

Technologies Supporting Value Creation

JTEKT leverages its No. 1 & Only One technologies to create new values and help solve the various issues society faces. This Special Edition introduces the stories behind the development of five products together with the impressions of the employees who took up the challenge of evolving the related technologies.

Helping to resolve social issues through the evolution and fusion of our technologies

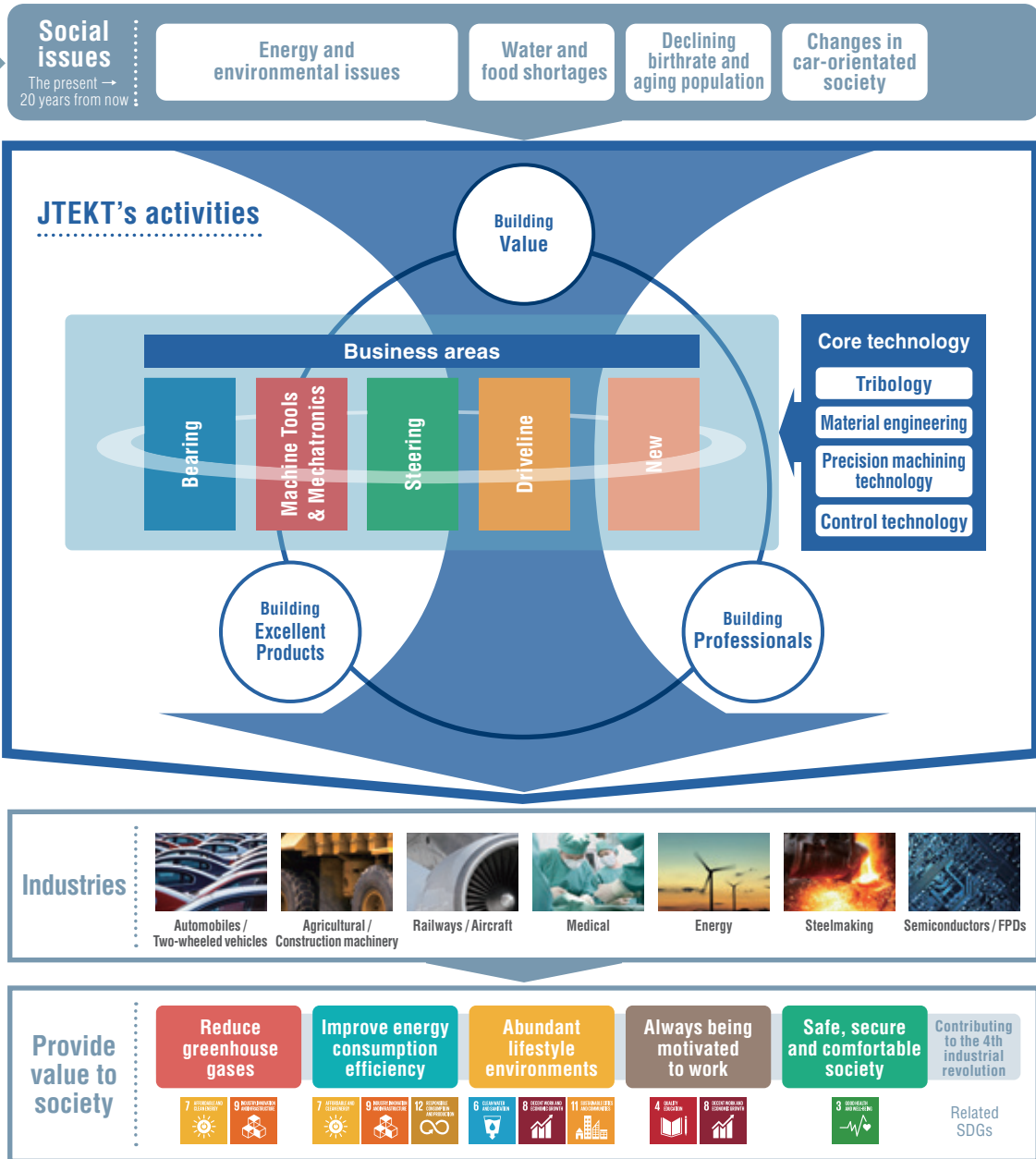
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Corporate Philosophy

Seek to contribute to the happiness of people and the abundance of society through product manufacturing that wins the trust of society.

