

CYBER WORLD

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Technology that supports the advancement of humanoid robots

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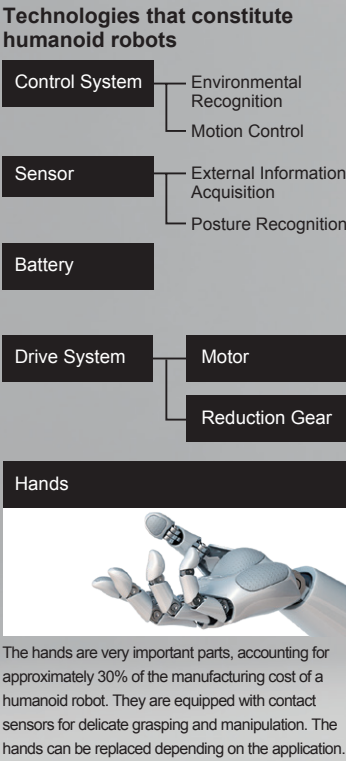
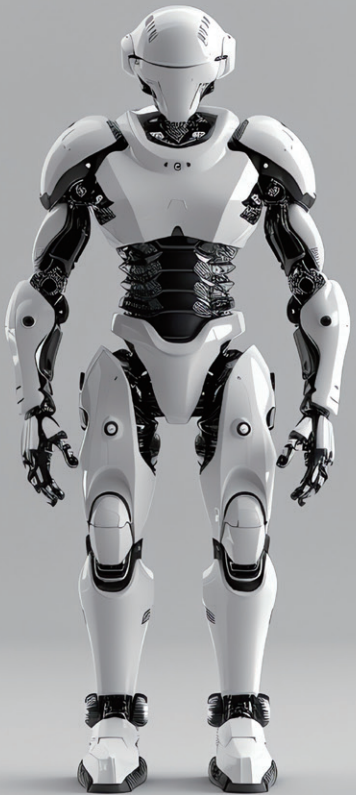
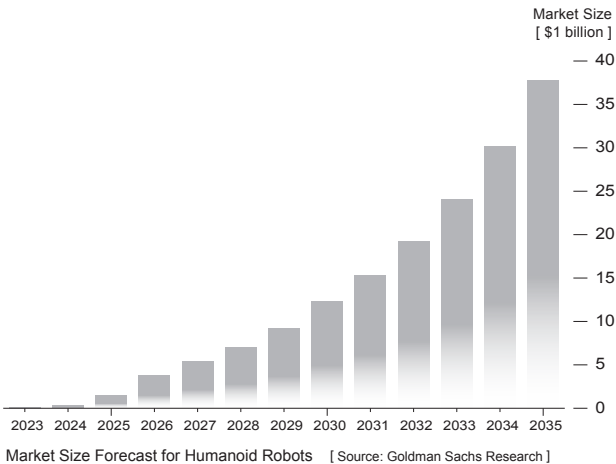


Humanoid robots take on jobs

The word “robot” was coined in 1920. It was originally used in a play to state an artificial life form that was created to resemble humans and perform work in place of humans. “Robots” - as we know them today - were put into practical use in the 1960s. Since then, robots in various shapes have been created to automate and streamline work. Nearly a century later from its origination, an era of robots returning to their original human-shaped form to work alongside us, is just around the corner.

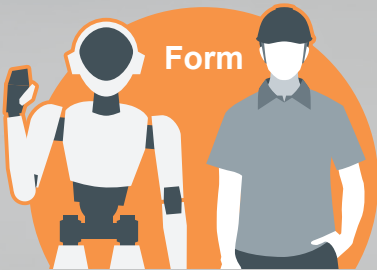
Why we should turn to humanoid robots

Robots began to be introduced into the manufacturing industry in the 1960s. Since then, robots have automated various kinds of work such as welding, painting, assembly, transportation, parts machining, packaging, and so on. Many robots are already in use in the field of manufacturing, such as articulated robots that are shaped like a human arm, and Autonomous Mobile Robots (AMR), which have autonomous transporting capabilities. Against the backdrop of the recent global labor shortage, the demand for automation and efficiency has expanded, and the roles required of robots are becoming more diverse. Humanoid robots are expected to be one solution to meet these needs. Humanoid robots are designed to imitate human appearance and movements. Manufacturing such human-like robots poses significant challenges, requiring not only the miniaturization of components such as actuators and batteries, but also development of advanced sensing and processing technology for autonomous movement. For this reason, the practical use of humanoid robots has remained elusive for a long time, but the recent rapid development of AI (artificial intelligence) has



