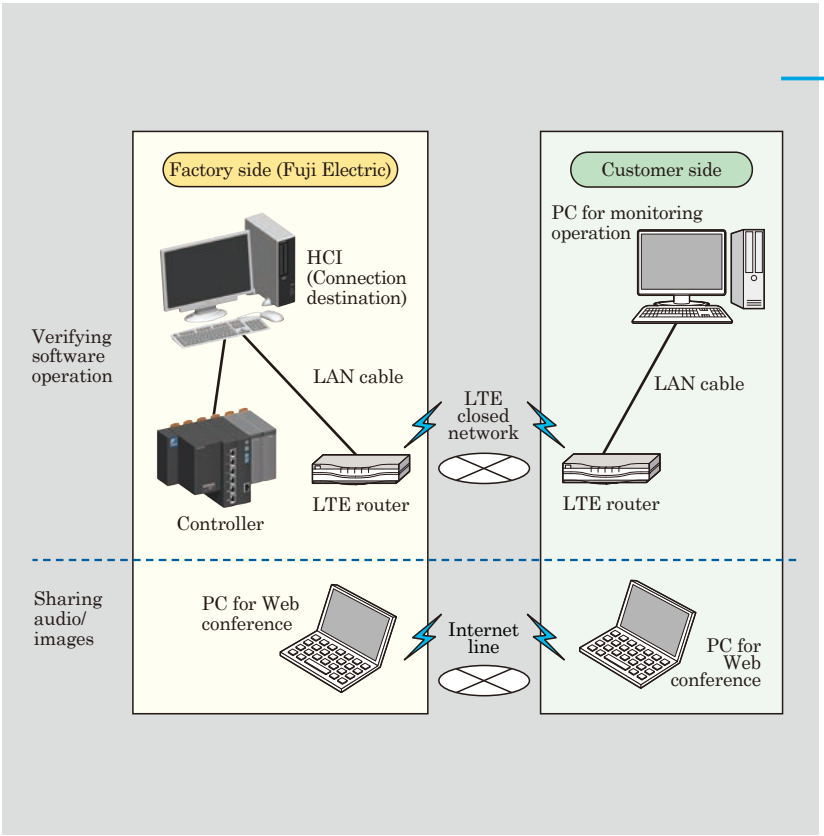
Hokkaido Gas Co., Ltd. is participating in the Shin-Sapporo Station Area Development Project and is constructing a new energy center that aims to save energy and labor through the automation of operations. For this project, Fuji Electric has developed a community energy management system (CEMS*) that makes use of AI.

The main features of this system are as follows:

(1) Statistical machine learning methods are used to predict demand with high accuracy and automatically detect changes in energy efficiency. Further, automatic extraction of efficiency change factors contributes to labor-saving analysis work.

(2) The system creates an optimal supply plan based on the amount of energy demand and automatically curbs demand while maintaining the comfort of consumers, thereby maximizing the efficiency of the entire urban areas.

* CEMS: Community energy management system



Remote Witness Inspections via LTE Wireless Communications

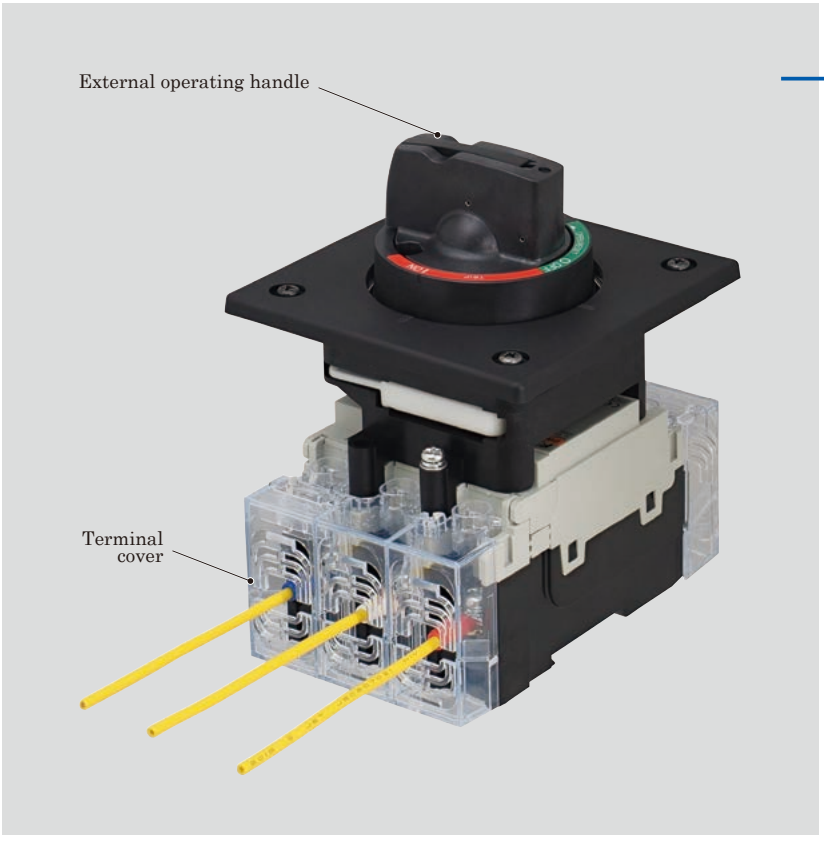
There has been an increasing number of cases that conventional on-site witness inspections, in which customers visit a Fuji Electric factory to check software functionality, could not be conducted due to the COVID-19 pandemic. Fuji Electric has created and put into operation a remote inspection system that can be operated remotely from a human communication interface (HCI) screen, taking security into consideration.