Find new issues

Recognition by society



The JTEKT group is contributing to the achievement of Sustainable Development Goals (SDGs) adopted at the United Nations General Assembly.

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 *LFT(Low Friction Torque) is a registered trademark of JTEKT Corporation. *GEAR SKIVING CENTER is a registered trademark of JTEKT Corporation.

Reduce greenhouse gases

Improve energy consumption efficiency

Abundant lifestyle environments

Safe, secure and comfortable society

RP-EPS or rack parallel type electric power steering

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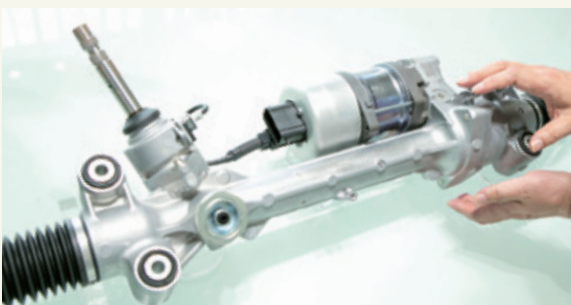
Newly Developing EPS for Medium/Large Vehicles with a Vision of Future Car Society

(3rd from left)
System Development Office 2,
Steering System Engineering Dept. 2,
Steering Systems Business Headquarters
Tatsuhiro Yamamoto

JTEKT's electric power steering (EPS) boasts the top share in the world, and of the three basic functions of a car (travel, turn and stop), focuses on "turn" and is helping to improve safety and comfort. Amidst predictions that even medium to large-sized vehicles, which conventionally adopt hydraulic power steering, will make the transition to EPS, JTEKT developed a new EPS for medium/large-sized vehicles in 2016 and has commenced its mass production.

With a forward vision to support advanced driver-assistance and autonomous driving

EPS can be broadly divided into two



Achieving one of the smallest packaging sizes in the world.
Received the Innovative Technique Award from Toyota Motor Corporation.

types; column assist type and rack assist type. The column assist type EPS is suitable for small vehicles as its motor and the computer that controls this motor (ECU) are located in the vehicle's interior cabin. Meanwhile, the rack assist type EPS has its motor and ECU located close to the vehicle's tire therefore has minimal power loss due to friction and is suited to medium/large-sized vehicles which require relatively higher steering performance. JTEKT stands out from other EPS manufacturers due to the diverse product lineup we offer for both EPS types. In particular, we currently occupy the highest share of the global market for our column assist type EPS. Moving forward, JTEKT plans to focus on popularizing and expanding our rack assist type EPS also.

"It is predicted that, in order to support advanced driver assistance and autonomous driving, even large vehicles and luxury cars which conventionally adopted hydraulic power steering, will make the transition to EPS. We have developed

a new rack assist product in order to answer this market need." (Yamamoto)

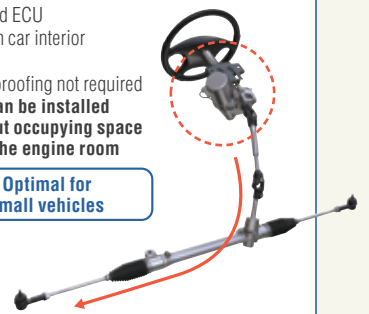
Features of each EPS system

Column assist type

Motor and ECU located in car interior

Waterproofing not required
Can be installed without occupying space in the engine room

Optimal for small vehicles



Rack assist type

Motor and ECU located close to tire

Less motor power loss due to friction
Achieving high steering performance

Optimal for medium to large-sized vehicles



← Flow of power ○ Motor position

Incorporating world-first technology to achieve high comfort and quietness

“RP (rack parallel) -EPS” is one of the newly developed rack assist type products. This system’s reduction gear uses a bearing specially designed through cooperation between engineers from JTEKT’s steering and bearing businesses to achieve one of the smallest packaging sizes in the world and improve onboard mountability. Moreover, by incorporating JTEKT’s original innovative ideas in the mechanism known as the ball screw, the RP-EPS offers smoother and more comfortable steering, in addition to quietness.



