

YOUR GLOBAL CRAFTSMAN STUDIO



*Machining Difficult-to-Cut Materials
for the Medical Equipment Industry*

Vol. 3 Stories

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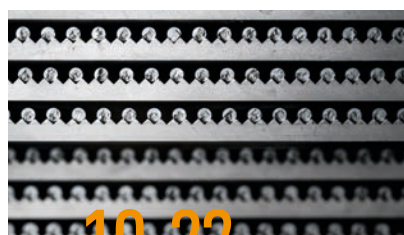
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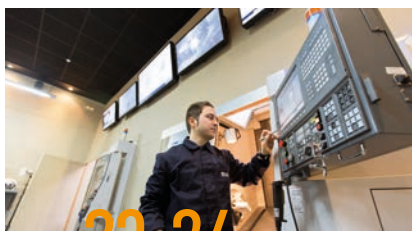
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EDITORIAL



Fumio Tsurumaki
Managing Executive Officer
of Mitsubishi Materials
Corporation
President of Advanced
Materials & Tools Company

Few really understand the relationship between tools and medical care. When I had my first orientation session after joining Mitsubishi Materials Corporation and was assigned to the carbide tools department, the presenter showed us a picture of a fruit knife being used to peel an apple. The presenter told us that the apple in the picture represented material to be cut and the knife represented a cutting tool. In medical care, the material to be cut is the human body, and the tool is a scalpel. In fact, tools in the medical industry are applied to a wide range of purposes, such as the manufacture of medical equipment, the processing of therapeutic implant parts and the production of instruments used during medical procedures.

A few years ago, my mother-in-law had trouble with her hip. When the doctor explained that surgery would involve a small plate fixed in place with titanium screws, I wondered if the parts were made by us or our competitors. I am very proud that the parts we produce play a role in the treatment of illness and injury and the reduction of pain to make patients' lives more comfortable. Of course, I feel sorry for these patients, but I'm very excited about being able to help them through my work as a manufacturer of the tools and parts used in healthcare. The mission of the Global Craftsman Studio is to respond to progress in medical care by continuing to provide the best solutions and services.



Welcome to the exciting world of Mitsubishi Materials Corporation!

Following our featured focus on the air (aircraft industry: Vol. 1) and the ground (automobile industry: Vol.2), we turn our attention to people (medical industry). Aircraft and automobiles have contributed to the increased speed and flexibility of transportation to significantly improve our lives. The medical industry has undergone significant progress. Although the medical industry was previously thought not to present significant opportunities for tool manufacturers, the contribution of our tools to the industry has increased due to continuing progress in medical technology and equipment along with the development and commercialization of new materials for medical use. As industry professionals, we place a priority on providing new solutions to customers. In this feature, we will take a look at some of our approaches to the medical industry.

Behind the progress seen in the above-mentioned areas, a wide range of advances has been seen in innovative technology, product development that applies such innovative technology and technological development that allows mass production with a reliable level of quality. The origin of our tools can be traced back to ancient Egypt where machining got its start. Since then, technology has advanced through the development and improvement of tool forms and materials, machining tools and processing technology. Commercialized some 90 years ago in 1926, cemented carbide has dramatically improved metal cutting processes. It is still being improved and development of new materials intended for use in medical care actively continues. Let's take a look at the history and development of these advances.

Since the last half of 2015, we have had greater opportunities to talk about our approaches to the development of tools during technical exchanges and seminars with our customers. On these occasions we are able to fully explain our development policy and future plans,

but while we provide information on products currently under development, it is information we do not usually share outside the company. We use these occasions to share our most up-to-date technical information on product development as well as our excitement about establishing relations with our customers that allow us to serve them better. We are committed to continuing to improve communication with our customers through the sharing of information. We are always eager to listen to customer comments and requests as an important means of facilitating the development and commercialization of unique products, the world's leading technology, as well as solutions and services for individual customers. We strive to achieve breakthrough solutions and realise them with our customers.

We continue to prioritize the Global Craftsman Studio for our customers. Please look forward to future changes and achievements.

Akira Osada, Doctor of Engineering
General Manager, Research & Development Division



YOUR GLOBAL CRAFTSMAN STUDIO

EYE on the MARKET MEDICAL INDUSTRY

Machining for the Medical Equipment Industry

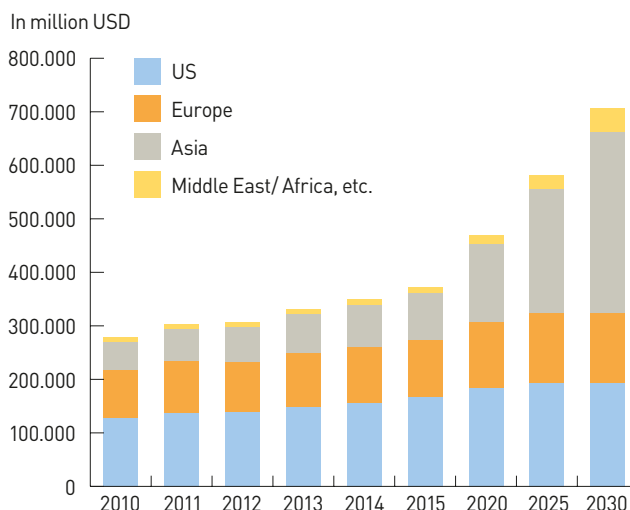
Medical Equipment Industry Markets Have Potential for Expansion

Increasing populations and significant economic growth in emerging countries along with aging populations in advanced countries create potential for an expansion and a stable demand for the global medical equipment industry. The US, Western Europe, and Japan, countries with higher per-capita incomes, well-developed healthcare systems and medical facilities, hold an almost 80% share of the medical equipment market. The high degree of risk management and tremendous amounts of time and money required for the development of medical equipment means the majority of that share is held by major manufacturers in the US and Europe; and is viewed as an area with a high added value. However, cost reduction by major manufacturers pursued through global acquisitions has increased in response to price restrictions in developing countries and efforts by advanced nations to reduce medical expenses. More companies are pursuing new market entry in cooperation with manufacturers, medical facilities and research institutions in the US and Europe, especially in developing

countries in the Asian region, including China, which represents the greatest expansion in demand. Globalization of production bases is also accelerating, acceleration similar to what has happened in the automobile industry. In addition, because medical equipment is

different from pharmaceutical products, it is necessary to develop a structure capable of facilitating collaborative sales, acquisition of medical authentication in individual regions, and improving the skill of medical staff.

Medical Equipment Market Trend Prediction



Source: Mizuho Industrial Survey Vol. 49 by Mizuho Bank
 *Figures in and after 2015 are Mitsubishi Materials predictions

Measurement Equipment

Measurement devices for biological phenomena (CT, MRI, etc.),
Specimen inspection and analysis devices,
Diagnostic systems, etc.



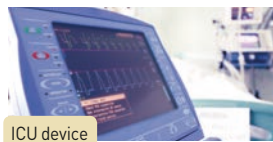
MRI



X-ray



Bed



ICU device

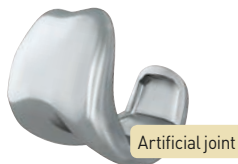


Home-use measurement devices

Analytical devices, measurement tools, in-house equipment, etc.

Therapeutic Equipment

Artificial internal organ apparatus and assistance devices,
Treatment devices, Surgical instruments, etc.



Artificial joint



Spine



Dental tools



Plate



Screw



Exclusive tools

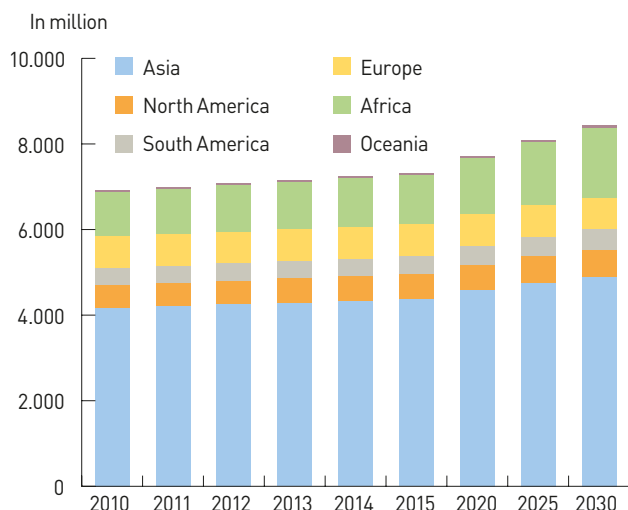
Development of emerging countries and aging in advanced countries are the keys to expanding markets

Recent increases in population and per-capita income in emerging countries have spurred rapid growth in demand for home appliances and automobiles and this signals the potential for increased demand as lifestyle in those nations continues to improve. With the rate of

aging in leading countries around the world by 2030 predicted to be more than twice that of 2015, steady growth in demand for medical equipment and advances in technological innovation are expected. Furthermore, recent developments in medical technology

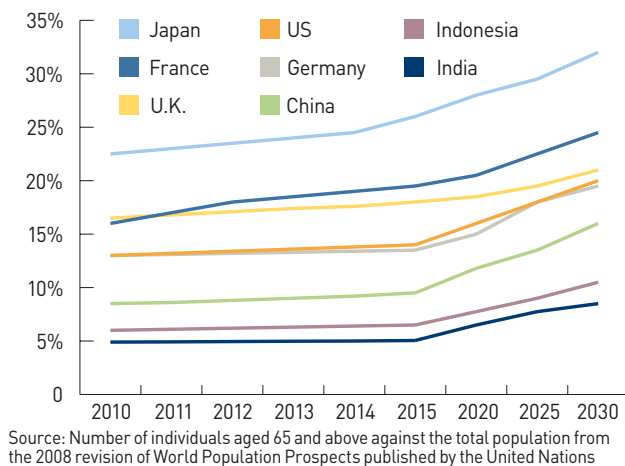
designed to address the aging of society means improved lifestyles for the elderly and the potential for increasing demand in regenerative medicine with a focus on the recovery and maintenance of motor functions.

