JTEKT Group Activities to Develop and Design Environmentally Friendly Products

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JTEKT has established six specialized environmental subcommittees under the Global Environmental Preservation Committee and promotes environmental preservation activities on a companywide basis. The Environmental Design Subcommittee, one of the six subcommittees, has been carrying out activities related to the development and design stages in order to promote the creation of environmentally friendly products. In 2003, it established a "basic equation for environmental efficiency" as a common index for all JTEKT products with the aim of preventing global warming. This paper presents various activities by the JTEKT Group to create environmentally friendly products in the areas of both automotive and industrial products and reduce environmental impact.

***Key Words**: environmental management, environmental performance, environmentally friendly products, eco-efficiency, Global Environmental Preservation Committee, Environmental Design Subcommittee, bearing, steering system, driveline product, machine tool*

1. Introduction[1)-6)]

The Kyoto Protocol was adopted in 1997 at the 3rd Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change and entered into force in 2005. Since then, member countries have been actively pursuing initiatives to combat global warming. With respect to emissions of carbon dioxide (CO_2), one of four greenhouse gases, the target agreed upon by all major industrialized countries for the first commitment period (2008-2012) is, on the average, 95% or less of 1990 levels, based on which the target level for each country has been determined. The target level for Japan is 94% or less of the 1990 levels (at least 6% reduction from 1990 levels in net volume of emissions). The transport sector including automobiles is responsible for 20% of CO_2 emissions in Japan. Based on the Law Concerning the Rational Use of Energy (the Energy Saving Law), automobile manufacturers achieved the Japanese FY2010 fuel efficiency standards for 90% of the gasoline-powered vehicles ahead of schedule at the end of FY2007. In order to meet the FY2015 fuel efficiency standards (16.8 km/L), they have been developing new technologies that enable both higher fuel efficiency and lower emissions.

Under this situation, JTEKT established a Global Environmental Preservation Committee in the 1990s to promote environmental management. This committee has been taking the initiative in reviewing and determining corporate policy and goals related to environmental activities. Six specialized environmental subcommittees formed under this committee have been promoting environmental preservation activities regarding important themes of the corporate environmental policy (**Fig. 1**). The Environmental Design Subcommittee, one of the six subcommittees, has been in charge of developing and designing environmentally friendly products from the perspectives of global warming prevention and environmental impact reduction. In 2003, this subcommittee established a "basic equation of eco-efficiency" to quantitatively evaluate the eco-efficiency of all JTEKT Group products. This committee has been implementing development and design activities for environmentally friendly products with technologies related to energy conservation, light weight, and compactness. This paper presents activities undertaken by the JTEKT Group for developing environmentally friendly products and reducing environmental impact in automotive and industrial areas.

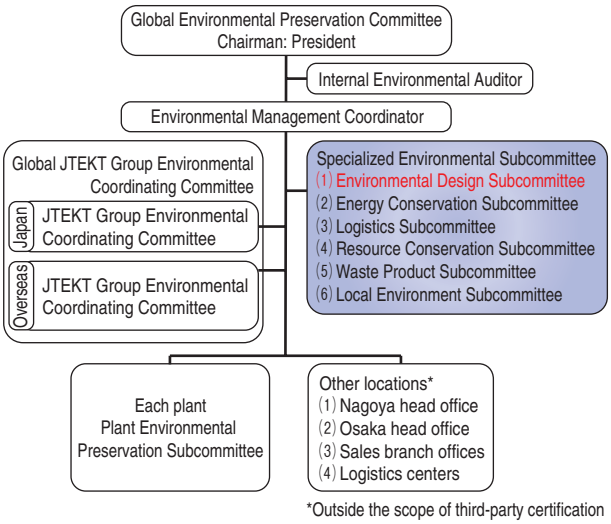


Fig. 1 JTEKT organizational structure to promote environmental management

2. Eco-Efficiency Index[5), 6)]

2. 1 Role and Aims of Environmental Design Subcommittee

JTEKT aims to become a manufacturing company friendly to the environment and has initiated activities to achieve a sustainable society, contribute to global environmental preservation through development and supply of environmentally friendly products, and minimize environmental impact made by production operations. With this in mind, the Environmental Design Subcommittee responsible for the development and supply of environmentally friendly products is making efforts to develop and design products as a top-priority issue in the development and design stage with the following aims and role:

[Aims] ① Strengthen environmentally focused manufacturing activities
② Supply unique products to the market with less environmental impact
③ Design and develop compact, lightweight and high-efficiency products that help prevent global warming

[Role] Set and promote guidelines for the development and design of environmentally friendly products in the JTEKT Group

2. 2 Eco-Efficiency

In 2008, the Japan Auto Parts Industries Association adopted the environmental index guidelines[7)] for products. In 2002, however, such guidelines did not exist. In 2003, JTEKT decided to establish an original eco-efficiency basic equation [equation (1)] as a common index for all JTEKT Group products in order to reduce environmental impact, especially by reduction of CO_2 emissions, and prevent global warming. In this equation, product performance (positive impact on the environment) is divided by product environmental impact (negative impact on the environment). As it was difficult to accurately grasp the environmental impact value by product, the calculation was devised to use mass (W), loss (T) and energy (E) as alternative properties. Improvement in product performance was not taken into consideration in the calculation for the time being, and in the case of product configuration being significantly different, other alternative properties were used for conversion. At the same time, calculation equations for eco-efficiency values [equation (2)] and environmental impact reduction ratios [equation (3)] were adopted in order to quantitatively and easily grasp eco-efficiency improvements of environmentally friendly products. These are expressed by either eco-efficiency ratio (%) or environmental impact reduction ratio (%) of conventional products and new products for the same applications. Here, conventional products mean products manufactured in 2002 before the equations were adopted in 2003.

With this originally established common index system, JTEKT has become able to assess the development results of all products by comparison on the same basis, set annual and medium/long-term targets for the JTEKT Group, and strived to contribute to global environmental preservation.

Eco-efficiency basic equation

$$= \text{Product performance} / \text{Product environment impact}$$

$$= 1 / \sqrt{(W^2 + T^2 + E^2)} \quad (1)$$

Eco-efficiency value

$$= \text{Eco-efficiency of new product} / \text{Eco-efficiency of conventional product} \quad (2)$$

Environmental impact reduction ratio

$$= (1 - 1/\text{Eco-efficiency of new product}/\text{Eco-efficiency of conventional product}) \times 100$$

$$= (1 - \text{Eco-efficiency of conventional product}/\text{Eco-efficiency of new product}) \times 100 \quad (3)$$

3. Activities in Automotive Applications[5), 6)]

As previously mentioned, automobile manufacturers have accelerated the development of technologies capable of meeting both higher fuel efficiency and lower emissions to achieve the FY2015 fuel efficiency standards. As an automotive parts manufacturer, JTEKT has strengthened the development of environmental technologies such as compactness, light weight or energy savings that are useful for fuel efficiency improvement in order to seek higher performance compatible with environmental requirements. Introduced here are examples of recent activities and results concerning steering systems and bearing/driveline products.

3. 1 Steering Systems

For steering systems, which perform the vehicle's turning function, performance and reliability are regarded as important. JTEKT, one of the world's few manufacturers supplying all types of steering systems, has made efforts to provide high performance compatible with environmental requirements to fulfill its responsibility.

Steering systems are largely classified into the three categories hydraulic power steering (HPS) systems, hydraulic-electric power steering (H-EPS®) systems, and electric power steering (EPS) systems. EPS systems consume one-sixth the energy of H-EPS® systems (**Fig. 2**) and are compact in size because they do not have such components as a pump and hoses. In recent years, because of needs for environmental preservation and energy savings, demands for EPS systems have significantly increased on a global scale. **Table 1** shows examples of the main activities regarding steering systems.