The main features are as follows:

(1) PC remote operation software allows both our factory staff and customers to operate software screens bidirectionally, making it possible to remotely conduct the same type of inspections as conventional on-site inspections.

(2) Since dedicated software such as a monitoring and control system includes confidential information, such as customer facilities and equipment, LTE closed networks, which are separated from the Internet, are used to prevent information leaks.

(3) Customers are not required to prepare specific special infrastructure.



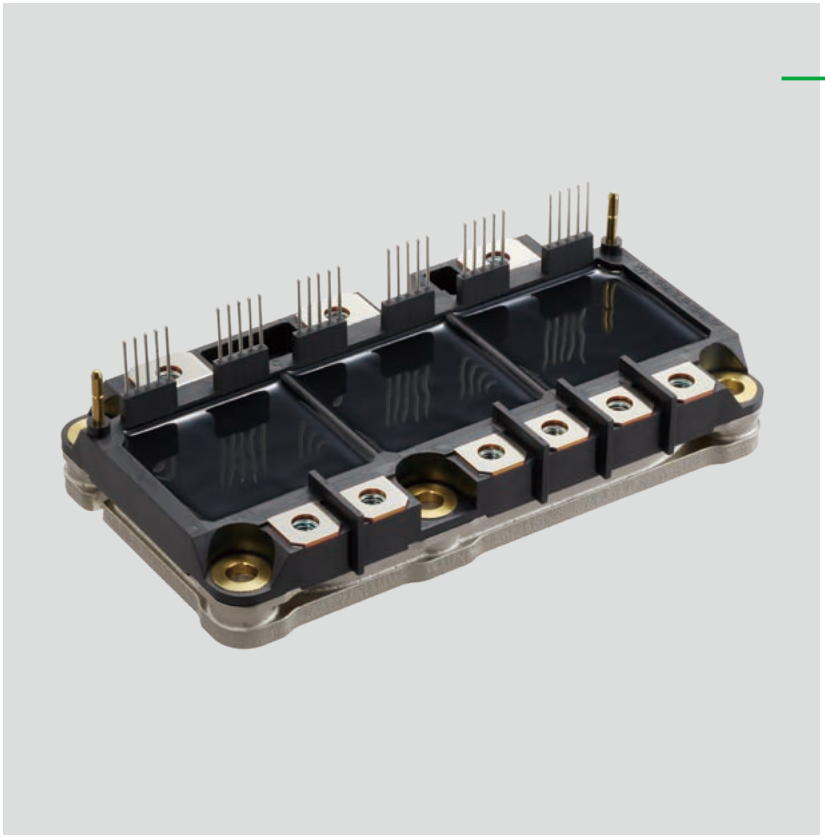
External Operating Handles and Terminal Covers with Improved Electrical Safety

Molded-case circuit breakers and earth leakage circuit breakers are required to comply with the electrical safety standard for machinery (IEC 60204-1) and to improve worker safety and product reliability in transportation and maintenance work as equipment and panel manufacturers, who are our customers, are expanding their business globally. Fuji Electric has developed external operating handles and terminal covers with enhanced electrical safety for molded-case circuit breakers and earth leakage circuit breakers. The main features are as follows:

