Fundamental and Advanced Technologies

Fundamental Technology
Advanced Technology

Fuji Electric has been tackling research and development on fundamental and advanced technologies to achieve differentiation, for early launch of new products and expansion of carbon-neutral-related businesses as "growth strategy promotion."

In order to achieve carbon neutrality in factories, we have developed the industry's first cooling technology which can cool hot waste water and simultaneously generate cold water with high efficiency using a refrigerating cycle driven by thermal energy of the hot waste water. This technology will help use low-temperature exhaust heat effectively and reduce power consumption accompanying generation of cooling water.

To support stricter environmental regulations, we have developed a gas measurement technology that can measure gases including SO_X of low concentration by using ultraviolet C rays that has no absorption spectrum of inhibitory components such as water. We also have developed a technology to reduce the burden of cleaning drainage pipes by dissolving slime components (such as polysaccharides) in the drainage pipes and removing them with bacteria with synthesizing alkaline water and supplying it to the pipes.

As a technology to promote substitution of low-environmental-load materials, we have developed a technology to magnetically drive arcs on electrical contacts to diffuse arc heat. SF_6 substitution enables improving insulation ability and cutoff performance which are issues and suppresses enlargement of equipment. We have also developed a high-thrust density linear motor for railcar door systems by magnets not using rare earth elements, of a new structure that utilizes magnetic design technology.

As an advanced technology for new products, we have developed a dust collection technology for marine engines in which both SO_X and fine particle removal are achieved in combination with scrubbers with directly repairing particles or removing them from exhaust gas of high temperature and high wind by the power of electricity. In addition, we are developing a spatial virus inactivation technology that can be used for countermeasures against infectious diseases by using a hybrid method of electrostatic collection and ultraviolet C rays irradiation.

By applying the meta-heuristics method to the control constant optimization operation of a voltage regulator for a distribution system voltage adjustment, we have developed a technology where an optimum control constant can be obtained in a short time from the combination of enormous control constants. This technology can properly maintain the voltage of the distribution system, which has been complicated with the large introduction of the renewable energy.

As artificial intelligence (AI) related technology, we have developed a technology which automatically analyzes the cause of the plant abnormality occurrence from the operation data by the application of causal inference in statistics. It has been already installed in the energy management system and is applied to the efficiency anomaly analysis. In addition, we have developed a technology where a user teaches a correct area to an image recognition AI for relearning to utilize an image recognition AI technology. It facilitates user engineering to maintain recognition rate after introduction.

To expand cloud usage, we have developed a log management platform that automatically collects and centrally manages the operation logs of a plurality of software with different log formats. It contributes to labor saving of operation management work of a cloud system.

As a technology to support design and manufacturing, we have been developing a method to perform large-scale simulation in a short time and constructed a machine learning model using 3D thermo-fluid analysis result data. Results were obtained within a few hundredth the time for 3D thermo-fluid analysis with the same accuracy. In the future, we will further improve the reliability of the method and aim to apply it in product development.

In order to reduce the number of person-hours required for software development, a means to sufficiently verify open source software (OSS), which is used for some functions, on an actual machine is required. We have developed a test environment where there are enough test cases, and a test can be automatically implemented for OSS on an actual machine. We will effi-

ciently develop high quality software utilizing OSS under this environment.

We have developed a noise canceler technology to cancel leakage current, which is an occurrence source of disturbance voltage, in a power-factor control circuit used for a small capacity power supply of several hundred watts. It will be applied to miniaturization of electromagnetic interference (EMI) filter.

We have constructed a freezing circuit model and internal air flow model as simulators instead of an actual machine test of a vending machine. An operation control test can be conducted with a short time simulation.

We have conducted outdoor exposure tests and accelerated degradation tests with the latest coating film configuration of our products, such as distribution equipment and vending machines, to establish the coating film configuration as a company standard. We contribute to quality assurance and enhancement of manufacturing fundamental technology.

In this way, Fuji Electric will continue to strengthen our advanced and fundamental technologies that support product development, aiming to create social values in the fields of energy and environment.