“Our new ball screw design is the first of its kind in the world to be used for auto parts. I was in charge of design, but truly believe it would not have been possible to accomplish this without the close collaboration between the Production Engineering and Manufacturing departments.” (Asakura) “The design is completely new so we had to make mass production equipment like none ever seen before too. The task of doing this was extremely difficult but our sense of achievement when we succeeded made it all worthwhile.” (Mizuno) “It was extremely challenging to develop mass production equipment that could provide both high accuracy and high efficiency but thanks to the cooperation of the Machine Tools & Mechatronics Operations Headquarters and JTEKT group companies, we achieved our goal.” (Yoshida)

A high-level safety design conforming to international standards

In 2011, JTEKT established a development process that conformed to the

international functional safety standard, ISO26262 and, in 2014, developed the world’s first column type EPS with a redundant design. “Redundant design” refers to a safe design whereby systems are duplicated so that even if one system fails during vehicle operation, it will be possible to continue providing assistance to steering wheel operation.

Based on our experience in this area, a redundant design was adopted for the torque sensor and motor drive unit in the newly developed RP-EPS also.

Striving to be a body of engineers capable of providing new values

Mass production of RP-EPS began at Hanazono Plant in December 2016. It was adopted on the Lexus models, LC500h and LC500, released in March 2017. Moreover, in order to meet an increased demand for EPS in medium/large-sized vehicles, JTEKT has established a plan for global production, including mass production in Tennessee, U.S. (commenced in June 2017) and China (scheduled to commence in 2019). “We went through a trial-and-error process to find a way to improve the steering experience even further. I truly feel we overcame this challenge and succeeded at our goal due to all members of the Design, Production Engineering and Manufacturing depart-



Production Engineering Group 3,
Production Engineering Office 2,
Steering Production Engineering Dept.,
Production Engineering Headquarters

Yuji Mizuno (left)

Design Group 1,
System Development Office 2,
Steering System Engineering Dept. 2,
Steering Systems Business Headquarters

Masayoshi Asakura (right)



RP-EPS was adopted on
Lexus LC500h/LC500 launched in March 2017.

ments uniting as one and combining their strengths.” (Yamada) “In this project, various conflicting opinions emerged such as ‘we want new ideas’, ‘we want higher accuracy mass production equipment’, ‘we want to keep costs down’ and so on and I feel I did a good job at balancing all of these.” (Suzuki) “I want to continue contributing to the creation of cars which consumers find even more appealing through the development of new steering systems. I want JTEKT to be a body of engineers that doesn’t just meet market needs, but also offers new values.” (Yamamoto)



Advanced Engineering Office
Production Engineering Development Dept.
Production Engineering Headquarters

Yoshimasa Yamada (left)

Advanced Engineering Office
Production Engineering Development Dept.
Production Engineering Headquarters

Takayuki Suzuki (middle)

Production Engineering Group 3,
Production Engineering Office 2,
Steering Production Engineering Dept.
Production Engineering Headquarters

Yuji Yoshida (right)

Reduce greenhouse gases

Improve energy consumption efficiency

Abundant lifestyle environments

Safe, secure and comfortable society

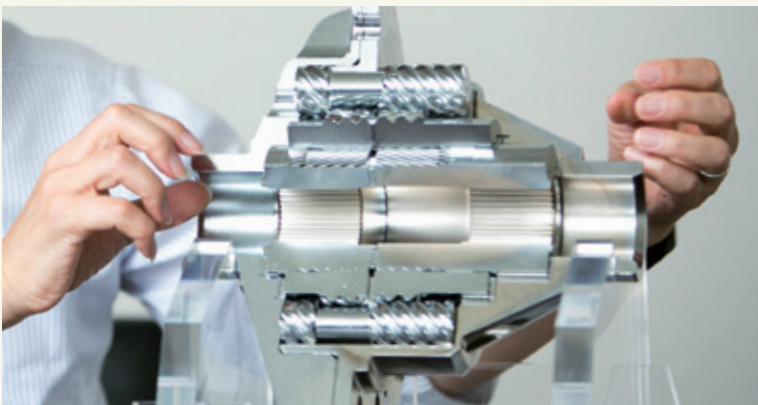
Torsen for small truck



Rolling Out Safety/Comfort-Enhancing Technologies to New Fields



Torque Control Device Design Office
Driveline System Engineering Dept. 2,
Driveline Systems Business Headquarters
Motoyasu Yamamori



Received the Innovative Technique Award from Hino Motors, Ltd. in recognition of its ability to improve driving in rough road conditions. Went into mass production in July 2017.