(1) Protection with the external operating handles (IP54)*
- ○ Inhibiting the ingress of splashing water at the rotating part or panel contact surface
- ○ Suppressing insulation degradation of internal equipment to improve electrical safety
- ○ Preventing transport damage and misoperation with the handle lying flush with the panel surface

(2) Protection with the terminal covers (IP20)*
- ○ Preventing finger and hand entry from all directions
- ○ Allowing the insertion hole diameter to be adjustable according to the electric wire size used
- ○ Improving maintainability with insertion holes for electric and temperature inspection

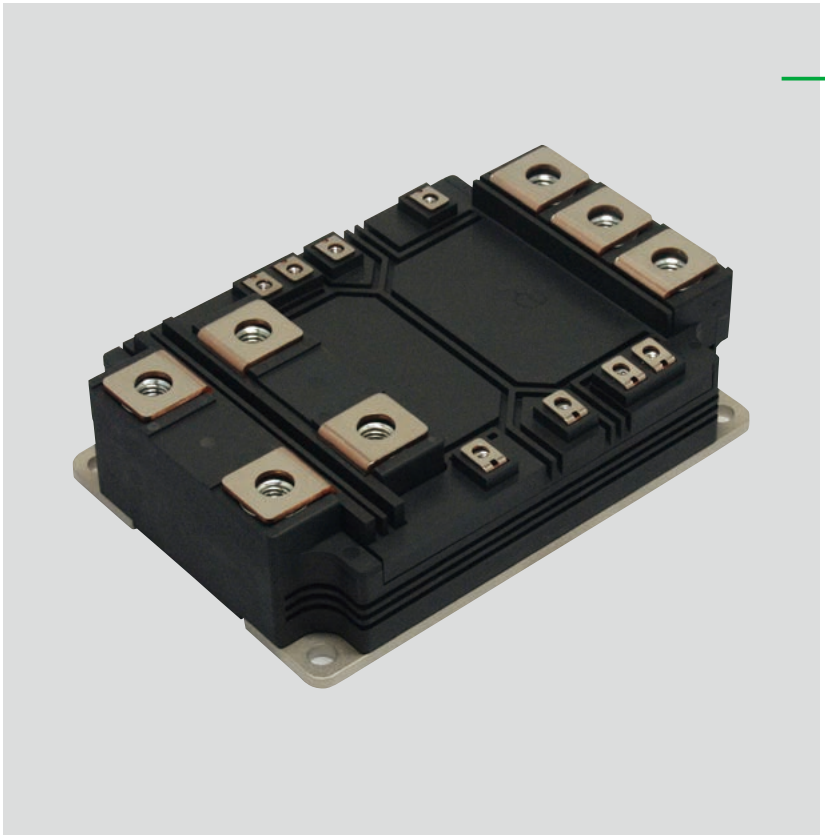
*Certified by a third party



"M677" 100-kW Class Ultra-Compact RC-IGBT Module for xEVs

Fuji Electric has been proactively offering IGBT modules for the market of EVs, PHEVs, and HEVs, which is growing both in Japan and overseas. Since inverters for vehicles are mounted in a limited space in vehicles, power modules for vehicles, which are key components, are need to have small size and high power density. To meet the requirements, we have developed an automotive power module that has doubled the power density of conventional products by using advanced 7th-generation RC-IGBTs (reverse conduction IGBTs) with low dissipation loss, aluminum water jacket integrated coolers with high heat dissipation efficiency, and a lead frame package that reduces internal wiring area.

6-in-1 power modules rated at 750 V/600 A are of the smallest class in the industry and are targeted at motors with an output of 100 kW-class.



3.3-kV All-SiC Modules integrated with the 2nd-Generation Trench Gate SiC MOSFETs

In the traction market, improving transport efficiency is an important issue. Thus, power conversion systems installed in railcars are required to be more compact and light-weight. To achieve this demand, reduction of power dissipation is essential for power modules. In order to realize lower dissipation, SiC devices are attracting attention alternative to conventional Si devices because of their lower dissipation. For this reason, Fuji Electric has developed 3.3-kV All-SiC Modules integrated with the 2nd-Generation Trench Gate SiC MOSFETs. Optimizing the SiC-MOSFETs cell pitch has reduced on-state resistance and eliminating SiC-SBDs has increased the chip mounting area, thereby increasing output current. Furhtermore, a newly developed low inductance package was adopted to take advantage of the high-speed switching characteristics of SiC-MOSFETs. These ones contribute to allowing power conversion systems to be more compact and light-weight.