Fundamental Technology

1 Performance Improvement of Image Recognition AI with Recognition Area Correction Technology

In recent years, the image recognition technology using AI has rapidly developed and its application has been advancing to industrial fields such as visual inspection. However, when an abnormal area was erroneously recognized in the detection by image recognition AI (image AI), it was necessary to tune learning parameters by an expert with advanced AI knowledge to correct it. To facilitate the tuning, Fuji Electric has developed a recognition area correction technology that enables users without AI knowledge to improve performance. The technology improves performance by teaching a correct area and retraining image AI so as to reduce an error with an anomaly detection result. Thus, image AI can be easily improved in quality without the knowledge of an expert.

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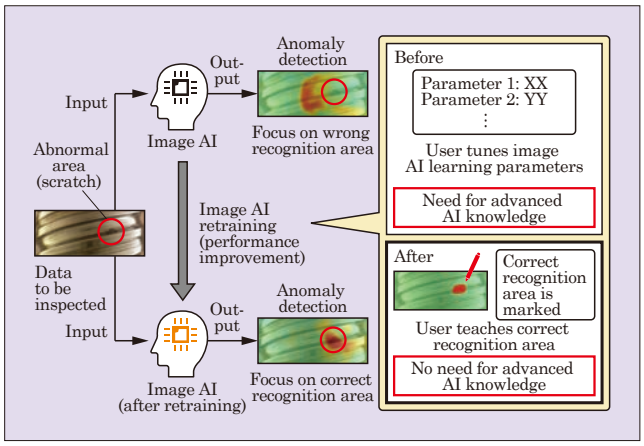
Fig.1 Procedure for improving recognition*



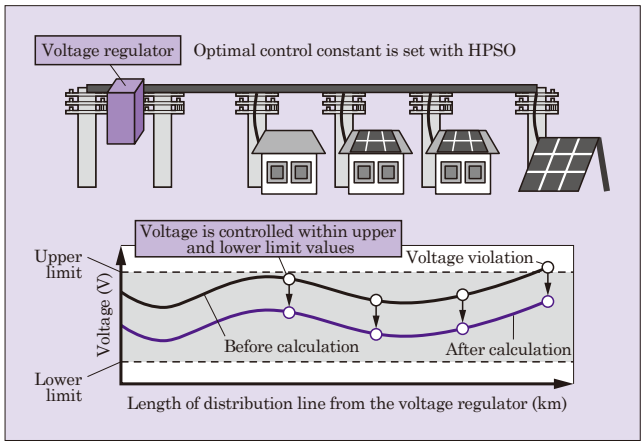
2 Control Constant Optimization Technology for Voltage Regulator

To achieve carbon neutrality in 2050, the introduction of renewable energy is expected to expand. Since effect on voltage of distribution systems becomes large with the introduction of a large amount of renewable energy whose output fluctuates depending on the weather, an advanced monitoring and control technology is required to maintain the energy within the upper and lower management limits specified by the Electricity Business Act.

Fuji Electric has developed a technology to optimize the control constants of voltage regulators that regulate the voltage in distribution systems. With this technology, by applying HPSO*, one of the meta-heuristics methods in the optimal setting calculation, an optimal control constant can be obtained in a short time from a combination of enormous control constants. By applying this technology to distribution system planning systems, we contribute to retention of stable operation of complicated distribution systems.

* HPSO: Hybrid Particle Swarm Optimization

Fig.2 Overview of control constant optimization technique

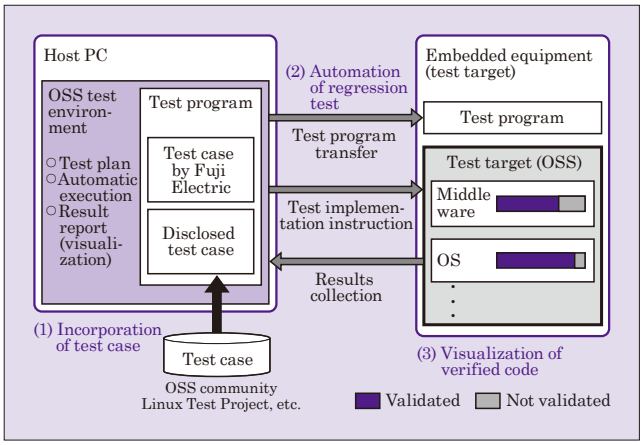


3 OSS Firmware Quality Assurance Technology

The scale of software for embedded equipment has been expanding with advanced functionality and the use of open source software (OSS) has been advancing to reduce development person-hours. Verification of software using OSS, on the other hand, has challenges such as labor saving for test case preparation, efficiency improvement of regression test for OSS, which is frequently updated, and clarification of verified code range. To solve the challenges, Fuji Electric has built an OSS test environment with the following features:

(1) Test preparation person-hours has been reduced by allowing incorporation of published test cases (2,000 or more).
(2) Person-hours for regression tests on OSS updates has been reduced by automating test case execution.
(3) Completeness of testing can be confirmed with visualization of verified codes.

