FANUC Open House was held for the first time under the new management scheme based on business divisions on April 15 and 16 in the Nature Hall at FANUC headquarters. At the event, a diverse line-up of products we have developed to meet the needs of as many customers as possible were exhibited in a plain-to-see manner.

The FANUC Open House was a perfect opportunity for visitors to see the whole line-up of our new products and features and feel the energy of the ‘newborn FANUC.’

In the FA section, the products were exhibited in groups divided by theme - Machining Performance, Usability, and Minimizing Down Time. Visitors liked this exhibition style, saying: “The way the products are exhibited makes it very easy to understand their features.” Many of them also welcomed the “seamless functions” between the 0i Series CNCs and 30i Series CNCs.

Many visitors to the ROBOMACHINE section expressed surprise at seeing the ROBODRILL machines with enhanced machining performance that demonstrated ultrahigh-speed machining of iron. The ROBOSHOT series, capable of precision and stable molding, now available in a full line-up, and the ROBOCUT series, featuring “CCR”, a lightweight, compact rotary table, were also well received.

Exhibited in the ROBOT section was the green Collaborative Robot designed to be operated safely in the presence of human operators without the need for safety fences. The robot was the target of high expectations and received abundant comments from visiting customers. Many of the other exhibits displaying the Learning Robot, Large-size Robot, Genkotsu-Robot, new welding power unit, bin picking gripper, etc. were crowded with visitors as well.

Also, we positioned Factories and Services sections in the center of the event site - our first attempt in the history of the FANUC Open House. The sections highlighted our highly automated factories, which are characteristic of FANUC, and our service network consisting of over 200 operating bases around the world. This brought home to our customers that they can feel at ease using our products anywhere across the globe.
Major exhibited products

**FA**

**CNC**

New features common to all series from the 0i Series to 30i Series
- Significant reduction in parts machining time
- Cycle time reduction for lathe turning
- Significant reduction in rigid tapping time
- New proposal for loader control by NC command
- High-precision machining through simple settings
- Advanced I/O network
- Significantly enhanced machining simulation
- CNC supporting the usability of a PC

New features of the 30i Series
- Enhanced usability of 5-axis machining

**Power Motion**

- Multi-axis, high-speed, fast-response motion control
- Use of a servo motor for the hydraulic mechanism

**SERVO**

- Wide line-up supporting high speed, high precision, and high efficiency
- High reliability and high cost performance
- Improved surface quality and precision in shape machining
- Simple machine protection at power failure
- "Visualization" of the machine

**Laser**

- Versatile CO2 laser supporting various applications including the cutting of thick plates

**ROBOT**

- Automotive parts machining line
- Safety fence-free robot
- Large-size wax pattern coating
- High-speed spot welding with the Learning Robot
- Automotive parts arc welding system
- Various applications of the Genkotsu-Robot
- Bottle arrangement system
- Intelligent deburring system
- Various applications of the Bin Picking Robot
- Intelligent robot system assistant tool

**ROBOMACHINE**

**ROBODRILL**
- Process integrated machining for automotive parts
- High-quality machining for IT parts
- High-precision simultaneous 5-axis machining for medical parts
- High-efficiency machining for aluminum and steel parts

**ROBOSHOT**
- Precision and stable molding by an electric injection molding machine

**ROBOCUT**
- High-precision wire-cut electric discharge machine

**ROBONANO**
- Ultra precision mold machining by a nano machine
Introduction of New Products (FA)

New product FANUC Series 0i-MODEL F to promote seamless functions with the 30i Series

We announced the FANUC Series 0i-MODEL F developed by substantially enhancing the specifications of its predecessor, the Series 0i-MODEL D. This new model is based on the same concept as the high-performance high-end models of the CNC 30i Series. Besides having compatible functions with the 30i Series, the CNC is the first model in its class to feature a 15-inch display. What is more, it comes with a rich set of functions, including the minimization of down time that has been confined to the 30i Series so far. With the announcement of the FANUC Series 0i-MODEL F, we intend to promote ‘seamless functions’ with the high-end 30i Series. You can choose from a variety of CNCs, from general-purpose machines to combined machine tools, and even five-axis machines, as suits your needs while at the same time ensuring compatibility in many aspects including usability and maintainability.

Major new functions:
- Same level of usability as the high-end 30i Series
- New loader control function to meet automation needs
- Enhanced cycle time reduction function
- Large (15-inch) display
- Latest minimum down time technology
- Latest I/O network supporting I/O Link

New product FANUC SERVO AMPLIFIER β iSVSP-B Series with high reliability and excellent cost performance

We have developed the β iSVSP-B, an all-in-one servo amplifier with three servo axes and one spindle, which can be used in combination with the Series 0i-MODEL F. This new model is based on the same concept as the α i Servo Amplifier, the high-end model. Improvements in machining performance, minimizing down time, and usability make it possible to build a cost-effective system.

Features
- With not only the servo axes but the spindle axis supporting an optical interface, the amplifier supports FSSB high-speed rigid tapping, which is effective in reducing the machining time.
- The amplifier has a built-in cooling fan motor and enables front-side maintenance as well.
- The fault diagnosis function allows you to readily locate the faulty part in the event of an alarm.
- The smart spindle acceleration/deceleration function increases the number of additional axes that can be connected.
- The Safe Torque Off (STO) function eliminates the need for an external magnetic contactor.
- The amplifier can be used seamlessly with the Series 30i, 31i, 32i, 35i-MODEL B.

FANUC Laser C Series i-Model C power failure restart function that minimizes down time by shortening the restart time during a power failure

We have developed a power failure restart function that shortens the restart time according to the LASER conditions during a power failure. The function can be used with FANUC Laser C1000i, C2000i, C4000i, and C6000i-C with FANUC Series 30i or 31i-LB. When a power failure is detected, the function immediately saves the operating status of the laser oscillator so that it can restart the machine as appropriate for the laser oscillator’s status when power is restored. This significantly reduces the time to restart operation.

