Kawasaki — Pioneering the Future of Hydrogen-Based Societies

With our technologies and products focused on transitioning to a decarbonized society, we aspire to achieve a future where people can enjoy an enhanced quality of life.

- **Liquefaction shrinks the volume of hydrogen to 1/800, making mass transportation possible.**
- **Japan's first plant to produce liquefied hydrogen by cooling it to -253°C.**
- **Development of a huge hydrogen storage tank equivalent to the total volume of 30,000 fuel cell vehicles' fuel.**
- **Realization of pure hydrogen gas turbine emitting zero CO2.**
- **Liquefaction shrinks the volume of hydrogen to 1/800, making mass transportation possible.**

Special Feature

The Power of Heat: Behind-the-Scenes Stars Supporting the Comforts of Everyday Life
The Power of Heat: Behind-the-Scenes Stars Supporting the Comforts of Everyday Life

Kawasaki Thermal Engineering Co., Ltd. (KTE) is a pioneer in the manufacturing of boilers and absorption chiller-heaters which support the comforts of our daily lives. This issue of Special Feature focuses on how the “power of heat” is demonstrated in thermal products manufactured by KTE—a heat technology specialist celebrating its 120th anniversary in the boiler business in 2019.

Boilers and Absorption Chiller-Heaters at the Frontline of Life-Saving Work

Osaka Medical College Hospital serves as a core community medical institution for the Hokusetsu area (northern Osaka Prefecture). It is located adjacent to Takatsuki-shi Station on the Hankyu Railway Kyoto Line, and is a five-minute walk from Takatsuki Station on the Japan Railway Line. With 29 clinical departments and 14 specialized centers (such as pathology, laboratories, surgery, radiology, etc.), the 1,800-staff hospital serves about 2,000 outpatients per day and has 882 beds. It is positioned as a core community medical institution in the Hokusetsu district (in the northern part of Osaka Prefecture).

In March 2016, a six-story Central Surgery Building was completed at the hospital. One of the largest surgery buildings in western Japan, it has 20 operating rooms, including a robotic surgery room and one for “hybrid” surgeries (a combination of catheter intervention under X-ray guidance and conventional surgical procedures), equipped with coronary and cerebral angiography.

KTE boilers and absorption chiller-heaters are working behind the scenes to support healthcare. Steam generated by the boilers is used in a variety of ways, including sterilization of surgical tools, maintenance of surgery rooms, nutrition services, and operation of oxygen systems. Absorption chiller-heaters provide cold and hot water, which are also used for cooling and heating the entire hospital.

Katsuhiko Tsutsumi, head of the Facility Section of the General Administrative Department at Osaka Medical College, which manages all facilities of Osaka Medical College and its hospital, comments, “Boilers and absorption chiller-heaters are energy sources that drive all medical activities at the hospital and are a lifeline for its 24/7 operations. That is why high stability and reliability are expected of them.”

Three units of the KF-A multi-tube once-through boiler are in operation at the hospital. This compact boiler, measuring 110 cm wide, 210 cm high, and 170 cm deep, generates a ton of steam per hour. Also in operation are two Efficient absorption chiller-heater units, each capable of 180-ton refrigeration (equivalent to 265 units of the KF-A compact once-through boiler).
household air-conditioners capable of cooling/heating a room with a floor space of 10 m². As for the reason why multi-tube, once-through boilers were originally adopted at the hospital, Tatsuumi says, decisively. “Because of KTE’s high stan-
dard of manufacturing and a mainte-
nance system that allows expedient service- ing.” He adds, “Boilers can last longer than 20 years if maintained properly. I support KTE’s approach to product development, which is based on its conviction that products should serve the users for a long time and should never be designed as disposable equipment.”

The speed with which service personnel can respond to equipment malfunctions can affect and sometimes jeopardize the mission of a hospital. On KTE’s quickness, Tatsuumi comments, “Absorption chiller-heaters have been the main products we have had busi-
ness with at KTE, and their responses to malfunctions have been extremely swift. The company also doesn’t change service personnel frequently, and the same staff are assigned each time, so that we can work as a team with the shared goal of protecting hospital operations. KTE has a sense of mission in supporting the frontlines of life-saving interventions. This is the biggest reason why our business rela-
tionship has lasted for half a century.”

