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NANOJIN
Breackthrough

2021 AUTUMN

EDITOR'S NOTE

I have been in China since the middle of July on a business trip (spite of COVIDs trouble situation!) for the first time in two years and was surprised by the big change after only two years. One is that electric vehicles are widely used and popular. There were different types of them in town and I often took them designed for taxies on a visit. Next is the face processing to check the registration at customer's gate. Security cameras can recognize our face and show the registration information on the screen soon after inputting them by smartphone. Many high-level technologies having some trouble or matter that should be improved quickly must be applied, though they already have a stable position in our life. This means that we are in this situation because of the strong requirement of high-quality production technology in the field of automotive, smart-device, security and medicals. Then, we have progressed in research and development both before and during the coronavirus pandemic, to respond above all for our customers.Now, we would produce four kinds of issues in this leaflet, which can play a good role on customer's requests.

The first issue is about the direct machining of cemented carbide. This is one of most difficult-to-cut materials and currently machined by grinding and EDM process which is hardly expected productivity, but originally has good characteristics as tool and Mold materials such as high abrasion and thermal resistance and superior to other kinds materials such as hardened steel and HSS. Therefore, we have studied the strategy of ductile mode cutting from the viewpoint of machine tools characteristics and considered that the stable motion is a significant factor to keep the depth of cut under the transition region to brittle mode. UVM consists of an aerostatic bearing spindle and linear motor driven system which achieves the stable and precision motion to satisfy the above cutting situation. As the first case study in the leaflet, it is shown a pair of gear molds fitted with only a micro-metered level gap.

The second is about the mirror finish by using diamond milling. To apply diamond tool has been an unusual method for mold production because of difficulties of tool operation and less cost performance though the demand for the improvement of shape accuracy and surface roughness was increasing. We have considered the reason for the lower performance of the machine tools, which is less run-out of spindle due to the ball-bearing and non-smooth feeding quality by ball-screw driving system. In other words, UVM having good run-out of aerostatic spindle and smooth feeding by linear motor driven system enable easier to achieve mirror surface with diamond tool operation. As a second case study in the leaflet, it is shown The micro channel path shaping by UVM. Microfluidic devices and microreactors consisting of micro channel paths are required to be smaller and higher quality in the field of chemistry due to quick and accurate inspection with a small amount of sample.

The third is about making reflector molds which consist of solid geometry. Though reflex reflectors which are well-known as safety goods for vehicles it's hard to manufacture by milling or other machining method due to the tool interfering with cutting tools. Hence, hand-made polishing and assembly which means less productivity may be applied for their fabrication. There are not only the above cases but many cases of giving up because of the negative reason of the milling process. We have developed the aerostatic bearing spindle having the capability of precise positioning like servo motor drive. The developed spindle can rotate with high accuracy as an aerostatic spindle, and make positioning, furthermore, make coordinate control motion with other linear axes. As a third case study in the leaflet, it is shown making solid geometry consists of arbitrary arrayed reflectors. This is made by milling in a rough cutting process and shaping in generating sharp cavities, coordinating motion with other linear axes.

Finally, it is about making a mold having a large area with mirror finish. Some machining tool companies produce a line-up of fine accurate machine tools having aero-static bearing spindle and linear motor driven system to get mirror surface finish. However, their ability could not be enough to achieve a good surface on the whole area of the mold needed a long time of machining because of lack of stability. Our company has long term experience in the manufacturing of aero-bearing from 1970's and stable structure applied iron materials casted in our factory. This means UVM can get high quality and less stripe on the cut surface, which needs long time pro-polishing. As a case study in the leaflet, it's shown that making mold designed with the idea of VR glass needed a large surface. Though UVM can generate a mirror surface with a milling process, it was applied with a vibration assisted device which enables the mold to make mirror surface with diamond tool for steel materials.

The samples for this EMO show were processed by our potential MZ generation, who will lead our business in the future. We strongly believe that their new ideas with our historical technologies would drive the better products developing and technical to the customer even in the rapid change of Covids Pandemic. Please come to our site!

Masahiko Fukuta
Expert / Ph.D. (Eng.)
SHIBAURA MACHINE CO.,LTD.

ARTICLE

CEMENTED CARBIDE

TEXT
SHO SAKATAYA

Cemented carbide is a type of alloy fabricated by sintering metal carbide particles with binder. Mainly WC-Co alloy is industrially used, which is composed of tungsten carbide (WC) particles and cobalt (Co) binder. Cemented carbide has extremely high hardness, bending strength, and rigidity, even under the high temperature condition. For that reason, it is used as material for cutting tools and press molds that require wear resistance.

Cemented carbide is difficult to cut because of its excellent mechanical properties. However, owing to the advancement of tool technologies, some cutting tools that can cut cemented carbide were invented. Since cutting is better than other machining method in quality, efficiency, and flexibility, cutting cemented carbide is receiving attention in recent years.

As cemented carbide is hard and brittle material, chips are usually formed not by plastic deformation but by brittle fracture. Exceptionally, plastic deformation occurs when cutting thickness is lower than 1 µm and cutting edges of tool are sharp enough. Due to this characteristic, it is essential for high-precision cemented carbide cutting to use an excellent machining center and tools.

We focused on linear motor and aerostatic bearing spindle as a structure to improve motion accuracy of a machining center. Unlike ball screw, linear motor generates thrust by magnetic force. Due to this mechanism, it is not affected by friction or backlash while driving, and it can output very large acceleration instantly. These characteristics are suitable for following NC commands with high accuracy. As aerostatic bearing is non-contact, it is not affected by wear or vibration caused by bearing elements. In addition, error averaging effect of compressed air absorbs machining errors in the spindle and housing, resulting in extremely high rotational accuracy. UVM series (Shibaura Machine Co., Ltd.) are machining centers that use the structure. Linear motors are used for three orthogonal axes, and the least input increment of them is 0.01 µm. Additionally, they equip the high-precision aerostatic bearing spindle that rotates with non-repetitive run out (NRRO) of 0.1 µm and total indicator reading (TIR) of about 1 µm up to 60,000 min-1.

To confirm the mechanical responsiveness of linear motors, cemented carbide cutting test was conducted using

FIG.1 AN EXAMPLE OF PRESS MOLD MADE OF CEMENTED CARBIDE.

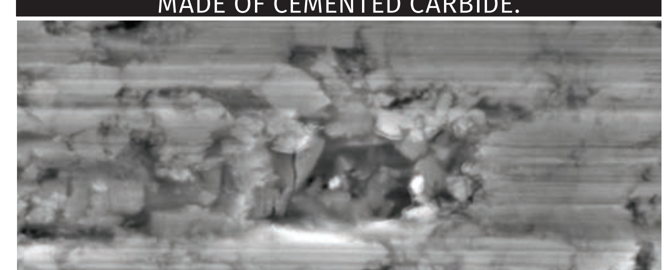


FIG. 2 A SEM OBSERVATION IMAGE OF MICRO FRACTURE.

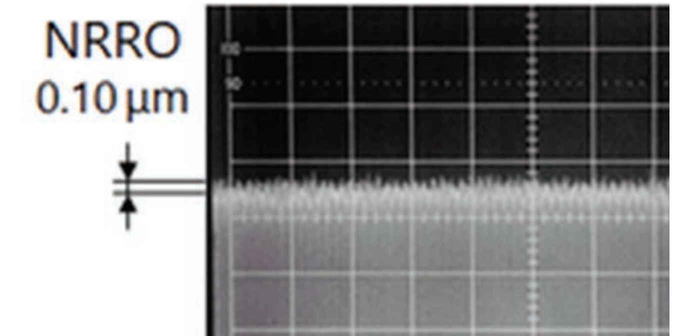


FIG.3 NRRO OF THE AEROSTATIC BEARING SPINDLE UVM IS EQUIPPED WITH.

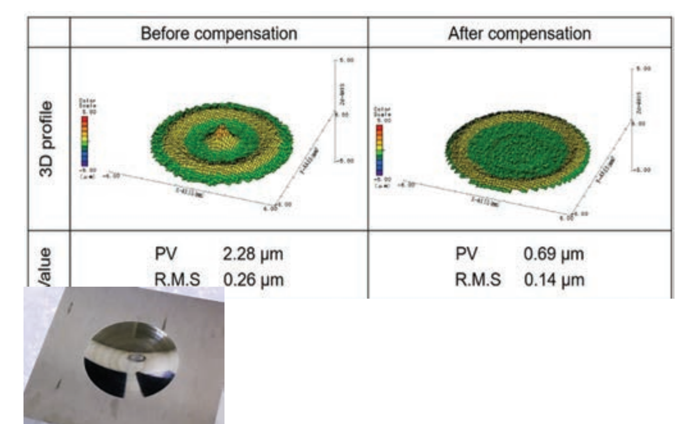


FIG.4 THE APPEARANCE OF WORKPIECE AND SHAPE ERROR PROFILE (DIAMOND COATED).