When this function is used with the automatic program restart function and machining restart function of the laser’s CNC, laser cutting can be restarted properly even if a power failure occurs during cutting.

Features
- The restart time is shortened significantly based on the operating status that the laser oscillator is in when a power failure occurs. Actual example: The restart time is shortened from 5.4 minutes to 0.8 minutes. (The amount of time shortened may differ depending on the model and the situation of the power failure.)
- The machine can also be restarted with control power on. Maintaining control power with the power backup module or a commercially available UPS enables the laser cutting system to restart more quickly.
- Restart of cutting by using this function with the automatic program restart function and machining restart function of FANUC Series 30i or 31i-LB

Even if a power failure occurs during laser cutting, the process can be restarted from the point at which it had been interrupted, thus minimizing workpiece waste.
Introduction of New Products (ROBOT)

Multipurpose intelligent robot FANUC Robot R-2000iC

We have begun to ship the R-2000iC Series, which we have developed by renewing our flagship robot product, the R-2000iB Series, for the first time in eight years. While stepping up the performance of its mechanical part with cutting-edge technology, the R-2000iC Series supports a broader range of applications and places emphasis on maintaining high reliability. While the R-2000iC is compatible with the previous model, the R-2000iB, in terms of the robot installation dimensions, tool mounting interface, etc., thorough efforts to optimize its mechanical elements and servo motor have made the new model lighter and slimmer than its predecessor by more than 10%. Also, strengthening the drive system elements has resulted in an average increase of 16% in axis speed and an increase of 5% in allowable wrist moment. The model is effective in boosting productivity by reducing the work cycle time and expanding the scope of tools and applications supported. A wide variety of options, including an arm for spot welding solutions, are available to suit customers’ diverse applications. What is more, using the R-2000iC in combination with more advanced vision and force sensors can automate sophisticated handling and assembly work, which conventionally requires human intervention, thereby making the robot more versatile.

FANUC 3D area sensor and bin picking gripper

We have newly developed a 3D area sensor tool for detecting the gripping position and a bin picking gripper, broadening the range of bin picking robot applications.

The 3D area sensor is a vision sensor suitable for 3-dimensional measurement of workpieces dispersed inside a container. The maximum measurement range is 1340×1000×1000 mm. Unlike conventional vision sensors, the 3D area sensor does not require the shapes of the workpiece to be picked to be set and registered in advance, which makes it easy to introduce the sensor. Also, the sensor allows the robot to pick workpieces of many different types or of irregular shapes with ease. The sensor unit has a closed structure and can be used in a dusty or misty factory environment. As its light source, the sensor uses an LED that has a long service life.

The bin picking gripper has been developed exclusively for use with a bin picking robot. It can freely pick workpieces of various shapes and materials that conventional suction hands, magnetic hands, and simple chuck hands are not capable of gripping. While simply made of a cylinder, a steel plate, and a pad, the bin picking gripper has a grip force comparable to that of a very expensive servo hand. This bin picking gripper substantially widens the range of bin picking robot applications.
Introduction of New Products (ROBOMACHINE)

■ New functions  FANUC ROBODRILL α-DiA Series
The latest functions of the high-reliability, high-performance ROBODRILL α-DiA Series support a wider range of ROBODRILL applications and stable machining.
- The latest CNC and servo functions, such as IS-C and HRV+ control, are adopted to provide higher precision for axis feed. The adoption of these functions allows the ROBODRILL to be used not only for IT and medical parts but also in other machining areas that require high quality cutting surfaces, such as mold machining, thus broadening the range of ROBODRILL applications.
- For the AI thermal displacement compensation function, compensation accuracy has been improved and a new automatic adjustment feature that uses a touch probe for on-machine measurement has been added. These improvements in the function enable highly reliable, highly accurate thermal displacement compensation and contribute to stable ROBODRILL machining.

■ New product  FANUC ROBOSHOT α-SiA Series
A full line-up of the high-reliability, high-performance ROBOSHOT α-SiA Series is now complete for various types of precision and stable molding.
- The α-S250iA designed for ultra high-speed injection is the latest model that supports a maximum injection speed of 1200 mm/s best suited for the molding of thin wall light guide panels. The newly developed twin drive injection system enables high-speed, highly-accelerated injection.
- The α-S50iA designed for high-precision clamping supports even greater die opening and closing precision through the use of a more rigid clamping unit. The enhanced ejector compression function enables precision and stable molding for such parts as small, thin lenses.

■ New functions  FANUC ROBOCUT α-CiA Series
The latest functions of the high-reliability, high-performance ROBOCUT α-CiA Series enable stable machining for ROBOCUT and broaden the range of ROBOCUT applications.
- The thermal displacement compensation function helps to increase mold machining precision in machining sites subject to changes in the room temperature. The core joint function that holds the slug of the workpiece supports unattended operation for mold machining.
- FANUC ROBOCUT CCR – the rotary table designed exclusively for ROBOCUT, is a lightweight, compact rotary table that is useful for machining a vast variety of parts including PCD tools and medical parts.

■ New function  FANUC ROBONANO α-OiB
The latest function of the high-reliability, high-performance ROBONANO α-OiB makes the ultra precision machine ROBONANO even easier to use.
An on-machine measurement guidance function has been developed that guides the operator in an interactive manner in conducting measurements and re-machining with the on-machine measurement equipment NANOCHECKER of ROBONANO. The function enables even novice operators to conduct complex measurements and re-machining with ease, thus enhancing the usability of ROBONANO.
On April 18, we invited the professors who provide us with advice and support in our daily research work, to see the products that were exhibited at the FANUC Open House. A round-table talk was held later in the day with the professors.