Prediction of World Population



Source: World Statistic 2015 by the Statistic Bureau,
Ministry of Internal Affairs and Communications

Rate of Aging in Major Countries



Special Feature

Machining for the
Medical Equipment Industry

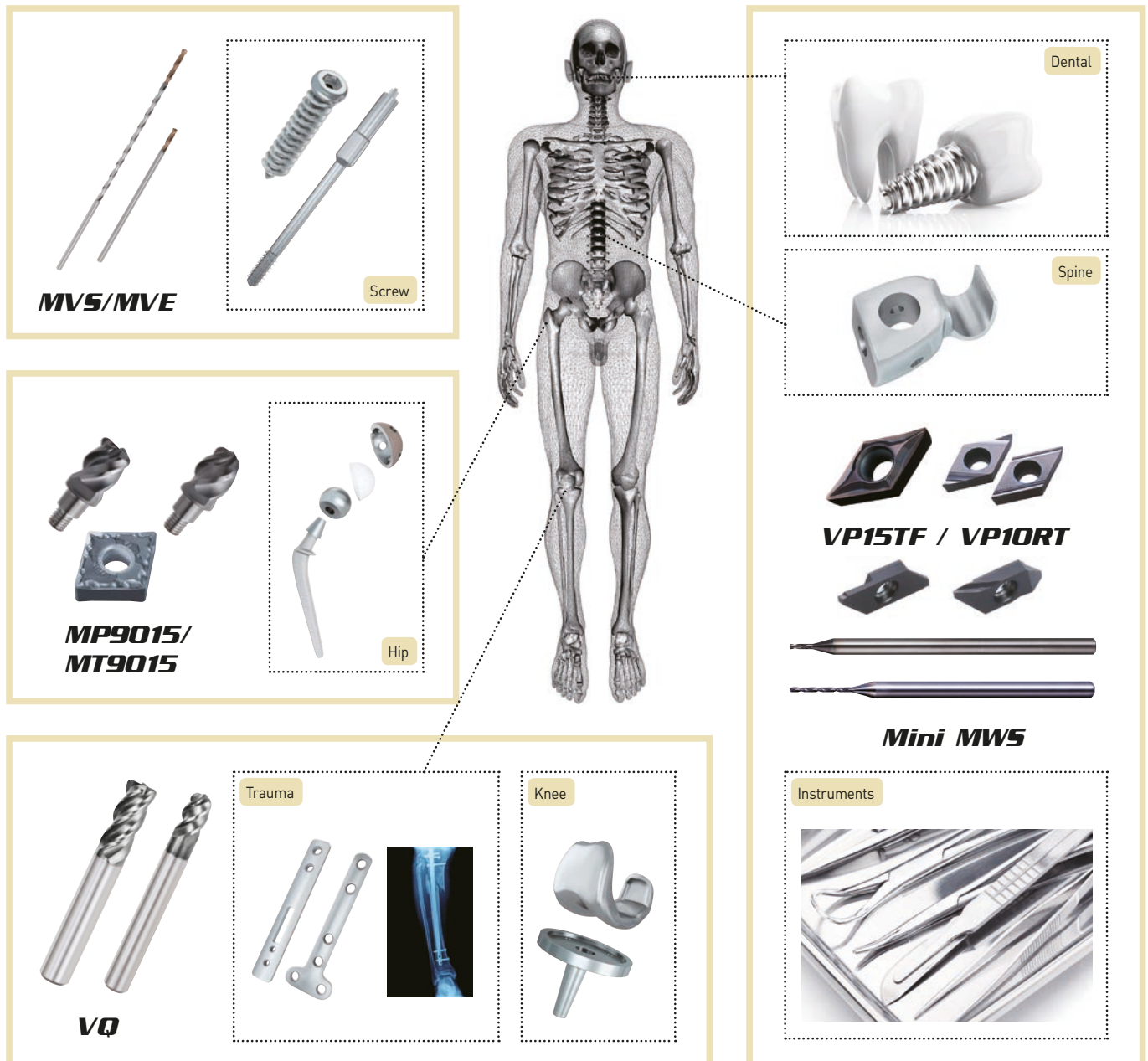
EYE on the MARKET MEDICAL INDUSTRY

Materials for Medical Equipment & Machining

Eighty percent of the demand for machined products in the medical equipment field is for implants (artificial joints, dental-use) as well as trauma and surgical instruments made from difficult-to-machine materials such as titanium alloys, stainless alloys and cobalt-chromium alloys. These products differ from conventional items because they must be made from approved materials with highly specific characteristics.

The materials that go into the production of medical equipment are very similar to those used in the manufacture of aircraft parts, chosen because they are lightweight and have superior corrosion-resistance. The demand for even lighter weight and longer life implant parts has prompted a shift from titanium alloy to cobalt-chromium alloy, a material that also exhibits high mechanical strength. The disadvantage of cobalt-chromium

alloy, however, is its extremely low machinability compared with titanium alloy. Cobalt-chromium alloy reduces the working life of cutting tools to one third that of tools used on titanium alloy. In addition, CFRP and ceramics are used with increasing frequency in medical equipment. This steady development of new materials means an increase in cutting difficulty.



Machining parts for regeneration treatment and major work materials

		Artificial joint	Trauma	Spine	Instruments	Dental
Metal Parts	Ti Alloy	<ul style="list-style-type: none"> • Ti-6Al-4V • Ti-15Mo-5Zr-3Al • Ti-6Al-2Nb-1Ta-0.8Mo 	<ul style="list-style-type: none"> • Ti-6Al-4V 	<ul style="list-style-type: none"> • Ti-6Al-4V 	<ul style="list-style-type: none"> • Ti-6Al-4V 	<ul style="list-style-type: none"> • Ti-6Al-4V • Pure Ti
	SUS Alloy		<ul style="list-style-type: none"> • SUS316L • SUS317L 		<ul style="list-style-type: none"> • SUS630 • SUS420J2 • SUS440C 	
	CCM Alloy	<ul style="list-style-type: none"> • Co-Cr-Mo (Casting, Forging) 		<ul style="list-style-type: none"> • Co-Cr-Mo 		<ul style="list-style-type: none"> • Co-Cr-Mo
Non-metal Parts	Al Alloy				<ul style="list-style-type: none"> • A2000 series • A6000 series 	
	Resin	<ul style="list-style-type: none"> • UHMWPE (Ultrahigh molecular weight, Polyethylene) 	<ul style="list-style-type: none"> • PEEK 	<ul style="list-style-type: none"> • PEEK 	<ul style="list-style-type: none"> • GFRP • CFRP • PEEK 	<ul style="list-style-type: none"> • Resin • PMMA • Special carbon fiber
	Ceramics	<ul style="list-style-type: none"> • Zirconia • Alumina 				<ul style="list-style-type: none"> • Zirconia • Alumina

Mitsubishi Materials applications for tools used in the manufacture of medical equipment materials

The difficult-to-cut and uniquely shaped parts found in medical equipment are a challenge to machine efficiently. Improving machining efficiency and product life requires total applications, from CAD/CAM programs through to the final cutting tools.

Cobalt-Chromium Alloy

Of the materials used in the manufacture of medical equipment, cobalt-chromium alloy is the most difficult to cut. However, compared with titanium alloys, it exhibits better abrasion resistance and contributes to extended product life; and this makes the manufacture of thin products such as sliding surfaces in artificial joints and small items such as spines implants and screws possible. On the other hand, however, it also has high tensile strength and welds easily. This makes it important to select machining tools with high abrasion resistance.

Titanium Alloy

Due to the excellent biocompatibility, titanium alloy Ti-6Al-4V is the most commonly used material for medical equipment parts. Titanium has low thermal conductivity and produces high cutting heat temperature therefore it is essential to have tools with high heat-resistance and forms that ensure low heat generation.

Stainless steels

Stainless steel materials are used often for small parts. Austenitic stainless steels (SUS315L/SUS317L) and precipitation hardening stainless steels (SUS630) have completely different cutting characteristics. Deep-hole drilling into austenitic stainless steels is very difficult because of the need to remove the chips produced.

FOCUS on PERFORMANCE

Mitsubishi Materials Corporation supporting the global medical industry

Part 1 - Laubscher (Switzerland)

Innovating precision parts machining that creates parts used for medical care equipment

Manufacturing millions of precision parts

The first stop on our trip was Laubscher in Switzerland. The company manufactures a wide range of precision parts with diameters measuring less than 42 mm. Laubscher's 280 employees work daily to realise its goal of responding to the full range of manufacturing requirements from customers around the world. While processing ultra-precision parts made from difficult-to-cut materials with diameters measuring as small as 0.3 mm is no easy task, Laubscher manages to handle more than 10,000 different product types annually and

more than 2 million products per day. The majority of products are intended for use in the medical industry. Others are used in the manufacture of watches, automobiles and electric products as well as in construction projects. During this visit, we interviewed Manfred Laubscher, Manager of the Technology and Production Department, and Alain Kiener, Chief of Tool Purchasing, about small-part machining tools and joint projects undertaken with Mitsubishi Materials.

Seeking highest quality and performance

About 400 out of the 500 machine tools used at the plant in Täuffelen, Switzerland are lathes. Processing a range of products with diameters measuring between 0.3 mm and 42 mm requires different machining techniques. To handle these different needs, the wide range of machines employed includes small automatic lathes with both movable and fixed main spindles, automatic lathes with multiple spindles and machining centres. "We manufacture equipment parts used in various areas of medicine; however, none of these are intended for implantation," said Manfred Laubscher. Typically the products made are tools

used during artificial joint replacement, for inserting stents to treat vascular occlusions and inhalers for patients with asthma. The main materials are austenitic stainless steels such as SUS303 (1.4305) and SUS304 (1.4301). "In order to ensure consistent quality, we need to use the highest quality cutting tools," says Alain Kiener. "There are many tool manufacturers, but few manufacturers provide tools for precision parts machining. We ask tool manufacturers to produce high quality tools for our products and Mitsubishi Materials is one of our most reliable business partners."

Manfred Laubscher, Laubscher Technology and Production Department Manager



- PART 1 Laubscher
- PART 2 Medilant
- PART 3 Greatbatch Medical
- PART 4 Nexxt Spine
- PART 5 Willemin-Macodel

Demand in the medical equipment industry has increased globally. Each manufactured part plays an important role in saving lives, this demands consistently high production quality and accuracy. Most medical equipment manufacturer production bases are in Western Europe and North America; and in this feature, we visited five major manufacturers in Switzerland, France and the United States to ask about their relationship with Mitsubishi Materials and its contribution to their business.

Possibilities from partnerships

Laubscher began discussing a change in turning inserts with the goal of achieving better quality and cost performance. They required highly versatile tools that enabled reproducible quality and reduction of machining costs. They asked Mitsubishi Materials to produce prototypes of ISO turning inserts for difficult-to-cut materials. Both companies were enthusiastic about taking this step forward. "First, we experimented with fine boring on lead-free cutting steel for medical equipment parts utilizing ISO DCMT 11 size inserts. We found immediately that the tool was very effective. Next, we used the same tools with another machine in the same

department, which also yielded extremely good results. Not only did the lifetime of the Al-Rich coating MP9015 increase twofold, but all aspects of performance - surface finish, appearance, and machinability - significantly improved compared with existing products. Furthermore, it enabled us to double the feed and speed. Such significant improvement does not happen often," said Alain Kiener. He added, "The test for the insert was satisfactory, so we would like to use it with different machines in other departments." Since the inserts are highly versatile, Alain Kiener wants to use them for more production lines as a standard tool.

Further expectations

Laubscher also focuses on precision small-part machining. Alain Kiener said, "Currently, we use a tool made by Mitsubishi Materials to machine holes measuring between 0.3 mm and 6 mm in diameter. We would like to use smaller sizes between 0.3 mm and 3 mm. Cooperation with Mitsubishi Materials is extremely important for us in this business segment."

Kobi Tobler of Mitsubishi Materials and Daniel Dietsch of Six Sigma Tools* said, "We are supporting the improvement of tools with smaller diameters." In fact, feedback from Laubscher, including requests and measures for improvement are sent directly to Japan from

Switzerland, then Mitsubishi Materials starts the development and manufacture of the requested tools. Alain Kiener said in the end, "As Laubscher increases machining of precision small parts, the importance of using tools made by Mitsubishi Materials also increases. We would like to increase our synergy and find effective solutions through a long-term partnership. Mitsubishi Materials provides a wide variety of products and this allows us to find the best cutting tools for different type of parts in different applications. We are very keen to maintain our partnership."

Website: www.laubscher-praezision.ch

*Six Sigma Tools is an authorised distributor of Mitsubishi Materials tools in Switzerland

(From left to right) Daniel Dietsch, Six Sigma Tools, Alain Kiener, Laubscher Chief of tool purchase, Manfred Laubscher, Laubscher Technology and Production Department Manager, Marco Schneider, Laubscher Production and Technology, Kobi Tobler, Mitsubishi Materials engineer

Part 2 - Medilient (Switzerland)

Manufacturing high quality implants as a technical partner

Manufacturing more than 500,000 implants per year

The next stop on our visit was Medilient, a manufacturer in Le Locle, Switzerland. It has 50 employees and manufactures more than 500,000 implants per year. Here they manufacture titanium screws, plates, nails and cages as well as products made of stainless steel and

cobalt chrome alloys. We interviewed Nicolas Pinguet, an engineer in the cutting department, Nicolas Foulaz, an engineer in the turning department and Laurent Ferreux, Manager of R&D and Industry, about Medilient's relationship with Mitsubishi Materials.