A History Lasting 120 Years, and the Industry’s Longest Warranty Provided
with Confidence

Kisha Seizo Co., Ltd., the predeces-
sor of KTE, was the first private company to manufacture a locomotive in Japan. It then launched a smoke tube boiler in 1899, which means that KTE will be celebrating the 120th anniversary of its boiler business in 2019. Boilers evolved as a family of steam-driven types of equipment which led the Industrial Revolution. Presently, once-through boilers account for 90% of the total boiler market in Japan.

A once-through boiler has a cylin-
drical body consisting of many heat-transfer tubes connected together by steel plates called “fins,” which are welded in between the tubes. A burner at the top of the cylindrical body burns the gas to heat the water in the tubes, supplied from the bottom section (water circulates continuously), and the heated water rises upward as steam. Because the volume of water in the tubes is small and therefore the energy stored in the water is also small, this type of boiler is less likely to explode due to pressure and there-
to safer. This type is also character-
ized by a short steam-start-up time after the boiler is activated. In terms of its simple structure, it is not mandatory in Japan for entities adopting compact boilers to employ a licensed boiler engineer. In recent years, many enti-
ties have chosen to adopt compact once-through boilers instead of one large system, in order to obtain the amount of steam needed.

Because of its simple structure, tech-
nologies associated with once-through boilers are considered to be already mature. However, Takahide Yanagida, Senior Manager of KTE’s Boiler Engineer-
ing Department, says, “We are pursuing further advancement of these technolo-
gies in four areas: firing, heat-exchange, control, and welding.”

For example, by reusing exhaust gas and using fins with high transfer performance, boiler efficiency (the ratio of the energy absorbed by the water and steam in the boiler against total energy input) of up to 98% can be attained. Efficient boiler operations are also attributable to KTE’s control tech-
nology, which stabilizes fluctuations in the load and in steam pressure.

Another component that demonstrates the logical prowess of KTE is a steam-water separator. Once-through boilers manufactured by other companies are designed such that the feedwater is supplied directly to the heat-transfer tubes. KTE’s model, however, heats the feedwater first, using waste heat from the boiler, and then guides the water through the steam-water separator before it is supplied to the tubes.

Yanagida comments, “If the feedwater is supplied directly to the heat transfer tubes, warm and cold waters are mixed abruptly inside the tube, causing thermal shock and releasing dissolved oxygen into the water when results in increased corrosion of the tubes. However, by having the feedwater pass through the steam-water separator in order to keep the water level at consistent level, thermal shock can be avoided, minimizing corrosion of the tubes and fluctua-
tions in steam pressure. This may not appear to be an eye-opening design, but many such ingenuities are packed into the boilers to prolong their lives.”

KTE provides a 15-year warranty with its boilers — the longest in the Japanese market. (Certain conditions apply, such as establishing an annual maintenance contract with KTE.) Yanagida says, “Offering the longest warranty in the market reflects our confidence in our products.”

Highly Efficient and Safe

An absorption chiller-heater is a piece of equipment used to cool or heat, using the principle of heat extraction through water evapo-
roration—the same mechanism as chil-
ning, the Japanese custom of sprinkling water in streets and gardens to cool the surrounding area. Water is used in this system instead of fluorocarbons with high global warming potential, or chloro-
fluorocarbon substitutes, so as to achieve a large, centralized, eco-friendly heating and cooling system. KTE successfully commercialized the double-effect direct-fired absorption chiller-heater in 1968, and the triple-effect direct-fired absorption chiller-heater in 2005—both of which were first in the world of their kind.