Fig.3 Embedded system test environment example

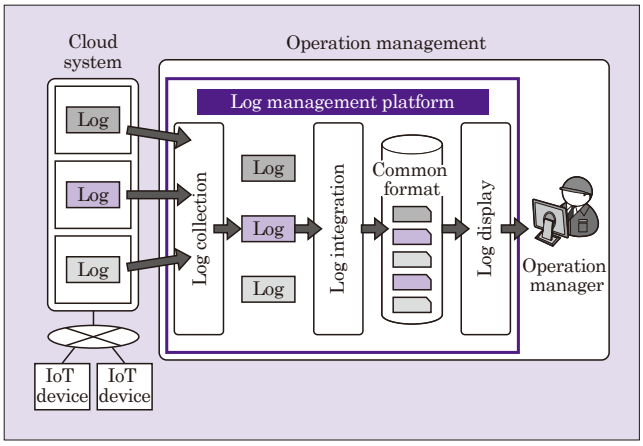


4 Log Management Technology for Cloud Systems

The use of cloud systems is expanding through the use of data collected from IoT devices. Since multiple software applications typically work together on a cloud system, monitoring operation logs of each software is essential for stable operation of services. However, since operation logs are stored for each software and the log format varies, management of operation logs has been complicated.

To make the job straightforward, Fuji Electric has developed a log management platform that facilitates log collection, integration, and display. The platform automatically collects operation logs from the cloud system, converts them into a common format, manages them in an integrated manner, and graphically displays the correlation of occurrence times to support improving efficiency of monitoring and quickly analyzing an error occurrence cause. We will promote application of this technology and contribute to the stable operation of cloud systems.

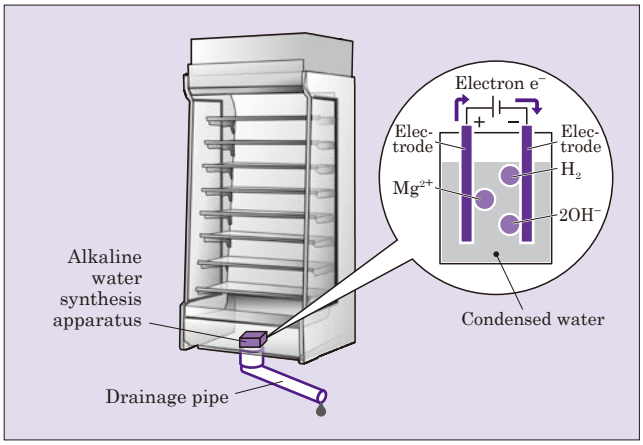
Fig.4 Log management platform



5 Alkaline Cleaning Technology with Water Electrolysis by Magnesium

Fuji Electric has developed a technology to synthesize alkaline water by electrolyzing water with alloy electrodes containing magnesium. One of possible applications is a cleaning of the drainage pipe of a showcase used in convenience stores. Condensed water generated in a cooler of a showcase does not contain chlorine component unlike tap water and therefore does not have sterilization or cleaning effect, and bacteria easily propagate. Stores regularly clean drainpipes because they become slimy and dirty due to the growth of bacteria, causing clogged pipes and odors. Condensed water is stored in an electrolytic treatment tank equipped with this technology, alkaline water above a certain pH is synthesized and supplied to a drainage pipe to dissolve slime compounds (polysaccharides, etc.), and remove them together with bacteria. Thus, the generation of slimy dirt is suppressed and the burden of cleaning drainpipes can be reduced.

