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Advanced fluid control technology creates high added value and helps bolster the productivity, reliability, and safety of manufacturing activities



Special Feature
From Japan to the World

Lunar Exploration
by Privately Funded Teams!



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The Google Lunar XPRIZE is a US\$30 million lunar surface exploration competition initiated in 2007. One of the 18 teams presently competing in this contest is a privately-funded team named HAKUTO, the only team participating from Japan. Team HAKUTO is striving to carry out its project while seeking sponsors to fund its endeavor. Team HAKUTO received the Mobility Prize in the GLXP Milestone Prize Award Ceremony held in January 2015. Toward the deadline at the end of 2016, the race to the moon is approaching its climax.

Taking on the challenge of overcoming obstacles including the procurement of funds of more than \$10 million and development of a space probe

HAKUTO is a privately-funded team formed for the Google Lunar XPRIZE (GLXP). Consisting of the rover research and development team headed by Professor Kazuya Yoshida at Tohoku University and 20 to 30 pro bono members (a group of volunteer specialists in related fields), Team HAKUTO was inaugurated with the aim of claiming victory in this grand race to the moon.

The team leader, Takeshi Hakamada, describes how the team was organized.

"Team HAKUTO originated from the team established jointly by private organizations in Europe and Japan. The lunar exploration mission consists of three stages: sending spacecraft toward the moon using a rocket, ejecting a lunar lander from the rocket and landing it on the surface of the moon, and sending out rovers from the lander for the exploration of the lunar surface. The European group, which was capable of procuring a rocket and developing a lander, joined hands with the Japanese group headed by Dr. Yoshida, an expert on rover development. However, the European group later withdrew from the project due to technical issues and financial difficulty. Therefore, the Japanese team is now engaged single-handedly in the project. HAKUTO means 'white rabbit' in Japanese. Since ancient times, Japanese people have associated the surface pattern of the moon with a rabbit pounding *mochi* (rice cakes). The name, 'HAKUTO,' derived from that."

The GLXP demands that participating teams complete the very difficult mission. Successful accomplishment of the mission requires not only cutting-edge scientific technologies but also sufficient funds to develop the necessary equipment and execute exploration activities on the surface of the moon. Team HAKUTO needs funds of about \$10 million to \$30 million for its project. Thus, the team is striving to raise such funds by seeking corporate sponsors and also utilizing crowdfunding to appeal for donations from the general public through the Web, while actively publicizing its participation in the GLXP challenge.

Takeshi Hakamada

Founder and CEO of ispace technologies, inc.
Leader of Team HAKUTO

What is the Google Lunar XPRIZE?

An international space development race organized by the XPRIZE Foundation and sponsored by Google. Aimed at opening a new era of unmanned lunar exploration, this competition started in 2007 and is participated by 18 teams as of 2014.

Conditions and requirements of the competition

mission 1

Land the unmanned exploration vehicle developed by a privately funded team safely on the moon by December 31, 2016.

mission 2

The exploration vehicle operates for a distance of 500 meters or more from the landing point.

mission 3

The exploration vehicle sends still image/moving image data in conformity with the specified resolution and other specifications to the earth.

Revolutionary two-wheel vehicle developed for the GLXP

HAKUTO is regarded as one of the most likely teams to win. One of the reasons is Dr. Yoshida's excellent record in ARLISS (A Rocket Launch for International Student Satellites), a competition held every year in the Nevada desert in the United States. Participants launch rockets to altitudes of 4,000 to 5,000 meters, at which rovers are ejected from the rockets and land safely on the ground using parachutes. The rovers must autonomously travel to the specified target point. The winner is determined based on the distance of the rover from the target point. In one of the most difficult missions, which simulates planetary



Driven by their dreams and admiration for space exploration, the members of Team HAKUTO maximize their knowledge and skills in specific fields towards successful lunar exploration.



Dr. Yoshida (left) and Mr. Hakamada conducting a running test with the prototype rover.

exploration, Dr. Yoshida's team has been undefeated in the past several years.