UVM-700C (H) of the above series. The machining shape was a concave spherical surface of 15mm spherical radius and 10mm diameter on a flat surface. The workpiece was ultrafine-grained cemented carbide with the mean grain size of 0.5 μm, and the cutting tools were diamond coated tools. The form accuracy after the first cutting was 2.28 μmPV, and it was affected by the tool edge profile and the spindle runout. After the second and third cutting process compensated these factors, the form accuracy was improved to 0.69 μmPV. From this result, it was clarified that the linear motors have the high mechanical responsiveness that can follow the compensation in the order of micrometers.

Then, in order to confirm the effect of the spindle rotational accuracy, spindle comparison test was performed using UVM-450C(H) equipped with an aerostatic bearing spindle and a machining center equipped with a general bearing spindle. The test was a simple cutting operation feeding the tool in one direction at a constant depth of cut. By this operation, the effect of the mechanical responsiveness was minimized and that of the spindle rotational accuracy stood out. The workpieces were ultrafine-grained cemented carbide and the tools were diamond coated tools. Comparing both machined surfaces at the cutting depth of 0.1 mm, the one machined by UVM had the 40% lower surface roughness, and the 75% lower variation of the surface roughness than the other one machined by the other machining center. Therefore, it can be said that the high rotational accuracy of the aerostatic bearing spindle contributes to the stability of the cutting thickness and the high quality of the machined surface.

Further experiments were carried out to determine the suitable tool for cutting cemented carbide. Firstly, cemented carbide was cut using diamond coated tools and polycrystalline diamond (PCD) tools so as to investigate the machining efficiency. Diamond coated tools are made by coating base material of cemented carbide with thin diamond film. On the other hand, PCD tools are made by forming PCD using electrical discharge machining, laser machining and so on. PCD is sintered material made of diamond particles with the mean grain size of several micrometers and binder. The workpieces were same as the previous ones. To find out the maximum cutting efficiency of each tool, cemented carbide was cut under some combination of radial and axial cutting depth. As a result of trying several cutting condition, the PCD tool achieved seven times higher machining efficiency than the diamond coated tool to obtain the same surface roughness. Furthermore, when machining the concave spherical shape same as the previous one with the PCD tool, the form accuracy was 0.8 μmPV, which was almost the same as the form accuracy of the shape cut by diamond coated tool. From the above experiments, it is clarified that PCD tools have good toughness and wear resistance, and thus are capable of machining the same shape accuracy and surface roughness as diamond coated tools with higher efficiency.

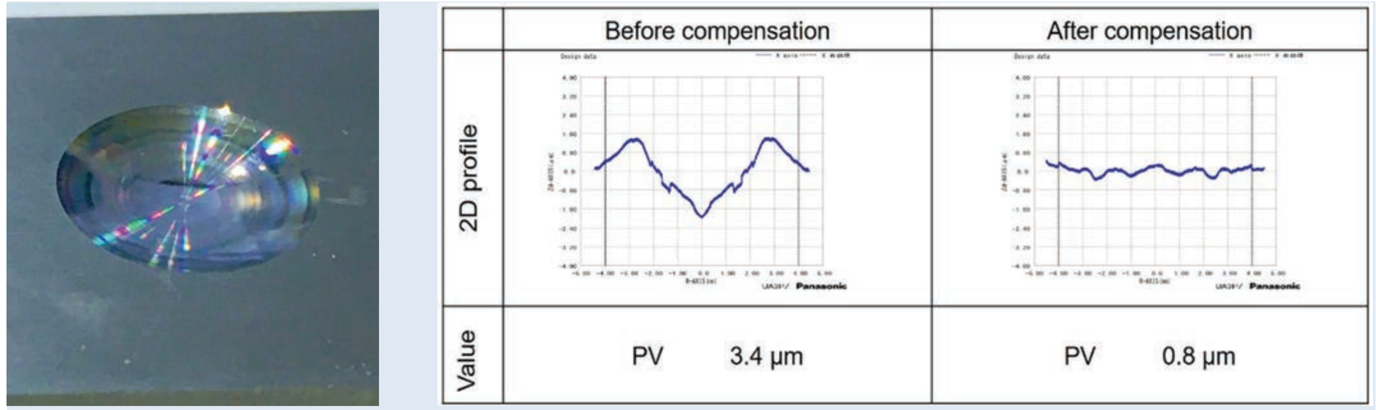


FIG. 5 THE APPEARANCE OF WORKPIECE AND SHAPE ERROR PROFILE (PCD).

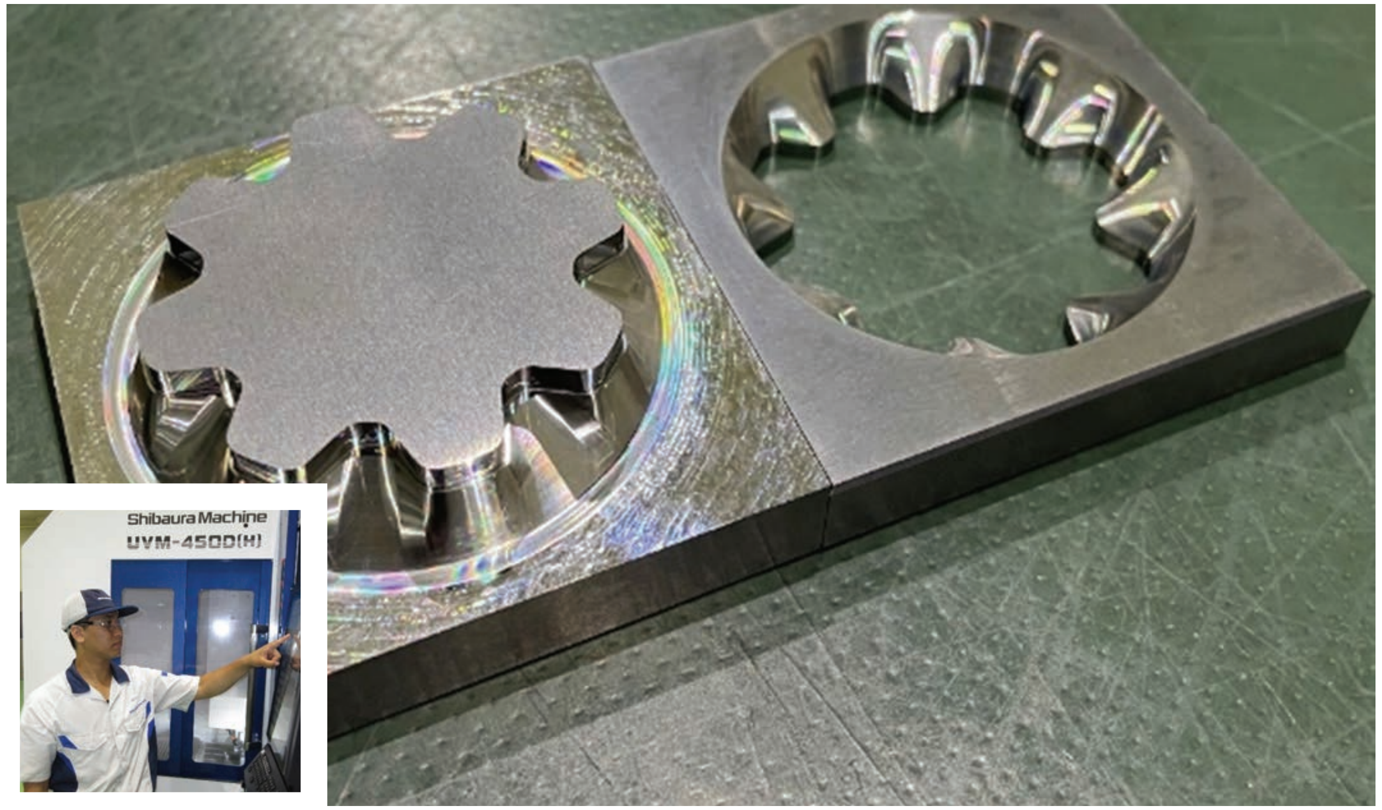
“IT CAN BE SAID THAT THE HIGH ROTATIONAL ACCURACY OF THE AEROSTATIC BEARING SPINDLE CONTRIBUTES TO THE STABILITY OF THE CUTTING THICKNESS AND THE HIGH QUALITY OF THE MACHINED SURFACE.”

Secondly, in order to compare the quality of surfaces machined by tools consisting of different material, plane machining test was carried out using diamond coated tools, PCD tools, and nano polycrystalline diamond (NPD) tools. NPD is similar material to PCD, but the mean grain size of sintered diamond particles is several tens of nanometers and it does not contain binder. As NPD is purely consisted of diamond particles, it has even better wear resistance than PCD. The planes were cut with the pick feed of 1 μm, assuming finish machining. To compare the quality of machined surfaces, the degree of grain pullout was measured in 0.17×0.13 mm^2 area. Grain pullout is a defect that WC particles are removed from the place deeper than the surface and thereby micro dimples are formed. Since micro dimples can be seen as black points, we regarded those as grain pullout and calculate the grain pullout ratio per area. Each grain pullout ratio was 1.70%, 0.28% and 0.02% respectively. When observing the cutting edges of the tools after machining, it was found that the tool with lower grain pullout ratio on machined surface also showed smaller wear. These machining results confirm that the cutting tool with higher wear resistance can keep the shape of the cutting edge as it was before machining, and thus can machine the surface with higher quality. Especially NPD tools showed excellent results, but it should be noted that they are relatively expensive compared with diamond coated tools and PCD tools.