Intelligence of Humanoid Robots: Sensors and Control Systems

Humanoid robots have a large number of moveable parts in order to imitate human movement. They are also equipped with a number of sensors, to acquire external information and recognize their own movement. This complexity poses a challenge, as manually programming each complex calculation and process required to integrate the numerous sensors and simultaneously control multiple moving parts is difficult. However, the recent advancement of machine learning technology through AI has contributed to this solution, making it possible to take a different approach to robot motion control. In the past, humanoid robots relied on pre-programmed motion patterns, which often limited their ability to respond appropriately in unfamiliar environments. However, machine learning technology now enables robots to derive suitable motion patterns on their own through experience and learning. In recent years, machine learning methods have become more advanced, leading to significant improvements in efficiency. It has come to a point that it is now possible to collect several years' worth of training data in just a few hours, by operating thousands of virtual robots in parallel within a simulated environment that replicates the real world. In addition to such training methods, there are also methods that involve observing and learning from actual human behavior. Through repeated learning and optimization using these methods, humanoid robots are expected to become capable of handling a wider variety of tasks in the future.



The humanoid robot is designed to work alongside humans in the same environment. By imitating human shape and movements, it can use the same environment and tools as humans.



It can grasp objects with both arms and carry them while walking on two legs. It uses acceleration sensors, torque sensors, gyro sensors, etc. to detect its own movement information and posture and control its movements.



It aims to operate autonomously just like a human by acquiring external information using cameras and range sensors called LiDAR, recognizing the surrounding environment and the target of the task, and acting accordingly.

ushered in a major turning point. Humanoid robots designed for actual work are now commercially available, and since around 2023, trial introductions of humanoid robots have been underway, primarily in the automotive industry. Looking forward, the shift toward the practical use of humanoid robots is expected to accelerate. In the future, they will be widely adopted not only in manufacturing but also in the service industry and everyday life, with the market size expected to exceed \$30 billion over the next 10 years.

The Future of Humanoid Robots

The advantage of humanoid robots lies precisely in their form. One reason this is an advantage is that they can operate in the same environments as humans. For example, they can be introduced without any infrastructure modifications, such as widening aisles or eliminating steps, and they can work alongside human workers. In addition, since humanoid robots are designed to be able to engage in a wide range of workstyles, they can flexibly perform tasks according to the purpose.

Humanoid robots, by their very nature, are roughly the same size as humans and must be as lightweight as possible for both safety and performance. Therefore, the components used in humanoid robots must be lightweight, compact, rigid, and be able to meet strict size standards. Humanoid robots are currently in a transitional stage. The cognitive and processing capabilities of sensors seek more improvement, and payload capacity and battery life remain as challenges. Therefore, humanoid robots are currently only being used for basic tasks such as transporting and sorting. However, future technological developments are expected to enable them to replace not only simple, repetitive tasks but also tasks in dangerous environments for humans, such as disaster sites. In the year 2025, the technology surrounding humanoid robots is advancing rapidly with new initiatives being announced one after another. Given their continuous evolution and ability to adapt to various environments, humanoid robots can be considered as a technology to keep an eye on, with their potential to excel beyond the boundaries of industry.

