The Values Which JTEKT Provides

We, JTEKT, create new values through
No.1 & Only One technologies and *monozukuri*
that seeks superior quality, and contribute to resolving
various issues within society.
This Special Edition introduces seven concrete
examples of our contributions.

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

F_02 Low-friction reduction gear using new grease
F_03 Electric power steering (EPS) conforming to JFOPS
F_04 Double-lapped structure of solenoid valve
F_05 TORSEN type Csm
F_06 New design anti-creep ball bearing
F_07 New ceramic ball bearing for motors
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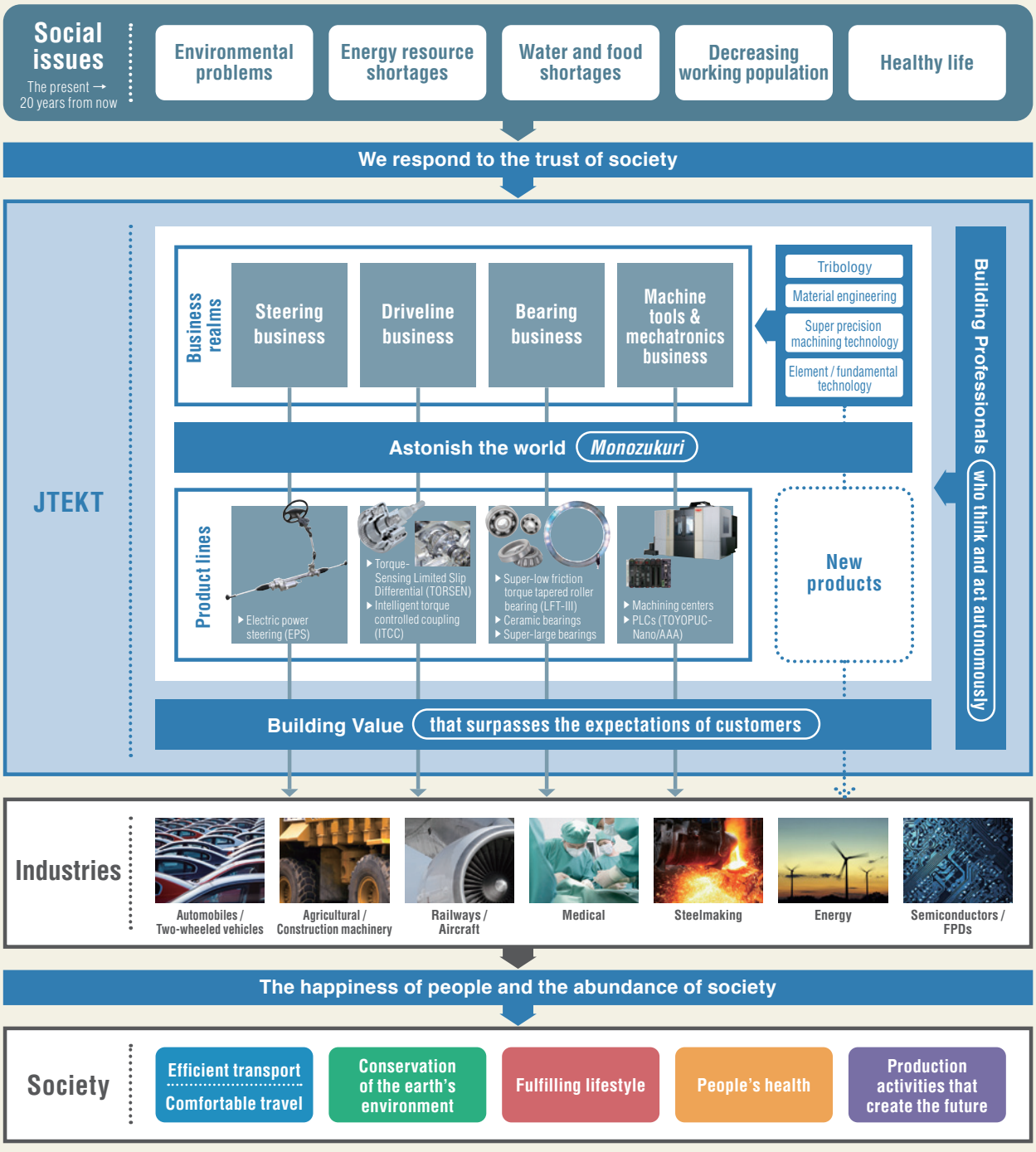
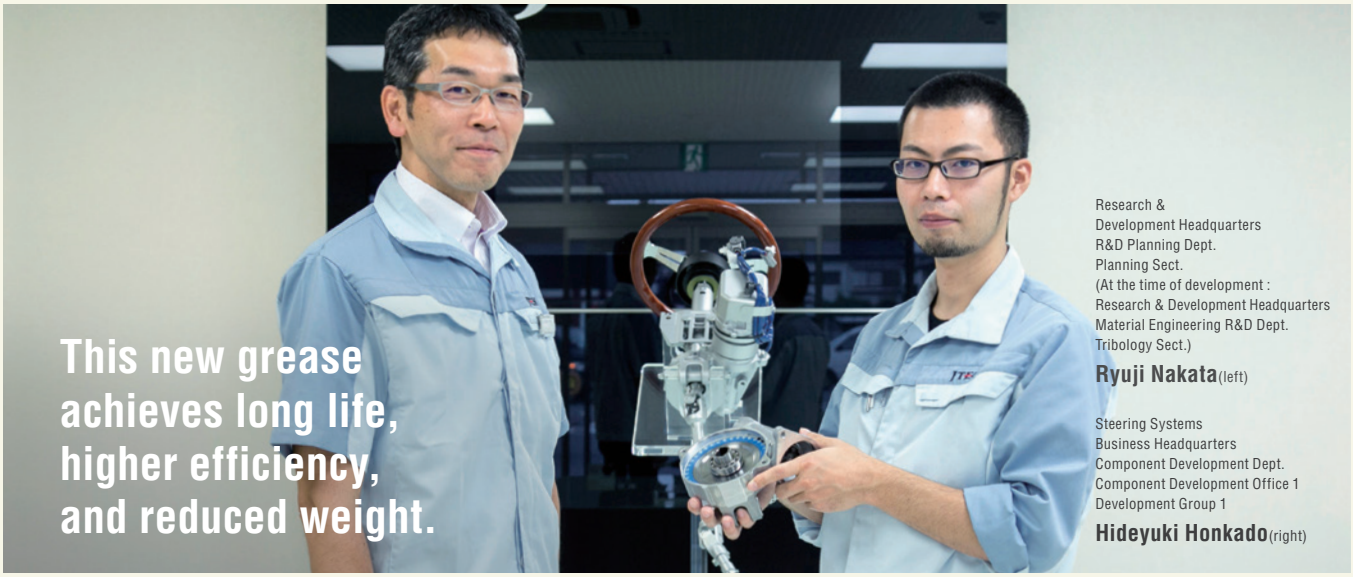
Business model