These experiments showed that UVM series combined with linear motors and an aerostatic bearing spindle are suitable for cutting cemented carbide with high form accuracy and low surface roughness. In addition, it was found that PCD tools are suitable for high efficiency and high precision machining, and NPD tools are suitable for finish machining to obtain mirror surface with almost no grain pullout.

“THESE EXPERIMENTS SHOWED THAT UVM SERIES COMBINED WITH LINEAR MOTORS AND AN AEROSTATIC BEARING SPINDLE ARE SUITABLE FOR CUTTING CEMENTED CARBIDE WITH HIGH FORM ACCURACY AND LOW SURFACE ROUGHNESS.”

FIG. 6 MACHINED SURFACE OF CEMENTED CARBIDE. GRAIN PULLOUT AREAS ARE PAINTED RED.



FROM INSIDER #1

FITTING GEARS

THE UVM-450D (H) EQUIPPED WITH AN AEROSTATIC BEARING SPINDLE AND A LINEAR MOTOR CAN MACHINE CEMENTED CARBIDE WITH HIGH PRECISION.

TEXT
TOMOYASU MAKIDA

Cemented carbide has high abrasion and thermal resistance which are ideal property for molds, but it also has high mechanical strength and it is difficult to be machined. The UVM-450D (H) equipped with an aerostatic bearing spindle and a linear motor can machine cemented carbide with high precision. The fitting gears with a gap of 5 µm were made to show that the UVM-450D(H) achieved high precision machining with cemented carbide. The error in the gap between the gears is less than 1 µm.

Cemented carbide has high abrasion and thermal resistance as a molding and forging material for dies, and it is expected to improve the accuracy of the molding and forging production. However, since cemented carbide is a hard brittle material, it is very difficult to be machined due to its high mechanical strength. Cutting hard brittle materials requires a machine that can maintain a constant cutting thickness. the UVM series equipped with aerostatic bearing spindles and linear motors makes that difficult process possible.

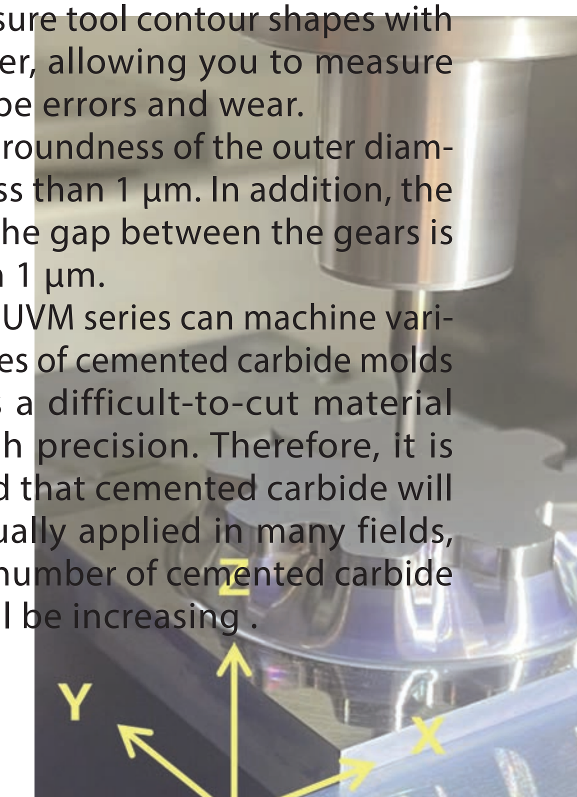
The fitting gears were made to show that cemented carbide can be machined with high precision. A micrometer-order gap is created between the gears to achieve a rattling-free fit.

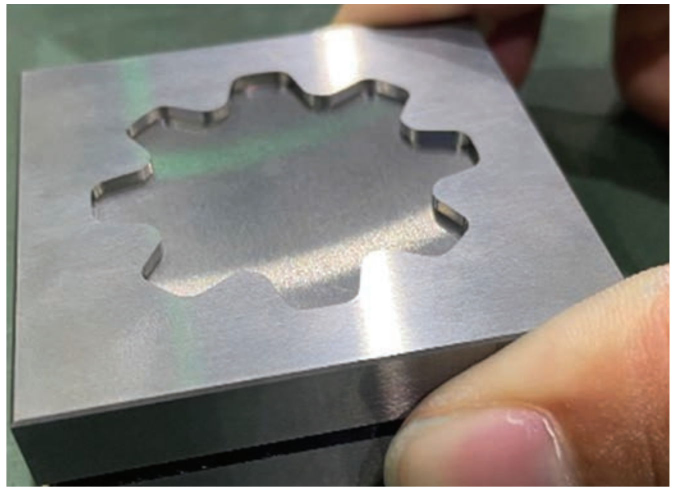
The fitting gears were made by UVM-450D(H) of high-precision machining center with an aerostatic bearing spindle and a linear motor. The tool was a diamond-coated radius end mill with a diameter of 2 mm and an angular radius of 0.1 mm. The spindle speed was 20,000 min-1, the table feed was 190 mm / min, and the depth of cut for finishing was 2 µm. The cemented carbide workpiece was HRA92.5 and WC particle size 0.5. The gap between the gears is 5 µm.
Since the UVM-450D (H) is equipped with a touch probe, form accuracy can be measured without removing the workpiece. This system makes easy to confirm the current value of the form accuracy and calculate the difference from the target value.

In addition, The UVM-450D(H) can measure tool contour shapes with tool setter, allowing you to measure tool shape errors and wear.

The roundness of the outer diameter is less than 1 µm. In addition, the error in the gap between the gears is less than 1 µm.

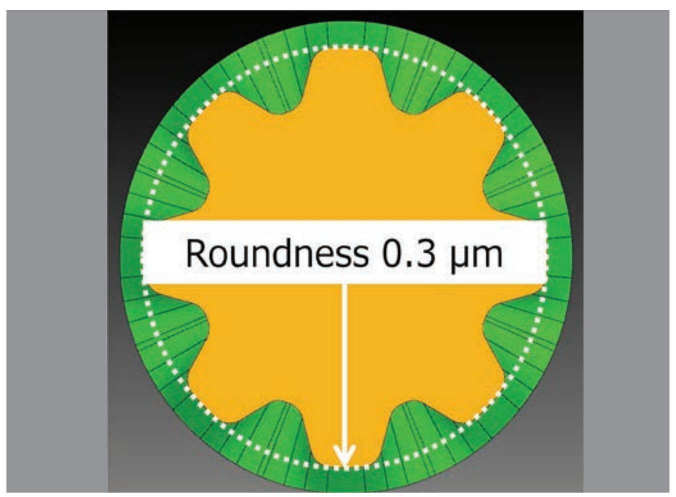
The UVM series can machine various shapes of cemented carbide molds which is a difficult-to-cut material with high precision. Therefore, it is expected that cemented carbide will be gradually applied in many fields, and the number of cemented carbide mold will be increasing .

