USER'S VOICE

Vol. 1

OKUMA
Vertical
Machining
Center
MB-V Series

An MB-V User Testimonial

Working toward a global standard—high-accuracy, confidence-inspiring machines

User Perspectives

Okuma engineers comment on customers' experiences

Development Story

Developers reflect on the making of the MB-V

Welcome to OKUMA

Impressions from new users

Stability, long-run accuracy, high rigidity, and speedy tool changing right from the start.
We asked the president of Kaibara Co., Ltd., Kaibara Goh, to tell us about the circumstances behind his company's introduction of the MB-V vertical machining center into their processing line, and about their impressions of the machine's performance.

Kaibara Co., Ltd.
President: KAIBARA Goh
Address: 1216-3 Nukatabe Kitamachi, Yamato Kooriyama, Nara Pref.
Scope of business: Materials development consisting primarily of copper alloys and aluminum alloys, design, and casting and forging, precision machining, and original design and manufacture of KC metal (oil less bearings) and KS bronze (oil retaining bearings).

"With Okuma's MB-V there's no need to worry about thermal deformation—a tremendous relief."

"Dimensional errors are not tolerated in the many important parts being used around the world."

Sliding machine parts formed mostly of bronze alloys are our main products, such as bearings for hydraulic equipment, cylinder blocks (construction machinery), bearing bushings and liners (press machines, bridges and dams) that maintain good contact conditions with the shaft, diesel engine parts and sealings for marine vessels, and worm nuts for elevator reduction gears. As you can see, our products are used across a wide range of industries and play a vital role in the heart of the devices in which they operate. They are used in extreme conditions and are subject to heavy loads and wear, grueling temperature changes, and water submersion, and therefore demand high accuracies, rigidity, and wear resistance.

Producing products such as these, we need machining centers with high-level cutting performance along with high speed so that lead time can be shortened. What is most important to us, however, is high machining accuracy. This is because if our products have defects, fail, or rapidly wear out—be it parts for hydraulic equipment or press or molding machines—the machine is brought to a halt. For this reason alone, quality assurance is needed for both materials and machining accuracy.

The number of regions using our products is steadily increasing due to the expansion of markets from globalization. For example, if you consider the large onus of conducting such after-sales service as parts replacement, repair, and exchange in expansive areas like North and South America, China, and the Middle East, it's easy to see why we cannot tolerate problems arising from dimensional errors in the products we ship. In the past, such errors occurred without incident in one out of every several ten thousand parts produced. When an error occurs now, however, we have to determine the cause of the problem by carrying out a 100% inspection. Considering this risk, we have to be really exacting about machine accuracy.

At present, we have some 120 machine tools in operation at our main plant, and, while the plant is air conditioned, we cannot fully eliminate the effects of ambient temperature changes from solar insulation throughout the day and by season or from heat generated between the machines themselves. Thus, we have to perform dimension corrections a number of times throughout the day depending on the workpiece.

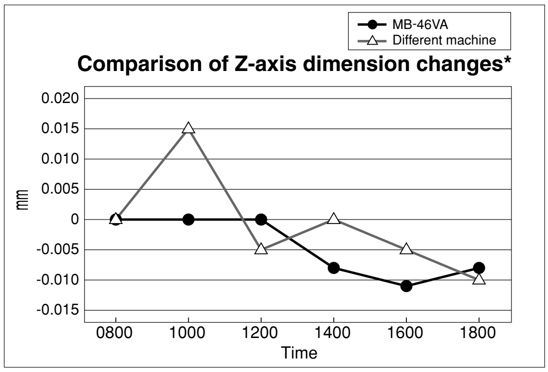
"The MB-V series machines have greatly reduced the time we spend performing dimensional corrections"

In our factory we have machining centers from several machine tool makers, including an Okuma MX-V vertical machine center that we installed previously. Our employees have commented that the MX-V is " well balanced and easy to operate," which led us to consider installing the successor to the MX for our next new machining line.

Our business manager informed us that the next-generation MB-V is equipped with a thermal deformation compensation system that gives the machine outstanding accuracy and keeps dimensional variations to less than 8-10 microns during long-run operation. Hearing this, both the plant manager and I were really excited about giving it a try. We were also exited because of the high regard in which our employees hold the LB300 CNC lathe that we had installed previously for machining hydraulic parts. Our machinists reported that "accuracy was very high because machining dimensional variations over time were smaller than expected. We had heard that the MB-V incorporated this same know how."

After installing the MB-46Vs we

The Kaibara plant has around 120 MCs—which include such powerful machining units as the MB-V as well as lathes—and machines various products ranging in weight from dozens of grams to several tons.



*Measured in environment where doors are often opened and closed.

Kaibara possess unique knowhow, from casting of original alloys to precision machining, and their products are made with unrivaled quality.

performed a faceplate-boring operation and measured depth dimension variations over time. The data showed extreme stability, as the dimensional variations were the smallest we had ever experienced.

Our workpieces are copper alloy and thus have high machinability, and while compared with a lathe the width tolerances are somewhat large, when machining them on the MB46-V, all we have to do is check the dimensions first thing in the morning after turning the unit on. After that absolutely no corrections are needed. In the past with other machines, we always had to check the dimensions after turning the machine on following the lunch break.