A Steam-water separator of the once-through boiler manufactured by KTE achieves highly-dry steam even when faced with fluctuations in steam load. Because the feedwater passes through the steam-water separator before entering the boiler tubes, thermal shocks are avoided, resulting in a reduced level of dissolved oxygen in the steam (dryness of the steam-water mixture that enters the separator illustrated by red arrows in the diagram can be enhanced by accelerating the speed of centrifugation using the inversion of the flow of the mixture. As a result, a dryness fraction (ratio of dry steam contained in the wet steam [i.e., steam-water mixture] of greater than 99.5% is achieved, preventing both corrosion of the connected equipment and overheating of the boiler system.

Steam-water is extracted from the bottom of the tubes. Feedwater separator connects the top of the tubes. After welding leak tests are conducted, the entire boiler goes through an annealing process to eliminate internal stress, so as to make it capable of withstanding high pressures and achieve prolonged product life.

For the once-through boiler’s casing, tubes and fins (illustrated below) are welded to the boiler’s cylindrical body. Four welding robots are widely used for the process.

A once-through boiler manufactured by KTE has already achieved highly-dry steam even when faced with fluctuations in steam load. The feedwater passing through the steam-water separator before entering the boiler tubes results in reduced level of dissolved oxygen in the steam.
Koichi Someya  
Senior Manager, Research & Development Department, Kawasaki Thermal Engineering Co., Ltd.

Shin-ichiro Noumi  
President*  
Kawasaki Thermal Engineering Co., Ltd.

Looking Forward to Tomorrow

Verification Testing for Hydrogen-Fired Once-Through Boilers Begins

In March 2018, KTE commenced verification testing for once-through boilers which utilize hydrogen as fuel. Although hydrogen-based energy is expected to play a critical role in realizing an energy-efficient society, there are many challenges to resolve. Ironworks and chemical plants, for example, have been challenged to utilize effectively the hydrogen byproduct which is generated in the production process. Verifying the functionality of the hydrogen-fired once-through boiler is KTE’s endeavor to achieve effective use of eco-friendly hydrogen resources, and thereby resolve various pressing environmental issues. Because the flame temperature of hydrogen is high, burning it results in high emissions of nitrogen oxide (NOx). In the past, reduction of NOx emissions during hydrogen burning required the use of water or steam. For the verification test, however, KTE developed a technology to achieve hydrogen emissions cuts involving water or steam, using a newly-developed dry-type burner. This testing is an opportunity to verify the viability of the technology, which KTE plans to apply to the boiler and commercialize it in 2019, in cooperation with the Corporate Technology Division of Kawasaki Heavy Industries.

Our Ever-Evolving Endeavor as “Heat Specialists”

In 2019, KTE will be marking 120 years in the boiler business, during which time we also developed the world’s first double-effect and triple-effect absorption chiller-heaters. In both sectors, KTE has been serving as a “heat specialist,” providing superior thermal technology.

In a network of three offices and 13 branches dedicated to product maintenance, one-third of the 500-member KTE team is working hard to ensure uninterrupted operation of their products at customer sites. We are also upgrading our remote monitoring system called “Tele-Mente-Advance,” through which our monitoring center collects operating data and evaluates equipment status in order to support optimal operations. The next version of this system currently being developed is compatible with the IoT (Internet of Things) platform being developed by Kawasaki Heavy Industries (KHI).

KTE plans to focus more on overseas markets, especially the Southeast Asian markets, where package deals inclusive of a maintenance contract are widely accepted. By collaborating with KHI and Kawasaki Gas Turbine Asia, we plan to implement aggressive marketing for both the once-through boilers and waste heat boilers.

Although the technologies for boilers and absorption chiller-heaters are considered to be in the mature stage, we continue to explore the possibilities of these technologies. KTE’s Research & Development Department, explains, “Our technological enhancements are focused on how we can flexibly accommodate customer needs, such as the leveling of running loads that change seasonally, which is essentially an improvement on so-called ‘seasonal efficiency,’ or the development of a technology to utilize low-temperature waste heat of 60 degrees Celsius or lower.”

Maximizing the potential of the power of heat in order to realize a more comfortable present and an optimal future—that is what KTE is pursuing. Its attention, but they certainly support our lives behind the scenes.