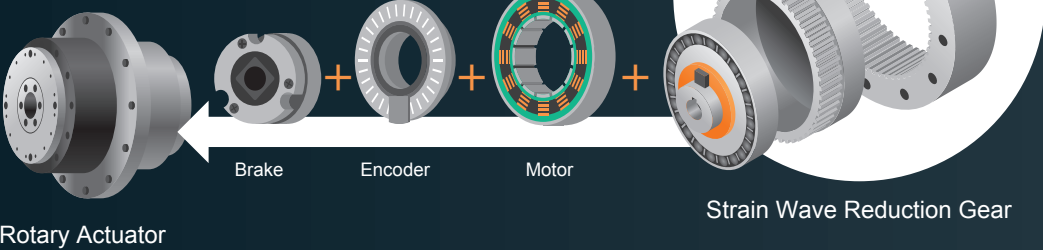
The Body of a Humanoid Robot: Drive System and Frame

Actuator

An actuator is a device that converts energy into physical movement. Different types of actuators are used depending on the part of the robot.

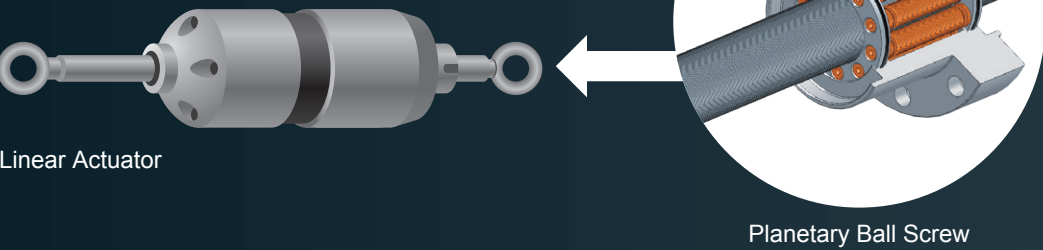
Rotary Axis

Rotary actuators are used in parts of robots that require rotational movement, such as the neck, shoulders, and hip joints. They consist of a small electric motor, an encoder and brakes that control the rotation with high precision, and a reduction gear that enables a large output from the small motor.



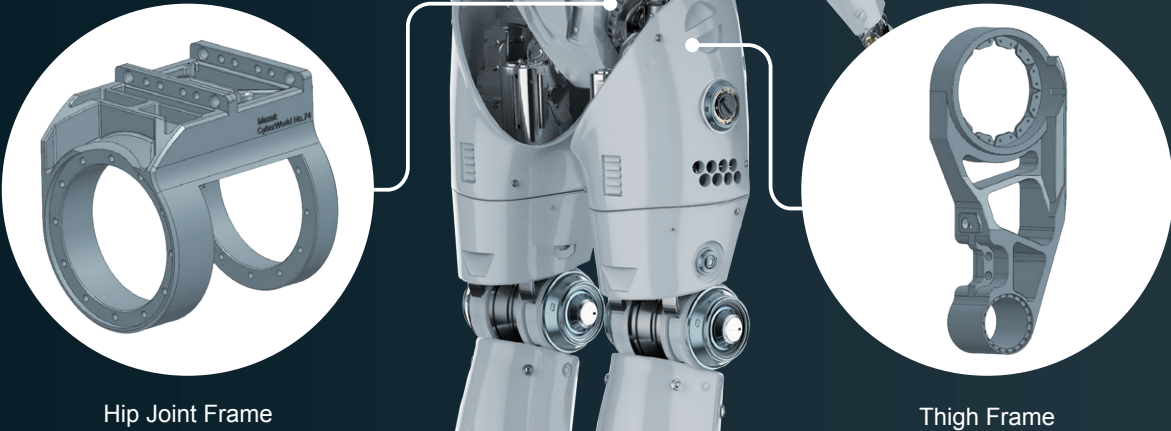
Linear Axis

Linear actuators, which operate on a linear axis, are used to control the three-dimensional angle of wrists and ankles, as well as to support the weight of the robot itself and the objects being transported.



Frame

The frame that holds the actuators must be small, precisely designed, and rigid.



The performance of humanoid robots depends on the precision and robustness of their components. To perform complex and diverse movements, These components must be precise, lightweight, compact, and highly rigid.