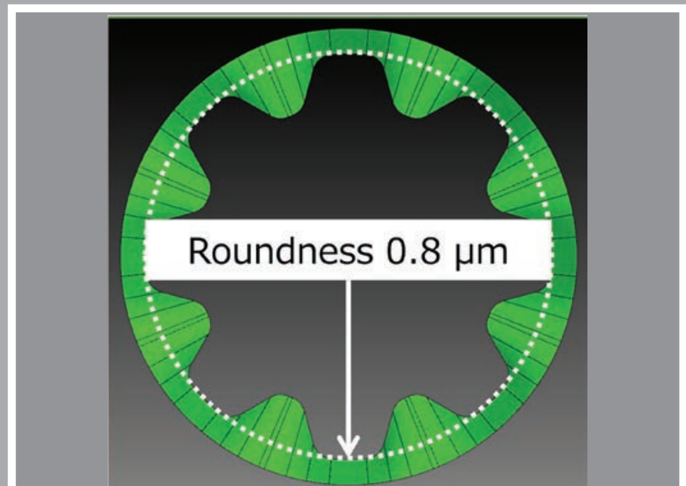


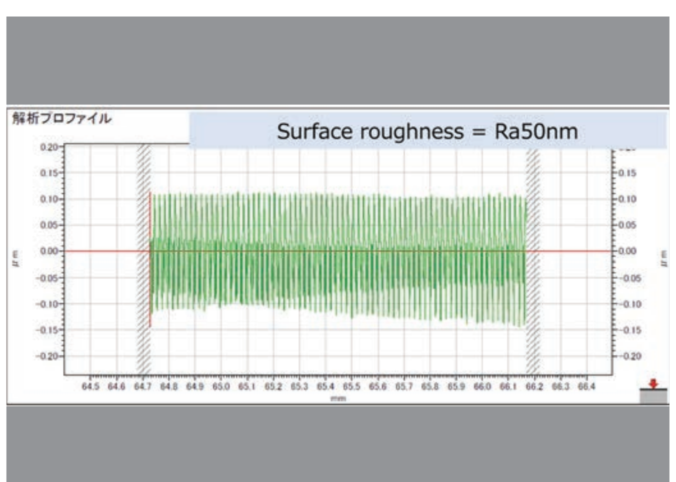


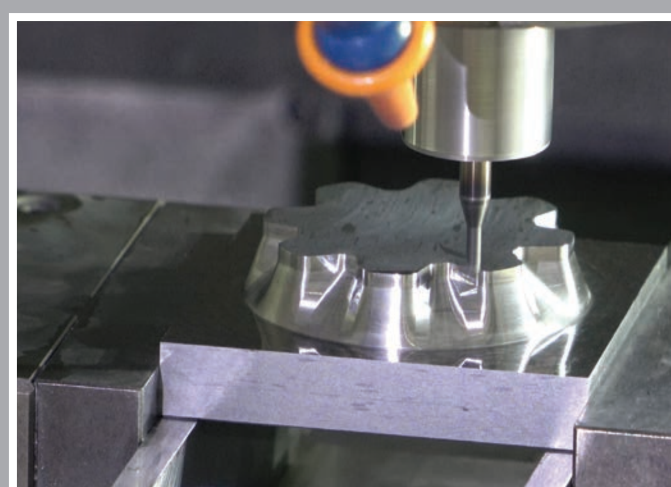
Cutting condition

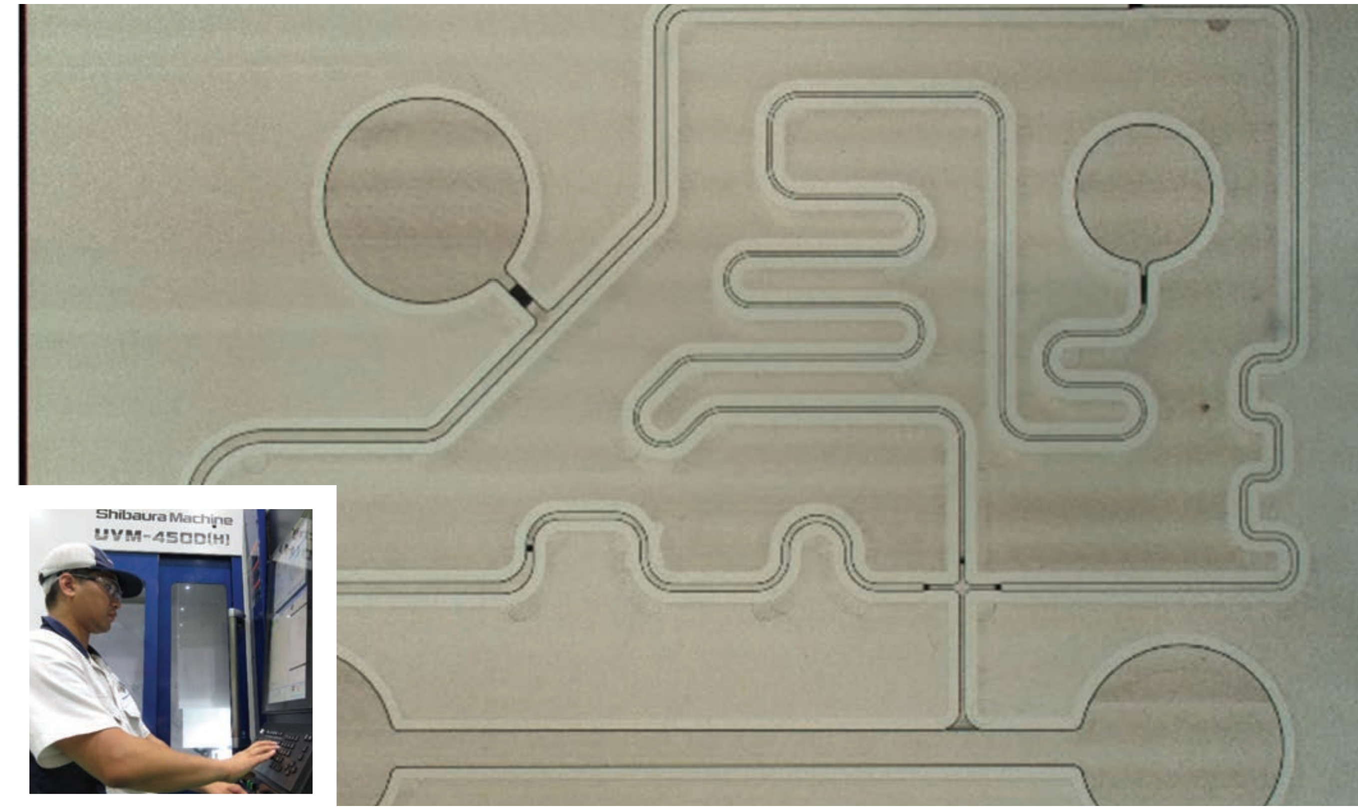
Work Material	Cemented Carbide
Tool	Diamond coated tool D2.0+R0.1mm
Rotation Speed	20000min-1
Feed	190mm/min
Depth of Cut	2μm











FROM INSIDER #2

MICRO CHANNEL

THE SURFACE ROUGHNESS OF THE WORK IS LESS THAN RA 5 NM. THE SHAPE ERROR OF THE WORK IS LESS THAN 1 MICRON IN BOTH HEIGHT AND WIDTH.

TEXT
TOMOYASU MAKIDA

Recently, in the field of chemistry, as analytical instruments become smaller, demand of microfluidic devices and microreactors that consist of micro channel paths are increasing. The mold was made by UVM-450D(H) with an aerostatic bearing spindle and a linear motor. The surface roughness of the work is less than Ra 5 nm. The shape error of the work is less than 1 μm in both height and width.

Demand for analysis and mixing using small amount of samples are increasing with the aim of speeding up analysis and reduction of environmental and human load. It means that interest in microfluidic devices to analyze with a small sample and microreactors to mix is growing. Both of them are composed of high precision micro channel.

The width and height of the micro channel is several to several hundred μm. In such a minute region, the surface roughness have an affect on the operating characteristics of the fluid. Thus, the molds are required to have a surface roughness on the nanometer order.

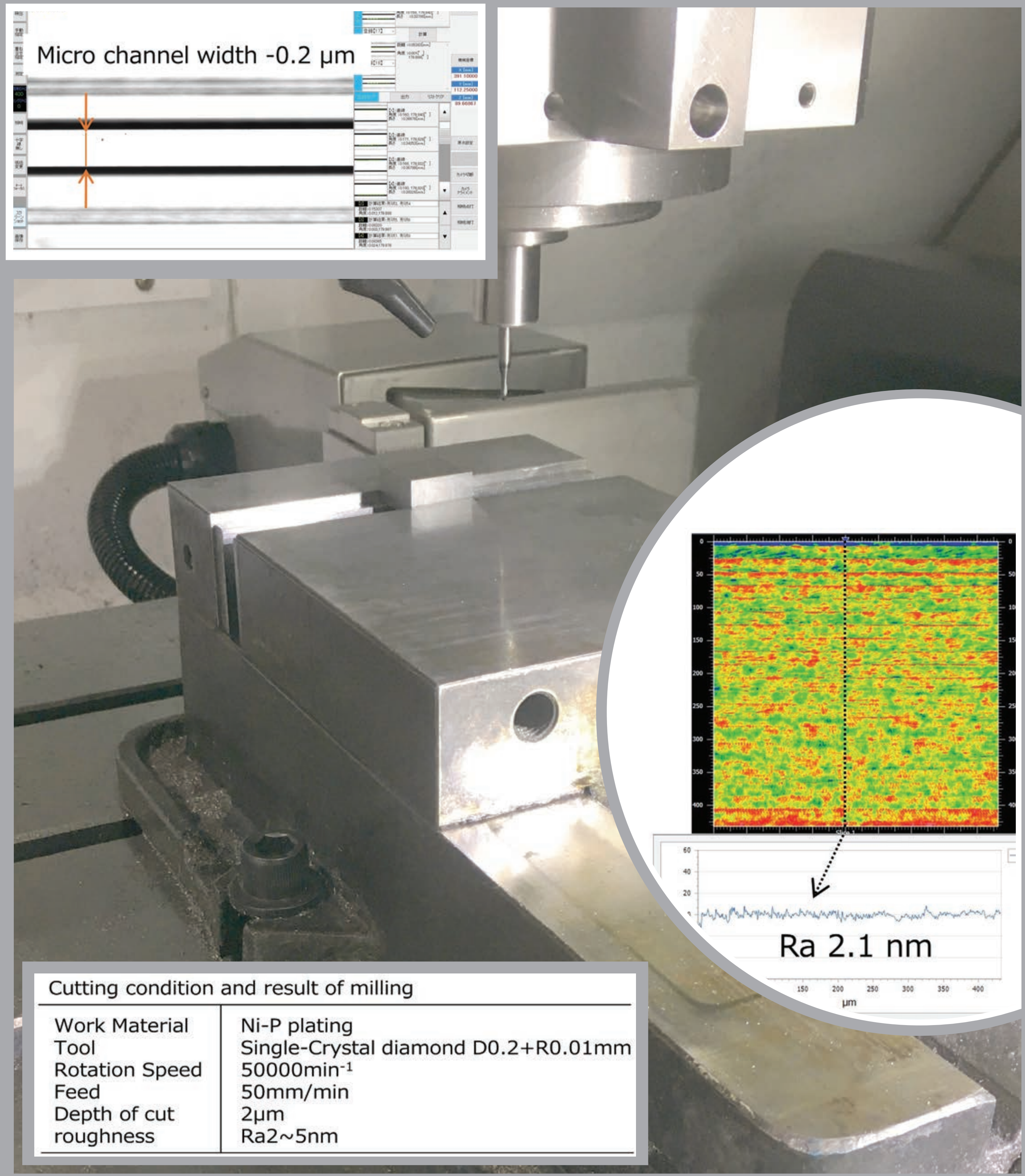
The micro channel mold was made by UVM-450D(H) of high-precision machining center with an aerostatic bearing spindle and a linear motor. The used tool was a single-crystal diamond radius end mill with a diameter of 0.2 mm and a corner radius of 0.01 mm. The spindle speed was 50,000 min-1, the table feed was 50 mm / min, and the depth of cut was 2 μm. The used work material was electroless Ni-P plating.

