Kawasaki's Floor Conversion System
Using Air Technology Supports the Stages of Athletic Victories

Special Feature
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Today, a wide range of people enjoy a variety of sports, and Kawasaki's "air technology" is facilitating this trend, supporting the operators of sports venues by broadening the uses of their facilities.

Where Japanese Martial Arts Flourish, the World's First Floor Conversion System Is Applied

Himeji City in Hyogo Prefecture is famous for Himeji Castle, a UNESCO-listed World Cultural Heritage site. It is also reputed to be a place where Japanese martial arts flourish, even more than other cities in the prefecture, which has produced many notable martial artists. Himeji-born artists include Mitsunori Kawasaki, who was entrusted with the mission of popularizing Judo in France by the Kodokan Judo Foundation. Juporo Ishibashi, who later became known as "the Father of Friends Judo," and Hidetsugu Takehara, "the Swordman of the Meiji Era." And the venerated swordsmen of the Edo period, Masayoshi Mochinaga, had a close association with the head of the Himeji Domain.

Given these connections, it is not surprising that the Hyogo Prefectural Government chose Himeji as the location for its WBNK (World Negative Pressure Airtracks) Air-Tracks Hall in 2002. Of the two days practice held in this facility, Day No. 1 is equipped with the world's first automated floor conversion system which lays tatami (woven mats) for judo on top of the Japanese cypress floor used for kendoo (Japanese swordsmanship).

Using this system, conversion from a judo hall to a judo hall with four judo rings, which meets international competition standards, takes just 40 minutes. In the conversion process, a base of 32 tatami mats (each mat being about 1.8 x 0.95 m, 3 x 3 ft, called a "takami unit") is brought in on two automated guided vehicles (AGVS), with four tatami units completing one judo ring. Since the venue consists of four rings (16 tatami units), a total of 512 mats are used.

"Converting kendoo halls to judo halls by laying down tatami mats is a common practice, but it has always been labor-intensive, time-consuming, and costly. It is estimated that converting a regular martial arts hall into a judo hall that meets international competition standards, which require the hall to have a 50 cm high base, takes 10 workers two days, costing five to 10 million yen (about US$48,700–93,150)," Director of the WBNK, Nipon Yosoyasaka, comments. "While we were preparing for construction of the Budokan, WBNK provided a solution for our need for an automated system which achieves both effective operations and the size and level of facility required for international competitions. When the WBNK system was opened, people called the conversion system a "magic carpet.""

The power of air is alms to this system. In 2002, Kawasaki delivered a "Novel Wing" (an innovative air-floating sports platform) to Sapporo Dome, which can be moved into and out of the stadium using pneumatics and other advanced technology for moving heavy objects. This system made the stadium operator's dream of hosting the 2002 FIFA World Cup come true. Another innovation contributing to this floor conversion system is an "aerating method" that Kawasaki makes use of in which the roof structures of liquefied natural gas (LNG) above-ground tanks are assembled at the bottom of the tanks and then raised, creating...

More technology for the Dynamic Conveyer (DC), a long-lasting, high-speed, long-distance, low-speed belt conveyor and other air-supported inventions were incorporated in the development of the Budokan's floor conversion system.

Nearly twenty years after its installation, a six-month project to renew the system began, and was completed in March 2020. Not only its aging parts but also its control system was replaced, as a result of which an improvement in the conversion speed was achieved.

Let's take a look at Kawasaki's technology which achieved the world's first floor conversion system using the air power.
A Heavy Base Is Elevated and Moved Using AGVs

The floor conversion system is comprised of four components: 1) Tafmuni (a three-level wooden platform), 2) AGVs that move and align the tafamuni to create the stage, 3) Storage bins for tafamuni and AGVs, and 4) Center equipment and panels for these components.