Also, our employees tell me that tool changeout on the MB-V is easier than it was on the MX-V and have stated that "from the users point of view, it is much improved and represents a very complete package." The MB-V therefore greatly reduces the daily workload of the employees who use it. The only thing I would mention is that because of the workpiece material that we use, a lot of chips are produced, so the rear cover and coolant unit could be arranged differently. Other than that, we are quite satisfied.

Recently, the trend is for customers to demand higher and higher accuracies and for drawings to show smaller width tolerances. I think this is why the MB-V's is highly esteemed for its high accuracies and reduced cycle times.

"We are establishing a strategic base in China and Okuma's MB-Vs will be a part of the production line."

At the end of this year, we will build our first overseas plant in Suzhou China, an industrial city in southern Jiangsu Province. This plant will feature a production line with a uniform system for casting and machining, just like that in our main plant. The probable destinations for our products will be overseas businesses, including local state-owned and Japanese enterprises, as well as the European, American, and Japanese markets.

On the domestic front, we have to resolve ourselves to severe price competition if we are to increase our market share. By operating in China we plan to reduce costs and advance into a larger market. For these reasons we decided to foray into China. We had actually discussed setting up operations in China ten years ago, but a look into the market showed it was still immature and we thus decided that the time was not right. After that, the economy and production in China experienced rapid growth that lead many auto manufactures to set up operations there. This led to a severe demand for higher accuracies from the parts industry.

This turn of events set the stage for a production environment in need of our materials know-how and machining accuracy. We will use MB-46Vs in our Suzhou processing line in order to set our sights on the world market and meet the need for high-precision products that that market demands.

Nearly one hundred percent of our workers will be local people, and we therefore need machines that are stable and highly accurate even if being operated by inexperienced users. Fortunately, because the weather in Suzhou is similar to that in Japan, dimensional variations over time can be kept within the tolerance ranges and large-scale air conditioning does not appear to be necessary. Later, once the new plant is on track, we are thinking about dividing production by making small- and medium-size products at the Suzhou plant and single piece and large-size products in Japan. No matter which we go, we have to develop the Suzhou plant as a strategic base that will allow us greater and more rapid advancement into the global market. The level of technology in China is sure to continue increasing, so we really have to get the most out of our MB-V machining centers.

By SAKAMOTO Atsunori.

User Perspectives

Okuma engineers comment on Users' experiences — *Okuma MCs* —

The Okuma Engineers

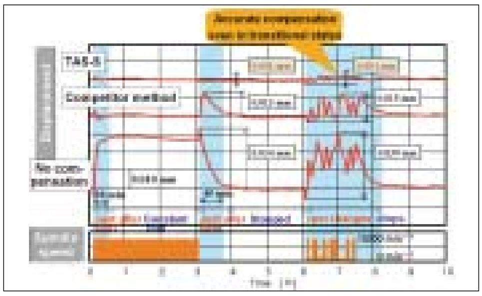
SATO Reiji	Mechatronics Module Development Group, R&D
NIWA Yasuharu	Design Dep
MASUDA Tomoyuki	Design Dep
NONAKA Kouzou	Design Dep
HIOKI Katsuya	Software Engineering, IT Products Dep

"One-micron precision machining in temperature controlled rooms."

It's the machining centers that carry out the precision machining which determines the performance of the end product, so we install them in rooms were the temperature is constantly controlled at 23°C. But even then the heat from cutting and electric motors affects machining dimensions by several microns, so frequent dimensional corrections are required. What really surprised us after installing the MB-56VA (25,000 min^{-1}; Super NURBS) was that, even after changing tools, there were no Z-axis machined surface steps. We were also surprised by the average 20,000 min^{-1} and 10-m cutting feeds. All together, we were able to get 40% shorter cycle times, reduce our dimension-correction workload and get a remarkable improvement in productivity.

FURUTA Nobuhiko (Itabashi-ku, Tokyo)
Executive Director of Gikenseiki Co., Ltd.

Okuma engineer comments—
"Real-time compensation in units of 0.1 micron via spindle thermal deformation control TAS-S."*



*TAS-S: Thermo-Active Stabilizer--Spindle

As the spindle turns, the shaft bearings and motor generate heat. There is a limit to the heat-inhibiting effect if only the heat-generating parts of the machine are cooled. This is why we developed the TAS-S spindle thermal deformation control, which regulates thermal displacement by NC. This function regulates all machining conditions, such as spindle start, stop, and, speed, to control thermal deformation through Okuma's independently-developed (patented, Japan Society of Mechanical Engineers award-winning) system--developed after years of basic experiments. The system performs fine-resolution compensation of thermal growth in real time in units of 0.1 micron. In addition, with the control system built-in, the customer can therefore use the machine without worrying about the operation of the TAS-S.

(SATO Reiji, Mechatronics Module Development Group, R&D)

"Speed and accuracy that surprised even our experienced machinists, and the effects of heat from chips are handled quite well."

UNO Hikoya (Wako City, Saitama Prefecture)
Executive Director of Yagishitagiken Co., Ltd.