Fig.5 Equipment implementation example (Slime removal in showcase drainage pipe)



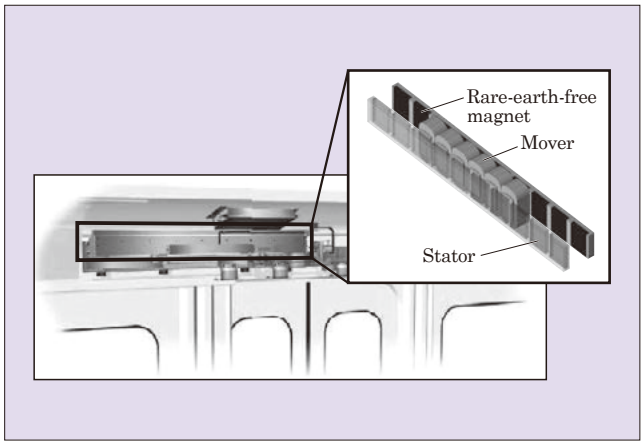
Fundamental Technology

6 High Thrust Density Linear Motor Not Using Rare Earth

Linear motors for railcar door systems require both high thrust density and reduced door opening resistance to allow passengers to open and close doors in emergency. This can be achieved by using a coreless structure and strong magnets; however, rare earths commonly used in such magnets have a uncertainty in long-term stable procurement. Fuji Electric has therefore developed a linear motor for railcar door systems using magnets that do not use rare earths by utilizing the magnetic design technology. By adopting a motor structure with a core and optimizing the structure, even a low magnetic force magnet achieves thrust density equivalent to that of a conventional magnet, while suppressing an increase in door opening resistance caused by the interaction between the magnet and the core.

This development has enabled the stable supply of linear motors for railcar door systems that require safety and security.

Fig.6 High thrust density linear motor

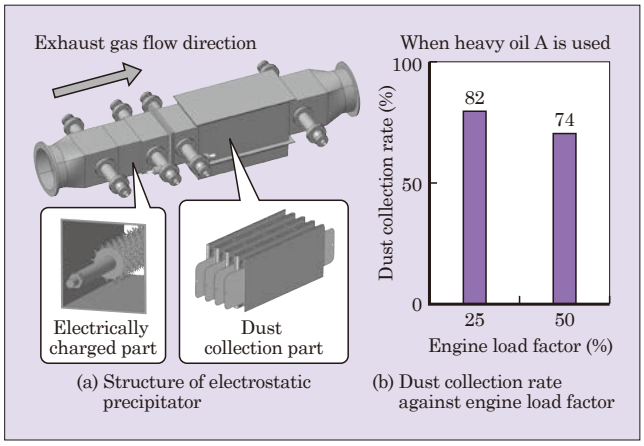


7 High Temperature, High Wind Electrostatic Precipitator Technology for Marine Engines

As a countermeasure for environmental problems related to marine transportation, a technology to remove fine particles contained in exhaust gas of marine vessels is required. Fuji Electric has been developing a technology to apply an electrostatic precipitator system for roads to marine engines. We have demonstrated that a high dust collection rate (more than 70 %) can be obtained for heavy oil A and heavy oil C and have been promoting safety evaluation to obtain certification by a third party. The main features are as follows:

(1) Directly collecting and removing particles using electric force from high-temperature (over 250°C), high-speed (over 20 m/s) exhaust gas flow in ducts
(2) Adopting a two-stage method of a charging section that charges fine particles by discharging a needle electrode and a dust collection section that attracts and collects charged particles with a high electric field. The function is retained by preventing deposition of particles in the charging section.
(3) Removing both SO_X and fine particles is enabled with combination with a scrubber.

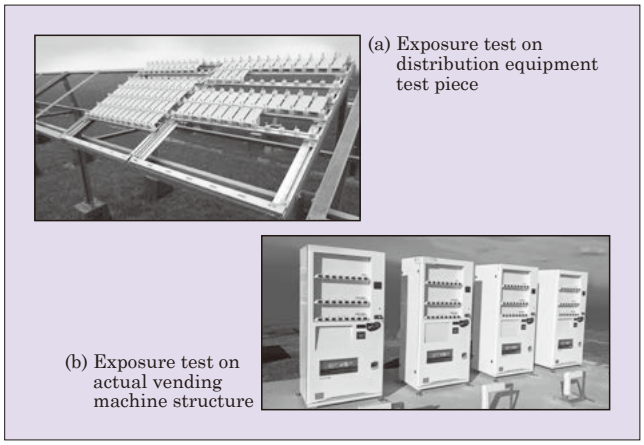
Fig.7 Electrostatic precipitator structure and dust collection rate