Regarding the features of this equipment, Koichi Someya, Senior Manager of KTE’s Research & Development Department, explains, “The triple-effect absorption chiller-heater achieves a COP* of 1.74. Compared to the double-effect models, it achieves 35% fewer carbon dioxide emissions and reduces annual running cost by about 3.5 million yen. For its high-temperature regenerator, the same cylindrical body design as the once-through boiler was adopted, which was achievable by KTE alone because we are in possession of both boiler and absorption technologies.”

Another feature contributing to the advantages of absorption chiller-heater is the versatility that allows the use of diverse heat sources for its regeneration process, including gas, oil, waste heat from the cogeneration system, cooling water heated by the large engines of the same system, etc. Moreover, KTE’s Efficio absorption chiller-heater series includes a model which uses gas or oil interchangeably as an energy source, making it a preferred model of medical institutions and other entities in need of such versatility. On the significance of this feature, Someya comments, "Operations at a hospital designated as a Disaster Relief Core Hospital, which serves as a medical hub in the event of large-scale disasters, will not be interrupted if it has the option of switching to oil if the gas supply is shut down. This means that this model could be positioned as a critical component of business continuity planning.”

Kawasaki holds a 25% share market in Japan (in terms of equipment capacity), making it one of the largest market share holders in the country’s absorption chiller-heater market. This is attributable to KTE’s capabilities for developing a number of the world’s first technologies, and to its maintenance system and other services accommodating users’ diverse needs.

The WILLHEAT Compact Once-Through Boiler Was Launched to Meet Diverse Customer Needs

In 2000, KTE launched the Efficio series (large once-through boilers), and 16 years later, the WILLHEAT series made its debut to better accommodate diverse customer needs. In April 2018, the Boiler Development Division—dedicated to developing next-generation once-through boilers—was established to strengthen KTE’s product offerings geared toward Southeast Asian markets and other regions where growth in boiler demand is seen. The division is focused especially on selling boilers with maintenance contracts and supplies of corrosion prevention chemicals. Presently, the division is based in Malaysia, at Kawasaki Gas Turbine Asia Sdn. Bhd (KGA). In addition, KTE plans to establish a subsidiary in Thailand in the future to bolster its marketing capabilities.

Regarding absorption chiller-heaters, we are hoping to develop compact boilers with a maximum steam output that is 1.5 times greater than current models. We will be exploring improved water flow, flow rate, circulation, and other functions to improve overall efficiency.”

Absorption chiller-heaters are also the subject of KTE’s improvement efforts. These include enhancement of operating procedures and compatibility with various heat sources. Expounding on KTE’s approach, Someya explains, "Our technological enhancements are focused on how we can flexibly accommodate customer needs, such as the leveling of running loads that change seasonally, which is essentially an improvement on so-called ‘seasonal efficiency,’ or the development of a technology to utilize low-temperature waste heat of 60 degrees Celsius or lower.”

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From Top Management

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The Rexpeller is an azimuth thruster that enables marine vessels to have precise and agile maneuverability and accurate positioning capability, which are essential requirements for operation in severe nautical conditions. Thirty-five years after receiving its first order, Kawasaki is ready to make a further leap forward in the evolution of the Rexpeller.

Epoch Maker

35-Year History of the Rexpeller: King of Marine Propulsion Units that Provide 360-Degree Thrust

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First order for the Rexpeller received

The first order was for a tugboat owned by a Japanese company. Production of Rexpellers started at Akashi Works (then Akashi Minami Works) in Akashi City, Hyogo Prefecture, and its all-in-one structure, arranging the clutch and hydraulic machinery on the platform foundation, drew much public attention as the first such design in Japan.

First delivery of the A-series Rexpeller made

Launch of the A-series dramatically extended the market share of Kawasaki, even though Kawasaki was the last to enter the market for azimuth thrusters in Japan. The A-series pulled a trigger that led to a variety of vessels equipping themselves with azimuth thrusters, other than tugboats.