Leveraging its experience accumulated in the sports car and SUV fields, JTEKT developed a technology to improve comfort and steering performance for small trucks driving on rough roads.

Preventing bogging in muddy conditions

The small trucks that work in Indonesia's palm fields must carry large loads of coconuts on unpaved roads. Often these trucks slip in the muddy ruts in the road and become bogged. As a prevention measure to this, Hino Motors, Ltd. established a plan to equip JTEKT's TORSEN product as a genuine factory-installed optional part and engaged in a joint development project with JTEKT. TORSEN is a form of LSD (Limited Slip Differential), a product which transmits power from a

driving wheel that has slipped to the other driving wheel. Its features are its superior durability, performance and maintenance.

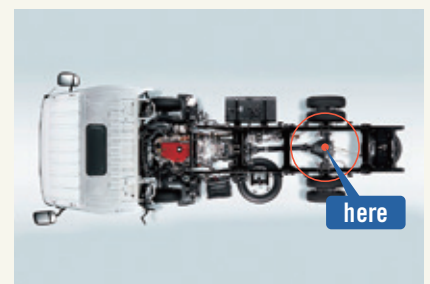
Development of a new product useful in tough operating environments

JTEKT's TORSEN is adopted on many vehicle types both in Japan and overseas, with a particular focus on sports cars and SUVs. However, this is the first time it has been used on trucks. This move has proven that TORSEN provides the performance to meet customers' needs, such as sufficient strength to support payload, the ability to drive on rough roads and reliability over long distances and long periods. "We ventured into unknown territory with this development, but through the cooperation of the Design, Testing, Production Engineering

and other divisions under the guidance of JTEKT WAY, we succeeded in launching it as a product." In 2017, a monitoring evaluation was carried out in Indonesia and there were absolutely no cases of vehicles becoming bogged, which earned TORSEN a strong reputation amongst owners. "I saw that JTEKT could contribute to society in a new arena when we successfully applied the technology we'd accumulated to date on trucks and this made me very happy."



Monitoring evaluation in Indonesia. The ability for a vehicle to get loose after becoming bogged was significantly improved.



*This photo of vehicle structure was taken from Hino Motors website.

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Next-generation super-low friction torque tapered roller bearing LFT-IV

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Contributing to Greater Fuel Efficiency with No.1 Low Friction Torque Performance



Roller Bearing Group
Powertrain Engineering Office
Automotive Bearing Development Dept.
Bearing Operations Headquarters
Akiyuki Suzuki

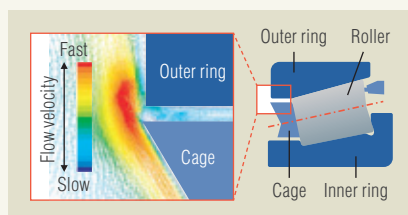
As a countermeasure to environmental issues such as global warming, there is an even greater demand to improve fuel efficiency of vehicles. In order to help solve this problem, JTEKT has developed a new-generation tapered roller bearing for use in cars with No.1 low friction torque performance.

Pursuing torque loss reduction from various angles

Many tapered roller bearings are used in the driveline units of vehicles, such as transmissions and differentials, and play a role in supporting each rotating shaft



External appearance of LFT-IV. The cage is made of resin, which has high design flexibility



The flow of lubricating oil is analyzed in order to find the optimal cage shape. Agitation resistance caused by lubricating oil has been greatly reduced.