We installed the MB-56VA machining center (15,000 min^{-1}) for the primary purpose of streamlining our production of precision automotive parts and to achieve higher accuracies. The MB-56VA cut aluminum and magnesium so fast even our machine shop veterans were a bit surprised. They were also surprised with the machine's stability and Z-axis dimensional variance under 10 microns. Also, the heat generated during high-speed cutting is carried away by the chips, even when cutting hard materials. As a result, the workpiece is almost completely unaffected by heat. We have young college graduates operating our MB-V series machines, who, being of the computer age, seem to get a feel for the OSP really quickly. These days, to meet quicker delivery times even for complex, three-dimensional workpieces, the MB-56VA gives us a dependable competitive edge.

Okuma engineer comment—
"Construction that keeps chip heat away from the bed, and a user-friendly OSP built for tough machine shops."

The important factors are a machine construction and spindle that effectively handle thermal deformation, and immediately discharges hot chips before the heat they carry is transmitted to the machine. Okuma's MB series fits this bill, as it is configured with an angular telescopic covers, right- and left-side chip flushers and conveyers for quick chip discharge away from the main body. In addition, the chip conveyors are not directly attached to the bed; rather, they float within an independent suspension structure to make it difficult for heat to be transmitted to the bed. Moreover, the conveyor drive motor is placed outside the unit so that motor heat also is not transmitted to the machine.

And, the OSP control system has been designed so that customers can intuitively operate the machine, from part programming to actual cutting. We accomplished this by having our own machinists test the system to incorporate their ideas, to make sure it had the "right feel" in actual applications.

(NIWA Yasuharu, Design Dep)

“Die and mold machining with almost no polishing required.” “Reduced setup times allowed us to expand our client list.”

Demand continues to increase for higher accuracies and shorter delivery times in plastic die-mold machining. Given these conditions, we judged our existing equipment to be insufficient and therefore installed Okuma’s MB-46VAE (15,000 min^{-1}; Super NURBS), as we like its double-column construction. It maintains stability and dimensional accuracy to within 10 microns even after continuous operation for 24-36 hours. Previously, in making dies and molds we had to re-machine about two times, but with the MB-V we can almost eliminate the polishing step—which really saves time. In fact, we depend more on the MB-V then we do our electric discharge machine, as it is difficult to calculate product finish time. After using MB-46VAE, we also found that the position and operability of the tool magazine were really well thought out, as was the configuration for tool change standby during machining—all of which gave us a big boost in productivity.

SUZUKI Katsuhiko
(Hazugun, Aichi Prefecture)
President of Miki Molds Ltd.

Okuma engineer comments—
“From rapid traverse to tool-change time, we reduced non-cutting time 35% compared with conventional machines.”

The key to improving productivity is reducing non-cutting time. We therefore made it easier to mount tools in the magazine and thoroughly applied ourselves to improving ease of operation, including cutting capacity capability and setup, by configuring the MB-VAE with 40 m/min rapid traverse and 0.7 G acceleration along with 1.2 second tool-to-tool time in the ATC. Moreover, the operational features requested by users are reflected even to the smallest details, such as table height and access designed to make tool and setup changes easy. To do this, engineers took tape measure in hand and discussed design ideas while measuring tools and workpieces.

(MASUDA Tomoyuki, Design Dep)

“After doing a core cutting test under side milling conditions, the amazing speed and brilliance decided it for us—we got the MB-56VB.”

We manufacture aircraft parts from machining pure aluminum and forged workpieces. When we were looking around for a machining center to improve our productivity, the MB-56VB caught our eye. We were a bit uncertain about how it would handle heavy cutting, so we performed a core cutting test by end milling a workpiece. The machining speed and finished product were absolutely great and we decided to get it for our plant. It has no hydraulic unit and operation speed and feed rate are the same night or day, and because rapid traverse and tool changes are really fast, we have been able to cut the machining time of some of our products by one third. Table height and access are well thought out ergonomically, so it is easy to use by all our employees.

KIKUURA Hiroyuki (Nagoya, Aichi Prefecture)
Plant manager of Kato Seisakusho Co., Ltd.

Okuma engineer comments—
“Established double-column construction, solid linear ways, and powerful motors for stable cutting.”

Featuring a well-established double-column main body and ram-type saddle feed, the MB-56VB has a sensibly designed structure with little overhang from slideway to machining side, together with thick, unitized linear ways for outstanding rigidity. In particular, while it can be difficult to reduce the weight of the ram saddle and maintain rigidity, we carried out repeated FEM (finite element method) analysis until we were able to ensure rigidity even for heavy cutting. Rigidity is high enough to control up to 199 Nm of spindle torque, making stable cutting no problem at low or high speeds.

(NONAKA Kouzou, Design Dep)

“Our productivity was greatly enhanced thanks to the MF-46VA's ability to rapidly perform complex contouring without errors.”