Previous lunar rovers had six wheels, and most rovers were about the same as a compact automobile in size and weight. Increasing in the number of tires gives the rover a high ground-covering ability, while enlarging the vehicle body enables the rover to carry more equipment. However, a large and heavy rover results in increases in the costs of rocket and lander. Therefore, as a strategy, Team HAKUTO is improving the rover performance while placing special focus on downsizing the rover as much as possible.

Dr. Yoshida is particularly skillful at making a rover with two wheels positioned opposite to each other. The rover developed by Dr. Yoshida has a unique shape with two larger tires that are bigger than the vehicle body to achieve excellent mobility despite having only two wheels. The prototype weighs approximately 2 kg when loaded with necessary equipment such as cameras and computers.

Mr. Hakamada places his full confidence in Dr. Yoshida.

"The surface of the moon is covered with extremely fine soil called regolith, so it is slippery. Furthermore, the surface temperature drops to -170°C at night, and the lunar surface is exposed to strong radiation. Dr. Yoshida's ability to develop a rover capable of operating and functioning in the harsh environment on the moon and also to achieve downsizing of the rover in a sense represents the underlying strength of Japan, a nation known for its advanced manufacturing technology."

Tackling the difficult challenge of sending a rover into a vertical hole

Team HAKUTO is examining the use of a dual rover system. The dual rover system is comprised of a two-wheel rover and a four-wheel rover, which are connected by a cable. This enables the two-wheel rover to enter a deep vertical hole for the exploration of the cavity and return to the surface safely, while the other rover waits outside the hole. There is a possibility that vertical holes are connected to a lava tube. If so, vertical holes can be utilized as natural shelters for protection against extreme temperatures and radiation, thus eliminating the need for constructing shelters on the lunar surface in the future. There is great significance in investigating vertical holes on

the surface of the moon.

As indicated by the plan for sending a rover into a vertical hole, HAKUTO aims to not only clear the GLXP requirements but also tackle a more ambitious challenge. However, the project cannot be carried out without sufficient funds. The reason the project budget varies broadly from \$10 million to \$30 million is that Team HAKUTO estimates the total cost to be \$10 million when only the two-wheel rover is used and \$30 million for employing the dual rover system. The team will decide on which system to use in view of the amount of funds procured and other factors.

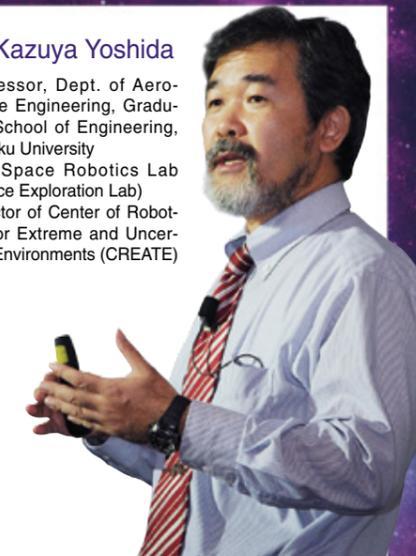
When I asked Mr. Hakamada where the team will get the rocket and lander, I was taken aback by his reply.

"The GLXP regulations do not stipulate that the team must develop the rocket and lander on its own. HAKUTO plans to purchase payload spaces in another team's rocket and lander for the transportation of the rover to the moon. There are three benefits to the team that provides the spaces for carrying the HAKUTO rover to the moon. First, the team receives the transportation fee that can be used to help fund its own project. Secondly, the team will be the world's first 'commercial transporter' of cargo to the moon. The third benefit is only my speculation. In the event the team fails in the GLXP challenge, the team will still have accomplished the task of transporting the HAKUTO rover to the moon, so that would be a guarantee against 'total failure.'"