Under the tafamuni unit, a balloon-like bag filled with air and with air fans on the bottom, is placed so that when air is injected inside the bag by a blower, the bag swells and elevates the unit about 40 meters. As the air then escapes through the holes, a layer of air beneath the bag is also created, reducing the friction between the tafamuni unit and the floor by one thousandth.

Osamu Daisukuri, who was involved in the development of the system and was in charge of the renewal project, said, "The idea behind this system was to make it easier for the performers to move around, and to reduce the friction between the tafamuni and the floor by one thousandth."

These storage bins are located under the floor of the tafamuni and the area of the stage, and are not visible to the audience. These bins are used to store and transport the tafamuni and AGVs.

A total of 14 AGVs are mounted on the four corners of the AGV (two AGVs at each corner for forward/backward movement, and two AGVs at each corner for left/right movement). This allows the AGVs to move smoothly and quickly, reducing the time required for setup.

Two AGVs Move in Perfect Coordination

Although the AGVs are guided magnetically, Daisukuri says, "The most challenging aspect of using AGVs in moving and aligning the tafamuni units is that they have to move in perfect coordination, which we call 'blow breathing'."

Because they are transported at a speed of 1.5 ms^-1, even slight dislocation can result in a major misalignment. To prevent this, Kawasaki developed a control technology that allows the AGVs to recognize each other's position using optical communication and move in perfect coordination.

Daisukuri adds, "This technology realizes perfect alignment of the tafamuni and AGVs, thanks to a level of precision which achieves a less than 5% difference between the AGVs, regardless of the time they come to a stop, and a mechanism that ensures the units are tightly fitted together.

Another feature contributing to efficient floor conversion is the storage floor lifting shelf, used to store the tafamuni units and AGVs. There are four storage shelves in the hall, with two each installed on opposite sides. This means that 18 units and eight AGVs can be hidden in four locations under the floor.

Weighing 40 t, a floor lift is a 4.5m high structure that can hold 120 people and tafamuni and AGVs. Therefore, the height of each floor when the floor lift is fully closed is 3.2m. When the floor lift is fully opened, Kawasaki developed a positioning system to position the lift to the perfect height.

The position and status of the tafamuni units, AGVs, lifters, and other equipment are controlled in real-time via wireless communication, and by moving multiple pieces of equipment simultaneously, the system deploys and stores the tafamuni units in the shortest possible time.

Daisukuri comments, "It was quite meaningful to develop this floor conversion system because it helped us establish technologies for creating large structures, elevating them using air, and controlling them to a millisecond level of precision. We can apply the same technology to transport heavy objects from place to place, which is a significant advantage for future projects."
A System that Accommodates Diverse Sports Requirements

Kawasaki has been making efforts to develop new customers for this floor conversion system, as one of the 48 public martial arts halls in Japan opened more than 40 years ago and are failing to meet the wider range of local sports needs. Yoshinaka Honda, the sales department manager in charge of marketing air conditioning products at Kawasaki, says, “Considering the scale of floor conversion systems, incorporating one requires Kawasaki to be involved in the project even before the designing process begins. Despite such a requirement, some public entities are already showing interest in the system.” Emphasizing the value of the technology in enabling facility operators to effectively increase the availability of sports for local residents, Honda says, “The use of technologies which utilize the power of air, such as the floor conversion system, greatly enhances a facility’s operating rate and saves a significant amount of labor, therefore contributing to the effective management of the facility.”

Kawasaki’s air technology is supporting the “stage of victory” for athletes in a city closely associated with Japanese martial arts. It is also meeting the desires of facility operators to enrich people’s lives through sports, and to support athletes in winning victories.

A User’s Voice

Nijo Kobayashi
Director, WNK Budokan

Flexible Conversion of Sports Halls Provides Facility Operators with Managerial Efficiency and Competitive Advantages

Opened in 2002, the WNK Budokan has been serving as a center for promoting and developing martial arts, the well-being and fitness of prefectoral residents, and a lifelong involvement in sports.