Using a horizontal machining center, we were producing 10 to 30 precision parts a month for use in semi-conductor manufacturing equipment. But, because of angle plate tilt, we were seeing Z-axis dimensional errors of 20 to 30 microns. We decided a new MC was required to solve this problem. We went with the MF-46VA (15,000 min-1; Super NURBS) vertical machining center equipped with a pallet changer, as it wouldn't break our pocket book and featured front and rear machining. The MF-46VA solved our dimensional-error problem. On top of that, even though we do a lot of three-dimensional grooving, it reduced our cycle time 30%.

MAEDA Toshikazu
(Izumi City, Kagoshima Prefecture)
President of Marumae Co., Ltd.

Okuma engineer comments—
“The MF-46VA merges high-speed, high-accuracy machining with Super-NURBS.”

Super NURBS ensures consistently accurate machining even in two- and three-dimensional contouring, and smoothly controls tool movement at near-maximum speed. It improves machining accuracy over conventional machines and realizes faster average feedrate, while also greatly shortening cutting and finishing times. In developing Super NURBS, we were careful to make sure that operation and functionality, including manual operation, were the same as in past machines. We did this by paying special attention to user friendliness. Marumae Co., Ltd., is using Super NURBS control, which has allowed them to reduce cycle time from 7-15 hours to 5-10 hours.

(HIOKI Katsuya, Software Engineering, IT Products Dep)

Development of the MB-V series

(Designer's story 1)

The Ace Center MB-V series was developed as the successor to the MX series of vertical machining centers.The many high-performance features in the MB-V machines were born from a combination of enthusiastic ideas from engineers and a bit of good fortune. The project team worked long and hard until they got the results they wanted, and Project leader Hori Yasunori talks about the development process.


HORI Yasunori

"The first thing that will surprise you is the basic performance, followed by the outstanding stability and accuracy."

"Let's return to the basics and redesign the whole machine."

At the start, the goal was to design a successor to the MX-V series of vertical machining centers, which had hit the mark for superior cost performance. Of course the new machine specifications had to be appropriate to those of a next-generation machine; so we reevaluated everything, from machining capacity to rigidity, accuracy, operability, and cost performance.

We took a look at how the MX series was being judged in the marketplace, and heard "can't you give it greater stability and accuracy?" Customers wanted a machining center that would eliminate the need for grinding, that could change from a dedicated finishing machine to a general purpose machine, and that boasted minimal dimensional changes from thermal deformation during long-run operation.

However, the primary causes of thermal deformation that affect accuracy are (1) ambient temperature changes in the factory. (2) heat generated by the machine, and (3) heat generated during machining. Moreover, there is a complex interaction among these three; thus, a single solution is not possible.

Considering this, we first decided to return to the basics of machine design. Machines were originally designed so that there would be a minimum of heat generated. Now, however, greater complexity has been introduced into designs—such as the addition of cooling systems to control heat arising from the increases in operation speed and covers for safety, which increase heat retention within the machine. The result is thermal deformation conditions that are extremely difficult to understand. We wondered how we could simplify things.

At that time, we heard that the Mechatronics Module Development Team was visiting MX users to gather data for research on such factors as spindle thermal deformation, so we had a group meeting and looked in on their progress. (see "The breakthrough..."). I guess you could say we were lucky because the timing for the mechatronics module development and research and development was right on—we got many important ideas and data from them. Their suggestions were also very helpful, "Why don't you take a closer look at the former VH-40 vertical machining center? It had little thermal deformation" or "The expansion and contraction of the metal can be best analyzed if you use a simple block structure."

"A simple, modular structure for higher accuracy."

By relaying information and ideas back and forth with the Mechatronics Module Development Dep., we gradually settled on the design for the MB-V series. In the end, our job was to find a surprisingly straightforward and simple form for the new machines.The basic structure comprises a building-block, double-column structure, and focuses on a uniform heat environment from right to left and front to back. And, to reduce the amount of heat generated and ensure efficient cooling, we incorporated a double-structure oil jacket to enclose the main spindle bearings, as the largest source of heat generation is from the main spindle motor.

Spindle thermal deformation is compensated for in 0.1-micron units by

Thermo-Friendly Concept

the spindle-environmental thermal deformation control system (see "The breakthrough..."), developed by Mechatronics Module Development Dep. This system measures heat through a sensor and then predicts and compensates for changes in the amount of heat.

“The first thing that will surprise you is the basic performance, followed by the outstanding stability and accuracy.”

The next major heat source is the hydraulic unit. Normally, actuators are placed in a number of locations on the machine, all of which generate heat during steady operation. To reduce heat in the MB-V series, we employed a small unit that only activates when needed, thus greatly reducing power consumption and amount of heat and noise generated. Next, on the uppermost portion of the machines, we placed a heat outlet that releases heat upward rather than to the side. With this configuration, the surrounding machines are not affected.This was the specific way in which we took the heat and controlled it using the thermal friendly concept.

We also put a lot of effort into making the machine parts modular. In pursuing a complete array of sophisticated features, rather than increase the number of individual parts, we worked with collaborating companies to produce high quality modules comprising large sub-assemblies. This allowed us to greatly reduce the length and time of the assembly line, made development of the series easier, and brought costs down. It also made for easier machine maintenance. What was unique about this approach was that it led us to develop and adopt Okuma's first cartridge-type spindle. With this setup, if there is a problem with the spindle, all the user has to do is exchange the problem spindle with an extra one. This really reduces the amount of machine down time. In the future as well, I'm sure we'll take this modular approach for any portion of a machine that has a large concentration of complex parts.