Expanding tool life threefold

Mitsubishi Materials currently provides several tools to the Le Locle plant, but Medilient was looking for a long-life rough machining tool to reduce the need for frequent changes, decrease the work associated with changes and improve machine utilisation rates. They were also looking to reduce per-part tool cost. "We needed to machine Ti-6AL-4V (Grade 5) bone plates from block material." Medilient uses both low- and high-rigidity type machines, and required an end mill that would work efficiently on both types. Mitsubishi Materials proposed the SMART MIRACLE (VQ) end mill.

"The tool life of the Ø12 mm (R2.5 mm) corner radius end mill was expanded to 640 minutes, three times that of the previous tool (200 minutes)," said a smiling Nicolas Pinguet. Kobi Tobler of Mitsubishi Materials and Daniel Dietsch of Six Sigma Tools* added, "SMART MIRACLE coating's Zero μ surface and extremely sharp tool edge reduces chips and cutting forces and the irregular helix improves vibration proofing." Medilient has now adopted the end mill for all of eight of its milling machines to process similar parts.

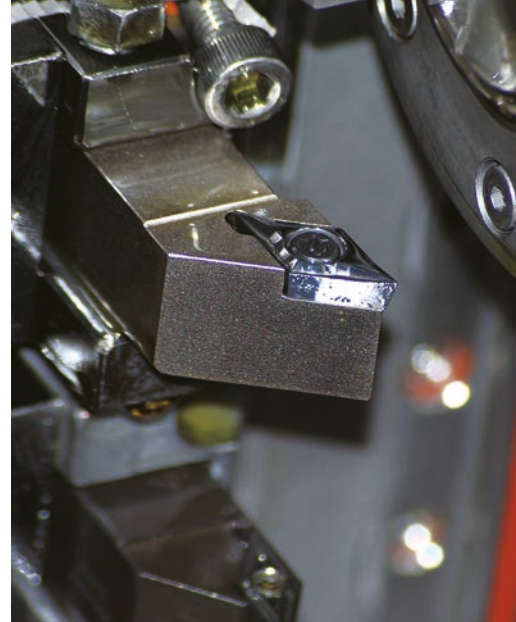
High quality turning machining

Mitsubishi Materials provides a wide range of precision machining tools that meet most turning machining needs. The wide range types provided include those for general turning, profiling, grooving, parting and semi finishing (pre-grinding) for small-size turning machines. Mitsubishi Materials also provides tools for boring in holes from 2.2 mm, drills from 0.1 mm. Furthermore, Mitsubishi Materials provides VQXL (small-diameter 4-flute long neck end mill) developed to machine the head of Torx screws for osteosynthesis. Medilient uses the uncoated turning inserts series (MT9000) and the SMART MIRACLE end mill range. Medilient turns titanium alloy components with diameters of 5 mm to 16 mm and has high regard for tools from

Mitsubishi Materials. Nicolas Foulaz said, "Normally, the chips produced at low-speed when turning titanium alloy screws in small-size automatic lathes damages inserts and impedes our ability to ensure stable product quality. In addition, large changes of machining speed resulted in uneven surface roughness. However, Mitsubishi Materials MP9000 and MT9000 series of inserts for difficult-to-cut materials solved this problem," said Nicolas Foulaz. He continued, "The inserts deliver impressive product life and the finished surface is extremely good compared with the previous insert." Mitsubishi Materials continues to turn customer feedback into improvements and provides new solutions on an ongoing basis.

*Six Sigma Tools is an authorised distributor of Mitsubishi Materials tools in Switzerland

Nicolas Foulaz, Engineer at the Medilient Turning Department



Solving problems together

Mitsubishi Materials is a long-term technical partner helping Mediliant to solve problems and realize improvements in manufacturing. Mediliant is now planning to adopt the SMART MIRACLE end mill for rough machining to increase efficiency because of its excellent performance in discharging chips.

"We expect our manufacturers to handle comprehensive quality management in the areas of raw materials, high-precision machining and quality. We chose Mitsubishi Materials as a capable partner and supplier," said Laurent Ferreux.

Website: www.mediliant.com

(3rd from the left) Arnaud Boujon, Purchase Department Manager, Mediliant
(3rd from the right) Nicolas Pinguet, Machining Department Engineer, Mediliant
(1st from the right) Laurent Ferreux R&D and Industry Department Manager

Part 3 - Greatbatch Medical (France)

Acquiring the best machining tools to improve productivity

Prosthesis specialist

After Switzerland, we headed to France. The third stop on our trip was Greatbatch Medical's Chaumont Plant, which serves as the centre for technical development and research for medical engineering. It is a well-known global company specializing in orthopedic implants and prosthetic apparatus, for which demand has been growing due to the world's aging population. It has 10,000 employees in Europe and the U.S. The Chaumont Plant is located in Champagne, France and serves as an important base for

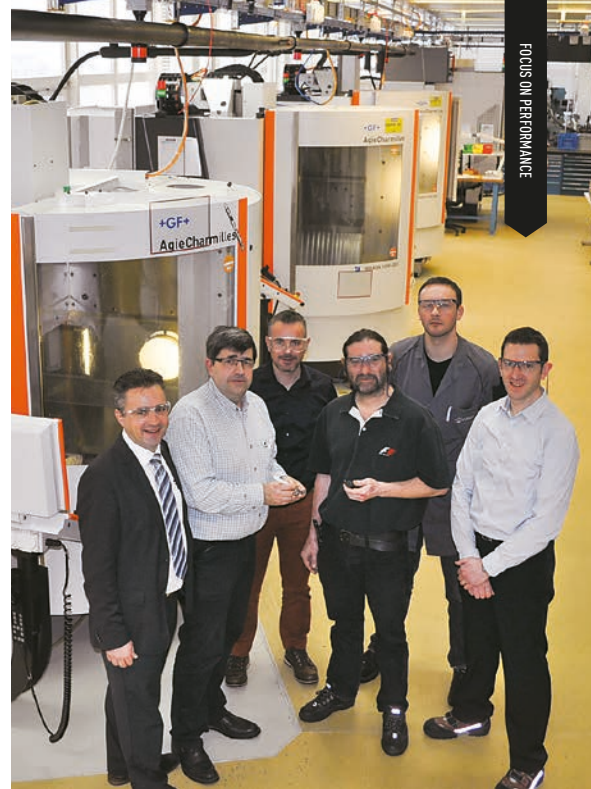
the Integer Group, which produces hip, shoulder and spine implants. It is also a pillar of the company's management strategy. Greatbatch Medical is currently active in employee recruitment, plant and equipment investment and facility enlargement to ensure future profits and achieve the goals set forth in its business expansion plan. We interviewed technical experts Richard Millot and Benjamin Martin about their approaches to new materials and the improvement of on-site productivity.

Machining new materials

Richard Millot, head of machining tools at Greatbatch Medical, said, "Mitsubishi Materials is our special business partner and it is essential for us to have close communication with Bento Valenté, technical coordinator for Mitsubishi Materials France. Both companies have communicated closely from the beginning of our partnership and our approaches to the machining of new materials such as cobalt chrome alloys and polyether ether ketone (PEEK) have strengthened that partnership." Richard Millot added, "These materials are very new for our

plant and their use is being expanded, plus they form the centerpiece of our improvements in machining. Mitsubishi Materials provides essential technical support, proposals for improvement and high-functionality tool development. For example, an important element that has a significant impact on the improvement of machining extremely thin parts (0.1mm thickness) and hard-to-cut materials is the selection of tools." After talking to us, he invited us to tour Greatbatch Medical facilities to see the results of our joint development.

(Left) Richard Millot, Technical Expert in orthopedics at Greatbatch Medical
(Right) Bento Valenté, Technical Coordinator at Mitsubishi Materials, France





Contributing to increased productivity

The PEEK machining site is kept at a temperature of 21 degrees Celsius. The high-precision corner radius end mills (VCPSRB series) they use start from diameter 0.6 mm. These tools reduce the chips during the machining of disks used for cervical implants, enabling high-precision and producing smooth surfaces. "This outstanding achievement was made possible by the excellent cooperation we received from Mitsubishi Materials, and it helped us to increase productivity." They also chose SMART MIRACLE (VQ) end mills, with improved welding resistance and IMPACT MIRACLE (VF) type solid end mills. These end mills are optimized forms that contribute to efficient chip discharge and reduced vibration, two problems that are usually faced when machining difficult-to-cut materials. The coating

exhibits excellent abrasion resistance, yielding extremely favorable results during thin plate machining of cobalt chrome alloy (HRC40-45). "Utilization of variable helix end mills suggested by Bento Valenté resulted in a significant vibration reduction effect that helped us realize high-performance titanium alloy cutting on a machining centre at a feed of more than 1,000 mm/min. This had been impossible with previous tools. Successful evaluations of tool life (cost), safety, and successful machining of the hardened layer cleared the way for adoption of these tools from Mitsubishi," said Benjamin Martin. Furthermore, using the MWS type small-diameter super-long drill with a through coolant hole (Ø1.3 mm) to machine deep holes made it possible to reduce the cycle time (30D depth) by 75%.

Future development

In addition to other projects, Greatbatch Medical is working on new product developments to increase machining efficiency and productivity that will ultimately allow a better response to the needs of patients. "In order to achieve this goal, our technical production team is planning to use the Mitsubishi Materials

Technical Center in Valencia, Spain." These visions are aimed at fully utilizing tool performance to address issues at the production site. Such cooperation enhances the close relationship between Mitsubishi Materials and Greatbatch Medical.

(Front row, left) Eric Crosland, Technical Manager, Mitsubishi Materials in France
(Back row, left) Stéphane Ligneul, Sales Manager, Mitsubishi Materials in France
(Back row, middle) Benjamin Martin, Technical Expert, Greatbatch Medical

Part 4 - Nexxt Spine (USA)

Delivering High-precision Tools to Restore Patients' Quality of Life

Saving patients who struggle with debilitating spinal conditions

Turning next to the United States, we visited Nexxt Spine in Indiana, a medical device company dedicated to improving patient outcomes for patients who struggle with debilitating spinal conditions by manufacturing such medical instruments as bone screws, plates and interbodies. Founded in 2009, Nexxt Spine has proven to be a leader in the industry with its state of the art, on-site manufacturing facility located in Noblesville, IN.

Having established an integrated system that manufactures 100% of all spinal implants and 95% of surgical instruments, it focuses on developing products that increase procedural efficiency through innovation. During our visit to Nexxt Spine, we spoke with Manufacturing Manager, Robert Thomas and Beau Riser, Processing Engineer, who highlighted current spine related applications and breakthrough technology.



Robert D. Thomas II, Director of Manufacturing, Nexxt Spine



(Right) Dan McCloskey, Senior District Manager, Mitsubishi Materials U.S.A.

Products are processed at an overwhelmingly faster speed

Nexxt Spine mainly manufactures bone screws, plates and interbodies. “We make art caddies, which hold all implants,” says Robert Thomas. “We mostly use aluminium and PEEK, but we actually also have a new interbody coming out, called NanoMatrix,” shares Beau Riser. “This innovative new interbody, still in the product development stage, created

a buzz at NAS (North American Spine Society), an industry trade show.” Nexxt Spine is unique in its approach of taking the process from design to development of the implants, products, and through the first runs to the final finished product, and boasts greater efficiency than most manufacturers in the industry. Riser says of Nexxt Spine’s development process,

“We are always working to improve our product development process. We could probably do 1/3 or 1/2 times faster than the industrial standard. Efficiency is key when working directly with doctors who require a special request. First tier technology enables altering of already formed designs, customized to the doctor’s specifications.”