It is used mainly for 11 types of martial arts, including judo, karate, and nunkei (grape fighting). But the arts hall is one of the largest in Japan that meet International competition standards. We enjoy a high operating rate, with various competitions held on weekends and many martial arts classes held weekdays.

For effective facility management, it is vital that martial arts halls be designed for multipurpose use. The floor conversion system in Dais No.1, in particular, is a major contributor to the highly efficient running of the facility. Because conversion from the regular floor to the tatami-covered version and vice versa takes only 40 minutes, we have flexibility in planning our event schedule. Ever since we installed the post of the Budokan’s eighth director in 2018, I have been committed to using this superior resource to our advantage in facility management.

During the renewal project, I observed Kawasaki engineers’ painstaking attention to their work, indicating a passion for their technology, while our collaborative discipline is practiced in meeting the timeline. I feel that such an approach fits harmoniously with our desire to foster harmonious through martial arts.

Sports and Kawasaki

Kawasaki’s Pneumatic Flotation Technology Supports Centers for Sports Promotion in Snowy Regions

Raising an 8,300 t Football Field

The Sapporo Dome, which is located in snowy Hokkaido Prefecture, is an all-weather multipurpose facility used for professional baseball games, J League football matches, concerts, motor shows, etc. Launched in 2001, the stadium is equipped with a natural grass football field called the “Hovering Stage,” which can be moved using Kawasaki’s pneumatic flotation system.

The football field (stage), which normally resides in the outside area of the bowl, is transferred to the inside area when such events as home matches of the professional football club Hokkaido Consadole Sapporo are held. In respect to the baseball field, the stands behind center field can be moved and the wall opened to bring the stage into the inside area (photo above).

The stage is then tilted 30 degrees so that the stands behind the bottom stage, where the number of spectator seats is the largest, becomes the grandstand.

Pneumatic pressure is applied when moving the stage. Pressurized air is pumped into the space directly below the stage and, at the same time, balloon bags (bag seal) which are installed under the floor成为 of the stage are inflated, making the air and creating greater pressure (see illustration below). This pneumatic pressure lifts the 8,300 t 130 m x 85 m stage, reducing its dead weight to one-tenth.

Next, 34 wheels around the outer perimeter of the stage are hydraulically extended down to the ground, and the stage is carried straight into the inside area, guided by the same magnetic plate system as that used in the WNK Budokan. The amount of air leaking from minute eeps between the bag seal and the ground varies according to the unevenness of the ground, but this exhaust air is controlled in order to maintain a constant pneumatic pressure. It takes about two hours to move and rotate the Hovering Stage.

Takashi Mimura, Senior Staff Officer of the Plant Engineering Business Division, who developed the Hovering Stage, comments, “The Hovering Stage was used for both the 2002 FIFA World Cup at Sapporo Dome, which was co-hosted by Japan and South Korea, and the Rugby World Cup 2019. I’m sure it will be a stage for many more sports events. Hokkaido residents are very happy that Sapporo Dome is allowing them to enjoy indoor sports even during the winter, making the stadium a symbol of sports promotion in Hokkaido. I’m very proud that Kawasaki’s technologies are supporting the operation of the stadium.”

How the Hovering Stage is Levitated

Air supply

Pneumatic pressure

Stage

Air leakage

Pressure blowers

Air supply

Exhaust

Bag seal

For adjusting internal pressure

Air leakage
In your opinion, what changes are required of the world's manufacturing sector today?

I think manufacturers are being tested for their ability to quickly accommodate changes and consistently continue upgrading the value they offer their customers. Today, manufacturers are required to improve the quality of the solutions provided by their products and to be capable of developing products more quickly in order to maximize the chance of missed opportunities being encountered by their customers.

For example, the volume of airplane production worldwide was expected to rise, but was instead severely hit by the COVID-19 pandemic, and that sector must now fundamentally change the way it manufactures products. Given this renewed caution, we must think hard about what technologies we are able to offer and how they could be utilized.