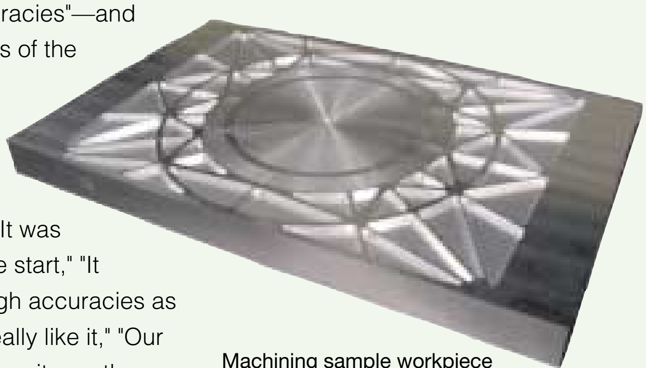
“The MB-V series machines will surprise customers twice.”

When the MB-V series was announced at the Okuma Machine Fair (OMF) in 2001, I was happily standing before the machines explaining their capabilities. I was pleased because we felt we had produced a really good machine and because customers' reactions were very positive. They were surprised by the machines' ability to keep dimensional variation to within 8 microns during long runs, thought well of the building-block double-column structure—which elicited such comments as "that kind of structure will produce higher accuracies"—and impressed by the flatness of the machining samples.

Also, after we sold and shipped the machines, we heard such customer comments as "It was easy to use right from the start," "It delivered consistently high accuracies as soon as we tried it; we really like it," "Our workload is lighter because it greatly reduced the number of times we have to make dimensional corrections." In other words, our customers were satisfied with the completeness of the machining centers' basic capabilities, and surprised by the long-run dimensional stability made possible by the thermal deformation compensation system.

The fact is, I was the one most encouraged by these responses, since when I was in Europe a market survey had shown that Okuma's small- and medium-sized machining centers were not very highly evaluated. After returning to home, we had designed a machine incorporating many challenging ideas. After introduction into the market however, a few technical problems were found and I was really busy dealing with these and in making improvements. This experience was extremely valuable and led me to change my approach to development, which I think has really borne good results in the new MB-V series.

At present, I am helping to incorporate the design concept of the MB-V series into a new horizontal machining center, and based on the development process we used for the MB-V, advising teams developing a new lathe and multitasking machine. I imagine that the thermal friendly concept and other technologies introduced to the world in the MB-V series will act like a booster shot to revitalize customers' machine shops, the machine center market, and Okuma itself.



Machining sample workpiece

HORI Yasunori

Senior Manager, Research & Development Dept., Technology Div.
Graduated in 1980 from Nagoya University, School of Engineering, Dept. of Mechanical Engineering. Assigned to the Engineering Dept., assisted with the design and development of double-column machining centers. After returning from Europe, worked on the MX-H and MA-H series of horizontal machining centers, after which acted as project leader in developing the MB-V series.

Development of the MB-V series

(Designer's story 2)

The thermal friendly concept has made possible amazing machining accuracy in the MB-V series of machining centers. But how was this unique system for dealing with thermal deformation created—Senda Harumitsu, the technical "backbone" of the project, talks from the point of view of thermal analysis about some surprising facts behind the development of the thermal deformation compensation system.


SENDA Harumitsu

"The breakthrough came when we changed our thinking and made thermal deformation a friend."

"I made up my mind after seeing the other department members struggling with ways to deal with spindle thermal deformation."

The first thing I was in charge of after entering Okuma was developing both an ultra-high precision machine and a machining technology allowing spherical accuracies of 0.1 microns and surface roughness of 0.01 microns. I was trying for higher accuracies in turning through diamond tools, and while my skill improved in analysis techniques, to be honest my secret dream was to have my work someday appear in a product brochure through a machine that was unique even to those who know machines tools well.

Around 1995, I saw that the development team members in my department were really struggling to develop technology to control spindle growth, and thought there must be something we can to counter the thermal deformation enemy. Okuma's technical provision at that time called for a thermal deformation tolerance range of within 10 microns on the X axis, 20 on the Y axis, and 30 on the Z axis at a spindle speed of 25,000 min^{-1}. These were really difficult targets, and the provision could not be adopted if they were not achieved. It was at that point that I spoke up and asked for the go ahead to work on a spindle thermal deformation compensation system.

"Customer requests led us to challenge the 10-micron wall."

The first step in developing a thermal technology is thermal analysis. We put a wide variety of machines into Okuma's environmental test chamber and collected thermal data from them. Machine tools have many sources of heat, which interact together in a complex manner to cause thermal deformation. We examined this phenomena and ascertained heat factors one by one.

Around 1997, when we were in the midst of our analysis, a survey was conducted on customers performing die/mold machining on a previously-released machining center equipped with a spindle thermal deformation compensation system. What we heard was "If two molds are clamped, we have to keep repeating time-consuming precision adjustments by hand until we can get red lead primer to cleanly transfer to the opposite mate. If we had a machining center capable of continuous machining accuracy to within 10 microns, finishing work would be a lot easier."