8 Establishing Coating Film Evaluation Technology

Fuji Electric applies coating to provide additional values such as corrosion resistance and design property to sheet-metal enclosures such as power distribution equipment and vending machines. In recent years, with the diversification of the environment in which products are installed and the evolution of paints, a new testing method have become necessary. Therefore, we have conducted outdoor exposure tests and accelerated degradation tests on the durability of the latest coating film and developed the type, thickness, and construction method of the coating film in accordance with the present product installation environment. In addition, by correlating the degradation of the coating film and the corrosion rate with the exposure test product and the accelerated degradation test product, we have simulated the actual use environment of the products and established the accelerated degradation test where degradation can be accelerated in a shorter period of time than before. These efforts enable selecting coating films suitable for the installation environment of products and confirming quality using the accelerated degradation tests and contribute to the provision of highly reliable products.

Fig.8 Exposure test appearance



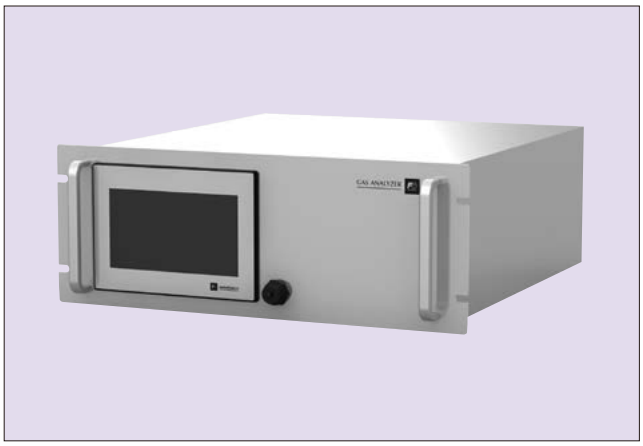
Advanced Technology

1 Low Concentration Gas Measurement Technology by Ultraviolet Absorption Spectroscopy

As environmental regulations become stricter, gas analyzers are required to improve the measurement accuracy in the low concentration range. With conventional infrared gas analyzers, stable measurement of low concentration gas has been difficult due to the influence of disturbance caused by absorption of inhibitory components such as water contained in the gas. Fuji Electric has developed a low concentration gas measurement technology that uses the ultraviolet spectroscopy technology, which does not have absorption spectrum of inhibitory components. The main features are as follows:

(1) Measurement of low concentration range (0 to 25 ppm) is enabled by extending the measured optical path length by application of a multi-reflection gas cell.
(2) Three types of gas components (sulfur dioxide, nitrogen monoxide, and nitrogen dioxide) can be measured simultaneously.
(3) Low running cost is achieved because the consumable nitrogen oxide conversion catalyst is not required.

Fig.9 Ultraviolet gas analyzer

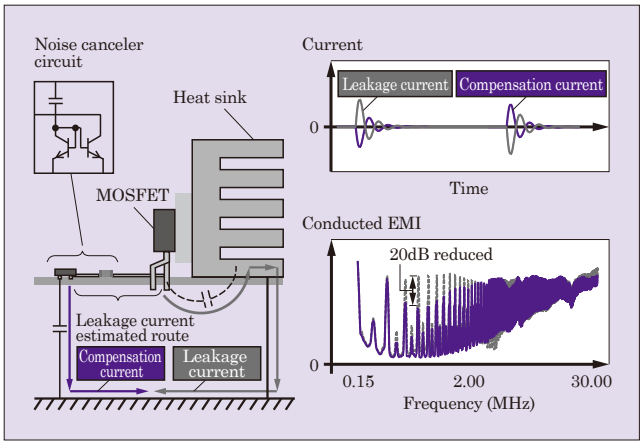


2 Noise Canceler Technology for Power Factor Correction Circuit

For a power factor correction circuit used in a small-capacity power supply of several hundred watts, an EMI filter provided for reducing a conducted EMI hinders miniaturization. Therefore, Fuji Electric has developed a noise canceler technology that cancels a leakage current, which is the occurrence source of the conducted EMI, by injecting a compensation current of opposite polarity. The main features are as follows:

(1) Sufficient effect is obtained even with a compact and simple circuit configuration using a general-purpose transistor.
(2) The conducted EMI is reduced by up to 20 dB (about 90%) in the 150 kHz to 2 MHz band.
(3) EMI filters can be miniaturized to approximately 50% of conventional ones by also using the spread spectrum technology.