High quality and robustness are essential assets

Robert Thomas says the following about Mitsubishi Materials’ contribution to Nexxt Spine. “Mitsubishi Materials develops world class products with a focus on innovation and precision. That level of quality and superb robustness

are essential assets in ensuring that Nexxt Spine fulfills customer needs. Mitsubishi Materials’ products deliver unrivaled performance that sets a platinum standard above competitors. For example, when we tried to use a

small-diameter coating end mill for coating an emerging exotic material called nitinol (shape-memory alloy), we had some difficulties with an off brand product, but a Mitsubishi 0.014” (0.35mm) diameter end mill held up!”

Cooperation is essential in achieving technological innovation

We asked what breakthrough or innovation has been achieved with Mitsubishi Materials. “I’d have to go back to what I was just saying about exotic materials. We’re getting ready to machine some cobalt chrome, sourcing out the tools. Nitinol is a new material that has only come out in the last 5 years. On the other hand, cobalt chrome has been around for a while, but has been definitely tough to manage on the shop

floor in terms of repeatability. It was then that Dan McCloskey, Mitsubishi Materials Senior District Manager for Central Indiana, recommended a 1.5mm diameter drill 20 times in length for drilling deep holes in the difficult-to-process material. Also, when drilling out some tiny holes in propylux, the tool walked and caused the holes to run together, which scrapped the part, but Dan gave me a new tool for it.” With regard to the two companies’

future relationship, Thomas proclaims, “I like Dan. He comes around more than most. He’s very helpful. So, the future’s wide open. I see a very bright future for Mitsubishi Materials and Nexxt Spine. We are cutting edge, growing companies, so I look forward to our cooperation in the future.” To this, Beau Riser adds, “I definitely recommend Mitsubishi Materials’ tools. They are efficient and reliable, hence cost-effective.”

(Center) Beau Riser, Process Engineer, Nexxt Spine

(Right) Hisashi Daiguji, Engineer, Mitsubishi Materials U.S.A.



Part 5 - Willemin-Macodel (USA)

Achieving Life Sustaining Innovation through Precision

Manufacture of diverse medical parts

On the last leg of our tour, we visited Willemin-Macodel, a Swiss-based machine tool builder company. The company name translated means "machine of Delémont," derived from the historical machine manufacturing town of Delémont. Known for its cutting edge machining innovation, Willemin-Macodel offers extremely high-precision products that are suitable for minute workpieces. With its expansion into the US, we spoke with Jim Davis, Applications Manager located in Noblesville, IN. "As a machine tool builder, we provide optimal machines for all sorts of medical components to the medical industry across the board. For example, we supply a broad range of industries including the dental, spine, maxillofacial, and major bone (which is hips, knees, elbows, toes) industries. We also do applications, process development and testing for

customers, as well as provide turnkey solutions for setting up a process in addition to delivering a machine tool. We recently finished machining a dental solution and Mitsubishi Materials' 0.5mm diameter Smart Miracle end mill was used for that. This latest model machine has already garnered a reputation that spans the country." The company also supports shops across the US by providing R&D (research and development) and training. "If a customer has a part that they don't know how to make, or if they want to make it faster and cheaper, we provide a more robust process with higher capability," states Davis.



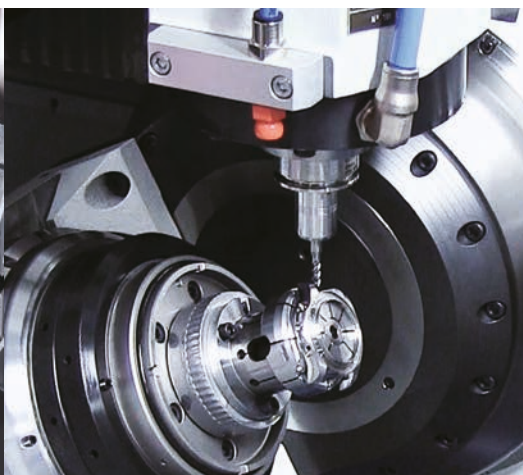
Jim Davis, Willemin-Macodel, Applications Manager

High quality and high precision are insurance

With an almost twenty year background in Swiss turning, Jim Davis is an expert in the field. We asked him how he sees Mitsubishi Materials' tools. "In a word, they make our machines look good!" he says. "The materials enable the crew to cut faster with more RPM, because it can take more heat, withstand more wear, and are more resistant to defects. The benefits are endless. The tools cut cleaner, the run out is better, and the

grind quality is also superior, which provides a better finish. With other end mills, we have to finish twice to gain a good finish, but that is not necessary with Mitsubishi Materials' products. They are the best drills on the planet." He furthermore adds, "In turning with Swiss CNCs, boring bars and thread mills are often used after drilling a hole to finish the hole or process it into a screw hole. If you use a cheap drill, it breaks,

and a domino effect occurs thereafter. The drill breaks, then the boring bar breaks, after that the thread mill breaks, and if the drill gets stuck, everything breaks. This is referred to as an 'unsetup.' A high quality drill is important above all else. In this sense, using a high-quality drill by Mitsubishi Materials is cheap insurance. It feels good to know that it's going to last."



Tools sought on the shop floor

High capability in the manufacturing process always leads to better results for the patient. If an implant has a better finish, the body typically accepts it better. As a result, there is less tumbling, which means shorter surgery time and less burden on the patient. In other words, making parts faster, specifically with more reliability, leads to better success. With respect to Mitsubishi Materials' contribution to the medical industry, Jim Davis says, "The medical industry is different from automotive and aerospace. Aerospace is a single job, where you may use a couple hundred tools to machine one part without using the same tool twice. The parts are also extremely large. Automotive is very fast and tends to require a change of tools every shift. On the other hand, medical utilizes small quantities made using the same facility. You may have 30 of this, 20 of those, and 15 of these, which means a lot of setups and change overs. In medical, effectiveness is often more important than efficiency. A tool that you know is reliable, and that works the first time without having to find a 'sweet spot,' leads to better results, because you can just set up and go, and save a lot of time. If you're making 30 parts, and you save a minute off the cycle, it's only saving 30 minutes on the whole run, but if you spend an extra day on the



set up, that's a big difference. Most shops in the US charge an average rate of \$300 an hour or more, and \$750 an hour for dental. Time is money! Most competitors' tools need to be changed every 100 parts, but Mitsubishi Materials' tools need to be changed only every 500 parts. That is a vast time difference in tool changes alone. Mitsubishi Materials' products are exceptional with miniscule parts that are measured in microns. For perspective, a sheet of paper is about 100 microns thick. Some parts need to be measured down to 10 microns. Such exact measurements are required. Widgets, in particular,

have lots of little holes and features, and every single one of them needs to be measured at all important points. Precision being essential, the grid quality of the tool and the quality of the shank makes a large difference in total quality. High-precision Mitsubishi Materials' products work good, and effectively contribute to improving the quality of the work we do."

Future medical instruments

"The future is seeing a rapid increase in finish machining. There will also be an increase in the 3D printing of acetabular cups, the component in hip implants replacing the natural ball-and-socket,

or the acetabulum. Recently, there are highly expensive cups that are 3D printed in metals, but the problem with 3D printing is that it cannot achieve an accurate finish. The future will involve

creating smooth, shiny and accurate parts using 3D printers, and medical parts will undoubtedly become even smaller and more accurate."



HISTORY OF MITSUBISHI

Vol. **3**

Zinc products responding to the
expectations of the region

Akita Smelter & Refinery

Akita Smelter & Refinery was built in Akita City in 1953 by Mitsubishi Metal Mining Co., Ltd., the predecessor of Mitsubishi Materials Corporation. The company worked to meet the growing demand for zinc needed for post-war restoration. The high quality of its electrolytic zinc production led to the company's rapid growth. However, the increasing cost of electricity and stagnant metal prices in the 1980s - 1990s forced the company to discontinue electrolytic zinc production in 1996. Currently, Mitsubishi Materials Group companies uses the vast site for a wide range of business activities. Japan New Metals Co., Ltd. recycles tungsten; a product used in the manufacture of cemented carbide tools, this means that the site plays an important role for Mitsubishi Materials.

New smelter & refinery brings hope to post-war restoration

Zinc has been alloyed with copper to make brass since before the Common Era. Smelting was developed in the 15th century, but the technique was not common in Japan until the 20th century. Demand began to grow as Japanese manufacturers started producing zinc-coated steel and galvanized anti-corrosive materials. Mitsubishi Mining Co., Ltd. began smelting zinc at Naoshima Smelter & Refinery and Hosokura Mining Plant in 1934. Naoshima stopped production when the war ended, but Hosokura Plant continued producing some 600 tons per month. Along with post-war restoration, the Korean War (1950-1953) spurred demand for zinc and production at the Ikuno and Akenobe plants surged. Yokkaichi Plant Construction

Headquarters was set up to lead the effort to establish a new zinc refinery. Its efforts to purchase land in Yokkaichi were unsuccessful, and the company turned its eyes to Akita. Approximately 35% of the electricity required for zinc refining could be procured at low cost from the Osarizawa Mine's Komatagawa Power Station and the sulfuric acid produced as a byproduct of zinc refining could be used by Tohoku Hiryo Co., Ltd., the predecessor of Mitsubishi Materials Electronic Chemicals Co., Ltd. These advantages also made Akita a desirable site for the new refinery.

Riding on a wave of increasing demand during Japan's period of rapid economic growth, and with the support of Michiyuki Hani, President of Mitsubishi Metal Mining Co., Ltd Akita Smelter & Refinery started operation in November

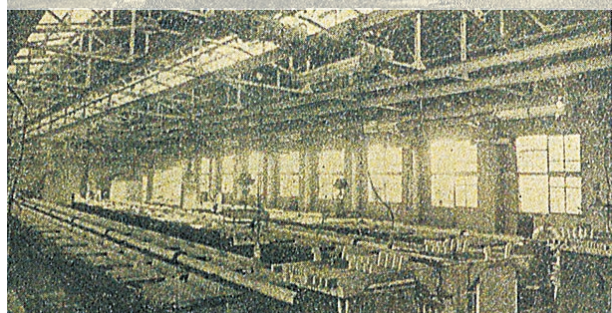
1953 with the most up-to-date fluidized roasters from the United States. The fluidized roasters were tested by Mining Research Institute engineer and former Mitsubishi Materials Chairman Ken Nagano. Applying this technique to cement production at the Higashiya Plant ten years later led to Japan's first successful SP kiln operation. The start of operations was the result of the efforts exerted by the people who moved to Akita from Naoshima, Hosokura, and Osarizawa. They hoped that this new refinery would serve as a symbol of post-war restoration. Starting with the delivery of 560 tons of zinc, production steadily increased. In March 1973, electrolytic zinc production reached 8,000 tons per month, spurring the company to realize its vision to produce 10,000 tons per month as the world's number one zinc refinery.



Groundbreaking ceremony for Akita Smelter & Refinery (1952)



Akita Smelter & Refinery when its operation had just started (Mr. Nakayama, the 1st Director of Akita Smelter & Refinery is shown in the circle.)