At that time, we really wanted to find a way to achieve 10-micron accuracy, but the problem in prolonged die-mold machining was not so much from spindle growth but deformation in the machine structure from ambient temperature changes in the room. On machining centers of that time, roughly 30-micron thermal deformation was normal if the ambient temperature changed, putting the 10-micron figure far out of reach. On top of that, deformations occurs constantly due to changes in the operational status of the machines and changes in room temperature, particularly in the winter when heaters are turned on, and room temperature can suddenly jump up. Under such difficult environments, the within-10-micon wall became an extremely high hurdle.

"After much analysis—we finally hit upon the thermal-friendly concept."

It took a change in mind set to offer a ray of hope. It was during the time we were doing thermal analysis day after day in the environmental test chamber, that a new idea began to emerge. "Even if we

Thermo-Friendly Concept

go all out and cool or insulate the machine room or the heat-generating parts as we do the spindle, it won't work: it would drive up costs too high and no one would use it. What we need is high-accuracy machining merged with thermal-deformation control." This idea, "even if we go all out and control the heat, it won't work," led us in the direction of "let's not fight thermal deformation; let's make it our friend." This is the concept of thermal friendly.

"The breakthrough came when we changed our thinking and made thermal deformation afriend."

The next problem then became "just what type of structure can control thermal deformation?" To solve this we closely examined Okuma's massive amount of existing data on machine thermal deformation. We found that the VH-40 vertical machining center and the LB300 CNC lathe possess outstanding thermal deformation characteristics. We took a year to examine the data for this machine, as its boasts extremely stable long-run dimensional accuracy. The LB300 uses a "box-slant bed" configured with headstock and turret as the major components.

Using this backdrop, what we determined to be necessary were (1) a simple structure that causes, obedient, non-bending thermal deformation, (2) a design that takes into account the arrangement of heat sources and temperature balance, and (3) a control system that compensates for spindle thermal deformation in real time. We presented the resulting principles and analysis data to the MB-V development team. We were quite happy that they took our recommendations across the board. It sometimes happens that the engineers' ideas are bounced right back under the admonition "that would just be excessive equipment so we can't use it," but we were glad they took our ideas and put them to good use.

"A year with no complaints really made us feel like we accomplished something."

We examined the MB-V under varying and quite detailed conditions in the environmental test chamber. At the initial stage, the long-run dimensional changes were within 17 microns, which were about half the thermal deformation found in conventional machines. With these kind of results, deformation within 10 microns appeared doable with some fine tuning and a thermal deformation compensation system. We therefore coordinated with the development team and completed the design while bouncing ideas back and forth.

The MB-V series of machines really look to have high potential, as we designed them under the MX base, which we thoroughly refined and improved upon. We wanted to make a thermal deformation compensation system that fully realized this potential. To design such a system, ideas for this and that came up one after another, and in the end we designed the machine ourselves, from the thermal deformation compensation system to the algorithm, which is the exception rather than the rule. And, after getting the FA systems people involved, since controllers are their specialty, within a short we were able to upgrade the controller system to an even greater 0.1-micron version, which allowed us to achieve accuracy within 8 microns.

When we introduced the thermal friendly concept in Nov. 2002 at the Japan Society of Mechanical Engineer's Conference on New Technology, the feedback showed us that customers thought it was a logical concept, a real eye opener. However, we know some of

Analyzing thermal deformation in the environmental test chamber

them would be using the MB-V's in environments not very conducive to thermal stability, so in the winter when we went into mass production, we were somewhat apprehensive about the possibility of complaints coming in over the winter. That is the state of mind of developers after they release a new product.

In the end though, we went the entire winter without a single problem. What a relief that was! At present, we are continuing our tests in the environmental test chamber to adapt the thermal deformation compensation system to other machines. When we first started our research, I had no idea we would end up so deeply involved with this thermal friendly theme. Right now, all I can think about is how I want many customers to try out our new machines with their innovative thermal friendly characteristics.

SENDA Harumitsu

Mechatronics Module Development Group Leader, Research & Development Dep., Technology Div.
Graduated in 1987 from Gifu University, Faculty of Engineering, Dep. of Precision Engineering. After being hired by Okuma, was in charge of ultra-precision machining technology as a developer of mechatronics module development. After this, asked to work on thermal deformation research and developed new ideas such as the spindle thermal deformation compensation system. Co-awarded the 2002 JSME Medal for New Technology for this system.

Welcome to OKUMA

Impressions from new users

The innovative MB-V series of vertical centers lets users experience "an evolution in machine tools." We asked customers using the MB-V series for the first time for their impressions of our new machining centers.

" I was surprised by the high accuracy during machining with quadrant changes in the Z axis."

Miuragoganekei Co., Ltd.
(Higashi Osaka, Osaka Prefecture)

We installed an MD-56VA (15,000 min-1; Super-NURBS) to machine high-precision glass dies/molds for IT products. When we were examining different machines to make a purchase decision, we performed machining tests to compare machines from different tool makers. The test consisted of three quadrant changes in the Z axis (the edges to the joints of a polygonal surface shaped like a soccer ball). All the results were similar so we decided to go with the most cost effective solution, the Okuma machine (Smiles). The first time we used it we got accuracies beyond our expectations, and we've seen the same consistent finish ever since.