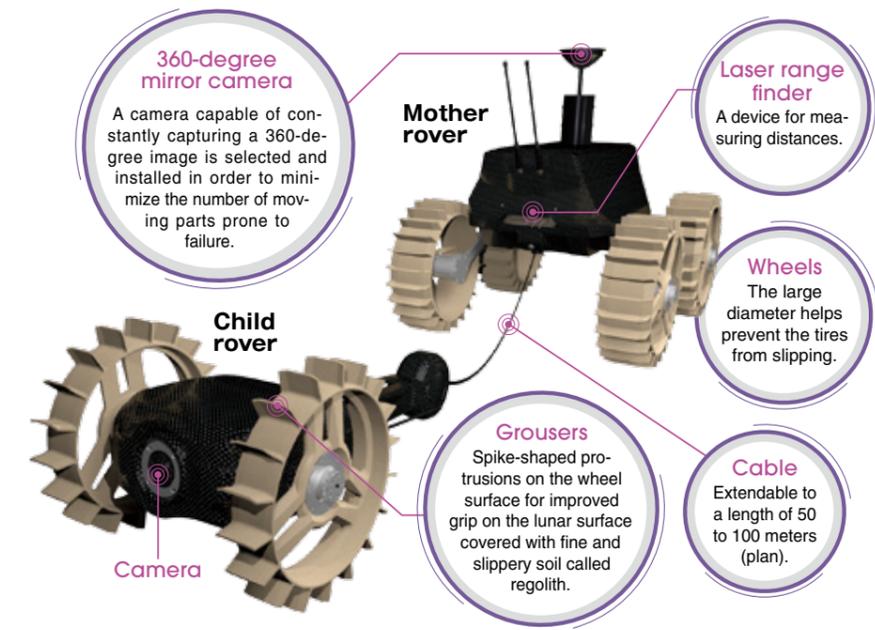
Will the HAKUTO rover be able to roam around on the lunar surface? The world is waiting with bated breath.

Kazuya Yoshida

Professor, Dept. of Aerospace Engineering, Graduate School of Engineering, Tohoku University
The Space Robotics Lab (Space Exploration Lab)
Director of Center of Robotics for Extreme and Uncertain Environments (CREATE)



Dual rover system being developed by Team HAKUTO



Ube Industries, Ltd.



Ube Industries' Ube Chemical Factory manufactures nylon raw material (caprolactam), nylon resins, and fine chemicals. In Japan, explosions and fires have occurred at chemical plants in recent years due to inadequate transfer of technology, labor shortages, and aging of plant facilities; thus, social demand for safer plant operation is growing. At the Ube Chemical Factory, a system for monitoring fluctuations in critical processes was installed for the purpose of strengthening safety measures for chemical plants. With the installation of this system, the Ube Chemical Factory has gained the capability to detect early signs of abnormalities that could lead to accidents and established a system to enable the plant monitoring staff to conduct accident prevention activities in cooperation.

Retirement of veteran operators has resulted in inadequate transfer of skills.

Ube Industries was founded as a coal mining company in 1897. Since then, the company has launched into new businesses one after another based on the principle of "from finite mining to infinite industry," thereby responding to changes in the times. Today, Ube Industries conducts business centered on chemicals for a wide range of applications in the fields of pharmaceuticals, construction materials, machinery, metal forming, energy, and environment.

The Ube Chemical Factory in Ube City, Yamaguchi Prefecture, is Ube Industries' main factory. It manufactures nylon raw material (caprolactam), nylon resins, and fine chemicals. Various chemical plants operate on the vast 660,000 m² premises to produce a total of approximately 120 types of products.

Having set "safe plant operation" as one of the most important issues in early years, the Ube Chemical Factory promotes various activities to strengthen the safety measures on the production floor. It not only provides routine safety education and training, but also focuses on maintaining the facilities from the perspective of safety. In 2012, the Ube Chemical Factory was designated as an Ac-

credited Safety Inspection Business Place*¹ as defined by the Japanese gas safety law (High Pressure Gas Safety Act), and its voluntary safety inspection activities are highly evaluated.

"Since explosions and fires have occurred frequently in chemical plants in Japan in recent years, social demand for safer plant operation is rapidly growing. One of the main reasons for the occurrences of accidents even in plants where extensive safety management is conducted is that veteran employees of the baby boom generation retired and the skills of experienced operators were not adequately transferred to young employees. The Ube Chemical Factory is no exception. We have been faced with the same problem," says Mr. Kenji Hoshino.

Using prediction technology, the fluctuation monitoring system detects early signs of process abnormalities that can lead to accidents.