Commencement of Commercial Operation of Rantau Dedap Geothermal Power Plant in Indonesia

Fuji Electric has completed construction and commissioning of a geothermal power plant (rated output at generator terminal: 49.2 MW × 2 units) of PT Supreme Energy Rantau Dedap. We received the order of this project in partnership with PT Rekayasa Industri in Indonesia as a turnkey contract, including design, procurement, manufacturing, installation, and commissioning. The commercial operation started in December 2021. This plant uses the world's first "double-flush multipressure combined system." This system was designed to maximize power output by optimizing the use of low-pressure secondary steam generated from high-pressure hot water in addition to the two types of steam, high pressure and low pressure, from the production wells. Furthermore, to minimize the fluctuation in geothermal fluid caused by topography, we applied a new method that the steam separator system absorbs sudden changes in water pressure and volume. This power plant supplies power to approximately 500,000 households, contributing to an offset of approximately 470,000 tons of CO_2 emissions yearly.

"Frozen Station" Frozen Food Vending Machine

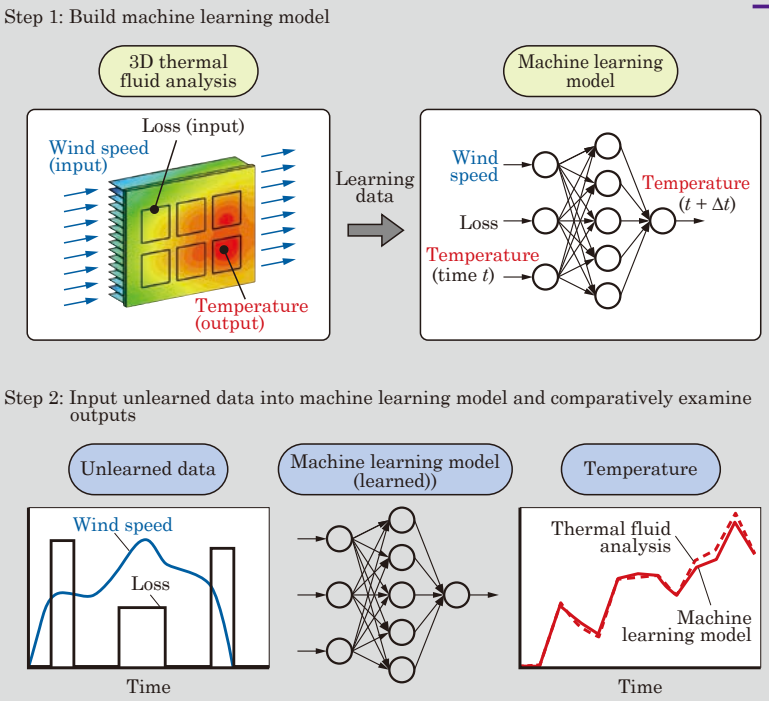
Restaurants and retailers are increasingly diversifying their product distribution channels. Processed foods traditionally served in stores have now started being sold as frozen products. Fuji Electric has developed the "Frozen Station," a frozen vending machine that can sell frozen foods 24 hours a day at a variety of locations, including storefronts, train stations, and parking lots.

The main features are as follows:

(1) Internal space-saving design delivers a large capacity (standard: 7 types, 70 items; optional: 7 types, 84 items).

(2) Enhanced airtightness of the internal structure improves thermal insulation and reduces power consumption (20% lower than our previous models).