Electrolyzing factory with the modern equipment



The arch of Challenge Again Akita slogan (1979)



Akita Smelter & Refinery opening ceremony (1954)



Electrolytic zinc



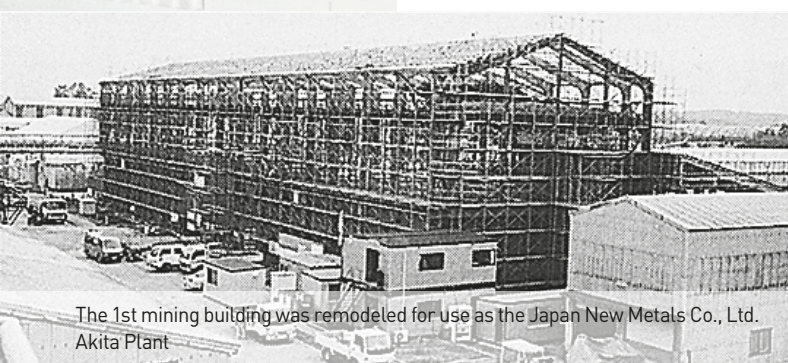
View of the Akita Smelter & Refinery (1970s)



Title on the first plant newsletter



Present-day Japan New Metals Co., Ltd. Akita Plant (2016)



The 1st mining building was remodeled for use as the Japan New Metals Co., Ltd. Akita Plant



Inside the Japan New Metals Co., Ltd. Akita Plant



Employees at the Japan New Metals Co., Ltd. Akita Plant



Tungsten carbide powder



Scraps to be recycled

Moving forward for Akita

The oil crisis in December 1973 caused the Japanese economy to languish at low levels; plus increasing electricity costs on top of stagnating metal prices forced the company into an economic slump. Despite employee efforts to save energy and streamline systems, together with cooperation between the work force and management to enhance business infrastructure, the prolonged slump and the sudden rise in the value of the Japanese yen around 1990 forced the company to discontinue zinc production in 1996. Following the cessation of operations, it demolished the plant and shifted to environmental operations. In response to a request from Akita City, the site was used by Mitsubishi Materials Group companies Mitsubishi Materials Electronic Chemicals Co., Ltd.,

Materials Eco-Refining Co., Ltd., Japan New Metals Co., Ltd., Diapla Co., Ltd., SUMCO Corporation and Japan Super Quartz (JSQ).

Further expansion as a recycling plant for cemented carbide raw materials

One of the plants built at the site was the Japan New Metals Akita Plant. It manufactures tungsten carbide powder, a raw material used in Mitsubishi Materials cutting tools. The Akita Plant is engaged in the complete production of tungsten carbide powder. In order to provide a stable supply of high quality products, regardless of the changing availability of raw materials, scrap materials containing tungsten, such as cemented carbide tools, are collected for recycling. Approximately 99% of the tungsten contained in the

scrap is successfully recycled, it is this contribution that goes significantly towards the ability of the achievement of goals, namely the realization of a recycling-based society. Utilizing know-how accumulated over a long period of time, water discharged from the plant at the existing Akita Smelter & Refinery building is also treated. The recycling facility will be expanded with the hope of further contributions in the vitalization of the region.



Akita Smelter & Refinery



Craftsman Story

Vol. 4

Hiroki Sugaya:
Tool Development
(Project Leader),
Joined in 2010

Kenji Sugawara:
Tool Development,
Joined in 1989

Osamu Ichinoseki:
Tool Development,
Joined in 1975

Tomoyuki Masuno:
Material & Coating
Development,
Joined in 2000

Designed for turning difficult-to-cut materials MP/MT9000 SERIES

Reduction in boundary wear when machining superalloys

Demand for difficult-to-cut materials in the industry has been increasing. It is important to develop the most appropriate standard products that can be applied over a wide range of applications for difficult-to-cut materials. We interviewed four members of the tool development department about their experience in the development of inserts for these materials.





Inserts designed for turning
difficult-to-cut materials

MP/MT9000 Series

Q: Would you give our readers some background information?

Sugaya: The need for difficult-to-cut materials has been growing in a number of industrial sectors, such as aircraft, automotive and medical. In order to respond to this need, we initiated a product development project to focus on machining difficult-to-cut materials. There is a wide variety of products and parts using these materials, however, the tool performance required by each of these differs significantly. We wanted to develop a standard tool that could be applied over a broad range of conditions. We first discussed target priorities with Sales Department staff, who have an intimate knowledge of customer needs and the people in Material Development. Based on these discussions, we selected the aircraft industry as target and started development of inserts, optimised to machine titanium and superalloys.

Q: What challenges did you face during the development process?

Sugaya: The mechanism that causes damage to cutting edges while machining difficult-to-cut materials such as titanium and superalloys is quite different from that which causes damage to general metals such as cast iron and steel. We focused on reducing boundary wear and realising long tool life.

Sugawara: We first thoroughly analyzed existing tools. The damage caused during machining depends on slight differences in condition, making it very difficult to evaluate performance. Therefore, we used as many samples as possible during experimentation and based our analysis of each sample on a larger number of criteria than is customary. During this analysis, we found that rake angles and honing sizes to be the most important elements in reducing damage.

Sugaya: The prototype with a large rake angle and small honing size reduced damage during initial machining; however, tool life when machining super alloys was very difficult to predict accurately due to the difficult nature of the heat resistant super alloy material group. This means that each application's parameters needs fine tuning to obtain optimum results. It was found that a key point in realising long tool life over a wide range of super alloy applications was to reduce boundary wear as much as possible. We experimented to find the best form of cutting edges that would cover many applications.

Ichinoseki: We went through a process of trial and error. Since we discussed rake angle and honing size in detail before development, we were able to devote a significant amount of time and effort on the production of prototypes, form measurements, machining evaluation and analysis when compared with previous development projects. Once we produced a prototype, we continued testing for three days. Although computers helped make the development more efficient, the repetition required to ensure accuracy required both persistence and patience. Our efforts paid off however, by allowing us to find the most suitable rake angle and honing size for each product.

Sugaya: Though trial and error we designed three types of breakers to respond to the needs of the market and launched them as a series in 2013. The LS breaker, which has a 20-degree rake angle and excellent chip control, the MS breaker, which has a 15-degree rake angle and prevents boundary wear, plus the RS breaker, which has a 10-degree rake angle and prevents chipping are now available for different applications. These products have been highly regarded for their sharpness and their ability to cover a wide range of applications beyond superalloy machining has meant they have gained a reputation for versatility. We are pleased that our products have met with such great approval.

Masuno: We significantly increased Al content over the existing (Al, Ti) N to give a high-degree of hardness stabilization, and this led to a significant improvement in abrasion and resistance to chip welding. We succeeded in improving performance more than 25% over existing products and when combined with the optimum cutting edge geometry, the overall performance of inserts for difficult-to-cut materials was further increased.

Q: What was the priority in development?

Ichinoseki: As developers we were particularly careful about design. The pursuit of functionality in chip breaking led to a final design that looked like a delta wing shape. This helped promote the appearance of each product to give the strong impression of high performance as an insert for superalloys.

Sugawara: Many different types of ISO inserts are available for turning applications. While we have maintained the basic performance of the prototype, we also provide a wide range of geometries combining different sizes,

clearances and corner radii. To prevent delay in product launch, we also worked to create a system that would allow us to complete our design process in one-third of the time that was required for existing products.

Sugaya: The greatest advantage of bringing four people of different ages and levels of experience together was that we could combine our individual know-how. Mr. Ichinoseki put the experience he has accumulated over his long career into the design manual we used, I can recommend that young designers read this very important work. I want to continue learning the technology developed by such experienced individuals and pass it on to the next generation.

Ichinoseki: I also think that the cheerfulness and positive outlook of our team leader, who was the youngest member of the team, put everyone at ease and helped a lot in developing these products.

Q: Do you have a message for your customers?

Ichinoseki: We are currently only selling negative type inserts, but we are also planning to release a range of positive inserts. After we introduced the products to the market, we discovered that both they and the technology used in their development could be applied to small parts machining. Therefore we will also continue developing smaller sizes.

Sugaya: Although they are for difficult-to-cut materials, they can be used for stainless and some other types of steel. I hope our customers take advantage of this versatility. We will expand this to a wide selection of geometries to enhance use over a wider range of businesses.

Sugawara: We have also implemented new ideas to ensure efficiency. The know-how we have accumulated in this project will be helpful in future development, and I am very happy that we could deliver these products to our customers so quickly.

Masuno: We will continue developing new materials and technology to provide high-quality and high-performance products.

TECHNOLOGY ARCHIVE

Changing technology of cemented carbide



History of changes in the
continuing advancement of
cemented carbides

When cemented carbide tools began spreading throughout the world in 1989, Mitsubishi Materials launched TF15, a cemented carbide for solid end mills that have been used by a wide range of manufacturers. Since then, Mitsubishi Materials has continued technical innovations to minimize tool size that led to innovations such as extremely small diameter drills. In this feature, we take a look at the history of superfine cemented carbide for solid tools.

TECHNOLOGY ARCHIVE

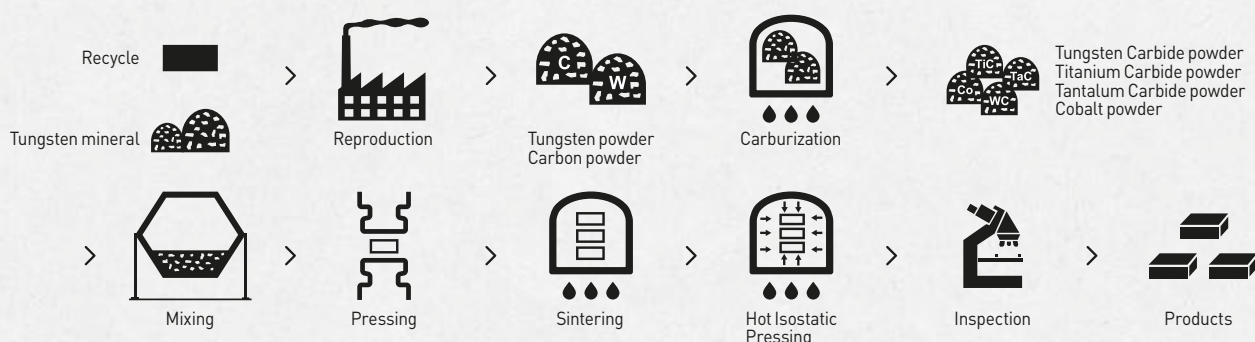
Close up

Cemented carbide is an alloy of tungsten carbide (WC) and cobalt (Co). WC is the main ingredient and the cobalt functions as an adhesive. Generally, as the WC particles become smaller, the material becomes harder. The more cobalt, the lower the level of hardness. Cemented carbide is hard but fragile, therefore it is important to consider the balance of hardness and toughness according to the intended use.

Cemented carbide manufacturing starts with the recycling of tungsten ore. This is followed by carbonization, pressing and sintering. Mitsubishi Materials provides products with consistently stable capabilities through an integrated process that covers material design,

manufacturing and production management. Furthermore, the company can reflect the intention of material design back to the raw materials, which expands flexibility of development and makes it possible to create new products that become market leaders.

Carbide Material Manufacturing Processes



Part

1

1989 ~

Launch of TF15, an all-round player with outstanding toughness

In the early 1980s, solid end mills were made primarily of high-speed steel materials. This period was still at the beginning of cemented carbide end mill development and the share was only 5% of the 700,000 end mills being produced domestically per month. At that time Mitsubishi Materials' first superfine cemented carbide UF20/UF30 series was being used. The series was selected because of its strength, which prevented breakage when used for high-speed steel materials. However, they proved inadequate for high cobalt content alloys. Abrasion resistance needed to be improved to make the widespread use of cemented carbide end mills practical. Each cemented carbide material manufacturer joined the competition for development of new fine particle cemented carbide alloys. By the end of the 1980s, each manufacturer had mostly decided which basic components would be used for the end mills that they were producing. Mitsubishi Materials sought versatility to respond to a wide range of cutting applications and chose a material design that would ensure toughness rather than hardness

in the cutting edge. We also used superfine particle WC powder that was developed jointly with one of our group companies, Japan New Metals Co., Ltd.; and in 1989 the grade TF15 was produced, a strong cemented carbide alloy featuring outstanding balance between hardness and toughness.