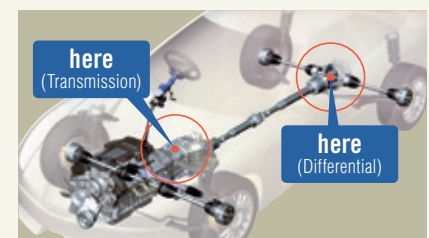
during the process of transmitting engine power to a vehicle's tires. For this reason, a major point regarding the extent to which such bearings can contribute to better fuel efficiency is how much torque loss created by friction can be reduced. For a long period of time, JTEKT has engaged in research and development activities aimed at reducing the friction torque loss of tapered roller bearings from a variety of angles and, as a result, commercialized the LFT (Low Friction Torque) series. LFT-III, a product developed in 2006, successfully reduced torque loss by approximately 50 percent compared to JTEKT's standard products of the same size. LFT-III is adopted by automotive manufacturers both in Japan and overseas and is significantly contributing to better fuel efficiency. Moreover, in 2017, JTEKT successfully developed LFT-IV, which has reduced torque loss by a further 30 percent or so compared to LFT-III.

Reducing agitation resistance of lubricating oil to the greatest extent possible

Tapered roller bearings are used in units filled with lubricating oil. LFT-IV was developed with a primary focus on reducing agitation resistance, which occurs due to more lubricating oil flowing through the bearing than necessary, to the greatest extent possible. The approach taken was to make the part of a bearing referred to

as the "cage" into a shape which minimizes the amount of lubricating oil that flows through the bearing using CAE (computer-aided engineering). In order to reflect the optimal cage shape found through CAE into the product, resin was used as the cage material instead of the conventional metal, due to its high design flexibility. By using this LFT-IV with its significantly lower torque, on differentials, a fuel efficiency improvement of 2.5 percent can be expected.

"Currently we are working on solving issues standing in the way of mass production for this product. I hope JTEKT continues to respond to the demand for low torque and contribute to society through technology."



LFT-IV supports all vehicle models, from light vehicles to pick-up trucks.

Torque reduction

Compared to LFT-III, currently the No.1 product in terms of low torque

Approx. **30%** reduction

Expected improvement to fuel efficiency

Compared to a standard product when used on a differential

Approx. **2.5%** improvement

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Safe, secure and comfortable society

Low friction torque deep groove ball bearing for motors

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Agricultural & Electrical Machinery Group
Industrial & Construction Machinery Bearing Engineering Office
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Takahiro Nishikawa

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Research & Development Headquarters
Kazunori Miyake

Group 2
Organic Materials Sect.
Material R&D Dept.
Research & Development Headquarters
Takeshi Tsuda

Higher-efficiency for Motors That Account for a Large Percentage of Domestic Power Consumption

In Japan, it is estimated that the power consumed by industrial motors accounts for around 75 percent of that consumed by the overall industrial sector. With motor manufacturers striving to develop higher-efficiency products, JTEKT has developed a motor bearing which achieves both significantly less torque compared to conventional products and longer service life.

Development of groundbreaking grease that solves opposing issues

In order to improve motor energy efficiency, there is a demand to reduce torque loss of bearings created by friction, etc. At the same time, in order to eliminate the need for maintenance, extending the service life of motors is a major focus. However, the properties required for lower torque and longer life oppose one another, therefore achieving both had been extremely difficult until now.



In order to solve this issue, JTEKT went through a process of trial and error to find a new design. As a result, we elucidated that one of the major causes of torque

loss was the agitation resistance of grease, which is sealed inside bearings to reduce the friction between metal components and prevent wear. We engaged in research and development from the approach of analyzing all the way back to the molecular structure of grease, something that had never before been attempted. Consequently, we successfully developed groundbreaking grease that reduces torque loss by around 50 percent and extends bearing life by approximately double compared with conventional products.

Improved performance achieved from original ideas and activities

“By being involved in this development project, I really felt that the key to accomplishing great feats was to take an approach that no one has ever thought of before and run with it.” (Tsuda) “One valuable experience I gained from this project was to learn that significant improvement of performance could be achieved through fundamental research. I want to continue pursuing *monozukuri* that contributes to society.” (Miyake) JTEKT will continue proposing motor bearings using the new grease for application in a broad range of fields, including industrial machinery, home appliances and electric vehicles.



Received the 2016 Tribo-Technology Award from the Japanese Society of Tribologists in recognition of the benefits towards significantly lower reduction and quietness.

“In our next development project, I want to once again listen to the true voice of the market and leverage JTEKT’s accumulated technologies in order to offer society new values.” (Nishikawa)



The results of tests by industrial motor manufacturers showed that energy efficiency could be improved between 1 and 3 percent merely by using this bearing.