Low-friction reduction gear using new grease

E_14 Related article



This new grease achieves long life, higher efficiency, and reduced weight.

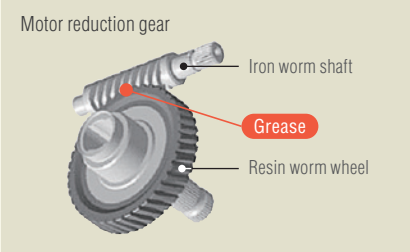
Research & Development Headquarters
R&D Planning Dept.
Planning Sect.
(At the time of development : Research & Development Headquarters
Material Engineering R&D Dept.
Tribology Sect.)
Ryuji Nakata(left)

Steering Systems Business Headquarters
Component Development Dept.
Component Development Office 1
Development Group 1
Hideyuki Honkado(right)

We have developed a new type of grease for the reduction gear of electric power steering (EPS) that resolves numerous automobile issues such as energy saving, reduction of CO_2 emissions, and improved quietness.

Achieves a superior low friction characteristic and improved compatibility with resin

Contributions to energy saving and cutting CO_2 emissions is a major theme within the automotive industry. To improve fuel economy, demands for lighter parts and the popularization of electric and hybrid vehicles are rising, alongside demands for quietness. Due to this, resin materials have become widely used for the sliding components (that move while rubbing together) of gears and other parts. The effects of using resin parts are lighter weight and less noise. However, since heat generated by sliding can lead to deformation or damage, grease used as lubrication must have an excellent low-friction characteristic. Furthermore, the grease must be compatible with the resin so as not to cause deterioration.