In addition to use in its own products, Mitsubishi Materials introduced TF15 to other end mill manufacturers to promote the use of cemented carbide end mills and expand the market, it is noted that it was accepted immediately by manufacturers in Japan. For more than a quarter of a century, the use of TF15 in products other than end mills such as the solid drill WSTAR series and general-use VP15TF inserts coated with Miracle Coating, has increased, making it a major product in the cemented carbide business. In addition, TF15 serves as the main material in current cemented carbide end mills. We believe this shows that the original TF15 material design

was excellent. We are proud that the quality and material design of our products, that is, the quality of the manufacturing technology that enables us to provide stable, high-performance products, is highly regarded by our customers.



TECHNOLOGY ARCHIVE

Part

2

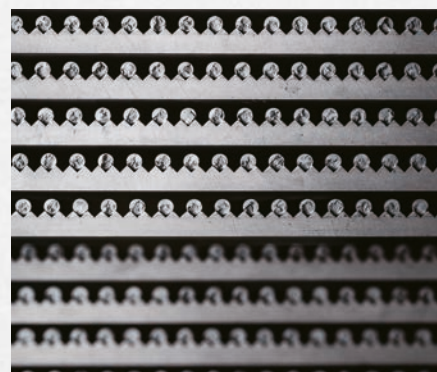
1989 ~

MF10 was launched at almost the same time as TF15, targeting the already expanding market for miniature drills used to make holes on printed circuit boards. The characteristics of cemented carbide end mills differ from standard end mills. Being highly rigid and hard, they were suitable for application. The priority condition for tools used to make holes in expensive circuit boards is that they are strong and do not break easily. In addition, the accuracy of the holes they produce must be precise. Our standard-diameter tool was the HTi10, and the small-diameter tools were UF20. However, neither the strength of HTi10 nor the rigidity of UF20 proved adequate for the requirements of circuit boards. New materials that were strong enough when integrated were required. We focused on minimizing defects, the original goal in developing cemented carbide alloy. The strength of brittle cemented carbide alloy is affected by even tiny internal defects. Since cemented carbide alloys were

MF10 – The standard for superfine particle cemented carbide - Dramatically improved tool strength

manufactured using the powder metallurgical method, micropores would remain regardless of how much care was taken in the manufacturing process. Addressing this problem required significant improvement in sintering technology. Even if we could prevent such defects, it was very difficult to reduce variability in strength if components included uneven parts. To address this, we worked jointly with Japan New Metals Co., Ltd. to develop superfine particle WC powder, which has smaller particle size distribution than standard WC powder. At the same time, we also successfully improved our sintering technology to minimized micropores. The result was strong and rigid MF10. It has established a stable position in the small-diameter miniature drill market.

Furthermore, its excellent performance in machining super hard steels addressed the weakness of TF15. Since then, MF10 has been used for super hard steels, and TF15 has been applied for general use.



Part

3

1999 ~

In the late 1990s, along with the increasing use of electronic devices, demand for standard-diameter miniature drills expanded compared with the smaller diameter MF10 grade drills. At the same time, circuit boards also became super hard, requiring improvement in the HTi10 carbide material. During the development of SF10; while the trend in miniature drill materials was superfine particles, we chose a rougher material design. This achieved greater

SF10 - Global standard for miniature drills with standard diameters

stability in the material and with the advanced manufacturing technology used in the processing of the MF10 grade, these factors combined in reducing microchipping caused by circuit board fillers. In addition to Mitsubishi Materials standard-diameter, SF10 has been used by many other miniature drill manufacturers and continues to be employed as a main material.



HISTORY

Tracing the history of cemented carbide materials

1970 UF alloy launched

1989 Tough cemented carbide alloy TF15 launched
MF10 superfine particle cemented carbide alloy, launched

1999 SF 10, material for standard miniature drills, launched

2004 Superfine particle cemented carbide commercialized for machining high strength steel Impact Miracle as a joint project with Mitsubishi Materials Kobe Tools Corporation (current Akashi Plant)

2009 MP8010, PVD cemented carbide for machining high strength steel utilizing Impact Miracle material technology

2012 Commercialization of materials used for miniature drills with extremely small diameters (less than Ø0.15)
Material manufacturing technology is significantly improved along with the development of composite miniature drills



TECHNOLOGY ARCHIVE

Part

4

2000 ~

In 2000, Kobelco's Tool Department (current, Akashi Plant) was brought into Mitsubishi Materials group as Mitsubishi Materials Kobe Tools Corporation. Its strength was end mills for machining high hardness steels. In order to exercise the synergetic strengths and other advantages of material technology that Mitsubishi Materials had, we started a joint innovative project to improve end mills. Kobelco was using KRZX8, a superfine particle cemented carbide equivalent to Mitsubishi Materials' MF10. It was necessary to improve the hardness of the material to respond to HRC60-class die steels. In addition, we needed to ensure the toughness of the cutting edge for use in end mills. We also needed to reduce the

Impact Miracle – Super high hardness material developed in the collaboration with Mitsubishi Materials Kobe Tools Corporation

size of the cemented carbide particles by half. In order to achieve this, we needed to cut the size of WC powder particles in half, and the particle size distribution needed to be small. Because there were no WC powders on the market that satisfied the requirements, we worked with Japan New Metals to jointly develop superfine particle WC powders with a mean particle size of 0.1µm. This new powder exhibited both hard-

ness that was significantly greater than that of MF10, and toughness that was equivalent to MF10. This powder was employed as the main material in the manufacture of the Impact Miracle series launched in 2005.



Part

5

2012 ~

Development of next-generation superfine particle cemented carbide

Current miniature drill development is two-pronged. While standard-diameter drills have become common, the sizes of smaller-diameter drills have decreased. We manufacture drills with diameters of less than 0.15 mm. Drills with extremely small diameters have centers that measure only a few µm across. It is impossible to place more than 100 WC particles when converting to MF10. The biggest issue here is the technology for mass production. It becomes increasingly difficult to manufacture when the WC particles are 0.1 µm. Smaller particles coagulate easily and their reactivity increases, which interferes with alloy uniformity.

Indirect influences on miniature drill materials also posed problems. The steep rise in WC

ingredient prices in the early 2000s prompted a shift from solid drills made of cemented carbide to composite drills made of steel shank and cemented carbide cutting edges. In the late 2000s, with the exception of drills with 2 mm shank diameters, almost all of the drills that were being manufactured were composite. This accelerated the production of longer drills with smaller diameters. This also increased the difficulty of drill manufacture. As a result, we needed to significantly improve the technology we were employing in all processes; that is, mixing, extrusion, and sintering. The new materials we developed through this technical improvement were adopted by some manufacturers in 2012; but we need to work more to increase the popularity of our drill materials.



Looking back at cemented carbide material development in the last quarter of the century

Looking back on the history of our product development, we realize our strength is in the ability to manufacture materials from raw ingredients. Our products are the result of raw-ingredient development that reflected material design. We also believe the popularity of our cemented carbide products is based on their consistently stable quality. High reliability requires severe quality management not only in material design, but also in the manufacture

of raw ingredients, and high-precision product manufacturing. Ingredients are the basis of everything we produce, and we cannot hide defects or mistakes. This, however, is the real pleasure in the development of cemented carbide materials. Utilizing our accumulated strengths, we continue to seeking to fulfill the potential of cemented carbide.



About Us

Mitsubishi Valencia Education Centre

M-VEC - A centre where education matches industry speed, remaining relevant in a changing world

An educational institution in Europe that complements Mitsubishi Materials' technology offering, delivering hi-tech manufacturing knowledge.

Combining theory and practice

Mitsubishi Valencia Education Centre (M-VEC) was founded in 2008. Its primary aim was to identify the main technical fields of interest and meet the educational needs of distributors, employees and customers across Europe. It is strategically located in Valencia, Spain, within walking distance from the Mitsubishi Materials production site, where solid carbide tools and both coated and uncoated inserts are produced for the European market. Today the centre provides various services, such as application tests for R&D, technical assistance and customer consultancy, while maintaining its strong educational character.

M-VEC comprises a modern machine room, two fully equipped training rooms that can host small to medium sized training groups (up to 36 people) and a tool showroom. These facilities ensure it can respond to a wide range of requirements, combining the theoretical foundations of machining processes with in-depth application insights. Training programs are held throughout the year with sessions designed to fulfil individual demands, emphasizing the profound relationship between theory and practice.

"When we first introduced the idea of M-VEC, the biggest challenge was to make the building operational and also be consistent with our sustainable development plans.

In an effort to differentiate it from competitors' centres and maximize training effectiveness, we chose to focus more on customised training and customer closeness by optimising the training materials and resources for this purpose, and for learning efficiency keep visiting groups to a reasonable size. As a result, we are able to conduct high quality technical discussions, because most of the training participants are already experts in their application areas, and this simplifies the information exchange," says Stephan Hulverscheidt, manager of the centre.

The current design and content of the curriculum reflects changes in machining technologies, emerging cutting tool trends and innovations in the metal working industry. Selected new tools, geometries and coating technologies are demonstrated in M-VEC for educational purposes prior to their official commissioning and are modified upon customers' requests.

M-VEC employee insights into customer educational needs

Eddi Melero and German Cabot (7 and 3 years with the company respectively) are the centre's machine operators. "Every year we welcome participants from all over Europe who wish to explore the latest machining technologies and find out more about our tools' performance. We also facilitate training sessions for students

"We focus on training customisation and customer closeness, simplifying information exchange."

Stephan Hulverscheidt
M-VEC Manager



from Valencia Technical University, but our primary focus is to educate and consult our European customers and distributors, says Eddi. "There are cases where we perform several trials for customers to demonstrate our tools' capabilities and this was the case when we had to find a successful solution for machining precision holes in hardened steel with solid carbide drills, Eddi continues.

"In this case the customer, a producer of plastic parts, made a request to drill holes of $\varnothing 1 - 3\text{mm}$, with a depth of up to $30\times\varnothing$ for ejector pins. During the moulding process hot, fluid material is blown into the mould and after a short cooling period the mould tool is opened and the ejector pins are responsible for pushing out the finished part. The holes for these pins require extreme accuracy, including roundness, diameter, straightness and positional tolerance and a smooth surface finish. The process started with the R&D Department supplying prototype drills specially developed for this application and then had to investigate which type was the most suitable and to also find the best cutting conditions. After our initial research, the final tests were successfully conducted at the customer's production plant. The customer is now using these drills intensively for this application and has been able to increase both productivity and finished product quality.

The findings were so successful and resulted in the drill now being included in our standard product portfolio", Eddie explains.

"The greatest value of our centre is that each MMC European office is free to use the facilities and customise training subjects according to individual needs. The authorised trainers of MMC adapt the training materials and we cater to their precise needs and provide the technical support required," confirms German.

"We strive to continuously improve our training in matters of quality, relevance and usefulness. We constantly exchange technological advancements and market information with all other Mitsubishi Materials technical centres worldwide (Japan, USA, Thailand and China), and endeavor to keep pace with today's high-tech global environment. The M-VEC project has proven successful and therefore merits to be expanded and enriched in the coming years," concludes Stephan.

"We welcome participants from all over Europe to educate them about latest machining technologies."