" In the past high-accuracy machining was only possible during the day, but now we can operate around the clock."

Ueda Molds Co. Ltd.
(Ueda City, Nagano Prefecture)

We wanted a machining center that would reduce plastic-mold cycle time, and decided to go with the MB-46VA (15,000 min-1; Super-NURBS) due to its excellent thermal stability from the thermal friendly concept. Even though we were using it to machine molds and parts (cavity work) demanding particularly stringent accuracies, dimensional errors were very small and we were able to reduce polishing labor and time. Before we installed the MB-V, we could only perform machining requiring high accuracy in the daytime because we were worried about defects from thermal deformation. Now, however, we can perform continuous, unattended operation even at night.

"Goes toe to toe even with ultra-high precision MCs."

Yoshida Casting Co. Ltd.
(Nishikamogun, Aichi Prefecture)

We purchased a MD-56VA (25,000 min-1) for machining molds and dies used to make automotive parts. We couldn't be more satisfied. We regularly carry out machining tests, and in terms of accuracy and cycle time the Okuma machining center beats the competition hands down. The MD-56VA can also stand in for our ultra-high precision machining center when it is unavailable, as it consistently delivers 10-micron profile accuracies, which really helps us out.

"Continuous day and night shape accuracies confirmed by our CMM."

Ishikawa Seisakusho Co., Ltd.
(Koshigaya City, Saitama Pref.)

In the past whenever we performed continuous day and night operation we were stuck with 20-micron dimensional errors no matter what we tried. After installing an MB-56VB, dimensional variance dropped to within 10 microns, which eliminated the need to carry out dimensional compensation in the evening before we head home—and reduced the number of mistakes. We compared the machining results of a high-class machining center with those of the MB-56VB—using a 3-dimensional coordinate measuring machine—and to our surprise, the Okuma machine had the smaller long-run dimensional variation.