Strain wave reduction gear that achieves high reduction ratio

Strain wave gear device are used in the rotating shafts of humanoid robots to provide powerful and highly accurate rotational axis control while achieving a range of motion equal to or greater than that of a human. A wave gear device is a gear component that utilizes the elasticity and flexure of components to achieve an extremely high reduction ratio. Despite its high reduction ratio, it features a simple structure, high torque capacity, and can be easily miniaturized. This mechanism is the exact opposite of machine components, which typically require the elimination of distortion and flexure. Because it relies on the elasticity of the components, it requires meticulously calculated, high-precision shape accuracy, which requires a variety of processes including not just turning, but also drilling, milling, and gear machining. Mazak's INTEGREX i-H series multi-tasking machines use a turning spindle and a tiltable mill spindle to perform a variety of machining operations with high precision. Additionally, by synchronizing the rotation of the mill spindle and the turning spindle, high-precision gear machining using hob tools and high-quality finishing of gear parts with simultaneous 5-axis machining is possible.



Simultaneous 5-Axis Control Multi-Tasking Machine
INTEGREX i-100H S

Planetary ball screws that enable superb braking performance

To generate large power from small motors, components with high reduction ratios are required for linear axes as well. A typical example is a linear actuator using a planetary ball screw mechanism. A planetary ball screw mechanism is a mechanism in which planetary screws rotate around a main shaft (sun shaft) powered by a motor or other device, smoothly converting the main shaft's rotational motion into linear motion. The ratio between the diameters of the planetary screws and the main shaft not only achieves a high reduction ratio, but also increases the number of contact points between the screw components, resulting in high rigidity and torque capacity. To meet these performance requirements, the screws that make up the components for this mechanism must be machined with high-precision shape accuracy and a smooth thread profile. Mazak's high-performance CNC turning center: HQR series, is ideal for machining these screw components. Thanks to its highly rigid mechanical structure, it delivers high machining capabilities. It also supports turning and milling using the Y-axis, and high-efficiency machining using a three-turret system, allowing it to complete machining of not only the main shaft threads but also keyways and motor connection sockets, all on a single machine.



3-turret / 2-spindle CNC turning center
HQR-200/3 NEO

Complex, integrated parts with higher rigidity and lower weight

The frame parts used to hold the actuators for both rotary and linear axes, as well as the structural parts of the robot itself, have different requirements compared to industrial robots. In addition to size restrictions, humanoid robots require components that reduce the number of parts, ensure both light weight and rigidity, and integrate complex geometries in order to maximize their performance. Frame parts with small, complex shapes and support sections often use high-precision cast parts as well as machined parts, requiring machining from multiple directions on a single workpiece. The VARIAXIS i-300 AWC, which has a multi-stage workpiece changer and excels at long-term, high-precision machining, is the ideal machine for machining small, complex-shaped parts. It not only stores materials in the workpiece changer to enable efficient, long-term continuous machining, but also perform multi-faced machining from multiple directions using a high-precision rotary table, and perform smooth curved surface machining with simultaneous 5-axis machining.



Vertical Machining Center with Multi-level Work Changer
and Simultaneous 5-Axis Control
VARIAXIS i-300 AWC



Customer Report 01

Nakata Co., Ltd.

A “White Base” controlled by “Newtypes”

Semiconductor manufacturing equipment and industrial robots are essential for improving productivity, reducing costs, and saving labor. Many of their main components are precision-machined aluminum products made by Nakata Co., Ltd. (Yao City, Osaka). Mazak machines contribute to these precision machining processes, which require micron level accuracy.

Multi-tasking machine INTEGREX i-250H S + Industrial robot TA-20/270 continuously operates 24-hours



Nakata Co., Ltd.