Attendees

Toshiro Higuchi
Professor at Tokyo University
Yoichi Hori
Professor at Tokyo University
Shigetaka Takagi
Professor at the Tokyo Institute of Technology
Atsushi Matsubara
Professor at Kyoto University
Tamio Arai
Professor at the Shibaura Institute of Technology
Masatoshi Ishikawa
Professor at Tokyo University
Shigeki Sugano
Professor at Waseda University
Ichiro Sakuma
Professor at Tokyo University
Takayuki Okatani
Professor at Tohoku University
Toshiyuki Obikawa
Professor at Tokyo University
Hidetoshi Yokoi
Professor at Tokyo University
Masanori Kunieda
Professor at Tokyo University
Yoshimi Takeuchi
Professor at Chubu University
Tsunemoto Kuriyagawa
Professor at Tohoku University
Eiji Shamoto
Professor at Nagoya University
(in the order of speaking)

FANUC CORPORATION

Yoshiharu Inaba
President and CEO
Kenji Yamaguchi
General Manager, Production Division
Hiroyuki Uchida
General Manager, ROBOMACHINE Business Division
Kiyonori Inaba
General Manager, ROBOT Business Division
Shunsuke Matsubara
General Manager, Research & Development Administration Division
Hiroshi Noda
General Manager, CNC Hardware Laboratory
Hidehiro Miyajima
General Manager, CNC Software Laboratory
Mitsuyuki Taniguchi
General Manager, Collaborative Robot Development Division
Yuji Nishikawa
General Manager, SERVO Laboratory
Dong Zheng
General Manager, LASER Laboratory
Satoshi Takatsugi
General Manager, ROBODRILL Laboratory
Yuji Takayama
General Manager, ROBOT ONE Laboratory
Hong Rongshao
General Manager, ROBONANO Research Department
Masako Sudo
Chief Engineer
Masahiro Morioka
General Manager, Collaborative Robot Development Division
**2014 Round-table Talk**

**President Inaba:** Today, we invited you to see our various new products and functions that were exhibited at FANUC Open House. And now, it is our pleasure to join you for a round-table talk. We would appreciate your frank opinion and feedback on what you saw today and suggestions you could give to us regarding the future of our company. We have the general managers of all our laboratories, general manager of the Research & Development Administration Division, and chief engineer with us today. I’m sure that your insight will be helpful for all of us in our future R&D efforts. Now, let’s begin.

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**FA**

**Professor Aoyama:** It has been a while since I attended the FANUC Open House. I found every exhibit easy to understand and very interesting. Actually, I’m interested in a lot of things. One is the general issue of ‘energy.’ I’ve heard that FANUC has element technologies, machining technologies, and three business divisions. I think it would be great to develop the big picture of putting all these resources together to create a FANUC world, or a total FANUC system in which we can figure out what kind of approach should be adopted to keep the energy consumption of the entire factory to a certain level and how performance can be improved by keeping the energy consumption to a certain level. You have these element technologies and explain what each of them is used for. That is very easy to comprehend. I’m interested in what you will get if you put them all together.

**President Inaba:** Like a total solution?

**Professor Aoyama:** Yes, that’s right. Also, universities have a big role to play in the development of human resources. We educate students to be competent engineers and send them out to society, and they devote their energies to manufacturing at FANUC and other places. I don’t mean to brag, but we established an institute in April called the Design and Manufacturing Center, where we are focusing on stepping up our capabilities in the field of manufacturing. In order to make our students more interested in manufacturing, I think we should show them the state-of-the-art hardware with first-hand experience. The simulator I saw today is not dangerous and easy to use for educational purposes. Even if we have only one actual machine, multiple students can practice individually when we have multiple simulators. That’s one of the things we intend to consider. I would like to see FANUC continue to organize exhibitions that university students will find interesting and stay committed to developing young generations of human resources who will support manufacturing in the future.

**President Inaba:** Thank you, Professor Aoyama. We also would like to see more university students visit FANUC, to help prevent young people from keeping away from manufacturing. I think it’s best for students to see the actual simulator for themselves. So, please bring your students with you to our exhibitions.

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**Professor Hori:** First, I would like to congratulate you on the establishment of the new management scheme consisting of business divisions. With my retirement coming in 2020, when the Olympic Games will be held in Tokyo, I am now in the process of winding things up for the second phase of my life. Since Associate Professor Fujimoto joined me, our laboratory has grown to be a large establishment with 40 to 50 students. On average, 10 new students join us every year, with as many graduates leaving the lab. I thought we had done enough in power...
electronics and servo control, so we switched to a different theme and began to focus on automobiles. Recently, we have directed our efforts towards wireless power transfer, which is said to have the potential to change the world in many different ways. So I was surprised to know that Mr. Fujimoto is working on basic stuff such as high-speed, high-precision positioning and power electronics as well. I was originally a researcher on control theories and have participated in joint projects with a number of companies that produced significant results. Come to think of it, the industry trend seems to swing between software and hardware in a cycle of 20 years or so. When I was a university student, microcomputers had just appeared and there was a persuasive idea in society that the age of motor hardware would end and be replaced by that of control. Power electronics, which was quite a new field at the time, became a core technology very quickly. And now, we are in the age of motor hardware again. Maybe, we'll see servo control and power electronics go back to the mainstream next. We have worked together with General Manager Uchida, General Manager Matsubara, and Vice General Manager Iwashita. Today, I saw the results of what we have done together. We are doing a lot of things at the university, and the people of FANUC are doing a lot of things, too, in a place closer to the manufacturing site. So what should we do? I learned a great deal about that today. When we consider what to do, we have to look slightly further into the future. Many things have changed from what they were in the past. For example, the resolution of an encoder has improved substantially to several millions or even tens of millions. What's more, putting the encoder on the load side may be acceptable in some cases. That's an unprecedented idea. Seeing all those small improvements you have made in performance, I really respect your work. But I think there is still much more that can be done regarding fundamentals. Of course, I understand that you are working on these things.