The Kawasaki Group must, therefore, develop products with a shorter turnaround time, offer even more effective solutions, and practice effective sales communication using our ‘innovating success’ integrated approach in order to keep generating new value. At short, we must commit ourselves to bringing our comprehensive technological capabilities to the world.

Is the Kawasaki Group sufficiently responding to these challenges?

Employees of the Kawasaki Group can be characterized as having integrity. Period. I am proud that they are so committed to offering products that satisfy our customers. The downside is that we sometimes do more than simply fulfill a customer’s request, to the point where we prepare a full-course meal even though the customer is just visiting. Tostada noodles are fine —Emergency rations." Rather, we must sharpen our senses to discern how the world is changing and what needs are emerging, and increase our ability to respond speedily to those needs.

To achieve this, it is necessary to promote digital transformation (DX), foster a culture where it becomes the norm to produce designs in a shorter time frame, and become more selective in which of our businesses we focus on, in order to accelerate the speed of operations. All of our businesses must be reviewed and redefined from the perspective of customers and market needs, rather than our own.

What measures has the pandemic compelled Kawasaki to take?

It has compelled us to accommodate changes rapidly as a company and at the same time demands expedited transformation of all our operations. This means that the ‘Kawasaki Changing Forward’ — the motto that former president Kanchijima advocated — must be accelerated.

We must first change our personal mindset and then that of the people around us. For example, the popularization of teleworking due to the pandemic made us keenly aware that there is value in not always being on the move. However, Kawasaki manufactures airplanes, rolling stock, and many other products that require the value obtained by going from place to another.

In terms of our products which aren’t "on the move," such as industrial plants and robots, it is important to provide more "data-based solutions. In regard to our products whose value is intrinsically tied to movement, such as airplanes and rolling stock, valuable new features, such as a mechanism to prevent infections from spreading from one passenger to another, must be explored in addition to general safety and comfort. I’d like to work on building a mindset among employees that flexibly accommodates exponential change.

May we ask why you wished to become a robot engineer?

"Astro Boy" and "Iron Man No. 28" were my childhood heroes, and I was a boy who was always dreaming of structural designs of robots. In the margins of my textbooks, I often drew pictures of robots. It was my university days, that opportunities to serve as a volunteer firefighter with muscular dystrophy, and I had one mother saying, "Ever since my child was born, I haven’t slept for more than two hours at a time because I needed to roll the child over every two hours." It was then that I determined to make a robot useful to the medical and nursing sectors.

The Kawasaki Group has long been manufacturing products that sustain society, and starting in spring of next year, we will begin building a humanoid-energy-based society. I believe that technological innovation is born out of product developers’ and providers’ passion for wanting to contribute to society. I think, therefore, that offering to the world "Trustworthy Solutions for the Future" is what we should commit to as the Kawasaki Group.

* Shoko Asahara, Honorary Managing Director and Managing Executive Officer and President of Kawasaki Heavy Industries, Ltd. In June 2020, Yasuhiko Hashimoto was appointed as the new President and Chief Executive Officer (CEO) of Kawasaki Heavy Industries, Ltd. For this issue of SCOPE, the editorial team interviewed the new president to find out how the manufacturing sector is apt to change in the post-pandemic era and what Kawasaki Group’s strategy for it will be.
Passenger Hydrofoil with Fully-Submerged Foils: Kawasaki’s JETFOIL

Commentary by
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Tokyo Island Blue: Used in Design
The waterbird of Tokyo Island Yi was designed by Akira Sato and presented to the World Turtle Olympics and World Aquatic Games. Painted in a shade of porcelain blue called "Tokyo Blue," the turtle was decorated with its name and logo in white. The colors used in the design were selected to match the colors of the ship, providing the passengers a sense of place.