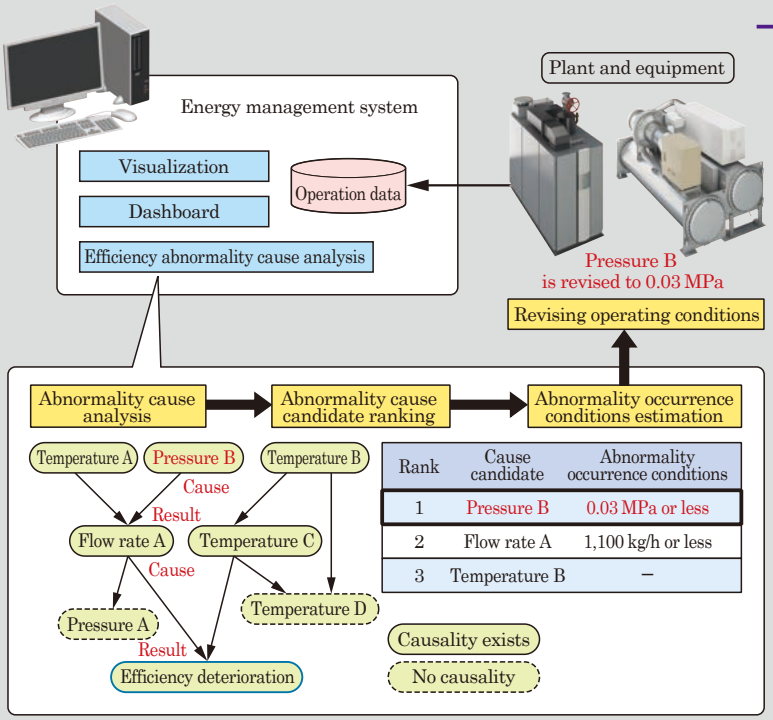
(3) Vending machine operation services that Fuji Electric offers allow customers to collect sales and inventory information online, reducing lost sales opportunities due to out-of-stock products while reducing operational labor (optional).



Model Reduction Technique Using Machine Learning Models with Thermo-Fluid Analysis Results

Advances in computing power have allowed 3D analysis to use larger models and shorten computation time. On the other hand, it remains impractical to estimate unsteady fluctuations over several hours or to perform structural studies involving hundreds of cases using only 3D analysis. Fuji Electric has thus been developing a model reduction technique that uses machine learning models with thermo fluid analysis results to reduce calculation time.

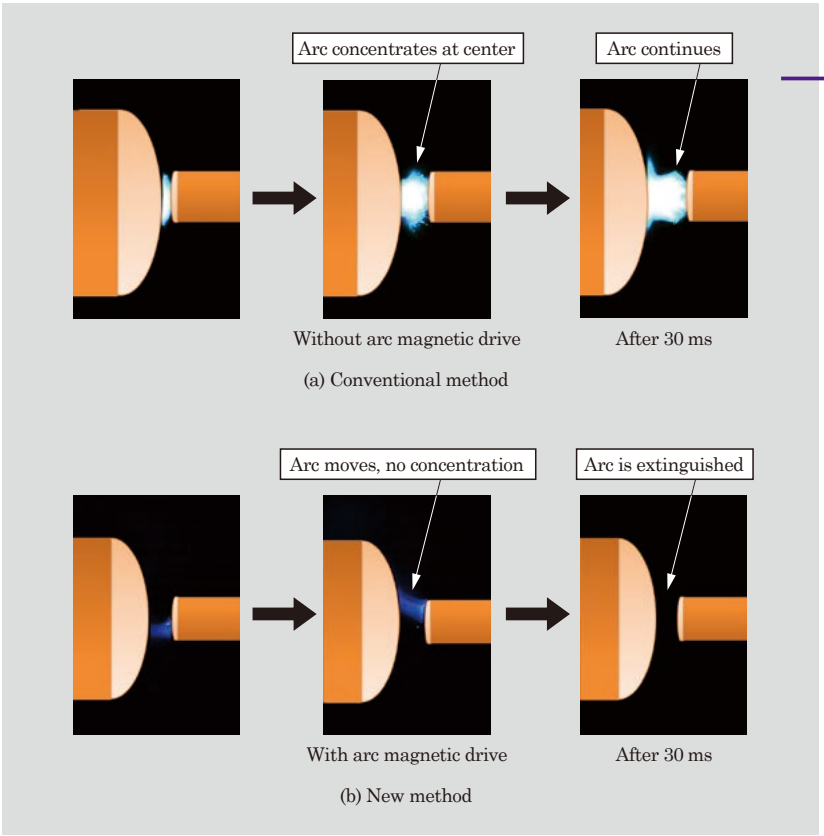
We comparatively examined peak temperatures observed in railicar inverter heat sinks, which fluctuate over several hours during operation. As a result, we confirmed that analysis with machine learning models obtained results with the same accuracy in a few seconds as 3D thermal fluid analysis. We aim to further develop this technique to increase the reliability of the method and apply it in product development.