Under such circumstances, the Ube Chemical Factory initiated a project to upgrade the aged DCS*² in the anone (nylon raw material) manufacturing plant. The existing TDCS3000 DCS was supplied by Azbil Corporation, so Azbil proposed the installation of the ACTMoSTM, an Advanced Critical Trend

monitoring System that automatically monitors and detects signs of abnormalities, together with the upgrade of the DCS.

"Ordinarily, if an abnormality occurs, the DCS generates an alarm and prompts the operator to take response actions. However, after response actions are taken and the problem seems to subside, the situation can suddenly start to worsen. In such cases, there is a possibility that the operator may overlook signs that indicate the worsening of conditions. Experienced operators are able to detect symptoms of recurrences of problems by grasping the process trend based on general equipment operating conditions and small changes in measure-



ACTMoS monitoring screen. The vertical white line indicates current data. The data shown on the left side of the white line are analog values previously obtained at registered points, while those on the right of the line indicate predicted values.



Instrument panel room for monitoring the entire operation of the anone manufacturing plant. The large 65-inch monitor is installed above the APS5000 monitoring/control panel. The monitor displays the APS5000's monitoring screen during normal operation. When an alarm is generated, the display automatically changes to the ACTMoS's monitoring screen. All members present in the room can grasp the condition of the generated abnormality so that they can conduct response activities in cooperation.

ments. The ACTMoS is so revolutionary that it is capable of predicting future trends just like an experienced operator," says Mr. Hoshino.

The Ube Chemical Factory decided to install the ACTMoS in tandem with the replacement of the existing DCS with its successor, Advanced-PSTM APS5000 (hereinafter referred to as "APS5000") plant automation system.

"We have the policy that when a DCS is upgraded, we should not only replace it with a new system, but also pursue the creation of new value. Since improving and expanding the safety measures for plant operation was our urgent issue, the enhanced safety assurance capability brought about by the ACTMoS was unquestionably an added value," says Mr. Shuuhei Tokumitsu.

Collaborative response capability improved by awareness-enhancing monitoring activity

After the installation of the APS5000 and ACTMoS was completed in January 2014, we made adjustments with due consideration given to the "rules of thumb" observed by the workers on the production floor, then began full-fledged operation of the new equipment in April 2014. Presently, the ACTMoS monitors the temperature and oxygen concentration levels at 10 locations in the oxidation reaction process since this process line in the anone manufacturing plant demands close attention. The large 65-inch monitor in the instrument panel room displays monitored data.

"Before the new system was installed, while the operator in charge was responding to an abnormality by operating the monitoring/control screens of the DCS, other operators could not clearly see the monitor screen. When an abnormality occurs, various operations have to be performed to correct the cause of the problem; therefore, it is difficult to re-



General instrument panel room where the operation of two anone manufacturing plants is monitored and controlled.

spond to alarms generated one after another. If only one operator takes response actions, there is a possibility that the operator may be too busy to notice important error messages. The ACTMoS uses a notification method and a sound different from that of the DCS, and generates an alarm from separate devices. In addition, the large monitor allows all operators to share information and pay close attention to problem correction procedures," says Mr. Hirotada Sano.

The ACTMoS enables all members in the instrument panel room to grasp abnormal conditions so that they can cooperate in problem-solving activities, thus strengthening the collaborative response capability. The factory no longer has to rely on one operator to take all necessary response actions. This reduces the emotional toll on each operator in charge and brings a greater sense of safety to the production floor. The easy use of the ACTMoS in normal plant operation is also praised highly.

"We will add more monitoring points as needed in the future. At present, we request Azbil to set required parameters in the ACTMoS, but we would like to perform that ourselves in the future," says Mr. Takashi Katsuki.

Thanks to the newly installed ACTMoS, the Ube Chemical Factory has strengthened its safety measures for production operation and obtained a value called "added safety" toward the complete elimination of serious accidents in production processes.

"There are 78 plants on our factory premises, and each of them is installed with a DCS. We will definitely consider the ACTMoS when those DCSs need to be replaced in the future. Furthermore, we will actively promote the installation of ACTMoS in other manufacturing facilities of our company inside and outside Japan," says Mr. Tokumitsu.

"The ACTMoS's prediction function based on process monitoring ensures safe operation of production processes, and I believe it can also be applied to the control of product quality. We look forward to Azbil's proposals of various ideas and systems for bolstering our production activities," says Mr. Hoshino.