The UVM-450D(H) can be equipped with a microscope, which allows the micro channel width to be measured without removing the work. This system makes easy to confirm the current value of the micro channel width and calculate the difference from the target value.

In addition, The UVM-450D(H) can measure tool contour shapes, allowing you to measure tool shape errors and wear.

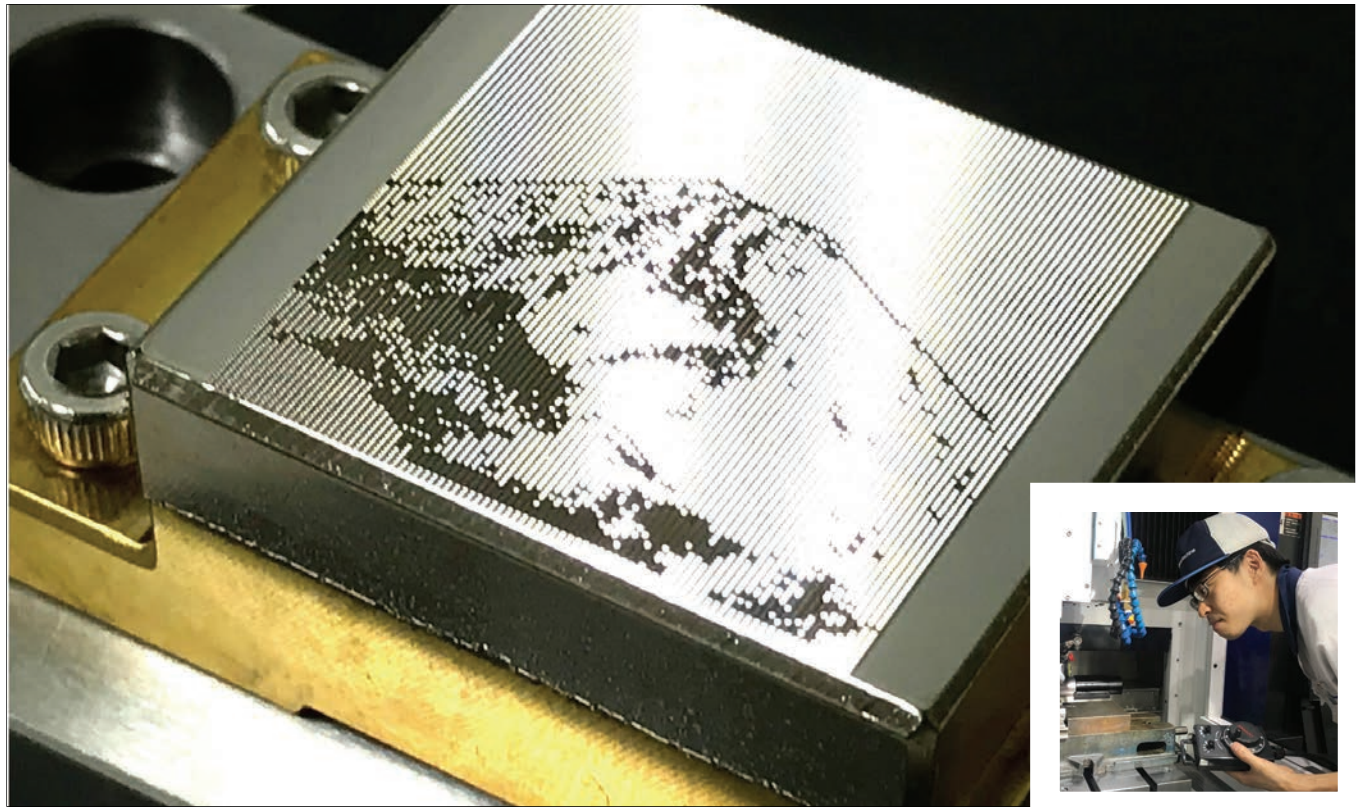
The surface roughness of the work is less than Ra 5 nm. The shape error of the work is less than 1 μm in both height and width.

The UVM series can machine complicated shapes with high precision, so it can be used for various type of micro channel mold. Therefore, it is expected to play an active role in a wide range of fields such as analyzers in the cell field and drug synthesis in the pharmacy field.



Cutting condition and result of milling

Work Material	Ni-P plating
Tool	Single-Crystal diamond D0.2+R0.01mm
Rotation Speed	50000min^{-1}
Feed	50mm/min
Depth of cut	2μm
roughness	Ra2~5nm



FROM INSIDER #3

REFELEX REFLECTOR

UVM MACHINING CENTER CAN BE APPLIED TO VARIOUS REFLECTOR MOLDS. FOR EXAMPLE ,REFLEX REFLECTOR MOLD IS CREATED BY 4-AXIS DIAMOND SHAPER CUT.

TEXT
RYOTA HISA

UVM machining center can be applied to various reflector molds. Aerostatic bearing spindle which has a function as a servo axis makes UVM machining center possible to achieve high-precision multi-axis synchronous operation. For example ,reflex reflector mold is created by 4-axis diamond shaper cut. Since it is required to have mirror finishing surface and sharp-corner edge, It used to be challenging to make reflex reflector mold with machining center

Reflex reflector molds for automotive is required to have mirror finishing surface and sharp-corner edge because high reflection rate and wide valid reflection area are most important elements for the mold. In a conventional process for reflex reflector mold making ,each cube which called arrow shape mold is made one by one by hand and combine them into a electrocasting mold. These process which include reassembling a electrocasting mold by hand for adjustment takes very long time (90~120days) and it prevent production lead time shorter.

We propose a new process to make reflex reflector using UVM machining center by 4-axis shaper with single-crystal diamond tool.

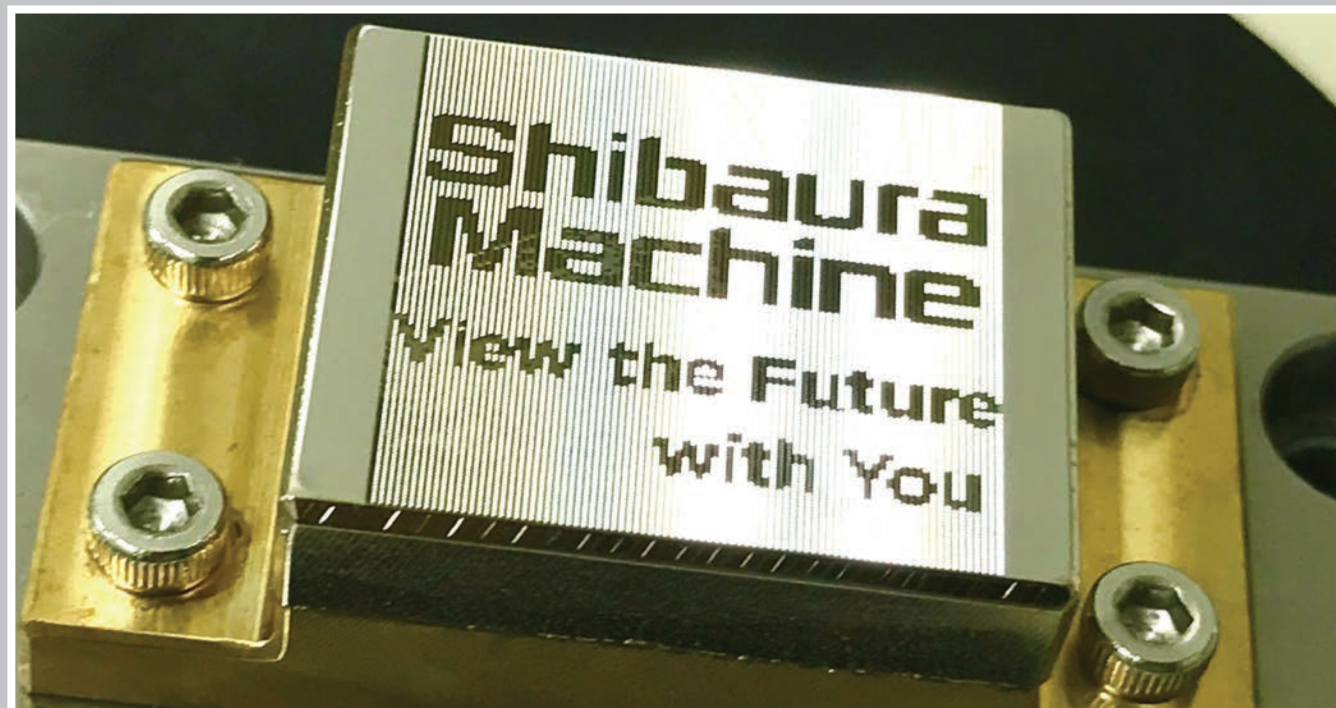
Reflex reflector is created by 4-axis XYZC diamond shaper cut. Indexing C-axis control makes it possible to freely design the direction of the reflective surface. Reflex reflector made by UVM machining center has sharp corner without fillet R because of using sharp edge single-crystal diamond tool .