Executive President : Hiroshi Nakata
Head office : 5-1-15 Kamiocho, Yao City, Osaka, Japan
Number of employees : 38

www.nakata-ss.co.jp



Hiroshi Nakata, Executive President



Taku Yamamoto, Director and General Manager



Executive President Nakata (center) and employees working at the second factory

Multi-taskingmachines # Automation # Industrialrobot # Aluminummachining
Preproduction # Massproduction # Japan



The second factory called "White Base" consists entirely of Mazak machines



5-axis machining center VARIAXIS i-600 + Automation system MPP contributes to improved productivity



MAZATROL CNC system helps employees improve engineering skills

Taking on work that cannot be done with just the machines

Nakata Co., Ltd. was founded in 1977 by Chairman Yoshifumi Nakata, the father of President Nakata, and incorporated in 1982. What began as a subcontracting business has steadily expanded since 1990, when the company began handling subsequent machining of aluminum die-cast products. Currently, the company specializes in precision machining of aluminum products. The company handles high-mix, low-volume production of aluminum products in six fields: semiconductor manufacturing equipment, optics, electronics, industrial robots, food manufacturing equipment, medical and pharmaceutical equipment, and the development of ultra-fine processing technology. The second factory, called "White Base", which began operation in 2022, manufactures consumable parts for semiconductor manufacturing equipment and parts for industrial robots. This is a dedicated factory for mass-producing aluminum precision parts with strict dimensional tolerances, using only Mazak machines. "We don't take on jobs that can be completed with just a program and a machine, as that would only lead to us joining price wars. Our goal is to have a small team of people take on difficult jobs that use unexpected ideas and wisdom to turn customers' thoughts into reality. I believe these people are the 'newtypes' who will lead the next generation," says President Nakata, explaining the aim of opening the "White Base."

Tripling the productivity with Mazak's automation

The company first introduced the VARIAXIS 500-5XII and QUICK TURN NEXUS200-II MSY to its main factory in 2011. This decision was made to realize President Nakata's vision of "launch a factory that is not bound by existing ideas and is run with an innovative approach like Mazak". Currently, the "White Base" is equipped with an INTEGREX i-200H S + TA-20/270, an INTEGREX i-250H S + TA-20/270, two QUICK TURN 250MSYs, and a VARIAXIS i-600 + MPP, and operates around the clock, including weekends, to manufacture mass-produced aluminum parts that require

micron-level precision. "Since we established a system consisting entirely of Mazak machines, productivity has increased by about three times. This improvement is not only due to the machines themselves, but also to the linkage with peripheral equipment and 24-hour service support," says Director Taku Yamamoto, evaluating the results of automation from his position as the factory manager. "However, manual work is still required in the final stages to ensure quality, so it cannot be said that our factory is fully automated. We are focusing on resolving this issue and creating a fully automated system," says President Nakata. "MAZATROL, which supports automation from a software perspective, is not only easy to use, but also excels in letting us know what to keep attention to, such as alerting users to points that are easy to overlook in easy-to-understand language. This is a very useful feature especially for young engineers," says Director Yamamoto.

Uniting factories to aim for a "stronger organization"

The company has several plans for its upcoming half-century anniversary in two years. "In general, we are aiming to build a strong organization. One option to achieve this is to consolidate our headquarters factory and our 'White Base', and develop it into a new manufacturing base," says President Nakata. President Nakata points out the contribution Mazak machines have made to the "White Base", the mass production base, by stating, "For example, by combining TA, which handles everything from bringing in raw materials to removing finished products, with our own developed automatic cutting oil supply system and temperature control system, the automation of the INTEGREX i-H series has advanced significantly." However, he also stated, "We are not satisfied with just that point. We want to exceed further by challenging ourselves to improve efficiency and engineering capabilities even more. We believe it will be the 'Newtypes' who will guide us to our goal." The eyes of the president were already on the next chapter of the story, where he believes the company will make a great leap forward by combining its accumulated knowledge with Mazak machines.

Workpieces machined by Mazak machines

Aluminum parts processed by Mazak machines





Customer Report 02

Xtek, Inc.