**Ube Industries, Ltd.
Ube Chemical Factory**



Location

1978-10, O-Oza Kogushi, Ube, Yamaguchi, Japan

Establishment

March 1942 (company founded in June 1897)

Business outline

Manufacture and sales of products related to chemical materials, pharmaceuticals, construction materials, machinery, metal forming, energy, and environment



Kenji Hoshino
Deputy Factory Manager



Shuuhei Tokumitsu
Instrument & Electrical Manager
Maintenance Section



Hirotada Sano
Instrument Manager
Maintenance Section



Takashi Katsuki
Maintenance Section

glossary

***1▶ Accredited Safety Inspection Business Place**

An accredited business place of a business operator recognized by the Minister of Economy, Trade and Industry as being capable of conducting self-imposed final inspection and safety inspection specified in Articles 20 and 35 of the High Pressure Gas Safety Act. To be accredited, a business place must establish a safety management system and conduct continuous improvement activities and the applicable systems in use must provide excellent functions/performance.

***2▶ DCS Distributed Control System**

A system that monitors and controls the manufacturing process or production facilities in plants and factories. To achieve even distribution of load, the DCS distributes the functions of each device over a network, resulting in safety and excellent maintainability.

Advanced fluid control technology creates high added value and helps bolster the productivity, reliability, and safety of manufacturing activities

Azbil TA Co., Ltd. became a new member of the azbil Group in November 2012 and began playing an important role in the Group's Advanced Automation (AA) business. Azbil TA mainly manufactures and sells lubrication units, which utilize advanced fluid control technology to regulate the supplies of air (vapor) and oil (liquid) to production lines and machining tools, as well as the dual valves used as a safety device in press machines. The company is continuously improving its products and strengthening its sales to automakers, machining tool manufacturers, and other customers with the aim of enhancing the productivity, reliability, and safety of manufacturing operations. Azbil TA is also focused on overseas markets in East and South Asia. As a member of the azbil Group, Azbil TA will contribute to the enhancement of customers' competitiveness in the markets by providing functions to suit market needs.

Supplying lubrication units that use a small amount of oil and help save energy

Guided by its philosophy of "human-centered automation," the azbil Group promotes the Building Automation (BA) business in the building market, the Advanced Automation (AA) business in the plant and factory markets, and the Life Automation (LA) business in the lifeline and other markets closely connected to everyday life. The azbil Group conducts these core businesses globally in close cooperation with partners inside and outside Japan, and also addresses the reform of business structures and operations in a bid to sharpen its competitive edge in the markets.

Azbil Corporation engaged in capital participation in Taco Co., Ltd. as part of the initiatives for sharpening its competitive edge in the markets. As a manufacturer specializing in pneumatic components, Taco had been engaged in the manufacture and sales of various components and devices incorporating fluid control technology since its establishment in 1955. In November 2012, Taco became a wholly-owned subsidiary of

Azbil Corporation to help strengthen and expand the azbil Group's AA business. In April 2013, the company changed its name from Taco Co., Ltd. to Azbil TA Co., Ltd.

Azbil TA actively conducts its three pillar businesses—lubrication unit business, dual valve business, and high-performance regulator business—inside and outside Japan. In the lubrication unit business, the company manufactures and sells MICRON LUB lubrication units as its main product. A MICRON LUB unit atomizes oil and supplies only the minimum amount of oil required to lubricate the high-speed spindle (the shaft equipped with a cutting tool and that rotates at high speed to process the workpiece) of a machining tool.

MICRON LUB products employ an oil mist system for atomizing lubricating oil inside the lubrication unit. By spraying oil in an amount suitable for specific machining conditions, MICRON LUB not only contributes to the improvement of productivity of customers' manufacturing operations, but also helps save energy and resources by supplying an appropriate amount of oil at all times.

TOTAL LUB is suitable for lubricating a



Masashi Hirano

President and Chief Executive Officer
Azbil TA Co., Ltd.

wider area such as a large-scale production line in an iron and steel plant or a large press machine. Previously, lubricators were installed on individual equipment units in a production line for the supply of oil or lubricating fluid. This hindered the smooth supply of oil to high places, dangerous sections,

Azbil TA's three pillar businesses

1 Lubrication unit business

Atomizes oil and supplies an appropriate amount of oil to lubricate machining tools and large-scale production lines.