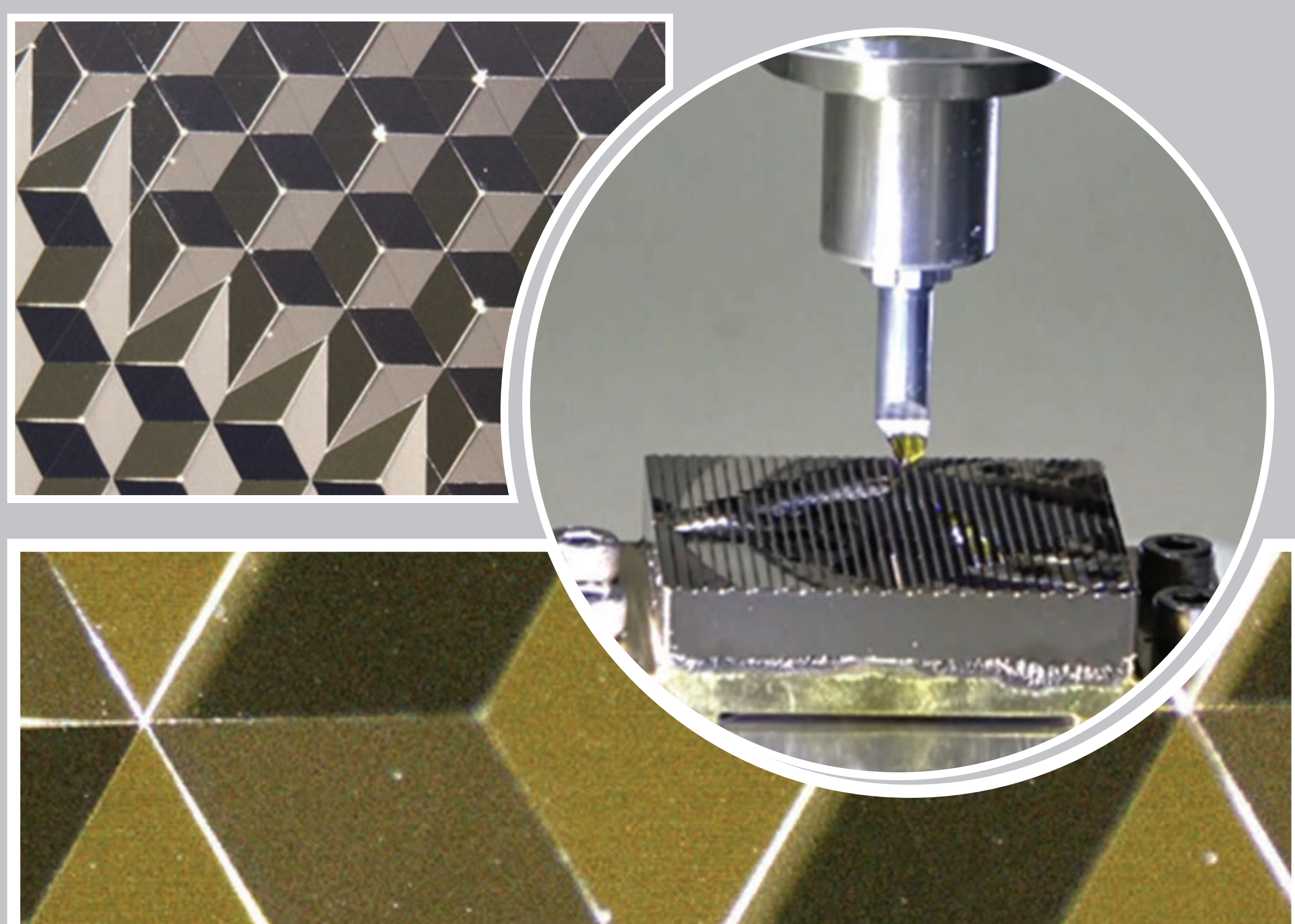
this process is not only production lead time shorter but also contribute to mold making process without manual work.

In this article, to show how advantageous reflex reflector making process with UVM machining center, we made seamless reflex reflector that a length of a side of each corner-cube is only 0.1mm that never be able to be made by hand.

As attached image, every single corner cube has sharp-corner and seamless shape even for complex shapes that combine multiple pattern shapes.

UVM machining center can be used for milling processing and shaper finishing even the above special shape. When changing the cutting processing, the trouble of changeover can be reduced by using options for automation (Tool changer, Tool length measurement device, Touch sensor). By taking advantage of large table working surface, large-sized mold can be produced the complex shape. UVM machining centres can provide an efficient machining process that combines high precision machining operations with high versatility.





FROM INSIDER #4

VR GOGGLES

BY USING OUR UVM SERIES AND ULTRASONIC ELLIPTICAL VIBRATION CUTTING, IT IS ABLE TO ACHIEVE ENOUGH ROUGHNESS FOR VR GOGGLES THAT CANNOT BE ACHIEVED BY PROCESSING WITH END MILLS.

TEXT
TOHRU SAITO

VR Goggles that allow you to easily experience Virtual Reality have been spreading in recent years.

Besides the games, contents such as 3D video compatible videos and 360 degree videos now become enjoyable at home.

It is also attracting attention in the education, medical industries. By using our UVM series and ultrasonic elliptical vibration cutting, it is able to achieve enough roughness for VR goggles that cannot be achieved by processing with end mills.

TO DO: VR goggle molds are required to shorten polishing time and smaller shape collapse due to the polishing.The work material is STAVAX, a steel for plastic mold made by Woodenholm company in Sweden. Hardness is about to HRC50. STAVAX is a chromium-alloy stainless steel cutter with excellent corrosion resistance and abrasion resistance. It is also well known as its finishing beautiful mirror surface, but it is a metal that is generally considered hard to cut. Although it is a mirror-like material when polished, it is generally difficult to make the finish roughness smaller than Ra100 nm processing with end mills because of its high processing hardening. It takes a lot of time to polish, and there is a problem with shape collapse.

About UVM: Using UVM-700E (5AD), a five-axis machine with a tilt head (A axis) and a rotation table axis (C axis).UVM is equipped with an aerostatic bearing spindle and has a maximum speed of 60,000 rotations. A high-speed spindle with sufficient rigidity and torque in processing by end mills. Equipped with a high-resolution scale and linear motor driven with a minimum setting unit of 10 nm, high-precision and smooth movement can be achieved.

Processing Method: There are two different processing methods.(ultrasonic elliptical vibration and milling). The side surface of the mold is cutting by PCD ball end mill. As using the PCD, a processing surface close to polishing is capable even if cutting on the steels. The TOP surface is cutting with ultrasonic elliptical vibration cutting. By repeating 40,000 vibrations per second, since the cutter wear due to heat can be suppressed, single crystal diamonds can be used.

Result: The surface roughness was measured by ZYGO Nexview NX2 and the result was Ra5~10nm (Rz30~70nm). The form accuracy was measured by MICURA 5/5/5 (3D measuring instrument) and the top surface was ±2 μm.

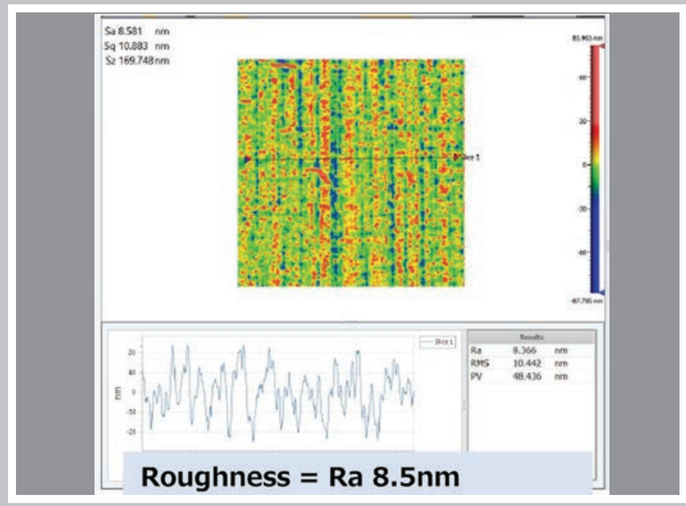
Consideration: The combination of a 5-axis linear motor machine and an aerostatic bearing spindle allows cutting to avoid cutter 0 points (the position of the cutter with zero cutting speed, consistent with the center of the cutter's rotation).In addition, by using ultrasonic elliptical vibration cutting, the steel material can be "cut with single crystal diamond" and can be finished at Ra10 nm only by cutting.As a result, the polishing time can be shortened and the shape error can be reduced.These combinations increase the possibility of shortening polishing time or non-polishing processing in various molds.