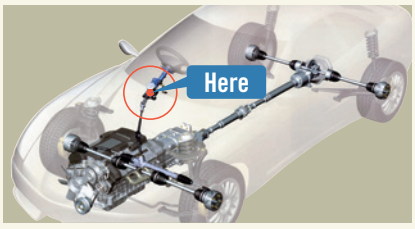
In 2012, JTEKT developed grease for the EPS reduction gear that achieves both a superior low friction characteristic and high compatibility with resin. This grease greatly improves the performance and reliability of resin wheels by increasing service life by roughly 1.8 times and raising reduction gear efficiency by 16.5 percent.

Contributing to the environment by cutting grease usage

In the development process, we worked to elucidate the mechanism of lubrication inside the reduction gear, using element analysis and other methods. We investigated not only how to improve the low-friction characteristic of grease and its compatibility with resin, but also how we could reduce the amount of grease used. As a result, we reduced the amount of grease used by roughly 50 percent, achieving both resource saving and a lighter reduction gear. We were awarded the JAPANESE SOCIETY OF TRIBOLOGISTS Technology Award in recognition of these accomplishments.

"EPS utilizing this new grease is already installed on many different car models. We would like to focus our efforts into future proposals to customers to expand utilization to an even wider range of models, since this would greatly extend the effects of improved fuel economy further throughout society." (Honkado)

"I want to lead the research division in a direction where engineers and researchers engage in development themes that enable JTEKT to contribute to future society." (Nakata)



Achieves low friction characteristic and improved compatibility with resin
Resin wheel life compared with that of conventional product
Approx. **1.8** times longer life

Amount of grease used
Compared with conventional
Approx. **50**% reduction

Reduction gear efficiency
Compared with conventional
16.5% higher

Electric power steering (EPS) conforming to JFOPS

Pursuing further EPS evolution in anticipation of automated driving

Steering Systems
Business Headquarters
Electronics System Planning Dept.
Planning Group
Toshihiro Takahashi

Automotive manufacturers are accelerating their technical development to actualize automated driving. As the supplier with the world's top share in electric power steering (EPS), JTEKT has worked to support this trend since early on in its history.

Products requiring top-level safety

EPS is an important product that bears the task of "turning", one of the basic functions of a vehicle besides "driving" and "stopping". EPS development is required to comply with the topmost safety level of the functional safety standard ISO26262.

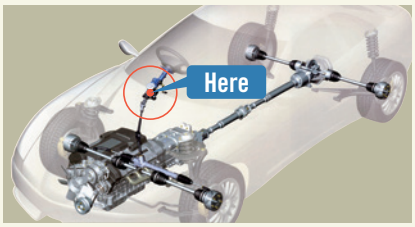
We, JTEKT, constructed a development process in 2011 that complies with ISO26262. From this process we developed the world's first EPS system with redundant design in 2014, and began mass production of this system in 2015.

Redundant design is a fail-operational design where two systems with the same function exist so that assistance can be maintained for handle maneuvers if a problem occurs in one of the systems during operation. Our EPS product for which we began mass production in 2015 utilizes redundant design in its torque sensor and motor drive.

Our goal is a "complete fail-operational function"

We, JTEKT, have taken the concept of the fail-operational function we wish to achieve within the development of EPS, and classified it into five stages which we have determined as 0 through 4 of JFOPS (JTEKT Fail-Operational System). Our fail-operational function has achieved JFOPS 3. We are promoting development to achieve JFOPS 4, which represents a complete fail-operational function, in anticipation of the sophistication of driving assistance systems and the introduction of automated driving systems in all countries. We estimate that mass production for such an EPS system will begin around 2020.