German Cabot (left) & Eddie Melero (right)
M-VEC Machine Operators



M-VEC - Mitsubishi Valencia Education Centre

1 TRAINING



2 DEMONSTRATION



3 FORUM



CUTTING EDGE

Vol. 3



Breaking chips with low frequency vibration

Fundamentally changing chip control

Chip control is one of the problems to be addressed in the use of small automatic turning machines employed in automobile parts production and small precision machining of parts in the manufacture of medical equipment and OA devices. If chips are not produced or handled well, they can become entangled and result in reduced tool life, damaged product surfaces and even machine breakdowns. In other words, chip control

is a priority factor for improving tool life. This in turn promotes a stable level of quality and for optimisation of machining efficiency, high pressure coolant that breaks chips directly and inserts with suitable chipbreakers should be used. Citizen Machinery took a completely new approach to chip control with low frequency vibration cutting technology. In autumn 2013, Citizen Machinery attracted attention both at home and

Cooperation: Citizen Machinery Co., Ltd.

abroad by introducing a machine that incorporated this technology. Yoshimitsu Oita of Mitsubishi Materials Sales Division and Akira Sato of Mitsubishi Materials Development Division visited Takaichi Nakaya and Kazuhiko Sannomiya at the Citizen Machinery Development Division to interview them about the concept and future of low frequency vibration cutting technology.

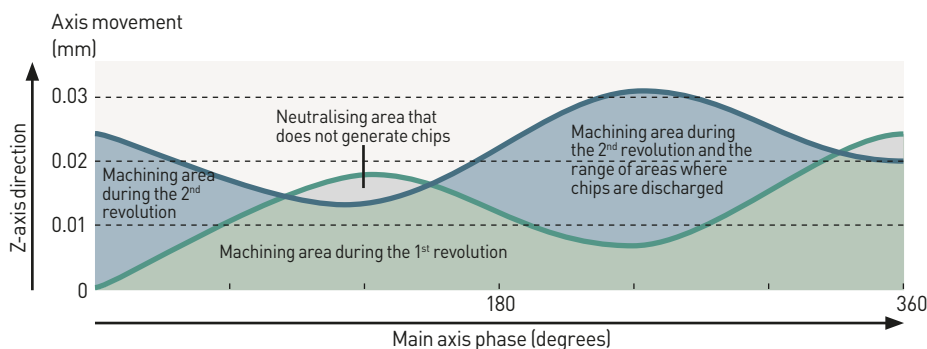
Low frequency vibration cutting LFV*

Citizen Machinery's unique control technology synchronizes the vibration of the servo axis with the revolution of the main axis. LFV breaks chips into small pieces and discharges them

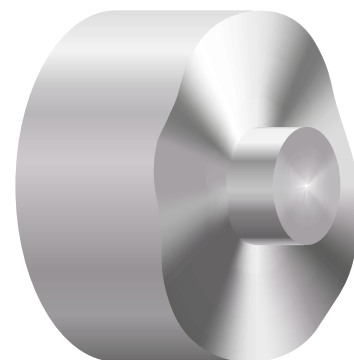
during operation. This addresses all the problems caused by entangled chips during difficult-to-cut material machining and deep hole drilling. LFV is the most advanced machining

technology and has the advantage of applicability to a wide range of cutting materials and geometries.

- Z-axis direction movement synchronized with the revolution of the main axis and low frequency vibration wave



- Image of cutting



*Low frequency vibration cutting (LFV) is a registered trademark of Citizen Holdings Co., Ltd.

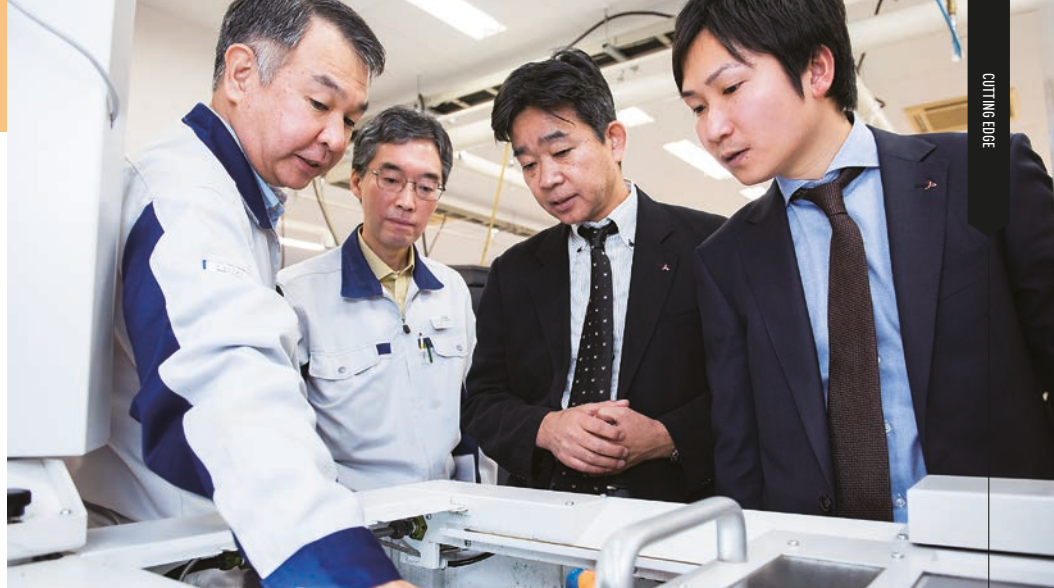
Applying neutralisation to completely break chips

Oita (Mitsubishi Materials): Chip control is an important problem that machining tool manufacturers need to address, and my interest in Citizen's machine development is rooted in this problem.

Nakaya (Citizen Machinery): It started with a request from our customer and some proposals involving the application of LFV. We were aware of the need for chip control and our discussions led to the idea that LFV would provide a solution, this prompted us to work on joint development.

Sato (Mitsubishi Materials): Generally, machine tools should not vibrate, right?

Nakaya: Sure. It is important that machine tools do not vibrate. When the customer made the request involving LFV, I wondered whether it would be possible to maintain the accuracy of machining and whether the machine would be able to withstand the vibration. However, I understood the potential of LFV technology, which gave me the



confidence I needed to work on this technical development.

Sato: The biggest problem with automating manufacturing sites is chip control and the biggest problem with chips is the damage they do to tools. There are many other problems with chip control, problems such as rough surface finishes and shortened tool life, etc.

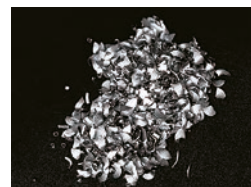
Oita: Machine operation rates are the key to productivity (cost) in machining mass-production parts on automatic lathes. Once chips get entangled in the machine, the flow of chips changes and this causes surface damage.

In the worst case, this may cause machine stoppage. Being able to discharge chips reliably, surface finishes are guaranteed, general problems during machining decrease and overall productivity increases. We are very excited about using LFV and it helps to achieve good results.

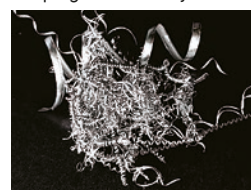
Nakaya: We think that cutting processes that we developed utilizing the LFV would make it possible to break and discharge chips utilizing neutralisation during cutting, prevent the increase of temperature on the cutting edge and lead to expanded tool life.



Deep hole drilling utilising oil hole drills. Broken chips are discharged up through the flutes on the drill, which prevents entanglement.



Chips generated by LFV



Chips generated by existing cutting technology

Shifting to a time in which difficult-to-cut materials become easy-to-cut materials

In 2014, Citizen Machinery released the VC03, a two-axis lathe with LFV. What was the most difficult challenge during the development of the VC03?

Nakaya: The major characteristics of the VC03 are shown in the bottom figure on page 27. The basic concept is zero

vibration in machine tool development, so it was very difficult at first for us to accept the idea of actually trying to cause vibration. What I mean is that if the LFV vibration frequency matches the vibration of each component, the machine itself will vibrate, making machining impossible.

In spite of this, we proceeded with development. LFV can completely break chips, reduce cutting resistance under specific conditions, reduce temperature at the cutting edge and increase tool life. LFV has proved to be an innovative solution for manufacturing.

CUTTING EDGE

Sannomiya (Citizen Machinery): I feel that we have achieved something great if the technology we develop can solve problems for our customers. It is a great pleasure for us to see that LFV technology has made our customers happy and it has been highly regarded since we launched the product.

How do you think manufacturing will change in the future?

Nakaya: Citizen Machinery set the goal of “Ko No Ryosan”*, mass customization in Citizen style as a business concept in 2013. The concept promotes innovative manufacturing for customer-oriented production and was established to achieve high productivity while ensuring the same level of efficiency in both mass and small-lot production. A wide range of forms and materials will be processed in product lines, this requires a unified chip control system such as LFV that applies to all materials and machining. We need to continue with the development of new machining technology to expand this concept.



(Left) Takaichi Nakaya, Deputy-Director, Development and Design Department, Development Division, Citizen Machinery Co., Ltd.
(Right) Kazuhiko Sannomiya, Chief, Solution Development Section, Development Division, Citizen Machinery Co., Ltd.

Sannomiya: We are dreaming about expanding our technology to make difficult-to-cut materials into easy-to-cut materials in the near future. LFV has significantly reduced the length of chips and has made it possible to reduce chip entanglement even with difficult-to-cut materials so that chips are easy to remove. This reduction in length of the chips also leads to easier disposal by recyclers, which makes it environmentally friendly.

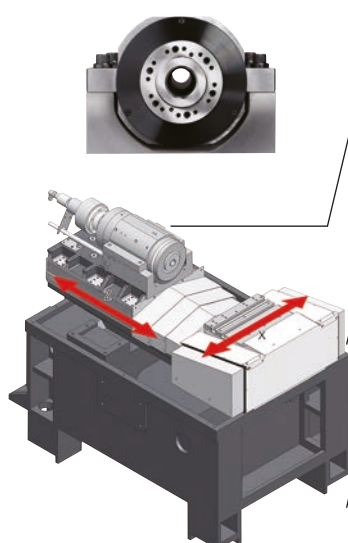
Nakaya: I believe that LFV will change the concept of machining technology significantly. Based on the concept of LFV, tool geometries and design

changes; and as soon as we reduce chip entanglement to zero, design flexibility can also increase. The future is filled with potential. We have a wide range of ideas that we are looking into and tool manufacturers will also be engaging in research and development.

Oita: Innovation will come if we can discuss tool geometries, design and parts with manufacturers and identify the ideal match between technology and individual tools. This could fundamentally change machining strategies at manufacturing sites.

VC03 – Mechanism for high precision

Symmetric heating system frame and bed, wing-type head stock and external coolant tank are basic VC03 specifications required to prevent time-dependent thermal displacement and processing heat from being conducted to the machine body. Its built-in motor is equipped with a forced cooling function, is beltless and vibration resistant, which promotes smooth revolution and highly precise product formation. The combination of peripheral devices such as an in-out stocker and a high-speed gantry loader, whose service time is only 3.5 seconds can respond to a wide range of systematic automation.



■ Wing-type head stock

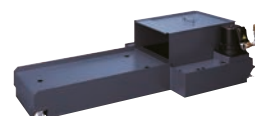
Only the wing section of the main axis is connected to the slide, which enables the centre of the sleeve to float. The structure allows even heat generation and prevents conduction to the head stock.

■ Symmetric heating system

A unified casting base with symmetric structure allows excellent symmetric heat conduction. This mitigates the impact of heat generation on machining accuracy.

■ External tank

The coolant tank is installed between the machine legs to separate it from the machine body to reduce the impact of heat from coolant and chips that absorb cutting heat.



*Ko No Ryosan, mass customization is a registered trademark of Citizen Holdings Co., Ltd.