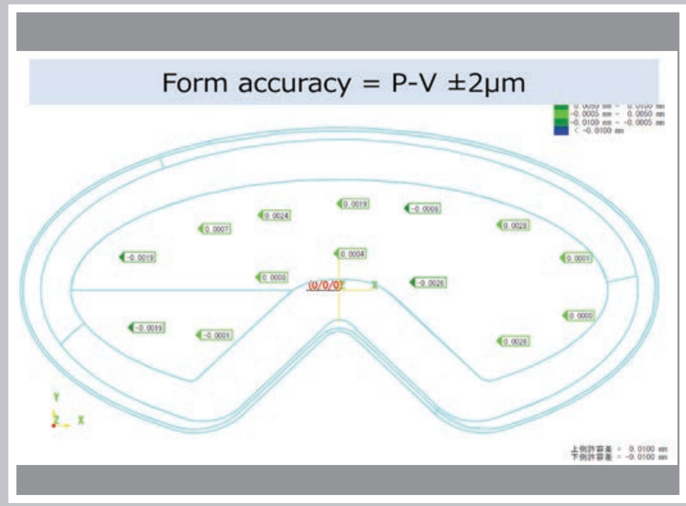
Cutting condition and result of milling

Tool	PCD R2.0mm
Rotation Speed	50000min^{-1}
Feed	800mm/min
Depth of cut	0.5μm
roughness	Ra10nm

Cutting condition and results of cutting

Tool	Single-Crystal Diamond R2.0
Feed	1000mm/min
Depth of cut	5μm
Roughness	Ra5~10nm
Form accuracy	P-V ±2μm





FIELD #1

NS TOOL

NS TOOL, a Japanese tool manufacturer specializing in the production small diameter end mills, with nearly 9,000 types of standard end mills. Our products include MUGEN COATING series, which is widely used in the cutting field, and MUGEN COATING PREMIUM series, which can be used for direct machining of hardened steel. We have a wide range of products that are highly appreciated by our customers.

In order to meet the common problem of "how to maintain stable and high precision even in long-time machining", we have developed a series of PCD milling tools that make it possible to achieve nano-level mirror finish machining.

This newly developed milling tool uses "Poly-Crystalline Diamond" as the tool material, especially the improved PCDRB, which can process a wide range of materials, from tempered steel to tungsten carbide, etc., with perfect mirror finished surface.

This article will focus on the PCDRB series of tools for mirror surface processing.

PCDRB has designed a special cutting edge shape and developed many related processing technologies to achieve nano-level finishing surfaces with milling process.

The machining range can be from tempered steel to hardened steel, and even Cemented-carbide can be machined directly.

The picture of the tool shown in Fig.1 is an enlarged view of PCDRB tool tip.

FOR MIRROR FINISH POLY-CRYSTALLINE DIAMOND BALL END MILL SERIES PCDRB (R0.05-R1)

FIG.1 PCDRB

FIG. 2 PCDRB PROCESSING SURFACE

Fig.2 shows the stable mirror finish of the machined surface after more than 114 hours of finishing with one PCDRB.

The amount of tool wear is less than 1μm.

FIELD #1

NS TOOL

THE AMOUNT OF TOOL WEAR IS LESS THAN 0.001MM.

Process	Roughing		Semi-finishing	Finishing
Tool	MRBH230 R2.0×8	MRBH230 R1.0×6	SSPB220 R1.0×5	PCDRB R1.0×5
Spindle speed (min^{-1})	20,000	20,000	40,000	40,000
Feed rate (mm/min)	2,000	1,500	1,000	1,000
Depth of cut (mm)	ap 0.2 ae 1.5	ap 0.05 ae 0.05	ap 0.02 ae 0.02	ap 0.005 ae 0.005
Stock (mm)	0.05	0.02	0.005	-
Time	9hrs 49mins	6hrs 33mins	26hrs 57mins	114hrs 49mins

TABLE 1 CUTTING CONDITIONS

Measurement position	Ra[μm]
① Parting line	0.028
② Product surface	0.026

TABLE 2 MEASUREMENT RESULT

DIFFERENCE OF MACHINED SURFACE QUALITY BY COOLANT

In order to verify the effect of coolant on mirror surface machining with a PCDRB, comparative machining was performed using four types of coolant: soluble, emulsion, oil mist, and water in-soluble cutting fluid on the polyhedral shape (STAVAX 52HRC) shown in Fig. 3.

Cutting conditions are shown in Table 3. As shown in Fig. 3, the surface roughness value was the smallest with Ra 0.024 µm when using water in-soluble cutting fluid, and the surface roughness value was the largest with Ra 0.071 µm when using soluble. It was confirmed that the surface roughness value tended to be larger when water soluble cutting fluid (soluble and emulsion) was used.

it is important to select a coolant that meets the required accuracy.

Process	Roughing	Semi-finishing	Finishing
Tool	MRBH230 R0.5×2.5	SSPB220 R0.5×2.5	PCDRB R0.5×2.5
Spindle speed (min^{-1})	40,000	40,000	40,000
Feed rate (mm/min)	2,000	1,500	1,000
Depth of cut (mm)	ap0.1×ae0.3	pf：0.03&0.01※1 Stock：0.01	pf：0.005 Stock：0.005
Coolant	Oil mist※2		

TABLE 3 CUTTING CONDITIONS FOR "COOLANT DIFFERENCE" AND "PICK-FEED VERIFICATION" AT SEMI-FINISHING

REMARKES
*1 PF:0.01MM FOR VERIFYING COOLANT DIFFERENCES,
PF:0.01MM&0.03MM FOR PICK FEED VERIFICATION ON SEMI-FINISHING
*2 SEMI-FINISH PICK FEED VERIFICATION

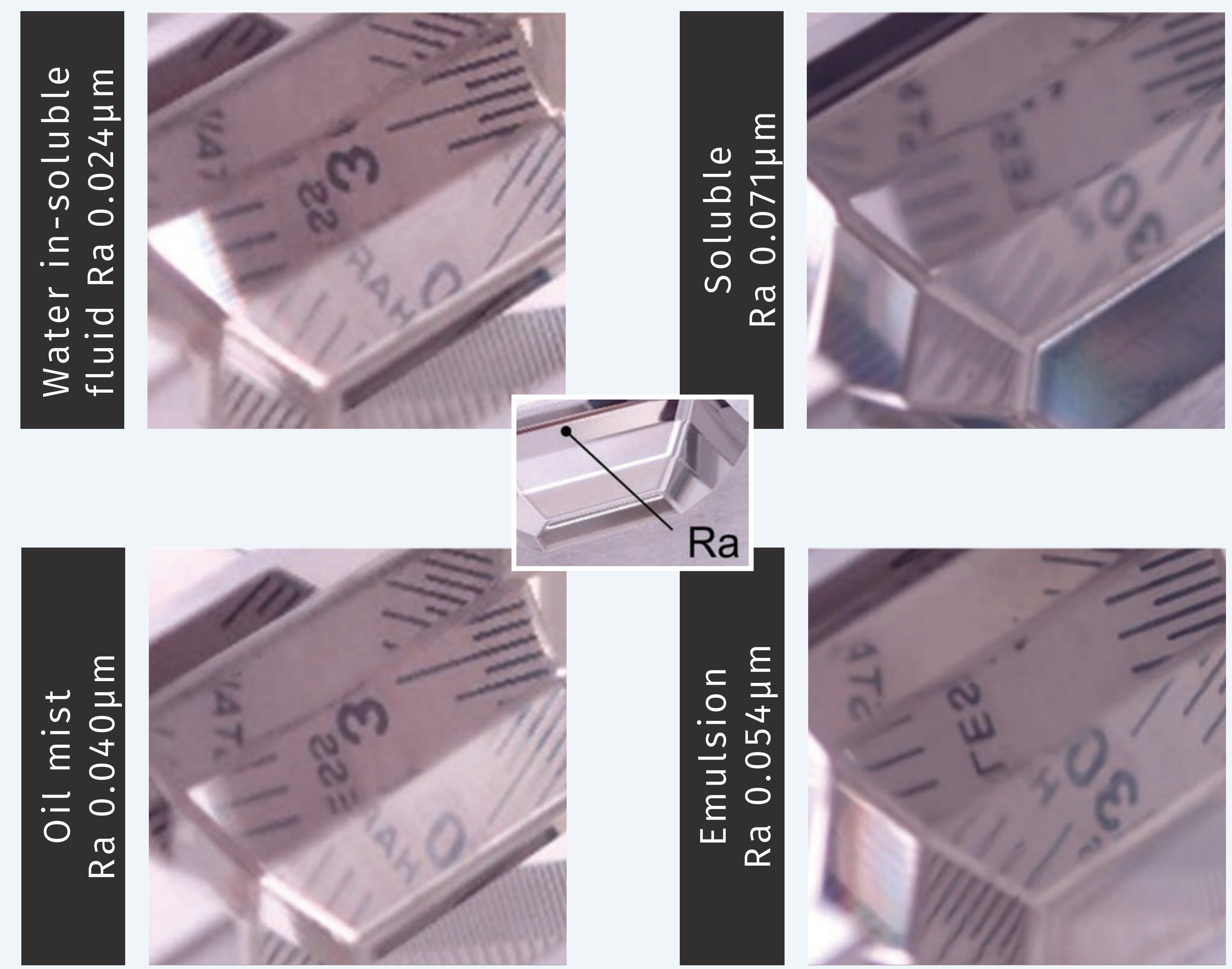


FIG. 3 EFFECT OF COOLANT COMPARATIVE VERIFICATION RESULTS (MACHINING AREA: 23 X 10 MM)