ACE CENTER Vertical Machining Centers MB-46VA/B

ACE CENTER Vertical Machining Centers MB-56VA/B

Machine specifications

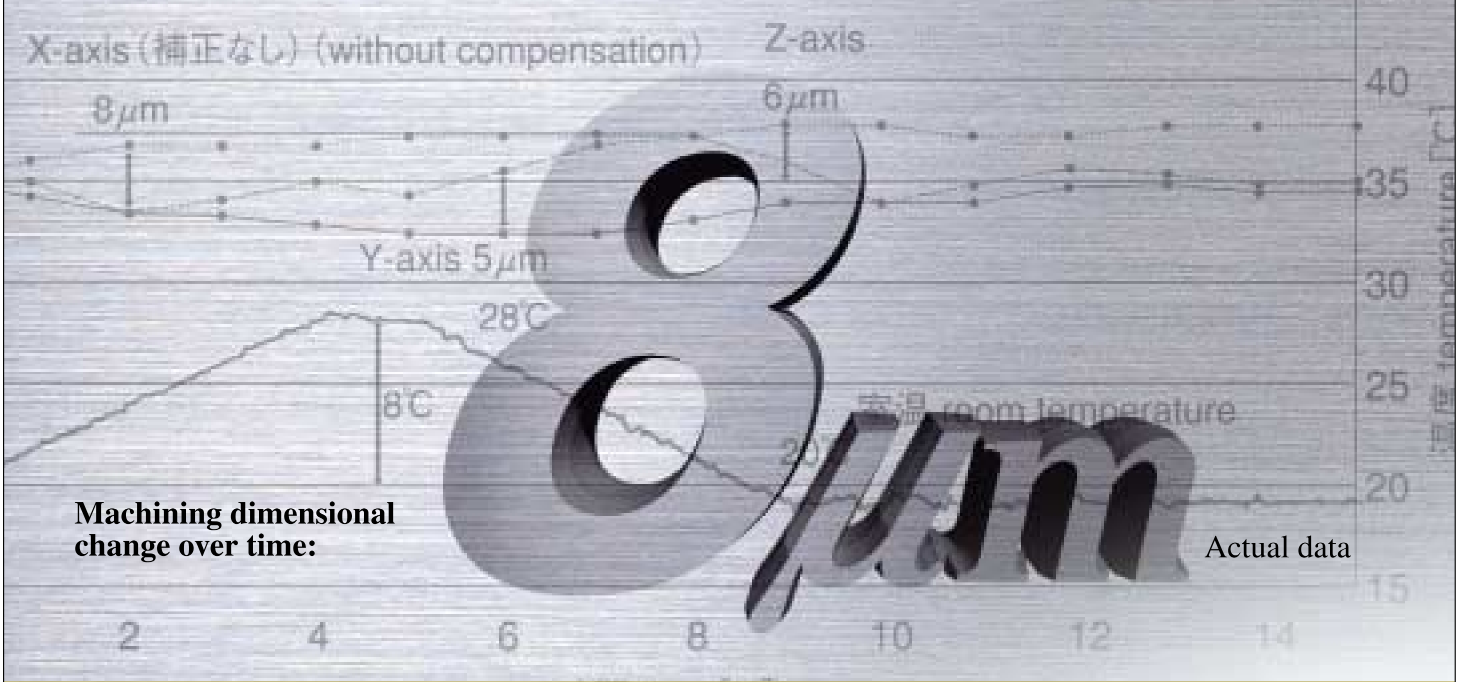
Model			MB-46VA [VAE]	MB-46VB [VBE]	MB-56VA	MB-56VB
Travels	X-axis (ram saddle R/L)	mm (in.)	560 [762] (22.05 [30.00])		1,050 (41.34)	
	Y-axis (table B/F)	mm (in.)	460 (18.11)		560 (22.05)	
	Z-axis (spindle U/D)	mm (in.)	460 (18.11)			
	Table surface to spindle nose	mm (in.)	150 ~ 610 (5.91 ~ 24.02)			
Table	Max work dimension	mm (in.)	760 x 460 [1,000 x 460] (29.92 x 18.11 [39.37 x 18.11])		1,300 x 560 (51.18 x 22.05)	
	Distance from floor to table surface	mm (in.)	800 (31.50)		800 (31.50)	
	Max load capacity	kg (lb)	500 [700] (1100 [1540])		900 (1980)	
Spindle	Spindle speed	min^{-1}	8,000 (15,000/25,000/35,000)	6,000 (12,000)	8,000 (15,000/25,000/35,000)	6,000 (12,000)
	Speed ranges		Infinitely variable	Infinitely variable	Infinitely variable	Infinitely variable
	Tapered bore		7/24 taper No. 40	7/24 taper No. 50	7/24 taper No. 40	7/24 taper No. 50
	Bearing dia	mm (in.)	ø70 (2.76)	ø85 (3.35)	ø70 (2.76)	ø85 (3.35)
Feedrate	Rapid traverse	m/min (ipm)	X-Y: 40 (1575) Z: 32 (1260)			
	Cutting feedrate	m/min (ipm)	X-Y-Z: 32 (1260)			
Motors	Spindle	kW (hp)	11/7.5 (15/10) (22/18.5,15/11,15) *1	11/7.5 (15/10) (26/18.5) (35/25)	11/7.5 (15/10) (22/18.5,15/11,15) *2	11/7.5 (15/10) (26/18.5) (35/25)
	Feeding axis	kW (hp)	X-Y-Z: 4 (5.4)			
ATC	Tool shank		MAS BT40	MAS BT50	MAS BT40	MAS BT50
	Pull stud		MAS 2-type	MAS 2-type	MAS 2-type	MAS 2-type
	Tool capacity		20 (32 [48]) 48-tool only for 46VAE, 56VA			
	Max tool dia (w/ adjacent tool)	mm (in.)	ø90 (3.54)	ø100 (3.94)	ø90 (3.54)	ø100 (3.94)
	Max tool dia (w/o adjacent tool)	mm (in.)	ø125 (4.92)	ø152 (5.98)	ø125 (4.92)	ø152 (5.98)
	Max tool length	mm (in.)	300 (11.81)	300 (11.81)	300 (11.81)	300 (11.81)
	Max tool mass	kg (lb)	8 (18)	12 (26)	8 (18)	12 (26)
	Max tool moment	N•m (ft-lbf)	7.8 (5.7)	15.3 (11.3)	7.8 (5.7)	15.3 (11.3)
	Tool selection		Random			
Machine size	Height	mm (in.)	2,750 (108.27)			
	Floor space	mm (in.)	1,900 (*1,950) x 2,715 [2,160 x 2,715] *3		2,470 x 3,010 (97.24 x 118.50)	
	Weight	kg (lb)	6,000 [6,500] (13200 [14300])	6,200 [6,700] (13600 [14700])	7,300 (16000)	7,500 (16500)

*1. (30/25,20/15,20) *2. (30/25,20/15,20) *3. (74.80 x 106.88 [85.04 x 106.88]) *MB-46VB ( ) indicate optional specs

OKUMA

Thermo-Friendly Concept

Okuma's new friendly approach to temperature changes



2002 Japan Society of Mechanical Engineers Medal Winner

Meet Okuma's Highly Accurate Thermal Deformation Compensation system for Machie Tools

The Thermo-Friendly Concept is Okuma's innovative method for dealing with heat variations in machine tools and workpieces, in order to assure consistently high-accuracy machining. Okuma's machine tools are designed with a box-built structure that is thermally symmetrical to control distortion in the machine from ambient temperate changes, translating to superb (friendly) thermal characteristics. Moreover, we have also taken into account heat dissipation: heat dissipated by the cooling system and controllers is designed to not affect the machine itself, or nearby machines.

Based on a vast thermal deformation data bank obtained using Okuma's environmental test chamber, distortion from changes in temperature was controlled in units of 0.1 μm through real-time thermal deformation compensation. These new technologies allow our machines to keep variations in machining dimensions under 8 μm over time under an ambient temperature change of 8˚C — thus delivering amazingly consistent, high-accuracy machining.

ACE CENTER Vertical Machining Centers MB-V SERIES

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