Six units of a Rexpeller model that was the world’s then-largest azimuth thruster for the Chikyu, a deep-sea scientific drilling ship, were delivered. The Chikyu was the first vessel in history which could drill into the earth’s mantle. Using six units of the coordinated Rexpellers, the Chikyu is able to remain in a specified position in the ocean while using an excavation drill to drill the seabed, without any anchors and/or mooring lines. Such stability of position is possible for as long as a year, even under challenging conditions where wind speeds of up to 23 m/s, waves 4.5 m-high, and currents moving at 3-4 knots are seen.

One of the Rexpellers was delivered to a shuttle tanker. The Rexpeller, which provides omnidirectional thrust, is instrumental in offshore operations, as they require accurate maintenance of positions. The retractable Rexpeller can be retracted into the hull by hydraulic means, allowing the vessel to sail at high speed by reducing hull resistance during transportation.

First order for the retractable Rexpeller for shuttle tankers received

For extended demand of azimuth thrusters in the growing oil and gas related offshore development market, a new factory was built at Harima Works (in Kako County, Hyogo Prefecture) and production commenced.

New factory completed to increase production capability

The E-series, which offers energy savings through improvements of propulsion efficiency, ease of onboard maintenance, and environmentally friendly performance, was launched. Four units were ordered, which will be installed onto tugboats to be operated by China’s Port of Tianjin, and the operation will start from the latter half of 2018.

First order received for the E-series Rexpeller – our newly-developed azimuth thruster

The E-series dramatically extended the market share of Kawasaki, even though Kawasaki was the last to enter the market for azimuth thrusters in Japan. First delivery of the A-series Rexpeller made

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The duAro: A Dual-arm SCARA (Selective Compliance Assembly Robot Arm) Robot that Achieves Human-Robot Coexistence

Commentary by Kazunori Hirata
FA System Section 1
FA System Department
FA and Clean Group: Robot Division
Precision Machinery and Robot Company
Kawasaki Heavy Industries, Ltd.

Pioneering Robot Applications in Areas Previously Deemed Unfeasible

The duAro, a dual-arm SCARA robot that operates alongside humans, was launched in 2015, based on Kawasaki’s experience as the first company to commercially manufacture robots in Japan. The debut of this robot marked the company’s commitment to pioneering a new era of coexistence and collaboration between robots and humans.

As Japan faces an ever-shrinking workforce, manufacturing sites are in dire need of replacing vanishing manpower with industrial robots are increasing. However, introduction of robots at companies such as those in the electrical and electronics industries has been hampered by unacceptably high cost-effectiveness, given the short life-cycle of their products and the lengthy preparation period required for their introduction.

Another negative factor contributing to reservations felt by small and mid-sized companies, which make up the majority of Japan’s industry groups most in need of robot applications — has been their lack of expertise in robotics.

The duAro was developed to resolve these challenges. Standing up to 170 cm tall and weighing 200 kg, the duAro is installable in the working space of a single human worker. It can be taught easily by the simple means of step-by-step direct teaching, or by using a tablet. Its two arms can perform separate tasks, and with its collision detection features, the safety of collaborative operations with humans is assured.

The duAro is also with a price tag that is reasonable enough to make it a viable option for implementation, which has been contributing to its popularity more than any other factor.

Since its launch, these benefits have been expanding the horizon of applications. From the fastening of screws for printed circuit boards (PCBs) to the picking and placing of rice balls into food trays, the duAro is an innovation that is sure to become a key contributor to the future growth of the manufacturing and service industries in Japan.

Low-Power Motors Adopted for Operations Free of Safety-Fencing

The arms are driven by motors mounted on their “shoulders,” “elbows,” and “hands,” and their movements are controlled by changing the number of the motors’ revolutions. The arms, padded with soft material, can be configured to move at different speeds in different zones, within the low-speed areas at either side of the robot, where human workers might approach, the robot to move slowly in those two areas when it operates at high speed in the center zone. The robot is also equipped with a collision detection feature which instantly stops any arm movement when people come in contact with the robot and the impact is detected.