Supporting the steel industry through production innovation

Xtek is a leading provider of heat-treated components in Ohio, USA, that has supported the domestic steel industry for over 100 years. Xtek is currently facing a challenge from the industry, as it is going through a major transformation in production method, and companies must adapt to survive. The company chose its long-standing partner, Mazak to overcome this challenge by making a drastic change in the manufacturing process.

INTEGREX i-800V/8, in operation utilizing its turning, milling, and drilling capabilities

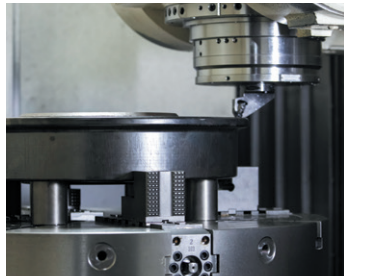
#ProcessIntegration #UnmannedOperation #Automation #Multi-taskingmachine #UnitedStates



The employees of Xtek, Inc.



Automation system PALLETECH which enables unmanned operations at night



Outer-diameter turning performed by INTEGREX i-800V/8

Providing heat-treated parts for over a century

Xtek Inc. is a manufacturer based in Cincinnati, Ohio, specializing in the production of components for the steel industry, including crane wheels, brake wheels, loose gearing and geared couplings for rolling mills. Founded in 1909, the company began as a manufacturer of gears for traction cars. Xtek established its position as a manufacturer through the production of components using its proprietary heat treatment process called the "Tool Steel Process (TSP)", and expanded its business to applications such as railways, coal mines, and steel mills. In 2005, under the leadership of Vice President Roger Miller (the current CEO), the company made significant capital investments to enhance production capacity. To accommodate diverse product lines and small-lot production, the company introduced Mazak's INTEGREX i-800V/8 multi-tasking machine and PALLETECH, a pallet-handling automation system.

Mazak machines bring innovation to production

Marketing Director Kris Tegeder says, "At first, we thought that automation could not be applied to a high mix/low-volume shop like us, with job lot sizes ranging from one to eight parts. We soon discovered that this multi-tasking machine and automation system was the solution for incorporating lights-out machining." Terry Emerson, Production Department Manager, says, "The INTEGREX i-800V/8's turning, milling, and drilling capabilities allow us to eliminate the need for parts to travel from one machine to another, which greatly reduces the amount of setup time required." For the PALLETECH system, Xtek utilizes its 16 pallets and one loading station by automatic loading / unloading of various-sized parts that range from 1" - 30" in size to the machine tool. This allows offline

setup while the machine is running and enables unmanned night production, which is expected to result in a 15 - 20% reduction in overall manufacturing cycle time.

Adapting to the Changing Steel Industry

With its proficiency in heat treatment / metallurgy and its ability to incorporate heat treatment into the manufacturing process, the company currently generates a significant portion of its sales from the steel industry. Among the products manufactured for the steel industry, gear couplings are notable for Xtek, due to the long history the company has with them and because Xtek focuses not only on new product development but also on repair and maintenance for the product. The company's reconditioning service, which includes improvement of part design and refining of its manufacturing techniques to make end products even better, is highly regarded by many companies that operate rolling mills. Currently, most of Xtek's sales consist of products for the steel market, with domestic products accounting for the majority of those sales. In the United States, which produces approximately 116 million tons of steel annually, production volume and equipment utilization rates have remained flat in recent years, but steel production bases and production methods are beginning to undergo major changes, and manufacturers are required to adapt to these changes. The company's slogan is "Solutions in Motion." To embody this slogan, Xtek is actively engaged in both product development and reforming of the production system, and is manufacturing with a view to the next product design and improvement. The company will continue to adapt flexibly to the ever-changing industry and expand its business opportunities.



Xtek, Inc.