2 Dual valve business

Uses pneumatic pressure to start / stop press machines for ensuring safety.



3 High-performance regulator business

Provides regulator products for special applications, such as depressurization control of fluids other than for high-pressure, precision, and pneumatic pressure applications.



and narrow and deeply set locations. Furthermore, oil could contaminate the work environment and pose a risk to the health and safety of employees. TOTAL LUB utilizes atomization technology, Azbil TA's specialty technology for changing a liquid into very fine particles, to supply a far-reaching mist of oil evenly to large areas to be lubricated. One TOTAL LUB unit can supply lubricating oil to several hundred locations in a production line. By centrally controlling the amount of oil supply, TOTAL LUB eliminates the need for working at heights or in dangerous places in order to supply oil, thus ensuring the safety of employees. Azbil TA develops lubrication units with high added value and delivers them to automakers, machining tool manufacturers, and iron and steel plants, as well as manufacturers in various other fields around the world, thus capturing a high market share.

Azbil TA's second-pillar products, dual valves, are double-solenoid valves used for controlling the starting and stopping of press machines, and they comply with the Japanese standards for mechanical power press machine structures. Even if one of the two valves in the dual-valve product fails to operate, the brake can be activated without engaging the air clutch to stop the press operation. This ensures extra safety on the production floor. Azbil TA's dual valves have a high market share in China where the press forming industry is growing. Installation of dual valves is also being promoted in Taiwan and South Korea.

Azbil TA's third-pillar products are high-performance regulators. Azbil TA supplies a variety of regulator products designed for specific applications, such as for de-

pressurization control in a pressure region higher than the standard working pressure range and for special applications other than precision and pneumatic pressure applications.

Azbil TA's dual valves for press machines and high-performance regulators feature rugged construction to withstand harsh production environments and boast high reliability.

Promoting the life cycle business encompassing maintenance

Azbil TA continues to strengthen its core technologies cultivated over many years, such as its spraying/atomization technology, and also modifies its products according to specific market needs, in an effort to contribute to the improvement of customers' productivity and competitiveness.

The company is also strengthening its capability to promote sales of products to automakers and other companies (machining tool manufacturers, tire companies, and iron and steel plants) in the automotive field. For instance, to develop and supply products that respond to changes in automotive industry trends, it is imperative to have full knowledge of the industry and grasp industry-related information quickly, to understand new production technologies and swiftly grasp manufacturers' needs, and to be able to convince customers to consider using our products in the design stages of production lines and machining tools. In addition, it is very important to respond to the needs of customers throughout the product life cycle by proposing product maintenance service after the delivery of products. We

plan to strengthen and expand the life cycle business in the future.

To expand its overseas business, Azbil TA has established in China and South Korea sales structures to sell products directly to customers and through local distributors. Azbil TA will further strengthen its sales capability in East Asia and focus on expanding business in South Asia such as India, as well as in Thailand, Indonesia and Malaysia, where key manufacturing industries are expected to grow and develop in the future.

Strengthening sales capability by leveraging the azbil Group's brand value

In order to strengthen its sales capability, Azbil TA has begun establishing various collaborative structures with azbil Group companies. For example, the company is conducting sales activities toward the automotive industry together with other members involved in the AA business. Furthermore, it is promoting the establishment of cooperative relationships with other group companies with the aim of creating high added value that only the azbil Group and Azbil TA can offer and expanding the business value and solutions it provides. Azbil TA pursues its mainstream business endeavors and also complements other group companies in order to produce synergistic effects and expand its business around the world.

Azbil TA strives to expand and develop its business operations and cooperates with other azbil Group companies as it continues to provide unique, optimum solutions to customers and contribute to the enhancement of customers' competitiveness.

This type of feedback control operates on the basis of sensor measurements in order to keep the temperature, pressure, and other variables inside of manufacturing or processing equipment at the desired levels. PID refers to proportional, integral, and derivative action.

To maintain product quality, manufacturing processes require strict temperature control.