Kawasaki Produces JETFOIL — Vital for Remote Islands — for the First Time in 25 Years

The JETFOIL, a type of passenger hydrofoil with fully-submerged foils, is considered essential for traveling to and from remote islands. Powered by gas turbine engines, waterjet propulsors (pumps) draw in and then discharge seawater generating lift by means of a set of fully-submerged foils ahead and aft, thereby raising the hull above the water’s surface. Achieving a maximum speed of 45 knots (83 km/h), it creates a sea mist even in rough seas with waves reaching as much as 3.5 m. It can currently be called a “flying ship.”

A hydrofoil with full-submerged foils was independently developed by The Boeing Company of the U.S. in an effort to apply aerospace technology to marine products. In 1974, a passenger-carrying hydrofoil was launched, which was named “JETFOIL” as it resembled a jet, with sharp, leaping wings. In 1977, Kawasaki acquired the manufacturing and sales license from Boeing, and 15 units were manufactured in Japan between 1989 and 1995.

A quarter-century later, a new JETFOIL was conceived and delivered at the end of June to Takikawa Kisen Co., Ltd., a Japanese maritime transport company. This 24-passenger ship, which is thrice the size of the original JETFOIL, has a longer 38-meter-long body.

ACS Realizes a Voyage Free of Seakeeping
The stake of the JETFOIL’s voyage control system, with minimal pitching and rolling, is attributed to eight sensors that detect the ship’s tilt and movements and its ACS (Automatic Control System), which constantly corrects pitching and rolling, and other movements, providing passengers with comfortable seakeeping travel. When the ship tends to change course, the ACS makes the rudder rotate vertically upward or downward to the ship’s direction of the turn, and the lean (or dive) of the turn, the ACS automatically controls the rudder to the desired position. The rudder is automatically controlled by the sensor data. The ACS enables the ship to be navigated easily in rough seas with minimal wave impact on the passengers.

Ability to Discharge the Equivalent of Half a Swimming Pool’s Water in One Minute
The water intake located at the center of the foil draws in and then discharges 160 t of water every minute, which is equivalent to approximately half of a 25 m x 10 m x 3.5 m swimming pool. The highly pressurized nature of the water being drawn in and discharged enables the ship to reach its top speed of 45 knots (83 km/h) in just three minutes.

How the Ship “Takes Off”

1. Hullborne Mode
- When JETFOIL is in hullborne mode, it travels at around 10 knots (18.5 km/h), and the forward and aft foils are retracted.

2. Rising to the Surface
- By lowering the foils and increasing speed, it is generated in the foils, making the vessel rise to keep the surfacing at 15 knots, with the hull emerging from the water at 26 knots.

3. Feibleborne Mode
- Once clear of the water, at 35 knots, the vessel enters into hullborne operation, which is less subject to the effects of waves. It takes one to two minutes; at 5-8 knots, the ship is in the process of being lifted, and it is towed by a tugboat, and it is towed by a tugboat technical staff until the vessel is lifted into the water, and it is towed by a tugboat technical staff until the vessel is lifted into the water.
**Leveraging the Strength of Kawasaki Against the Novel Coronavirus**

**Development of Test Systems Using Robots**

In response to the spread of novel coronavirus infections, Kawasaki has been developing a polymerase chain reaction (PCR) testing system using the daVRa collaborative dual-arm SCARA robot and producing medical face shields in its factories to reduce infections among medical personnel and support the enhancement of testing systems.

**Introducing a Temperature Measurement System Using a Robot at Kawasaki Good Times World, Collaborating with Kobe City in PCR Testing, etc.**

Kawasaki has developed an automatic temperature measurement system using daVRa grabs. In addition, it is the Kobe Maritime Museum and at Kawasaki Good Times World in Kawasaki Heavy Industries Co., Ltd., located in the same building, since the museum reopened in June, all visitors have been temperature-checked to ensure the safety of visitors and staff.