Effect of Semi-finishing accuracy on the finished surface

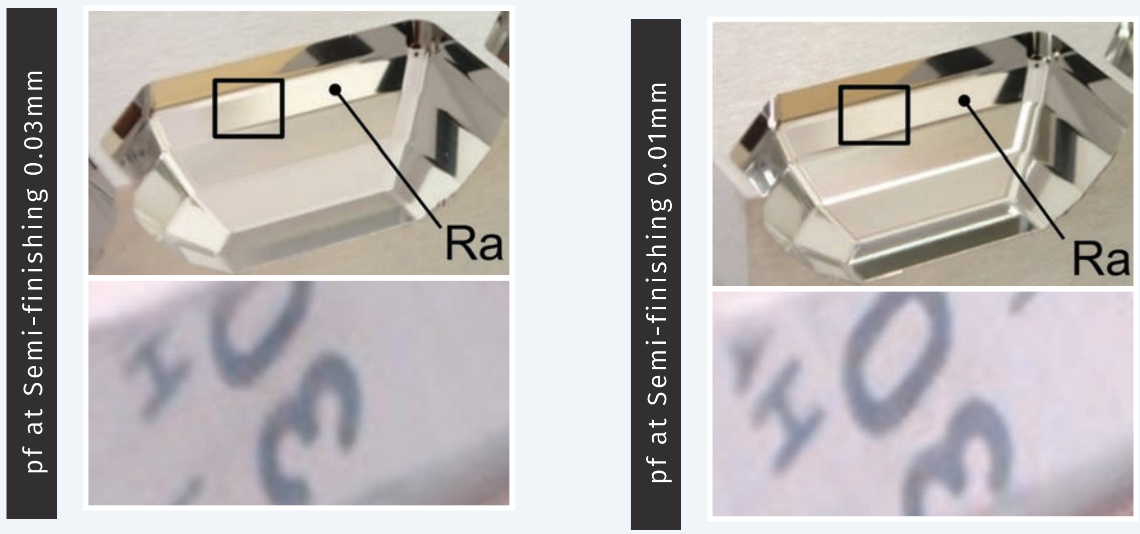


FIG. 4 EFFECT OF PRE-MACHINING ACCURACY COMPARATIVE VERIFICATION RESULTS (MACHINING AREA:23×10MM)

In order to verify the effect of Semi-finishing process accuracy, two types of cutting conditions were set such as pick feed of 0.03mm and 0.01mm for semi-finishing on a polyhedral shape (STAVAX 52HRC) of the same shape as in Fig. 3, and the effect on finishing was compared.

The tools used and cutting conditions are shown in Table 2. As shown in Fig. 4, it was found that setting a smaller pick-feed during semi-finishing resulted in a smaller value of finished surface roughness Ra, which was closer to a mirror surface.

From this result, it can be said that it is important to set the appropriate semi-finishing accuracy according to the required accuracy.

Setting the allowance according to the cut point

In order to verify the actual allowance for shapes that use the area around the tool tip, such as flat areas, two allowance settings of 0.002mm and 0.005mm were used.

As shown in Fig. 5, the results showed that the 0.002mm allowance was closer to the target value.

The surface that machined at the 0.005mm stock allowance setting showed unevenness due to adherence to the tool, and the tool tip was worn. Near the tip of the tool, abrasion due to adhered materials and uncut value by tool deflection are likely to occur, and

FIELD #1

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The mirror finish is also expected to deteriorate. Therefore, it is important to set the optimum allowance according to the machining area.

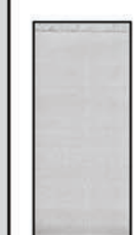
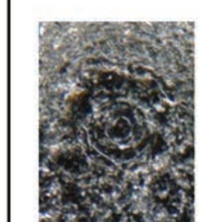
Tool	PCDRB R0.5×2.5					
Cutting condition	n:18,000min^{-1}, vf:50mm/min, pf:0.005mm					
Stock allowance	0.002mm			0.005mm		
Result	Machined surface	Tool wear after machining (Tip)	Actual stock allowance and surface roughness	Machined surface	Tool wear after machining (Tip)	Actual stock allowance and surface roughness
			Actual stock allowance 0.0014mm Surface roughness Ra:0.023μm Rz:0.113μm			Actual stock allowance 0.0023mm Surface roughness Ra:0.057μm Rz:0.283μm

FIG.5 GROOVE MACHINING CONDITIONS, MACHINING ACCURACY AND TOOL WEAR

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SHIBAURA JAPAN

The Shibaura Machine Group respects human values. The Group's mission is to contribute towards building the foundation for industry through creating an abundance of wealth and helping to improve people's lives and cultural development.

We started business in 1938 as Japan's first large-scale machine tools maker. The brand name "Shibaura" has been used and refined since the establishment to support manufacturing processes of our customers, mainly in the machine tools industries all over the world.

We would like to introduce where we are located and how we are coexisting socially.

SHIBAURA JAPAN

OUR HEADQUARTERS ARE LOCATED IN TOKYO AND NUMAZU.

NUMAZU WHERE WE ARE IS THE MAGNIFICENT SCENERY OF MT. FUJI.

SHIBAURA JAPAN

STUDENTS WILL BE RESPONSIBLE FOR MONOZUKURI IN THE FUTURE.

WORK PLACE FOR CASTING

SHIBAURA MACHINE IS HAPPY TO GET REQUESTS FROM SCHOOLS FOR WORKPLACE EXPERIENCE DAYS FOR THEIR STUDENTS.

THEREFORE, AS AN ACTIVITY TO PROVIDE STUDENTS WITH AN EXPERIENCE THAT HELPS TO DEVELOP DESIRABLE WORK AND EMPLOYMENT TRAITS, SHIBAURA MACHINE ACCEPTS REQUESTS FROM SCHOOLS FOR WORKPLACE EXPERIENCE DAYS FOR THEIR STUDENTS.

SHIBAURA JAPAN

31 EMPLOYEES PARTICIPATED IN A PLANTING EVENT SPONSORED BY MT. FUJI NATIONAL TRUST (INCORPORATED NON-PROFIT ORGANIZATION) AT THE GOTEMBA ENTRANCE TO THE MOUNTAIN. THIS ACTIVITY IS INTENDED TO PREVENT, BY MEANS OF GREENING, THE COLLAPSE OF THE SOUTHEAST FOOT OF MT. FUJI, WHICH BECAME A VAST GRAVEL LAND BECAUSE OF AN ERUPTION IN THE HOEI ERA.

WE PARTICIPATED IN A CENTRAL PREFECTURE ILLEGAL DUMPING ELIMINATION CAMPAIGN (KANAGAWA PREFECTURE). WE CHECKED ON ABOUT 2KM SECTION OF THE RIVERSIDE FROM THE SAGAMIGAWA FIELD TO ZAKAE BRIDGE, PICKING UP COMBUSTIBLE AND NON-COMBUSTIBLE WASTE WE FOUND ALONG THE WAY.

WE CLEAN THE AREAS AROUND OUR PLANTS EVERY YEAR IN ORDER TO CONTRIBUTE TO THE LOCAL COMMUNITIES AND THE ENVIRONMENT AND RAISE AWARENESS OF THE IMPORTANCE OF BEAUTIFICATION. IN FISCAL 2018, CLEANUP CAMPAIGNS WERE CONDUCTED AT TEN OF OUR SITES, INCLUDING AFFILIATED COMPANIES, WITH THE PARTICIPATION OF 1,072 PERSONS, INCLUDING EMPLOYEES AND THEIR FAMILIES.

WE AS SHIBAURA MACHINE GROUP AIM A TRULY ECO-FRIENDLY PRODUCTS KEEPING BOTH ENVIRONMENTAL AND HUMAN SAFETY AS OUR SUSTAINABLE DEVELOPMENT GOALS. WE CONTRIBUTE TO SOCIETY THROUGH OUR BUSINESS.

NANOJIN

Breackthrough

JMTBA

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