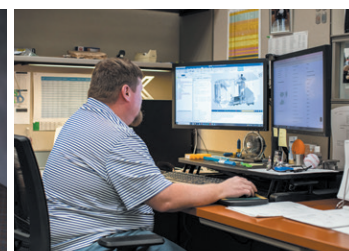
President and CEO : Roger Miller
Headquarters : 11451 Reading Rd, Cincinnati, OH 45241 U.S.A.
Number of Employees : 475

<https://www.xtek.com/>

Xtek
Solutions in Motion



President and CEO of Xtek, Roger Miller



The office of Xtek, Inc.



Operator controlling the Mazak CNC system

Workpieces machined by Mazak machines

Workpieces machined by INTEGREX i-800V/8



Mazak News & Topics

➤ Founding Partnership Agreement signed with IG Arena



Yamazaki Mazak has signed a founding partnership agreement with Aichi International Arena Co., Ltd., which operates the "IG Arena." We aim to create opportunities for more people to learn the role that machine tools play in manufacturing, and to enhance recognition of the industry as a whole. We also hope to inspire interest among the next generation who will lead the future of manufacturing.

➤ Capsule toy photo contest held on Mazak's community site



Mazak has held a photo contest using capsule toys on its community site, "Mazak Community." Many of the members participated, competing for the most "likes" in the community. The three participants with the most likes were presented with original trophies, machined by a Mazak machine. Many elaborate and spectacular pictures were submitted, making the contest a great success.

➤ Mazak Corporation's Kentucky Factory celebrates completion of its 40,000th machine



Mazak's US branch: Mazak Corporation has produced the industry's most advanced machine tools in North America since 1974 and now celebrates the completion of its 40,000th machine built at its main factory in Florence, Kentucky. The factory has just celebrated its 50th anniversary in 2024, showing its contribution to the local economy and job creation through both its history and its production achievements. The 518,320 sq-ft facility on Mazak's nearly one-million sq-ft manufacturing campus produces various machines including CNC turning centers, vertical machining centers, and 5-axis machining centers to meet a wide variety of requirements. The factory is designated as a Mazak iSmart™ Factory, a factory with a state-of-the-art manufacturing system that achieves advanced process control through digital integration. This facility has also been a key site for the evolution of Mazak's CNC systems, beginning with the introduction of MAZATROL T1 in 1981 and continuing through to today's SMOOTH Technology and cutting-edge AI and digital twin capabilities. The technological innovations and automation solutions developed here have made significant contributions to a variety of industries including aerospace, automotive, medical, and construction. Mazak will continue to enhance production capacity through continuous investment to our factories and product development to meet the diverse needs of our customers and support the U.S. industry with innovative machine tool technology.

➤ Central European Mazak branches take actions to protect forests



Tree-Planting Event at Mazak Hungary

Planting trees is a growing trend among Mazak's central European branches, as Mazak Hungary and Mazak Poland have recently joined tree planting activities as part of Yamazaki Mazak's global environmental program "Mazak GoGREEN". Mazak Hungary has extensive experience in tree planting, having continued its efforts since autumn 2022. They have been proudly collaborating with the MyForest Community Forests Foundation to support native forest regeneration across Hungary, planting trees each spring and autumn. To date, Mazak Hungary has contributed to the planting of over 1,400 trees — a meaningful step towards a greener, more sustainable future. During the last autumn campaign of the reforestation program, 10 members of Mazak Hungary attended the program along with their family members in Szarvasgede, planting a tree per every guest attending in Open House days and other customer events from last spring's campaign. Meanwhile, Mazak Poland is a newcomer to tree planting, as they launched their first forest planting initiative in April with the local organization: the Katowice Forest District. The members of Mazak Poland planted a section of the forest after receiving professional training with the local forester. While this marks their first step in tree planting, Mazak Poland is a role model in environmental activities – their achievements extend to making an apiary in its facility, organizing regular cleanup efforts, operating its facility with 100% green energy, and so on. This tree planting event is sure to be another beginning of Mazak Poland's brilliant environmental milestones. Mazak Hungary and Mazak Poland will continue to show us that technological innovation and ecological responsibility can grow together — one tree at a time.