[Left] Yoshimitsu Oita, Manager, Business Development & Planning Department, Sales Division, Advanced Materials & Tools Company, Mitsubishi Materials Corporation
[Right] Akira Sato, Drill, CBN & PCD Products Development Center, Research & Development Division, Advanced Materials & Tools Company, Mitsubishi Materials Corporation



Low frequency vibration cutting machine – VC03

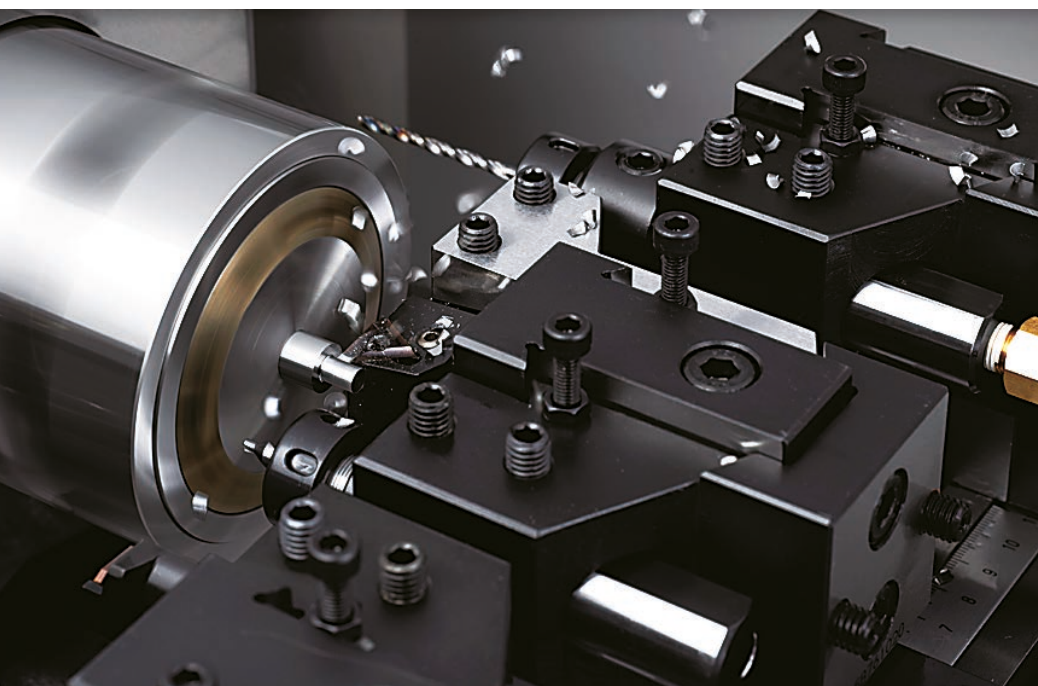
Nakaya: In the manufacture of large machines, safety becomes an issue when operators leave the cover open during manufacturing to remove chips manually. They do this because they want to prevent damage caused by entangled chips, but it is dangerous. LFV provides excellent chip control to enable safe and automated machine operation. We will continue to expand the application of LFV technology in VC03 to other machines to promote safe operation in other manufacturing processes.

Sato: We also put energy into tool development from the standpoint of our customers and want to provide innovative machining methods that prove valuable for manufacturing sites around the world.

Oita: Mitsubishi Materials has established a cutting-edge technology development team and our young engineers are also engaged in tool development.

Sato: LFV technology made it possible to discharge chips completely, which showed us the possibility of producing new tools with a wide range of functions such as tools exclusively for LFV cutting.

Considering the progress of such new technology and machine tools, we would like to continue developing tools that are useful at actual customers manufacturing sites.



UKIYO-E

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Woodblock prints and paintings

Thirty-six Views of Mount Fuji by
Hokusai Katsushika

Ukiyo-e is well known throughout the world as a traditional Japanese art. It was developed in Edo (now known as Tokyo) during the Tenna Era (1681-1684) of the Edo Period, when Japan's doors were closed to foreign trade.

Ukiyo is the sorrow of the physical world in contrast to the joy of the afterlife. In the Edo Period, the idea of transience prompted a shift in thinking toward seeing life as enjoyable rather than as a time of suffering before the release of death. This concept spread to the world of art, where artists began to take the people and events of everyday life as their subject. Most of these were single-colour ink woodblock prints which then evolved into lively pieces printed to entertain the public. Ukiyo-e is the forerunner of pop art.

The main entertainment available at that time was found in licensed quarters and theatrical performances, which artists captured in Ukiyo-e prints such as Bijin-ga (portraits of beautiful women) and Yakusha-e (portraits of kabuki actors). These gained immediate popularity. At the same time, Ukiyo-e prints became popular as souvenirs among visitors to Edo, which helped Ukiyo-e to spread to other regions.

The first Ukiyo-e were black-ink prints known as Sumizuri-e (single-colour woodblock prints). The style gradually changed to include beautiful colours, which



marked the beginning of what we have come to know as Ukiyo-e prints. In the mid-Edo Period, woodblock prints in multiple colours were mass produced as Nishiki-e. These Ukiyo-e were produced as joint projects by publishers (Hanmoto), painters (Eshi), woodblock artists (Horishi), and printers (Surishi).

It was during the time when Japan's doors were closed to most foreign trade that Ukiyo-e prints first found their way outside of Japan. Old Ukiyo-e prints were used to wrap ceramics when they were exported through the Netherlands, which was the only country that Japan traded with.

These Ukiyo-e prints were highly regarded and in the late 19th century, when Japan opened itself to foreign trade, a large number of Ukiyo-e prints were exported to European countries where they became very popular. Currently, many Ukiyo-e prints, which play an important role in introducing Japanese culture abroad, are exhibited at museums in Europe and the U.S.

Vincent van Gogh and Ukiyo-e prints

With the opening of Japan to the world at the end of 19th century, traditional Japanese art, fashion and aesthetics began to influence Western culture in a movement known as Japonism. Ukiyo-e in particular attracted the interest of a wide range of painters, novelists, poets and musicians, including Vincent van Gogh, who was an enthusiastic collector of Ukiyo-e prints and despite living in near

poverty, he purchased a number of them. Approximately 500 of the Ukiyo-e prints that Vincent van Gogh and his brother Theodor van Gogh collected are exhibited at the Van Gogh Museum in Amsterdam. Ukiyo-e also had a strong impact on his work. One of his works, Portrait of Peré Tanguy, shows Ukiyo-e prints in the background, one of which being an imitation of Hiroshige Utagawa's work.



Portrait of Peré Tanguy by Vincent van Gogh

Woodblock artists' tools

Ukiyo-e prints are joint projects undertaken by publishers, painters, woodblock artists and printers. The woodblock artist carves a picture on wood for printing.

The most important thing for woodblock artists is their tools. A knife to carve lines, a flat chisel for line edges, a round chisel for broad and flat areas and a scoop chisel for small areas. The knife is the most important tool among these. The artist places a grinding stone next to a

printing block and sharpens the edges of the blade during work. Mastering the art of carving requires the ability to edge blades freely and it usually takes years to master this completely.

The beautiful Ukiyo-e prints that have attracted people around the world required not only the artist's exquisite technique, but also excellent tools.

Interview with David Bull, woodblock artist

I want to sense new trends and culture to expand the possibilities of Ukiyo-e and other traditional woodblock prints.

I saw traditional Japanese woodblock prints for the first time when I was 28 when working at a music store in Toronto, Canada. I was passing a small gallery when I saw a sign that read, "Japanese Woodblock Prints." I saw Ukiyo-e prints from the Edo (1603-1868) and Meiji Periods (1868-1902) and they astonished me with their beauty.

I moved to Japan when I was 35 to study woodblock printing. While I was teaching English, I also worked reprinting old woodblock prints, including Ukiyo-e. In 1989, my third year in Japan, I started a 10-year reprinting project involving Nishiki Hyakunin Ishu Azuma Ori by Shunso Katsukawa, an Ukiyo-e printer in the Edo Period; and it was this that started me on the path to becoming a woodblock printer. I completed the 10-year project in 1998 and held an exhibition. Many people and media gathered to see my work.

Currently, while I am reprinting Ukiyo-e from the Edo and Meiji Periods, I am also creating original Ukiyo-e prints. It's been four years since I started making woodblock prints based on pictures drawn by Jed Henry, an illustrator living in the U.S., as a series of Ukiyo-e Heroes. He made Ukiyo-e of well-known Japanese video game characters. The Ukiyo-e Heroes are an integration of Japanese pop culture and traditional woodblock prints. They are highly regarded overseas and are being ordered online by people in 60 countries around the world, including the U.S.

The essence of Ukiyo-e is present-day life. People creating Ukiyo-e in the Edo Period applied innovative techniques to express the trends and popular topics of the day. We also want to express new trends and culture in our work and expand the possibilities of Ukiyo-e and other traditional woodblock prints.



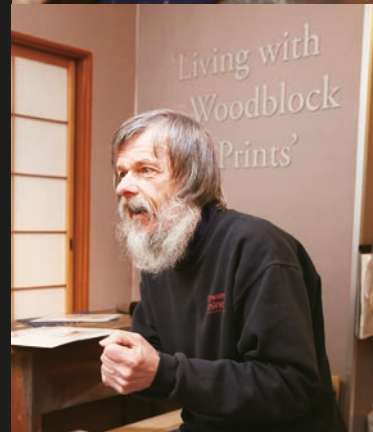
Rickshaw Cart



Fox Moon



Popular works by David Bull and Jed Henry that have been sold online



Changes in our world

Stopping to check a map, deciding on a time and a place to see people, or making a phone call to confirm a message sent by facsimile were all common when I started working 20 years ago; however, such actions have already become unusual.

In the next 20 years, our world will also change dramatically, things such as artificial joints and spinal cord implants that are rare now, will become routine. Due to the expansion of artificial joint functions, our range of motion may increase and new rules for sports will be written one after another.

Changing difficult-to-cut materials into easy-to-cut materials is a very complex problem that many engineers at cutting tool and machine tool manufacturers are working hard to solve. Some may think that achieving this is out of the question, but enthusiastic innovators in history have opened doors to new worlds time and time again. I hope that I will recall my memory of "difficult-to-cut materials" twenty years from now while reading this editorial note. I hope that I can do something to help change our world.

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David Bull, Woodblock Printer, Owner of Mokuhankan and Seseragi Studio



- Born in England in 1951.
- Moved to Canada when he was 5 years old.
- When he was 28, he encountered traditional Japanese woodblock prints for the first time.
- In 1986, he moved to Japan.
- Between 1989 and 1998 he worked reprinting Nishiki Hyakunin Ishu Azuma Ori, old woodblock prints by Shunso Katsukawa an Ukiyo-e artist in the Edo Period and became well known.
- In 2014, he opened Mokuhankan in Asakusa. In cooperation with painters, woodblock artists and printers, he reprints old woodblock prints from the Edo Period and creates original Ukiyo-e.



Mitsubishi Materials is not just a tool manufacturer

We are committed to responding promptly to customers' challenges and to actively contribute to their success with the dedication of a professional craftsman.

We will strive to become the only tool manufacturer globally offering "your personal craftsman studio", a unique service for our customers.

It is the place where you can:

Find state-of-the-art technologies and products.

Find solutions, anytime, from anywhere in the world.

Share our excitement about the latest technology trends and product innovation.

It is the studio where we think, share, create and develop together with our customers, exciting solutions to meet their specific needs.

YOUR GLOBAL CRAFTSMAN STUDIO
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YOUR GLOBAL CRAFTSMAN STUDIO

The meaning of our icon

Our logo shows people, standing on a circle, holding hands. The circle represents the earth. Holding hands reflect our commitment to grow and succeed "hand in hand" with our customers and closely work with them to improve performance across the globe.

The shape of the logo embodies a variety of ideas. It captures the image of "cutting tools" combined with the dominant letter "M" of the Mitsubishi Materials brand name. It also depicts a flame that symbolises our passion for craftsmanship.

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