President Inaba: Thank you. Professor Hori: The products and functions that I saw today are all orthodox yet innovative, which I find very unique to FANUC. I look forward to working with you in future projects. President Inaba: I agree with you that there is still much more that we need to do. We would appreciate your continued guidance.

President Inaba: The next speaker is Professor Takagi. Professor Takagi: All the high-speed, high-precision products and functions that are exhibited are not just interesting, but I also find them impressive and very surprising. Among the exhibits is the prototype of a collaborative robot, and I have made some contribution to its development. The robot currently on display is capable of moving an object as heavy as 3 kg. Achieving a contact detection voltage of 0.6 mV at 2.5-volt voltage is extremely difficult, and I think this is an outstanding technology at the moment. There is a plan afoot to increase the load capacity to 35 kg, which would require a contact detection voltage of 0.04 mV. This is an unimaginable level of precision that goes far beyond my commonsense knowledge. In terms of the bit count of an analog-to-digital converter, it is equivalent to 17 bits. Normally, 10 bits is the limit. Of course, 17-bit and even 24-bit converters are on the market. But I think your efforts to attain such high levels of precision are remarkable. My area of expertise is sensors and analog circuits, and I hope I can give you some more help on these things.

President Inaba: Thank you, Professor Takagi. I had no idea that the technology used for that prototype was so difficult to implement. So I asked my people quite casually to increase the load capacity to 35 kg, thinking that it would be readily possible. As a matter of fact, however, the robot will not be usable in the actual assembly line unless it has a load capacity as high as 35 kg. I think it's going to be a huge challenge to accomplish this. We count on your support.

President Inaba: The discussion on FA will be concluded by Professor Matsubara. Professor Matsubara: I specialize in machine tools. Today, two things impressed me. One is precision correction. This is very difficult in five-axis machining. What's difficult is that the precision of movement is hard to estimate. A slight displacement of the rotary axis results in an enormous error. That's the biggest problem. Mr. Ibaraki, an associate professor of my university, works on spatial error measurement, and I think that error measurement should be studied in parallel with error correction. I would like to ask the people of FANUC to keep enhancing some of the functions that I saw today, and it would be my pleasure to work with you in the process. The other thing that impressed me is this. The primary purpose of production machinery is to achieve automation and stability. But, on the other hand, I think one important aspect of machine tools is that people are trained through machining. The current generation of skilled operators have acquired their skills from using general-purpose machines. I want to see operators acquire high levels of skill through five-axis machining. Today, I saw a function that allows an operator to perform simultaneous five-axis machining by manually turning a rotary table. This function is fantastic. I want it now. It is a very simple function, but I think it will make significant progress in five-axis machining technology.

President Inaba: Thank you, Professor Matsubara. In terms of five-axis machining, European manufacturers have outperformed us in some respects, but we are now making efforts to take the initiative in this field. We would appreciate your insightful advice.

President Inaba: Now, let's move on to the topic of robots. Professor Arai, are you ready? Professor Arai: Today, I saw all the boards for the first time in quite a while and realized that they were all very much advanced. I was impressed at the same time that FANUC is not only pursuing advanced technologies but remains deeply committed to the 'unglamorous' technologies of the manufacturing site. For example, the wire-cut machine designed to prevent the slug
from dropping struck me as marvelous. What attracted my attention in my field of expertise is, above all, the bin picking gripper. I started to work with Mr. Morioka and other members two years ago, and seeing the gripper shown at last year’s robot exhibition made me very happy. I was pleased to see it again today. I know that developing a gripper at this point of time does not seem to be a big deal to most of you. It’s true that the research on grippers ended in the 1980s, and there are almost no dedicated researchers now. The gripper technology, however, is still very crucial in the manufacturing site. It is particularly difficult to pick parts of many different shapes. This has been an obstacle in introducing a bin picking system. FANUC came up with a gripper capable of picking heavy parts of various shapes through a simple mechanism. But analysis has not progressed very much, so I would like to ask you to advance the analysis work in order to broaden the scope of potential applications. Another thing that impressed me was the green collaborative robot. Mr. Morioka and I continued research on the safety of human-robot collaboration for five years. My concern during this period was how the ISO industrial safety standards would change. When I asked about this, I was told that the ISO standards on industrial safety have been finalized and that we are able to adapt to those standards. From now on, as human-robot collaboration, especially one without the need for safety fences, is achieved, the robot market is expected to grow substantially. I would like you to keep working hard on this. Servo technology is essential for human-robot collaboration, but equally important are the problems arising from the unstable factor of human operators being involved. This field of research requires a considerable amount of experience. We have Professor Sugano and several other professors here who have been working on humanoid. I suggest that you base your research on the experiences of these distinguished experts. Let me end my talk by adding one more thing. Since last year, I have been in charge of overseeing the Technology Research Association for the decommissioning of the Fukushima Daiichi Nuclear Power Plant. What we need is a small robot that is capable of handling an object weighing several hundred kilograms. But that seems impossible. So I would like you to create a robot that has few protrusions on its surface, like those used on food processing lines, and that is capable of decontamination as well as handling an object that is between 100 to 500 kilograms in weight. If possible, a robot tiny enough to put into a small pipe would be great. I understand that, from the viewpoint of mechanical engineering, such a robot is almost impossible to create. But I would appreciate it if you would give it a thought someday.

**President Inaba:** Thank you, Professor Arai. You have given General Manager Morioka a lot of advice on human-robot collaboration, and we intend to reflect your philosophy in the green collaborative robot as much as possible. The request that you mentioned last seems to be a pretty big hurdle to overcome, but we will see what we can do.