Analysis of Abnormality Causes with Cause and Effect Analysis and Machine Learning

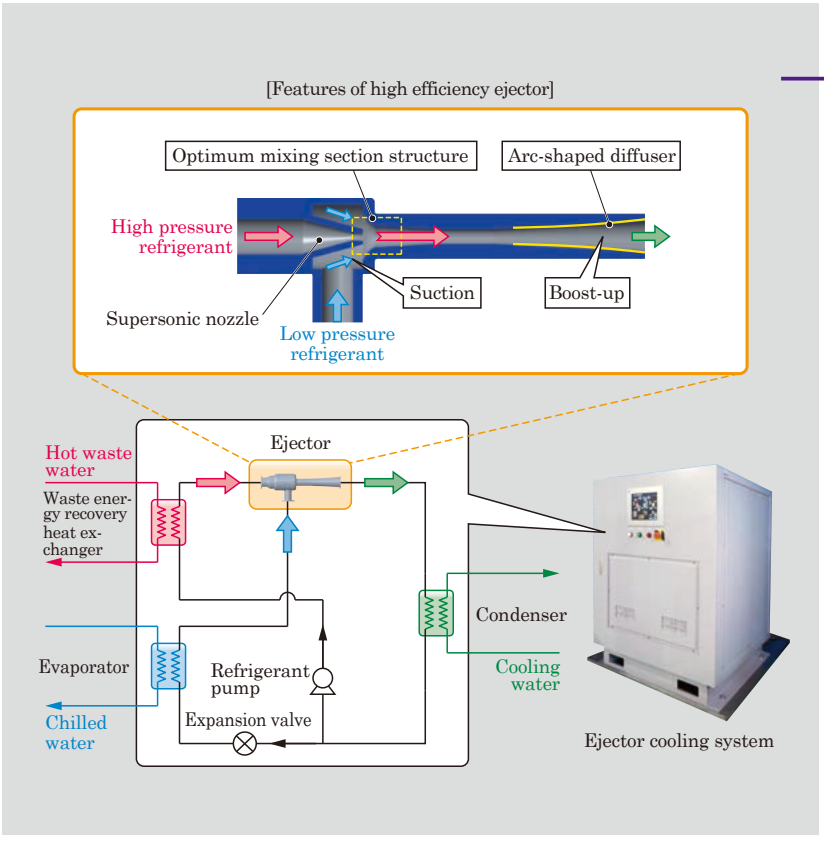
Plant operations require quick recovery in case an abnormality occurs. Cause analysis of abnormalities, which is required to implement countermeasures, had been conducted manually, relying on the knowledge of expert engineers, which was time-consuming. To address this issue, Fuji Electric has developed a technology to automatically analyze the cause of abnormalities from operation data.

This technology uses statistical causal inference to automatically extract candidate causes of abnormalities and display them in order of likelihood. It also uses machine learning to automatically extract abnormal conditions, which are the boundaries between normal and abnormal conditions. Combining these management functions can identify abnormality causes early, reducing time for recovery. Energy Management system software that Fuji Electric provides use this technology to streamline the abnormality cause analysis in energy efficiency of utility facilities.



Electrical Contact Technology for GIS with a SF_6 Alternative Gas

In line with international greenhouse gas reduction policies, SF_6 gas used in gas insulated switchgear (GIS) is required to be replaced with an alternative due to its high global warming potential. Air, a candidate alternative gas, has approximately one-half the breakdown voltage and approximately one-hundredth the arc extinction velocity of SF_6 gas. We have been developing the technology to compensate for the differences because obtaining the same performance would otherwise require GIS to have a larger size. For the breakdown voltage, we mitigated the electric field by reviewing the layout of the charging section around the electrical contacts. For the arc extinguishing speed, we magnetically drove the arc on the electrical contact and diffuse the arc heat. Our basic test demonstrated that these technologies above are promising to achieve a breakdown voltage and arc extinction speed equivalent to that of a GIS of approximately the same size and using SF_6 gas. We will apply these technologies to future designs.



Compressor-Less Highly Efficiency Cooling Technology

To achieve the carbon neutral plants, the effective use of low-temperature waste heat (hot waste water) and power reduction in chilled water supply are required. To address this, we have developed the industry's first cooling technology "ejector refrigeration systems." This system produces chilled water with lower power consumption than the conventional compressor-used refrigeration system by utilizing the waste heat energy.

The main features are as follows:

(1) The high efficiency heat driven ejector is utilized in the system and achieves approximately one-third power consumption of conventional compressor-used refrigeration system. It leads reducing chilled water supply costs and the amount of CO_2 discharge.

(2) The optimization of the mixing section structure and adopting the unique diffuser (arc-shaped diffuser) lead the utilization of low temperature waste heat (50°C to 60°C).

Fuji Electric

Innovating Energy Technology