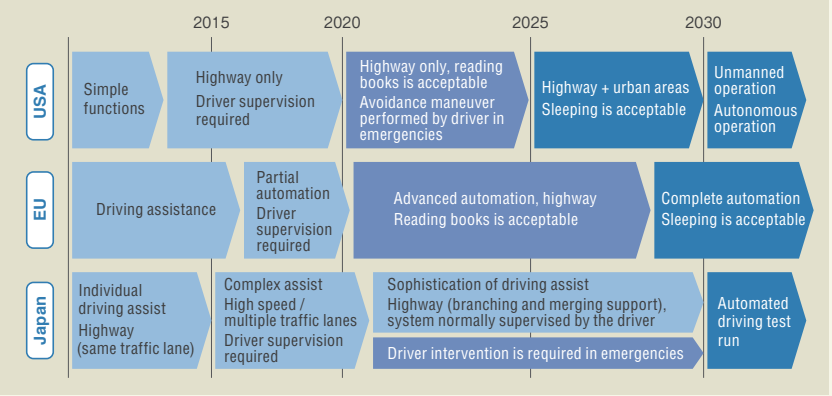
"Driving is a cycle of perception, judgment, and maneuvering, and from here on out we will move into an era where cars support a part of this cycle. I hope to bring about an era with better convenience and safety where riding in cars enriches people's lives, by using JTEKT technologies to provide high-level driving support." (Takahashi)



JFOPS (JTEKT Fail-OPerational System)

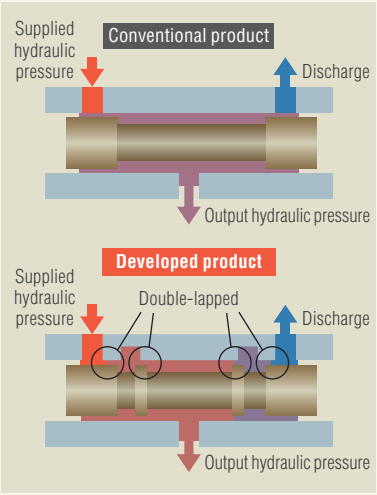
JFOPS	Concept	Method
JFOPS 4	Complete fail-operational function	Complete redundancy of electronic hardware of the EPS system, including electric power supply of vehicle
JFOPS 3	Fail-operational function	Redundancy of electronic hardware of the EPS system
JFOPS 2 And JFOPS 1	Partial fail-operational function	Backup via software
JFOPS 0	Stops the system in the event of failure	Conventional EPS

Roadmap of introduction of automated driving systems in each country



Resolving conflicting issues concurrently with unconventional ideas

Driveline Systems Business Headquarters
Hydraulic System Engineering Dept.
Hydraulic Engineering Office 2
Design Group 2
Kaori Fujita



Vehicle automatic transmission (AT and CVT) contains a product called a solenoid valve. We have conceptualized an unconventional and original structure which we have adopted for this product, achieving substantial results.

Achieving both leakage reduction and downsizing

Vehicle automatic transmissions (AT and CVT) shift the clutch through hydraulic pressure. The solenoid valve controls the hydraulic pressure generated from the pump to enable smooth gear shift without shock.
The solenoid valve controls the flow of oil by opening and closing the valve via magnetic force. Our challenge in improving the product was to see how much leakage (leakage into the transmission) could be reduced, as well as how much smaller we could make it. Leakage reduction and downsizing are usually conflicting themes for the solenoid valve, with one of the two being sacrificed to improve the other. However, JTEKT has developed a solenoid valve with an original structure of two serial laps (valve throttles) on both the supply side and the discharge side, where conventionally there was only one lap. This has achieved both a reduction in leakage and downsizing of the solenoid valve. This solenoid valve with a "double-lapped structure" enables downsizing of the pump (which draws in leaked oil), and this in turn improves vehicle fuel economy.

Awarded the Aichi Prefectural Grand Prize for Invention

JTEKT began mass production of the double-lapped solenoid valve in 2012. The valve is already installed on numerous car models produced by Toyota Motor Corporation, who recognized it for its effects in improving fuel economy and awarded it the Project Award. In addition, the Aichi Institute of Invention and Innovation awarded this technology the Aichi Prefectural Grand Prize for Invention in 2015.
"With the progression of multiple stages in AT and expansion of ratio coverage (range of gear ratio) in CVTs in recent years, the number of solenoid valves installed on a single vehicle is increasing. This will increase the effect of replacing solenoid valves with our product, and so we expect that it will be adopted on many more models. We hope to go one step further and work on unitizing this technology with other related products in our desire to contribute to reducing fuel consumption even more." (Fujita)

Volume
Compared with conventional
Approx. **47%** smaller

Leakage
(oil leakage into the transmission)
Compared with conventional
Approx. **27%** reduction