**President Inaba:** Next, let’s hear from Professor Ishikawa.

**Professor Ishikawa:** The event site had a collection of diverse robots, and I had a lot of fun checking out each of the exhibits. Especially, the fact that all these various robots use vision sensors makes today’s world seem completely different from what it was ten years ago. Using a vision sensor in combination with a range finder is the best way, so I suggest that you stick to this current approach. There is only one thing I would like to point out. The speed is a little slow. We have already developed a high-speed vision system and want the camera to operate at a speed of 1/1000 seconds. At the same time, the projector probabil-
year’s FANUC Open House and was impressed with the safe robots, sensitivity, and, in some way, hardware (or machine design). Students nowadays tend to try to control everything by using a computer. But, by designing hardware elaborately, we can do quite complex things and bring costs down without the help of software. I have a robot in my lab that is designed to crack an egg. This capability is implemented by having the robot’s fingers resemble those of a human being. The gripper, which Professor Araki mentioned earlier, is capable of picking parts through a simple mechanism without the need for complex control. This is very different from what I had in mind about FANUC. The same is true for safe robots. Safety is ensured by attaching something like a sponge instead of relying on control such as compliance or damping factor. Remarkable levels of human-robot collaboration can be achieved simply by enhancing hardware. I would like you to pursue this approach. I think that, by doing so, it will be possible for human workers and robots to work close together in a factory holding things in their respective hands. In this sense, my image of FANUC has changed greatly today. President Inaba: Thank you, Professor Sugano. We have succeeded in creating the prototype just recently after painstaking efforts. Your continued support would be appreciated.

Professor Sakuma: Our areas of research are medical equipment and medical engineering. Although they are different from those of FANUC, I come here quite often. Today, I attended the FANUC Open House for the first time in two years and enjoyed seeing the exhibits very much. The ultimate goal for factory operation is full automation. But I think that, in the transition period, human workers will remain working with robots. In this sense, it seems to me that collaborative robots are an answer to this expected situation. The word “healthcare” is very often associated with “nursing care”. But, when we look carefully, there are very few hospitals that are run economically. Most hospitals seem to be overstuffed. On the other hand, however, doctors struggle to move large machines around during surgery. Under these circumstances, some other manufactures provide robots that can collaborate with human beings. And there is a growing need for these robots to support high positioning precision for radiation therapy, for example. In actual medical practice, equipment is remotely operated in the human body to a precision of millimeters. Seeing the exhibits today, I felt that some of your technologies might find applications in this area, not necessarily soon but perhaps in the future. I think that, in terms of safety, they are related in some ways. And I look forward to working with you on this.

Professor Okatani: I specialize in vision sensors. Currently, the focus of our team is not on machine vision sensors but on a bit more advanced AI vision sensors. Today, I was presented a variety of vision systems. As was said earlier, various robots using vision sensors have completely changed the world from what it was ten years ago. But the reality is that the most advanced technology in the research area is not necessarily used in the manufacturing site. That’s not very surprising. I think that, in the case of vision sensors, it is common that the latest technology cannot be used in the real world of manufacturing without making adjustments. Considering the extent to which a vision sensor is used in combination with a robot, I have to say that we still have a long way to go. Demand is probably very high, but we have not yet reached a technological level where we can meet the demand. To put it another way, robots currently cannot do what human workers can do with ease. The ultimate goal of robot-based automation is to enable robots to do everything that humans can do. If so, I think that more attention will be directed from now on to research and development of AI. Recently, significant advancements have been made in research of AI. The situation is completely different from what it was 10 or 20 years ago, with the possibility of automatic driving of cars now coming into view. In this sense, we should pay attention to the news that several robot manufacturers have been bought recently by Google, an IT company engaged in the research and development of automatic driving and other AI capabilities. It is considered that IT will come to influence real-world robots in many ways in the next 10 or 20 years. Given this situation, I think it will be necessary from a long-term perspective to adopt some AI technologies in the future. I don’t think that day will come soon, but it will certainly come.

Professor Obikawa: Today, I saw the new ROBODRILL machine and was very much impressed with it. Before talking about it, however, I would like to spare a few moments to tell you about the conversation that I had this January with a director of a production technology laboratory in the U.K. He explained with enthusiasm why manufacturing is important and why production technology is necessary. The first thing he mentioned was employment. Keeping many people employed helps promote social security. Social security costs are high in the U.K., and he said that taxes could be lowered by reducing social security costs. This man did not say anything about making profits by manufacturing products. His talk was mainly focused on how to make many people happy. Until then, I had seen
manufacturing technology as a means that businesses use to make profits, bringing about a trade surplus and making Japan rich. The conversation with this man made me realize that such a paradigm is no longer appropriate for a mature society in which we live today. In order for just small exclusive groups of people to become happy, it may be good that the financial and other related sectors stay powerful. It was brought home to me, however, that manufacturing technology is necessary to make a majority of the general public happy. From this point of view, I would like to express my profound respect to FANUC for continuing manufacturing in Japan. In the past, I regarded the ROBODRILL as a machine for cutting light metals. But, you now have high-torque models with high-pressure coolant systems, which make the ROBODRILL competitive against other high-precision or high-horsepower machine tools and capable of dealing with a wider range of materials from light metals to steel and titanium. I am deeply impressed with that. I also find it very innovative that you have these models equipped with a high-pressure coolant system to allow them to grind and drill even hard materials quite efficiently. Your high-pressure coolant system currently supports 7 MPa. But I think that increasing the pressure to around 10 MPa will give an additional boost in the performance of the ROBODRILL. Finally, I suppose that a slight change in structure will make the ROBODRILL an even better machine. I also expect that, if it is bigger in size, the ROBODRILL can be used in other applications such as airplanes. The FANUC Open House featured many interesting exhibits other than the ROBODRILL, and I had a very good time today.

President Inaba: Thank you, Professor Obikawa. The ROBODRILL was originally born from the idea of adding an NC to a drilling machine. The beauty of it is that it’s inexpensive, compact, and versatile. We were able to supply this product in large quantities. So we arranged that we could mass-produce it for cutting applications as well, in addition to the conventional machines mass-produced for molding applications. I think that, by doing so, we offered added value to society. We count on your advice as we seek to evolve this product further.