Fig.10 Active noise canceler technology principle and effect



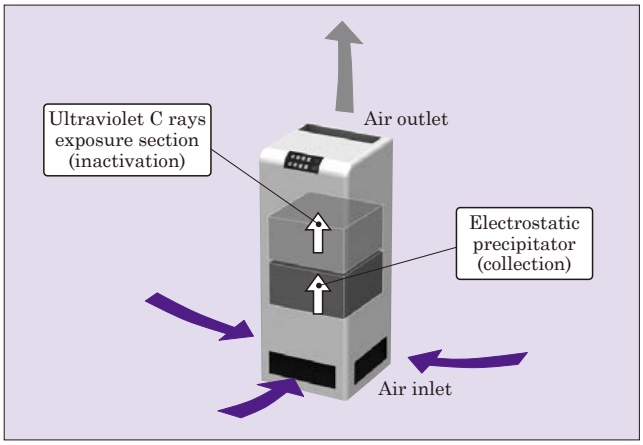
3 Airborne Virus Inactivation Technology

Fuji Electric has been developing a hybrid airborne virus inactivation apparatus combining electrostatic precipitation and ultraviolet C rays irradiation in the demonstration project* of the Ministry of the Environment for infection control measures. This apparatus eliminates the need for ventilation of large air volume and can reduce the electricity cost for air conditioning by up to 40%. The main features are as follows:

(1) Using our proprietary disk-shaped electrodes can highly efficiently collect viruses while suppressing the discharge of ozone, which is harmful to the human body (99% of collect rate, ozone emissions under 0.05 ppm).
(2) Viruses passing through the apparatus are highly efficiently inactivated (99% of airborne virus inactivation rate) by a LED module with uniform irradiation of ultraviolet C rays developed based on the interaction analysis of spatial illumination intensity and airflow.

* "The Demonstration Project for Implementation of Innovative Infection-Control and Digital Technologies with Low CO_2 Emissions" from the Ministry of the Environment, Government of Japan.

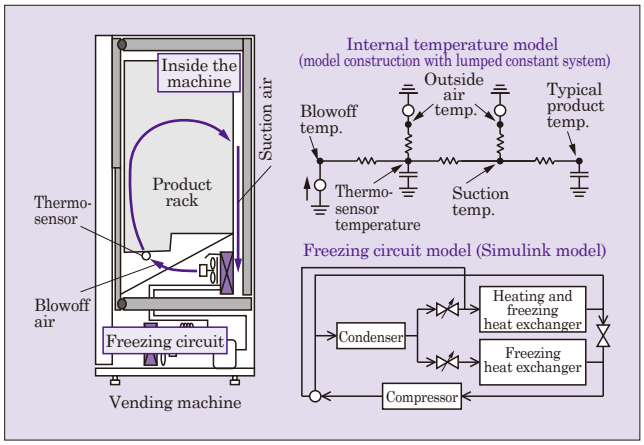
Fig.11 Hybrid airborne virus inactivation apparatus

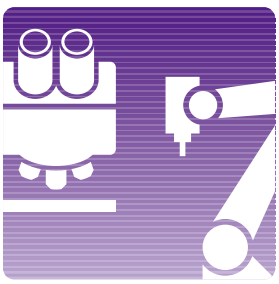


4 1D Simulation for Freezing and Heating Technology Development of Vending Machines

In the COVID-19 pandemic, contact-free, non-face-to-face sales channels have attracted attention, increasing product diversity sold through vending machines. Conventionally, development of vending machines has taken time because operation control tests have been conducted on actual machines for each model. Therefore, we have constructed an internal temperature model using the simulator MATLAB/Simulink. This model is simplified by representing the three-dimensional air flow with a 1D circuit model connecting the minimum necessary temperature points to shorten the analysis time. As a result, the operation control test, which had taken 48 hours for the prototype test, was shortened to 15 minutes. The error between the actual machine and the simulation has reached the average prediction accuracy of ±1.5 K at the commodity temperature. Ultimately, we aim to shorten the total development period for a vending machine to approximately half.

Fig.12 Vending machine 1D simulation model





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Innovating Energy Technology