Bringing high stability and controllability to even more people

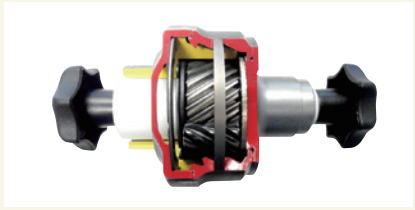
JTEKT TORSEN Europe S.A.
Product Development,
European Technical Center-Belgium
Tomoki Yoshihama(left)

JTEKT TORSEN Europe S.A.
Product Development,
European Technical Center-Belgium
Nicolas Poulet(right)

The tires are the only parts of the car that touch the road. The way in which engine torque is distributed to the four tires is extremely important for raising stability and controllability. JTEKT's TORSEN type C optimizes torque distribution to the front and rear wheels of four-wheel drive vehicles instantaneously according to driving conditions, enabling not only a safe driving experience, but also a comfortable one.

Cooperating across businesses to achieve a new structure

For many years since 1985, TORSEN had held 100 percent of the share of center differentials (a device that resolves the rotational difference between the front and rear wheels) for four-wheel drive vehicles produced by Audi AG. However, when competitors entered the market in 2008, JTEKT developed a product, based on the TORSEN type C, in order to largely improve our product competitiveness. This product, the TORSEN type Csm (sm: smart module), has been equipped on four-wheel drive vehicles produced by Audi AG since 2012. TORSEN type Csm features, first of all, the elimination of large parts and bolts, and instead employs laser welding. This accomplishes a smaller size and lighter weight, contributing to better installability and reduced fuel consumption. In addition, the carbon-based material for the friction disc, a main component, has been modified to enable support for high loads, achieving both quietness and durability. Furthermore, the new structure of this product increases the level of freedom in setting torque distribution. To lower the cost of the TORSEN type Csm, the TORSEN Engineering Division of JTEKT in Belgium and the Machine Tools & Mechatronics Operations Headquarters of JTEKT in Japan cooperated in pursuing increased performance of equipment for machining compound gears. As a result of their efforts, JTEKT introduced the gear skiving center (*) into the market.

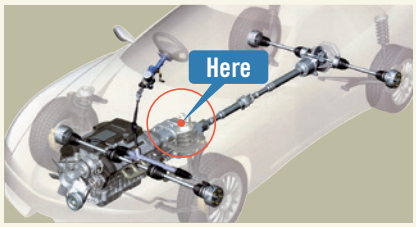


Achieves the lightest weight in the history of TORSEN

Another feature of TORSEN Csm is that through part commonization, it facilitates development and production for compatibility with numerous other transmissions. The product adopted on the Audi A4 2.0 TFSI quattro in 2015 achieves the lightest TORSEN weight to date.

"The entry of competitors into the market raised our awareness towards improving our product competitiveness. It was a good opportunity for us to work on raising product competitiveness with a constant sense of urgency." (Poulet)
"We will continue to utilize products that exemplify JTEKT and engage in development with regard to a wide range of products in order to offer society cars that are safer and more enjoyable." (Yoshihama)

* **Gear skiving center** This JTEKT product integrates the processes for gear production into a single unit, and is the first machining center in the world to adopt, and perform mass production through, the skiving technique.



Volume Compared with conventional	Approx. **37%**	smaller
Mass Compared with conventional	Approx. **34%**	reduction
Part commonization rate Conventionally 18% in the developed product	**73%**	

New design anti-creep ball bearing

E_14 Related article

Suppresses wear through an unprecedented structure

Bearing Operations Headquarters
Bearing Engineering Dept.
Bearing Engineering Office
Ball Bearing Group
Yasuhiko Ishii

How do we ensure durability of bearings while designing them to be smaller and lighter? To solve this issue, JTEKT has developed a bearing with an innovative structure.

Prevents creep without altering size

In bearings with large unilateral applied loads such as those used in vehicle transmissions, a phenomenon called creep (where the outer ring rotates in a position that has slipped relative to the housing) occurs now and then due to strain on the outer ring (Fig. 1). Creep causes wear to progress between the bearing and housing, eventually causing the center of the rotation axis to deviate, which may lead to defects within the overall transmission. Conventionally, this has been prevented by thickening the outer ring to suppress strain, however this method increases the size and weight of the entire bearing. Therefore, we at JTEKT have developed an "anti-creep ball bearing" where strain is suppressed through a shallow groove on the outer ring, thus preventing creep without changing the bearing's size (Fig. 2).