Professor Obikawa: These days, the major trend is more oriented towards the shift from cutting to molding. So I consider the ROBODRILL an impressive product in the sense that it has reversed this trend.

President Inaba: The next speaker is Professor Yokoi.

Professor Yokoi: I have been working as an expert on injection molding for a long time, and my relationship with FANUC has lasted for a quarter of a century now. Having seen all the machines developed since the first prototype of AUTOSHOT, I have to admit that I honestly wonder what is left to be done after molding machines have advanced this much. FANUC is not the only company facing this problem. It is difficult for most manufacturers to figure out how to differentiate their products when there are molding machines that are this advanced. The specification table of every product shows similar numbers. For example, however, molding completely changes with the start-up speed of the screw alone (multi-step speed acceleration at start-up). Nonetheless, there is no international standard whatsoever regarding how results of start-up speed evaluation should be indicated. I think that some kind of standard ought to be established as to the basic characteristics that determine the performance of a molding machine. Such a standard will make it clear what is good about FANUC’s machine and other manufacturers’ machines as well as how good they are. Universities are partly to blame for this low level of “visualization,” and I think we should work to solve the situation. Today, I saw a variety of exhibits and learned a lot. I may have gotten a little too fanatical looking at all those products and functions. Now, I would like to talk about the twin drive. You developed a molding machine called SUPERSHOT (ROBOSHOT LINEAR) before, which was a linear motor-driven molding machine supporting a screw injection speed of 2000 mm/s. We still use that machine, but its insufficient power has been a big problem for us. The new twin drive model supports an injection speed of 1200 mm/s, close to that of the previous model, and is powerful at the same time. It seems to be usable in a very broad range of fields. Frankly, I think it’s an awesome molding machine. The capacitor caught my attention too. It looked a little dangerous to me. Does it play the same role as the accumulator of a hydraulic ultra high-speed molding machine?

President Inaba: That’s right.

Professor Yokoi: If asked about what an electric-powered accumulator is for, I’d say that it suppresses fluctuations. So I think it’s a pretty good idea to use an accumulator as a standard feature. The ROBOSHOT has many unused controller ports, which I find wasteful. Making effective use of these ports will enable the ROBOSHOT not only to measure and control the molding process itself and other processes, but also to exert intelligent control over many more things including “visualization.” That might change the ROBOSHOT from a mere injection molding machine to a bona fide robot. I guess that’s the technology for making the most of the controller ports. But, in order to do that, it will be necessary to do a little more research on the process itself at the same time and find out what to do and where to do it to create a good product. That’s the way of doing element technology research. In the field of screw design, a very serious problem has arisen recently regarding breakage control for carbon fiber and long glass fiber. What really needs to be done is to enable advanced screw design. Other difficult problems include the quantification of machine durability and reliability. You’ll never know them unless you actually use the machine. FANUC’s machines in general may be a little excessive in performance in my view. Your philosophy of not making any compromise on anything seems to be reflected in every machine. What’s important for society is how such excessive performance is quantified. The machines provide the reliability of long failure-free operation, but it’s still a challenge to figure out how to indicate such performance objectively. Today, I was able to see the ongoing evolution of machines for myself from the maniac’s point of view. Thank you very much.

President Inaba: Thank you, Professor Yokoi. You have given us a great deal of guidance through our visualization project for a long time. We intend to reflect the results of the project in our research. The new twin drive mechanism is a challenge for us, too. As you said, we have all the capacitors lined up across the frame.

Professor Yokoi: The sight of those capacitors looked overwhelming when I first saw them.

President Inaba: There is a possibility that there may be further advancements in mechanical energy modules as well. We count on your continued support.
President Inaba: Now, let’s hear from Professor Kunieda.

Professor Kunieda: I specialize in electric discharge machining. FANUC’s field of expertise is numerical control, and little research has been done on the phenomenon of electric discharge itself here, as at other companies. I am very pleased to hear that you will direct more effort towards the research on the phenomenon of electric discharge from now on. There are a lot of things you cannot understand unless you figure out the underlying phenomenon. I don’t think you will be able to find a breakthrough without doing that. For example, all of your competitors have rolled out electric discharge machines that use oil machining fluid, while FANUC still deals with only ones that use water machining fluid. Water machining fluid is useful for fast machining, but it is said that there is a wide gap and that its surface roughness is not good. There are various theories as to why oil machining fluid is so different from water machining fluid in nature, but probably no one knows for sure. At least I don’t. I want to figure it out. And I would like you to do research on this as well. That would help you decide whether you can get by with only electric discharge machines that use water machining fluid or need to launch ones that use oil machining fluid. I will provide whatever support I can in your current and future research.

President Inaba: Thank you, Professor Kunieda. When we take into consideration the risk of fire in fully automated factories, we see water machining fluid as the better choice. Of course, as you pointed out, water machining fluid has a number of demerits such as poor surface roughness and rust. We would like to do research from the basics. Your advice would be appreciated.

President Inaba: Professor Takeuchi, it’s your turn now.