Torque loss	Compared with conventional	Approx. 50% reduction
Bearing life		Approx. 2 times the conventional
Quietness	Compared with conventional	Approx. 33% improvement

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Small-sized gear skiving center GS200H

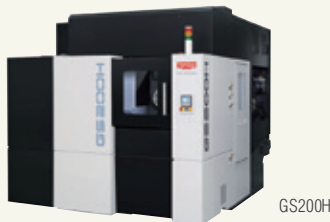
Reforming Gear Production with a World-First Product.
Widely Contributing to the Evolution of *Monozukuri*



Cutting Group
Machining & Process
Engineering Office
Machine Tools & Mechatronics
Engineering Dept.
Machine Tools & Mechatronics
Operations Headquarters
Kazuki Natsuda

Cutting Group
Machining & Process
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Lin Zhang

Cutting Group
Standard Machine
Development Office
Machine Tools & Mechatronics
Engineering Dept.
Machine Tools & Mechatronics
Operations Headquarters
Yoshio Ootsuka



GS200H

Gears are used as component parts of machines in all fields. Various machining processes are required for gear production, therefore production lines must consist of special-purpose equipment for each process arranged in a row. JTEKT developed a gear skiving center that integrates all gear machining processes into one machine for higher-efficiency production of higher-accuracy gears. Gear skiving is helping to reduce size and weight as well as improve productivity for machines of all fields.

A world-first product created through collaboration beyond business boundaries

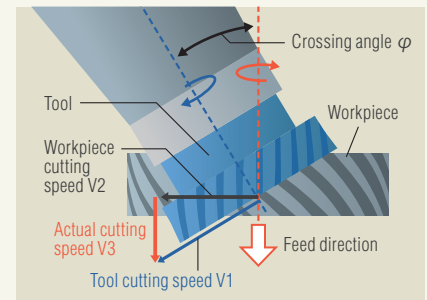
There are various gear machining techniques. Skiving is the most recent of these and involves tilting the tool on an angle against the workpiece, then simultaneously rotating the tool and workpiece at high speed in order to generate gears. Compared to conventional techniques, skiving

offers the advantages of reduced machining time, smaller and lighter gears, etc. The doctrine behind skiving was presented in Europe in the 1960s however there were many issues due to the level of technology at that time, and it never reached the practical realization phase. JTEKT began development of production equipment with the skiving technique in 2005. Aiming to improve the commercial viability and production efficiency of TORSEN, a product for automotive use made from various gears, the JTEKT group company that manufactures TORSEN in Belgium and Japan's Machine Tools & Mechatronics Operations Headquarters went beyond the traditional business boundaries to bring their respective wisdom together. From 2006, JTEKT accumulated tool and control technologies while mass producing gears using the skiving technique. As a result of these efforts, the GS300H gear skiving center was commercialized in 2013 and was the first case of the skiving technique being used on a machining center in the world.