In factories and plants, very precise temperature control is often needed to manufacture products such as semiconductors. If a heater is simply turned on and off (ON-OFF control), the temperature fluctuates significantly, overshooting the setpoint or causing other problems. Reliable control is difficult to achieve. To solve this problem, PID control, which is a kind of feedback control, is used.

A widely applied fundamental method of automatically controlling temperature, flow, pressure, etc.

PID control consists of the three components of proportional, integral, and derivative action.

First, proportional action, which is basic feedback control, changes the output (called the manipulated variable or MV) of a heater, etc., in proportion to the amount of deviation from the setpoint or SP (deviation = $SP - PV$ [the process variable, for example the current process temperature]). This

is done within a preset "proportional band" (the range of allowed temperature or pressure change). Depending on the amount of deviation between the preset temperature and the current temperature in the proportional band, the output is increased or decreased so that the temperature reaches the target. If a wide proportional band is set, control operation is relatively slow. Reaching the target temperature takes more time, but overshoot of the target and temperature fluctuation can be prevented.

Next, in contrast to proportional action, which operates based on a preset proportional band, integral action adjusts the control input according to the surrounding environment. For example, in the case of a heating furnace, once the furnace has heated up, 100% output of the heater may not be necessary. In this case, integral action decreases the output.

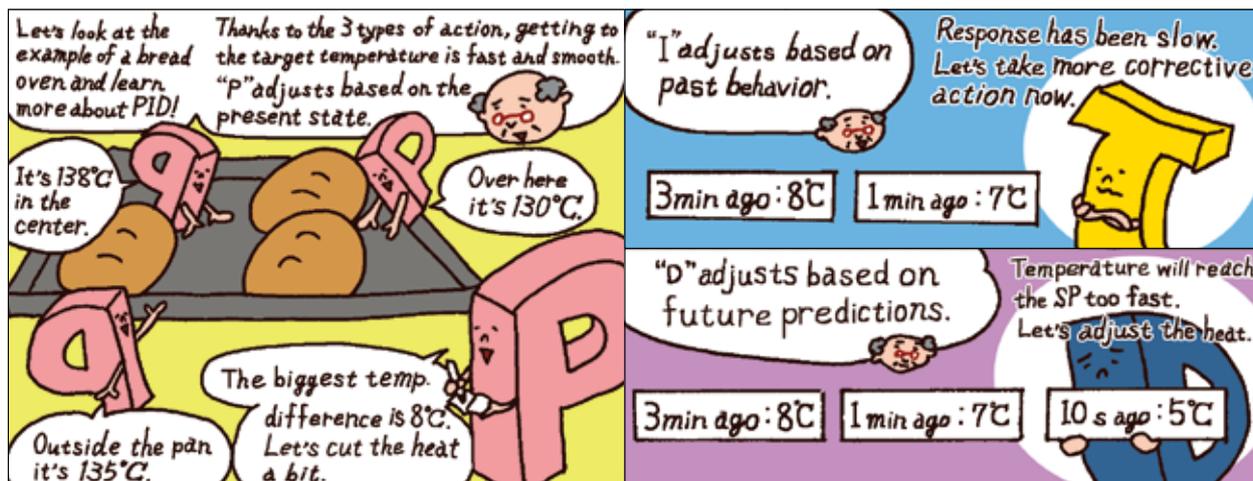
Finally, derivative action changes the amount of control output (MV) by adjusting the proportional band, depending on the latest change in temperature. For example, when the temperature is falling, rapid heating is necessary. On the other hand, when the temperature is rising, derivative action

can reduce the risk of overshooting the temperature target by suppressing the MV.

These three actions together can maintain reliable control, preventing significant temperature overshoot and undershoot and repeated ON-OFF action. As a result, the optimal temperature can be reached rapidly.

PID control is widely applied not only for temperature, but also for flow rate and pressure, etc. It is an indispensable technology for all kinds of automatic control.

The R15 and R35/36 Single Loop Controllers made by the azbil Group provide high-accuracy control of temperature, humidity, pressure, flow rate, and other variables, achieving the target value rapidly and smoothly.



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Yamatake Corporation changed its name to Azbil Corporation on April 1, 2012.

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