Professor Takeuchi: Since moving to a private university, I have been tied up with my class. So I couldn’t attend the last FANUC Open House and the one before that. But seeing the exhibits at JIMTOF and other events, I have realized that FANUC has been steadily advancing in terms of technology. What surprised me at today’s Open House is that ease of use seems to be stressed overall. My recent research work involves creating a CAM system for advanced machining technology as what we call a sophisticated machining application for five-axis combined machines. I have been working with FANUC since 20 years ago in the research on the ROBONANO. When I moved to Chubu University two years ago, I handed over the research on the ROBONANO to my subordinates. There is no ultra high-precision machine that can readily be used by anyone. Once you have set up the machine, the machining process takes only several hours. But setting up such a machine is difficult and may take all day. With the ROBONANO, therefore, ease of use is crucial and, in order to ensure its effective use, it is essential to solve the problem of the difficult set-up process. I’ve heard that the ROBONANO Research Department is now under the direction of Senior Executive Vice President Uchida. In order to market the ROBONANO abroad, I think it is necessary to create a machine that is easy to maintain and requires no after-sales care. Its current precision is good enough in my view. So you should review the design while keeping the precision at the current level. A machine that is easy to maintain with a structure that allows for easy assembly and disassembly will probably eliminate the need for after-sales care, which I think will reduce the total cost as well. I have been able to present a lot of research results using the ROBONANO. In order to put the ROBONANO into practical use and promote it worldwide beyond the realm of research, it is important to review the design and provide ROBONANO software that can be used on a CAM system. If you direct your efforts towards this, your share of the global market will surely increase. I hope to see that happen.

President Inaba: Thank you, Professor Takeuchi. At this FANUC Open House, we have a number of things on display concerning FA under the major theme of “machines that do not fail, alert before failure, and are easy to repair if failed.” As for the ROBONANO, by contrast, we have been able to do very little in terms of these things. As you pointed out, we should explore ways to make the ROBONANO easier to use. Currently, the ROBONANO is mainly used in laboratories and research institutes because its maintenance requires a high level of skill. We intend to commoditize the ROBONANO by developing specifications that will make this machine easier to use in mass-production factories. I totally agree with your suggestion, Professor Takeuchi. We look forward to your continued support.

President Inaba: Next, Professor Kuriyagawa will speak to us.

Professor Kuriyagawa: I was transferred to the School of Engineering in March, where I specialize in nano precision machining. We use the ROBONANO machine a lot. President Inaba said a moment ago something to the effect that the ROBONANO is not robust, but our machine did not break down at all when the Great East Japan Earthquake hit the Tohoku region (laughter). I am more concerned about my students bumping the machine to something out of their carelessness. My work is now suspended because we are in the middle of relocating to a new laboratory, but I intend to continue my research with the ROBONANO. I attended the FANUC Open House today for the first time in a long while and discovered several new functions. The things I found very interesting are the ROBODRILL models for medical applications and the head-up display, which I think will create increasing demand in relation to the ROBONANO from now on. My transfer to the School of Engineering is one of the reasons why these things interest me. Before that, my research had been focused on shape precision, that is, ordinary simple manufacturing where high levels of surface roughness and shape precision are pursued. Now I am shifting from shape creation-oriented manufacturing to a functional interface where we create functionality.

For lens molding, for example, we can create a variety of functions. The keyword is “complexity.” Complexity is very crucial for shape, as well as for the machining process. In this sense, FANUC’s ROBONANO is very effective as a base machine.
What’s important is to understand what it is used for, that is, to grasp and use customer needs. A machine does not sell well just because its performance is great. What is it used for? I think it’s necessary to figure that out and strive to meet the identified need. Considering all this, I want to stress that medical applications, which I mentioned earlier, and other stuff like automobiles are going to be important.

President Inaba: Thank you. Professors Kuriyagawa, Takeuchi, and Aoyama have given us a great deal of support in our work on the ROBONANO. Until now, the top priority theme of our development has been to achieve the highest level of performance for handling parts with five axes with a 1 nanometer step. I am afraid that this has made the ROBONANO difficult for unfamiliar operators to use, resulting in a problem in terms of operability. I may have made an overstatement when I mentioned my intention to commoditize the ROBONANO. But I really want to make this machine much easier to use. Your advice would be appreciated.

President Inaba: Now, the discussion will be concluded by Professor Shamoto.

Professor Shamoto: My field of expertise is cutting work. I attended the FANUC Open House for the first time today, and it was a lot of fun to see a variety of elementary technologies used in a really broad range of fields. As an expert on the machining process, I saw the exhibits with the primary focus on the control technology for machine tools. I understand that ensuring a machine tool operates quickly and accurately is of course difficult in many ways and that various advancements have been made in technology development. What has kept me thinking for a long time is that the machining process changes every time. Users will not be satisfied unless they get a good result in the end. From this point of view, there have been improvements in various technologies. I am impressed to see today that you not only control the motor accurately but go further correcting the friction effect, providing damping for parts prone to vibration, and so on. I think that the next step is probably going to be the machining process, which is our field of research. I hope that you will advance your research to the point where you consider the machining process.

President Inaba: Thank you, Professor Shamoto. As you suggested, nothing makes sense without cutting and grinding. So I agree that the machining process is going to matter. We intend to focus more of our research and development efforts not just on control but on that aspect as well. We count on your advice and support.

## Exhibition Information

### INTERMOLD 2014 (Die Machining Technology Exhibition)

**Period:** April 16 (Wed) - 19 (Sat)
**Venue:** INTEX Osaka

- Exhibits:
  - Highly efficient machining of iron parts using the high-output ROBODRILL
  - Automated copper electrode machining system using the ROBOT and ROBODRILL
  - Rapid cycle molding of food containers using the ROBOSHOT α-S100iA
  - High-precision mold machining of automobile metal gaskets using the ROBOCUT α-C600iA
  - Ultra precision lens mold machining and measurement using the ROBONANO
  - Exhibition of a system comprising of a CNC, I/O unit, servo amplifier, and servo motor

### Japan International Welding Show 2014

**Period:** April 23 (Wed) - 26 (Sat)
**Venue:** Tokyo Big Sight

- Exhibits:
  - Arc welding system for automobile seat parts using FANUC’s new welding power supply
  - Arc welding system for building materials using FANUC’s new welding power supply
  - Arc welding system for aluminum automotive parts using Lincoln’s welding power supply
  - High-speed spot welding system using a learning robot
  - Exhibition of the features of the ROBOGUIDE robot software
  - Panel exhibition of FA and ROBOMACHINE
FANUC has developed a system that automates the masking work necessary to paint casting parts. We have this system installed in our paint factory to support the masking work for various robot casting parts. Compared to the conventional manual masking work, the system offers about twice the production efficiency and a significant reduction in the manufacturing cost.