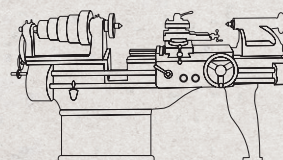
➤ Mazak exhibits at MF-TOKYO 2025, attracts the crowd with its new oscillator and automation system



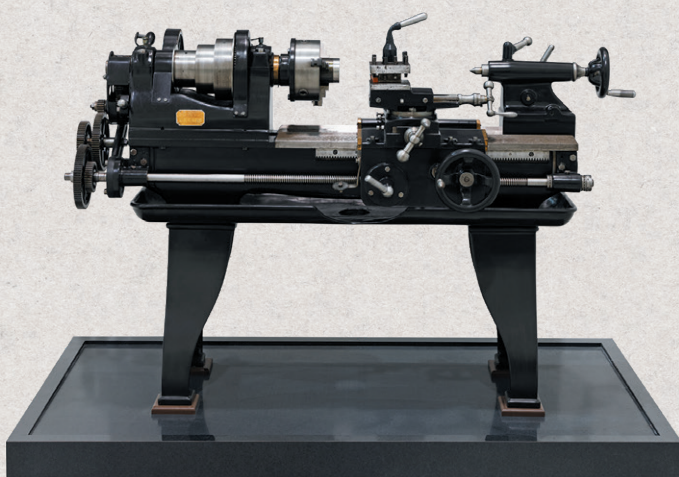
"MF-TOKYO2025," an exhibit showcasing the latest metal press and forming technology, was held at Tokyo Big Sight, Japan from July 16th to 19th, 2025. The first day of the event started with rain, but the weather improved in the following days, resulting in an astounding 31,000 visitors, exceeding the number of visitors at the previous exhibition. Mazak participated in the event with our largest-ever booth at a laser-focused exhibition. The booth featured three models: STX-3015, equipped with a new Mazak-branded oscillator "Mazak SmoothCUT", making its debut in exhibitions; OPTIPLEX 3015 HP, capable of processing thick plates with a high output of 20.0 kW; and the FG-400 NEO, with an increased output of 5.0 kW. In addition, the booth also showcased a fully automated solution, the "MAZAK LASER FA SYSTEM," which covers everything from material loading and unloading to cutting, tapping, and sorting. The "Tapping cell" of the system, was a longed-for system by our laser processing machine users. It was very well received and has shown the prowess of Mazak as a machine tool manufacturer, attracting a lot of attention from visitors every day.

Machine tools, past and present

THE COLLECTION OF THE YAMAZAKI MAZAK MUSEUM OF MACHINE TOOLS



1927 Yamazaki Line Shaft Drive Lathe



This line shaft drive lathe was manufactured by YAMAZAKI MACHINERY WORKS (now Yamazaki Mazak Corporation) in 1927. Sadakichi Yamazaki, a lathe operator, founded YAMAZAKI MACHINERY WORKS in Naka Ward, Nagoya, in 1919 as a manufacturer of tatami mat-making machinery, and later expanded the business to include woodworking machinery. When they manufactured lathes and milling machines to increase production, they gained popularity and began selling them externally, marking the start of their journey to become the current manufacturer of machine tools for metal and plastic processing. This Yamazaki Line Shaft Drive Lathe features a sliding surface suitable for heavy cutting and a reverse gear for boosting torque, demonstrating Sadakichi's passion for machine building and his commitment to high efficiency.

Manufactured by: YAMAZAKI MACHINERY WORKS Ltd.
Manufactured in: Japan



**M THE YAMAZAKI MAZAK
MUSEUM OF MACHINE TOOLS**

<https://machine-tools-museum.mazak.com>

YAMAZAKI MAZAK MUSEUM OF MACHINE TOOLS is a unique museum that specializes in machine tools. It is an interactive museum where visitors can see, touch, and enjoy all kinds of exhibits, which includes working historical machine tools and key industrial products made with the tools such as steam locomotives, automobiles, and aircraft.

Mazak

Yamazaki Mazak
Corporate Website
www.mazak.com