Figure 1

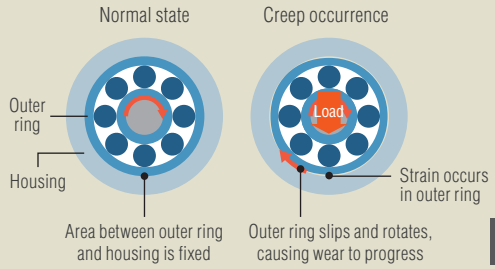
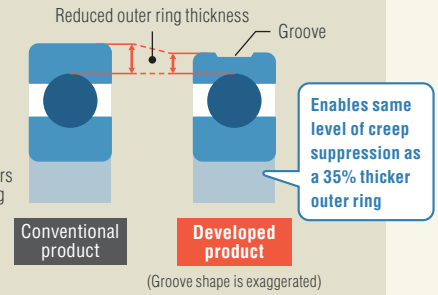


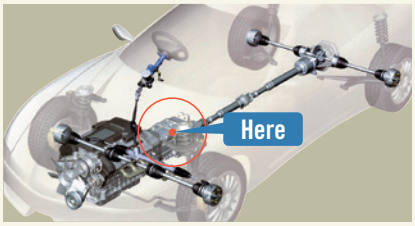
Figure 2



Contributing to a compact, lighter transmission

This product is the world's first bearing employing a structure and shape with a groove to prevent creep due to strain in the outer ring (according to JTEKT research). Without the need for a thicker outer ring as in the past, the transmission can be made more compact and lightweight, thus improving fuel economy. The development of the anti-creep ball bearing was completed in March 2016, and proposals are already being made to automakers and transmission manufacturers in Japan and overseas.

"We consulted with those in production engineering about the optimal width, depth and shape of the groove and, after much trial and error, achieved commercialization of the bearing. When we explained the mechanism at an exhibition, many people from the automotive industry were interested, which made me realize just how necessary creep suppression is. I want to continue my involvement in development that will lead to better fuel economy in vehicles in order to help resolve environmental and energy issues." (Ishii)



Weight Compared with conventional	Approx. **12%** lighter
Amount of housing wear Compared with conventional	Approx. **50%** reduction

A new material to prevent abnormal noise and maximize life

Bearing Operations Headquarters
Industrial Machinery
Application Engineering Dept.
Industrial & Construction Machinery
Bearing Engineering Office
Agricultural & Electrical Machinery Group
Yasuhiro Sakamoto (left)

Bearing Operations Headquarters
Industrial Machinery
Application Engineering Dept.
Advanced Precision Machinery
Bearing Engineering Office
Machine Tools & EXSEV Group
Kazuma Okada (right)

For motor bearings, the issue is how to prevent a phenomenon called electric corrosion, which damages the inside of the bearing. As a countermeasure against this phenomenon, JTEKT has developed and begun mass-producing a bearing that uses a new ceramic material.

Ceramic bearings: A bearing used in a variety of fields

Electric corrosion is a phenomenon where electrical discharge occurs inside

a bearing, damaging areas such as the rolling contact surface. As this phenomenon progresses, it can lead to abnormal noise and reduced life of the bearing, and therefore bearings used within motors must be insulated.

The most reliable method of insulation is to make the rolling elements (balls) ceramic, instead of the usual metal. Since their first-ever successful mass production in the world in 1984, JTEKT's silicon nitride ceramic bearings have been utilized in numerous fields, which currently include aviation and space, medical equipment, semiconductor manufacturing equipment, railway vehicles, and wind power generation.

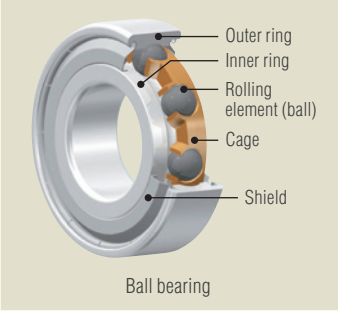
Utilizes a new ceramic material used for the first time in Japan

The new ceramic ball bearing for motors that we have developed is targeted for use within air conditioners. For air conditioners, preventing abnormal noise due to electric corrosion is a major issue. Although silicon nitride has traditionally been used for this bearing, we have adopted a new ceramic material that has never before been seen in Japan. This material has allowed us to reduce the variations in the clearances between the balls and the outer and inner rings, enabling usage within a wider range of temperatures. We began mass production of this bearing in June of 2016, and are considering proposals within a broader spectrum of fields, such as in servo motors used in robots.