Flexible Direct Teaching Features

The controller for the robot arms is housed in a wheeled, box-shaped platform which is easily moved to a desired location, allowing the robot to perform tasks in any part of the production line. There are two simple ways to teach the duAro direct teaching or via the Android-based tablet in the former, the operator performs a task holding the robot arms, to make it reproducible by duAro. In the tablet-based method, the operator configures the required movements by inputting numerical values. Both are very simple means, requiring no special knowledge.

With its weight accounting for 75% (145 kg) of the entire robot, the platform provides needed stability for the duAro to move its arms.

Diverse Tasks Can Be Robotized as Needed

Various tools are attachable to duAro’s arms, enabling the robot to perform various tasks. Tool applications include the mounting of parts on PCBs, the placing of rice balls into food trays, and inspections of functions and response capabilities of touch screens, to name a few, and many more are likely to be added.

Existing Tools Are Also Usable

Tools that customers have been using are attachable to the duAro, using base chucks and adapters. An impressive lineup of options is available for customization. The duAro can remedy increasing labor shortages.

Automated Smoothing of Horizontal and Vertical Movements

The arms of the duAro are movable in horizontal and also z-axis (up and down) directions, and each arm is capable of lifting a workload of up to 2 kg. The movement in the z-axis direction can be taught through direct teaching, and the arm covers are made of urethane to soften the impact, should people come into contact with them.

Mounting of parts on a PCB

Placing of rice balls in food trays

Inspection of functions and response capabilities of a touch screen

Dual-Arm Feature that Mimics the Marvelous Dexterity of Human Hands and Arms

The duAro is an innovation that is sure to become a key contributor to the future growth of the manufacturing and service industries in Japan.
Win or Lose, Be Sure to Forget It

An ancient Indian board game called Chaturanga, which is believed to be the forerunner of shogi, was brought to Japan in the Heian period (794-1185/1192 CE) and evolved uniquely to become what shogi is today. In the latter half of the 20th century, computers enabled widespread data sharing of the moves and outcomes of shogi games, revealing the game’s real essence to be that of a “brain sport.” Against such a backdrop emerged 15-year-old shogi prodigy, Yoshiharu Habu.

At one point, his annual victory rate exceeded 80%, and he still maintains an average rate higher than 70%. Critics say that Habu’s unrivaled strength lies not only in tactics, but also in his flexibility in accommodating changing times and the tenacity to achieve continued victories.

Asked what the secret of remaining an undefeated player is, Habu says, “I feel that the life of a shogi player is like a marathon. It is vital that you stay in the lead group. As long as you are in that group, you can be the last runner (and still remain an active player).” He adds that for prolonging a shogi career, forgetting the past is essential.

“Win or lose, you must let go of the game quickly, because victories make you pompous and careless, and defeats undermine your aggressiveness. You should let go of those residual images of the games. After you review the results, it’s best to forget about the outcome—win or lose. Of course I have feelings, but I think it’s important to learn how to channel the emotional ups and downs into motivation for improvement.”

Habu’s favorite description of a desirable state of mind is “reiro” (clear-minded, serene), but it is not difficult to imagine how challenging it is to stay reiro in a world where only victory counts. “I’m still exploring how to control my thoughts,” says Habu, scratching his head.

Competencies You Must Develop for the Future

With 81 squares on the board, and possible moves amounting to 10 to the power of 220, shogi is a very complex game—complex to the degree that no infallible strategy is known to date, even with the help of artificial intelligence (AI).

Speaking about his approach to competing, Habu comments, “Throughout the course of the game, I try predicting each move in detail, but 90% of my strategies prove ineffective. So, I’m not playing with a fully-working prediction most of the time, but with a hunch that this move might work better.” He does so, of course, after intensive data research on past games and after all possible predictive simulations.

Failure to do data research results in immediate defeat. However, since such research is a prerequisite to playing any game nowadays, there is no chance of getting ahead of your opponent in that regard. Instead, generating something unique out of the data is critical,” explains Habu.

The emergence of AI and shogi apps has allowed the development of new moves or strategies on a weekly basis. Habu thinks, however, that although collective research may result in effective strategies, it also poses the risk that they will slide into uniformity.