Integrating processes that required 5 special-purpose machines into 1

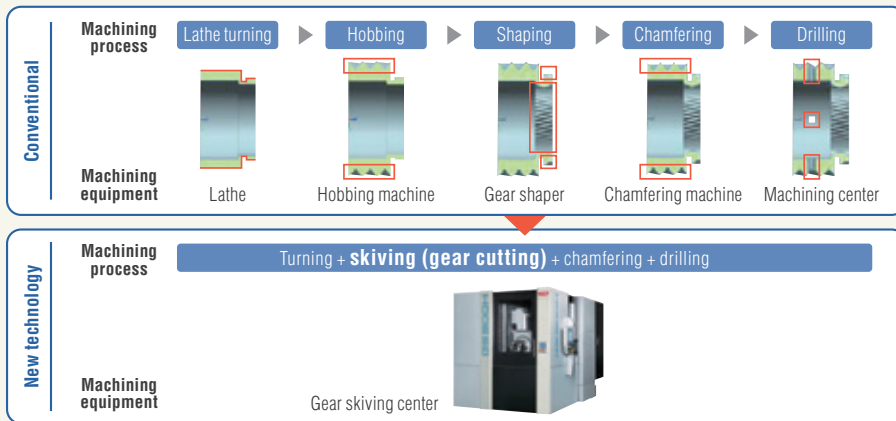
GS300H integrates the gear machining

How skiving works

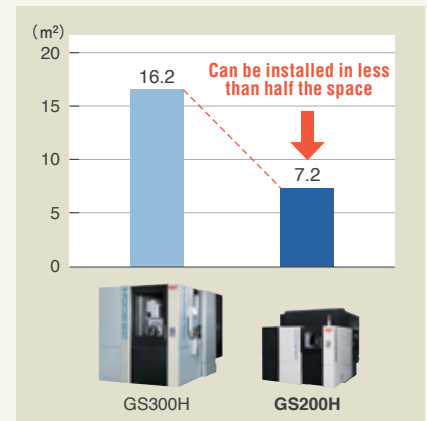


processes that conventionally required five special-purpose machines into a single machine, thereby contributing to space-saving and power-saving on manufacturing shop floors. Workpieces only need to be loaded once to proceed with multiple processes, meaning error that tends to arise during loading and unloading is significantly reduced, which in turn helps to increase machining accuracy. Based on this solid track record, in 2015, JTEKT released GS700H as the second machine of the GS series.

Flow of gear processing



GS200H footprint



GS700H is optimal for machining large gears used in industrial robots, construction machinery, trucks, etc. JTEKT is answering the needs of faster, high accuracy gear machining in a wider range of industrial fields.



Achieving groundbreaking size reduction and a significant increase in accuracy

Then, in May 2017, GS200H was released as the third machine of the GS series. This machine is optimal for machining small gears used in cars, etc. GS200H inherits all of the technologies and know-how JTEKT has accumulated to date, such as process integration, our proprietary tool and control technologies, etc. at the same time as achieving a groundbreaking size reduction whereby installation space (footprint) is less than half of that required by GS300H. Furthermore, machine rigidity has been increased by more than double that of GS300H, and the design minimizes distortion of the equipment due to heat, thereby increasing machining accuracy. In addition, as a part of our IoE (*) initiatives, a TOYOPUC-AAA is a standard feature of GS200H as a module for the accumulation and analysis of data. By gathering and

analyzing data on vibration during machining, it is possible to identify signs of malfunction and tool replacement, which helps achieve the goals of quality improvement and greater maintenance efficiency.

The strength of having machine tool users within JTEKT

GS200H enables car parts to be made smaller, lighter and integrated, therefore it can be anticipated as a model that will help improve fuel efficiency. Moreover, GS200H reduces abnormal noises by improving the accuracy of gears, of which a high number are used in cars, thus contributing to a higher degree of quietness. The strength of JTEKT's Machine Tools & Mechatronics business is that we have a steering business, driveline business and bearing business within our own company. Due to having manufacturing car parts directly within our own company, we have the advantage of an environment in which we can easily incorporate the users' opinions in our development of new machine models. Moreover, JTEKT is also capable of developing and mass producing bearings, which are necessary to increase the performance of machine tools. The GS



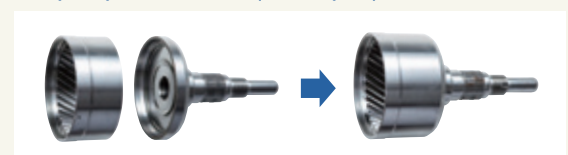
series was born by taking full advantage of this ideal environment. "JTEKT designs optimal tools and sets optimal machining conditions to enable customers to create the parts they want. Drawing out the capability of machine tools to the maximum extent possible as we have through these developments is, I believe, also important in fulfilling our customers' wishes." (Natsuda) "I am convinced that one of JTEKT's major strengths is our culture of engaging in machine model



development by listening closely to our customers' viewpoints. I want to continue evolving machine tools as one with our customers." (Otsuka) "I think that it is important to not only evolve existing technologies, but also create technologies that don't yet exist in this world. My future goal is to be able to contribute to the advancement of *monozukuri*." (Zhang)

*IoE: In recent years, much attention has been given to "IoT" (Internet of Things), however JTEKT proposes "IoE" (Internet of Everything), which includes connection between not only "things" (objects) but also people and services.

Example of product innovation (TORSEN parts)



In conventional equipment, two individual parts had to be machined separately, then welded (left), however the GS series enables machining of a single integrated part (right). This means strength is improved as welding is no longer required.