"Bearings are known as the "backbone of industry", and are used extensively within all types of machinery that exist in

society, although they aren't usually seen by the general population. I want to keep making improvements and send out products with higher reliability into the world to help build a more abundant society." (Sakamoto)

"I want to raise our engineering capability to firmly answer the needs of our customers, which continue to increase in sophistication with each passing year. For example, if we can develop a bearing that spins with less force, it can suppress energy consumption in the machines on which it is installed, which will contribute to resolving environmental and energy problems. To me, responding to demands one at a time in this way is important to engineers." (Okada)



Ball bearing

Quality improvement through IoE (Internet of Everything)

Machine Tools & Mechatronics Operations Headquarters
Machine Tools & Mechatronics Engineering Dept.
Machining & Process Engineering Office
Grinding Group
Masaya Hikita (left)

Machine Tools & Mechatronics
Operations Headquarters
IoE Promotion Office
Group 1
Koichi Kato (right)

The development of IoT (Internet of Things), in which all things are connected by the internet, is causing a massive revolution within the manufacturing industry. Following this trend, JTEKT has proposed the concept of IoE (Internet of Everything) which incorporates not only things, but people and services as well, and through which we aim to create new value.

Developing a system that detects grinding burn

We, JTEKT, develop and manufacture both the machine tools and the control devices necessary for achieving IoE. As a *monozukuri* manufacturer, we also possess a production line to evaluate and verify the effects of IoE. Leveraging this advantage, we have made it our policy to propose to customers the creation of a smart factory through IoE within production, quality, and maintenance.

For "IoE for Quality", we are furthering the development of a system that detects grinding burn. Grinding burn is a defect where the structure of a metal degenerates and softens due to heat. This defect is difficult to see and there are many cases where it is first discovered in the inspection process. When grinding burn occurs, it is necessary to stop the machine and inspect the workpieces both upstream and downstream of that machine, drastically impacting production efficiency.

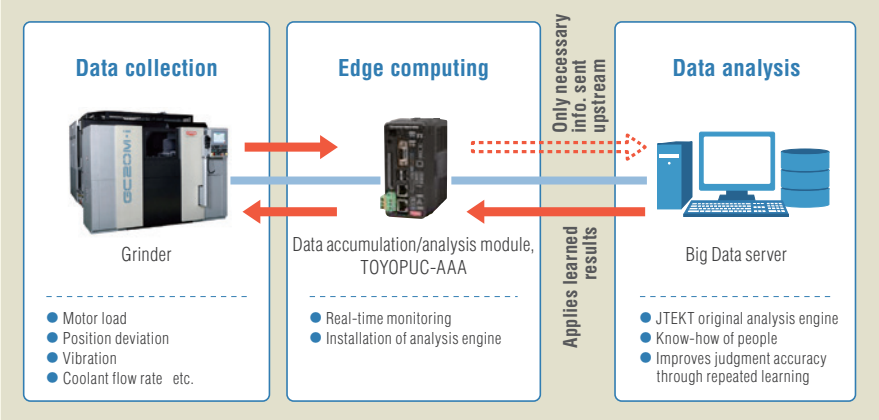
A system that develops through repeated learning

In the system currently being developed, data collected from each sensor installed in the grinder is accumulated and analyzed through a data accumulation and analysis module to determine the presence of grinding burn. Analysis is performed using original JTEKT software while incorporating the know-how of people. Another feature of this system is that analysis results are fed back in a repeated learning process to improve judgment accuracy.

"We are still at the stage where judgment is performed after machining, but through further accumulation of data and expertise, we will in the future achieve a system that notifies the user of symptoms of grinding burn and other defects before machining to prevent machining abnormalities. Through this, we hope to contribute to preventing quality defects for our customers who utilize this system." (Kato)

"By preventing quality defects, equipment can be run efficiently, thereby saving energy and cutting production costs. We will continue working to create a technology with high added value that combines "machinery", "machining technology", and "control technology", so that we can contribute to higher productivity." (Hikita)

Proposal for equipment on which no machining defects occur, through monitoring of grinding status



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