Collective thinking often overshadows that of an individual, but I still check out research results and ideas released by individuals and small groups, in search of something truly novel that might become an effective strategy. Cutting-edge developments are always in the trial-and-error stage, and you just have to try them to find out whether or not they work,” he adds.

Sectors threatened by the growing sophistication of AI are not limited to shogi. Regarding this trend, Habu comments, “It’s frightening that people so easily believe what AI suggests. AI can increase probabilities, but it is not error-free. You must be skeptical about the results AI produces, and verify them personally by thinking through them.”

In response to a question about how one can develop the sensibility, individuality, and capability of thinking hard that Habu has mentioned, he replies, “Put yourself in a new environment. It could be as simple as walking around a town that’s unknown to you. Routinely bend to constrain your thinking, go out and meet the unknown, think hard, and decide for yourself. As you repeat this process, you will naturally develop such capabilities.”

“‘A genius carries an air of coolness,’” is a comment made by Kunio Naito, holder of the ninth dan (the highest shogi rank), on the character of Yoshiharu Habu—a shogi player who made a great achievement in his 33-year career: he became the first to hold an eisei (lifetime honor) in all of the then-seven major shogi titles, and, as a result, was given a People’s Honor Award by the Japanese government in 2018. Yet, Habu never ceases to seek new ventures. What aspirations does he hold today?”
In March, Kawasaki completed development of a combined cycle power plant (CCPP) with the world’s highest level of electrical efficiency, and has commenced marketing activities. The CCPP employs the L30A, a 30 MW class made-in-Japan high-efficiency gas turbine featuring the highest output of all Kawasaki gas turbines.

A CCPP consists of two stages of power generation. A gas turbine generator provides the primary power generation, and the gas turbine exhaust is utilized as the heat source for a heat recovery steam generator (HRSG). Steam from the HRSG drives a steam turbine generator to provide secondary power. A CCPP has a shorter startup time than a conventional steam turbine power plant of the same output, and features excellent load response as well as high electrical efficiency, meaning minimal thermal energy is wasted.

The newly developed CCPP is composed of two L30A gas turbines, two HRSGs, and one steam turbine, all produced by Kawasaki. This brings together Kawasaki’s product technology and plant engineering capabilities cultivated over many years, to achieve high efficiency in the combined cycle as a whole, in addition to that of the gas turbines alone*. Total Electrical efficiency is 55.2% (heat rate type) in the 180 MW class, and 54.4% in the 90 MW class systems, both among the world’s highest levels of electrical efficiency.

Some of the technologies for increasing efficiency and improving load imbalances of 100 MW gas turbines were developed by the New Energy and Industrial Technology Development Organization (NEDO) Program for Strategic Energy Saving Technology.

*This is a reheat type CCPP, in which steam is extracted from the middle stage of a steam turbine and reheated in the reheater of an HRSG before being returned to the steam turbine in order to increase power output.

This high-pressure hydrogen regulator is the fruit of joint development with NuCellSys, a subsidiary of Daimler. Fuel cell vehicles store hydrogen in a tank at extremely high pressure (approx. 700 atmospheres), and the regulator plays the important role of reducing the gas pressure to prepare it for use in the fuel cell stack.

Exploiting the fluid control technology that Kawasaki has developed through its many years of developing and manufacturing hydraulic devices, together with NuCellSys’ expert knowledge in fuel cell systems, we have developed a regulator that takes up less space and contributes to increased range by improving fuel efficiency, while at the same time offering superior reliability, having cleared durability tests that suggest a product life of 20 years. This is all possible through the efficient pressure reduction enabled by high precision gas control technology, and the stable hydrogen gas pressure it delivers during power generation.

* A device that generates power through the chemical reaction of hydrogen and oxygen.

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Kawasaki — Pioneering the Future of Hydrogen-Based Societies

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- Japan’s first plant to produce liquefied hydrogen by cooling it to -253°C.
- Development of a huge hydrogen storage tank equivalent to the total volume of 30,000 fuel cell vehicles’ fuel.

Liquefaction shrinks the volume of hydrogen to 1/800, making mass transportation possible.

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