Instead of the traditional method whereby human workers attach masking tape to castings manually, the system uses two intelligent robots that stick cut masking materials to those portions of casting parts that do not need painting, successfully automating the masking process.

The intelligent robots are equipped with FANUC’s vision sensors, which enable the robots to measure the target casting part in 3D and stick masking materials accurately. We are going to promote this masking automation system to those industries that deal with casting parts, such as the machine tool industry, construction equipment industry, and auto industry.
From February 14 (Fri) through 15 (Sat), Yamanashi Prefecture had an extraordinarily heavy snowfall, which far exceeded the snowfall record in the past 120 years. The area where FANUC’s headquarters is located was hit by a snowfall of more than 180 centimeters. The snow severely affected our lifeline and distribution channels, forcing us to suspend operations for two days. During this two-day suspension, we made all-out efforts to remedy the situation, removing snow day and night and taking other necessary actions. The employees living in the dorms and company-owned houses spent several days plowing the snow around headquarters.
The FANUC Global Conference was held at FANUC’s headquarters over a three-day period from March 5 through 7. This is an important conference where the representative members of the FANUC Group gather from around the world to decide on the group’s future global strategy. More than 300 members, including over 100 members from abroad, attended the conference and decided on future targets through repeated discussions on sales strategy and development policy.

On March 5 and 6, the FA Business Division, ROBOT Business Division, and ROBOMACHINE Business Division separately had discussions on their respective issues. On the final day of the conference on March 7, a plenary session was held at the main hall, where a conference summary was presented. The outcomes of this conference will be used to develop and market better products and services so as to meet the diverse needs of customers.

On the final day, a party hosted by the president was held, bringing all the participants closer together.
Could you tell us how you use FANUC robots at your factory?

President Iwai: We use them to pick and carry parts as well as for palletizing and replacing the electrode bars of electric discharge machines. For example, we use two NC lathes in combination with one LR Mate robot for parts picking as a set. Between two sets, we put one LR Mate robot for palletizing. We have arrays of these systems and keep them in operation around the clock.

General Manager Katayama: These days, the requirements for parts are becoming increasingly demanding. Even a single scratch is not tolerated in some cases. By having the robots palletize forged parts one by one, we can manufacture high-quality parts efficiently.

President Iwai: We create high-value added products that competitors cannot produce. By doing so, we remain the manufacturer of choice for our customers.

How do you like FANUC robots?

President Iwai: Coolant splashes on robots, and our factory operates at full capacity around the clock. We appreciate the FANUC robots for working without a hitch in this tough environment.

General Manager Katayama: It also helps us a lot that the operation speed of the robots keeps improving. There were times in the past when we had to wait for the robots to finish their job after we were done with machining. Another thing that helps us is that FANUC responds quickly to our requests for maintenance service. No matter how durable they are designed to be, there is a possibility that machines may become cranky at times. In order to meet our customers’ production demands, it is important for us to be able to have equipment failures repaired rapidly.

We’ve heard that you have a factory in Thailand as well.

President Iwai: In Thailand, it is still common to see human workers standing along the assembly line in a manufacturing factory. We decided from the beginning that our factory would be an automated one. When we brought the robot system to the factory, the local staff seemed very surprised (laughter).

General Manager Katayama: Labor costs will inevitably go up in the future, and there is also the risk of the drain of human resources. Our intention is to draw a distinction between jobs that can be performed by machines and those that cannot be done without human intervention and automate the processes as much as possible. I think that will make a big difference several years later.

Are you going to keep automating your factories?

President Iwai: When people think about the forging industry, what comes to mind is generally a dirty, greasy factory. I want to change that stereotype. Automating the manufacturing process enables us to create products with a small workforce and make a profit steadily. Having robots perform the demanding parts of the work eases the physical strain on human workers. To make our workplace more worker friendly, we intend to advance factory automation just as we have done so far. So we are very interested in how much control will be enabled by new image sensors and other technologies in the future.

(Interviewed by Kyoko Takatsugi, Manager of the Public Relations and Advertisement Department)
Probably delayed by the heavy snow, spring was very slow to arrive at FANUC's forest this year. Here are some photos of the long-awaited signs of spring.

- **Asian skunk cabbage** (photo taken at the Ashiike Pond on April 2)
  While the flower of this plant reminds us of the arrival of summer according to a school song, we found a group of skunk cabbages in full bloom at the Ashiike Pond near FANUC's headquarters in early April. Although it is a perennial of the Araceae family, the plant is not edible.

- **Butterbur sprout** (photo taken in front of the Takiike Pond on April 2)
  Butterbur sprout is the messenger of spring that appears soon after snow melts away. Its unique scent wafts in the spring breeze, stimulating employees' appetite.

- **Forsythia** (photo taken in front of the Ashiike Pond on April 17)
  The flowers of this plant give a vivid color to a still-wintery landscape of FANUC's forest. At this time of year when forsythia flowers come into full bloom, it is as if the forest is covered in yellow - the color of FANUC.

- **Amur adonis** (photo taken in front of the "Akebono-kan" Hall on April 16)
  This plant, also known as New Year's Day plant, bloomed a little late this year. Although its thick root, which looks like that of burdock, has some health benefits such as cardiac and diuretic effects, you need to be careful about its strong side effects.

- **Magnolia kobus** (photo taken in front of the Ashiike Pond on April 23)
  This plant is widely used as roadside trees. Its dried buds are used as an herbal remedy for symptoms such as headache and nasal congestion.
Collaborative robot
that works safely
with human workers