The system has a non-contact temperature sensor attached to the right hand of daVRa, unless otherwise specified, to the visitor’s forehead level, which covers the temperature detection sensor to begin measurements. If the visitor’s temperature is over or below a preset acceptable maximum or minimum temperature, the robot indicates that the visitor may enter by removing the barrier barrier held in its left hand. However, if the visitor’s temperature exceeds the acceptable maximum, the barrier remains in place and a staff member is called to the entrance.

**Producing Medical Face Shields and Gowns and Donating Them to Medical Institutions**

Starting April 30, Kawasaki’s Kobe Works and Hanama Works began producing medical face shields (plastic right and gowns to reduce transmission of the coronavirus, donating them to medical facilities. A total of 6,430 face shields were produced using a transparent pattern film used for steel processing, and 15,880 gowns were produced in accordance with the method announced by Osaka University Hospital. We donated them to Kawasaki Hospital and prefectural hospitals in Hyogo Prefecture.

Regarding sample collection, regulatory approval will be obtained so that doctors will be able to remotely collect nasal samples. Regarding saliva sample collection, pre-sample analysis work and transportation and storage work will be automated. In addition, each process of the PCR test is automated, utilizing a robot. The number of tests processed can be increased by three to four times that of manual labor. The design, production, and evaluation of these systems are planned for completion by September 2020, and a facility in Kobe Biomedical Innovation Cluster near the plant will be completed in October.

Yoshikazu Tamura, Manager of the Corporate Planning Department of Kobe Steel, says, “By using robots to automate various tasks, we reduce the risk of infections as well as the burden of work on medical personnel and support the expansion of PCR testing systems.”

**Creating a Kawasaki Products Coloring Book for Enjoying Time at Home**

As more children spend time at home to reduce the spread of coronavirus, Kawasaki has published on its website a “Time at Home” coloring book of its products. Ten products are depicted, including the Shinkansen, a motorcycle, an LNG carrier, and a BK117 helicopter. Please click on the link to view them.

https://www.khi.co.jp/stayhome_nurse/stayhome_nurse.html
From June, Kawasaki commenced sales of a high-efficiency hydrogen liquefier. This liquefier, developed in collaboration with leading hydrogen liquefaction technology companies, helps to realize hydrogen liquefaction processes in various fields.

**Main Features**
- **High Efficiency**: The liquefier is designed to achieve high efficiency in converting hydrogen to liquid form
- **Compact Size**: The liquefier is compact, making it suitable for various applications
- **Versatility**: It can be used in various fields, including transportation, power generation, and industrial processes

**Kawasaki Receives 2020 MEXT Commendation for Science and Technology**

Kawasaki has been awarded the Prize for the 2020 Commendation for Science and Technology by the Ministry of Education, Culture, Sports, Science and Technology (MEXT). This recognition is in honor of the company's successful development of a high-power, high-efficiency supercharged engine for large motorcycles.

**Kawasaki Awarded Contract for New Waste Treatment Facility**

Kawasaki has been awarded a contract by the Kodaira, Musashino, Yamato Hygiene Association (Tokyo) for the new Waste Treatment Facility Construction and Operation Project (Tentative Name). This will be a design-build-operate (DBO) project, where Kawasaki will design, build, and operate a new waste incineration and processing facility to handle about 150 tons of waste per day, as well as a new waste incineration and processing facility to handle about 150 tons of waste per day.

**Successful Test Flight of a Large Hybrid Drones**

Kawasaki has successfully tested a large hybrid drone prototype. The test model measures about 2.5 meters wide and 2 meters long, and is designed to test the technical possibility and performance of a large hybrid drone with a cruising range of over 100 km at cruising at a cruising speed of 80 km/h. The drone uses a 200 kg class engine and 40 kWh battery pack.

**Kawasaki has made a short comment in behalf of Kawasaki**: "It is a great honor to be selected for this commendation. I consider this recognition to be a stepping stone in the development of the project. Following this commendation, we will continue to refine our technologies and further develop the technology that meets the increasingly diverse needs of customers, and contribute to a better future for our global environment."