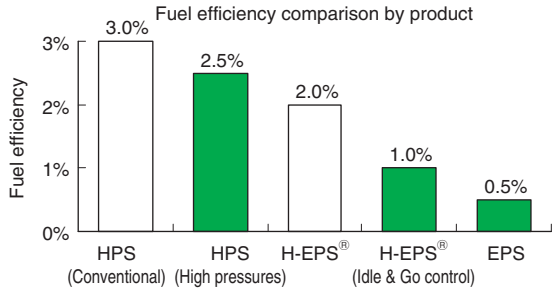


Fig. 2 Comparison of energy consumption ratio by steering system

As for C-EPS® systems, JTEKT developed a high-powered C-EPS® system equipped with motorized tilt & telescopic mechanism in 2008. Reducing the size and weight of the reduction gear and the torque sensor as well as the size of the key lock mechanism resulted in an overall 30% weight reduction. In addition, torque loss was reduced 22%, and an environmental impact reduction ratio of 39% was achieved.

In regard to R-EPS® systems, JTEKT succeeded in integrating an electronic variable-gear-ratio steering (E-VGR®) mechanism with a high-powered rack direct-drive type electric power steering (RD-EPS®) system in 2006. Through integrating E-VGR® and improving motor efficiency, high-powered and compact systems were achieved. System weight was reduced by 26% and torque loss by 40%, which resulted in an environmental impact reduction ratio of 44%. This system has improved vehicle driving stability by enabling changing the steering gear ratio flexibly depending on vehicle speed. This system moreover is an intelligent front steering (IFS) system equipped with the function that assists drivers' steering wheel maneuvering by detecting vehicle running conditions and running stability. The system has won the praise of users for its safe performance and compatibility with environmental requirements.

Concerning H-EPS® and HPS systems, continuous efforts have been made to pursue technological development and optimal designs in consideration of their characteristics, by which environmental impact ratios have been reduced 29% for H-EPS® and 17% for HPS.

3. 2 Bearings and Driveline Products

A great number of bearings and driveline products are used in automobiles. As a world-leading manufacturer in the field of automotive bearings and driveline products, JTEKT has actively promoted the development of environmental technologies in areas of tribology including materials and lubrication as well as design and manufacturing in order to improve fuel efficiency through compactness, light weight and energy savings.

Table 2 shows JTEKT's main activities related to bearings and driveline products. Regarding automobile chassis applications, a typical example is technology development activities to reduce the weight and size of wheel bearings (hub units) in order to improve performance and ease of assembly. With regard to 3rd generation hub units*, weight was reduced by 20% while strength and durability were maintained by pursuing a lightweight design by CAE analyses on axle assemblies including brake drums and wheels as well as utilizing manufacturing technology. Torque loss of the hub unit seals was reduced by 30% by development of a material for low-torque performance and an optimal configuration design for securing waterproof performance. Thanks to these improvements, hub units have achieved an environmental impact reduction ratio of 16%. JTEKT plans to successively introduce hub units with built-in ABS sensor for small vehicles.

With respect to drive-train applications, tapered roller bearings used for differential gears and intelligent torque controlled couplings (ITCC®) for 4WD vehicles are JTEKT's main bearings and driveline products. JTEKT's wealth of experience in design technology and tribology technology development related to materials, heat treatment, lubrication, etc., have greatly helped product innovations in this field. The torque loss of super-low-torque tapered roller bearings (LFT®-Ⅲ) was reduced 80% by optimization of internal specifications and optimal control of incoming oil volume. At the same time, weight was reduced 40% (more compact) and environmental impact 32% by means of new heat-treatment technology that enables the material surface hardness and material structures to be optimized to increase bearing fatigue life in contaminated oil (higher load carrying capacity). Likewise, the environmental impact of intelligent torque controlled couplings (ITCC®) for 4WD vehicles was reduced 19% by development of

such tribological technology as high-performance oil with small viscosity change in changing temperatures for exclusive use in ITCC® and diamond-like carbon (DLC-Si) coating technology with higher wear resistance to improve clutch durability. Both the LFT®-Ⅲ and ITCC® are already being mass-produced. JTEKT received Minister of Economy, Trade and Industry Awards in 2006 and 2007 for their energy-saving contribution, unique technologies and economical benefit.

Regarding products for other applications such as engines, transmissions and transfers, JTEKT has been pursuing compactness and lighter weight through developing technology aimed at optimal designs based on each product's characteristics, and environmental impact reductions of 17%-32% have been achieved.

*Structure of 3rd generation hub units: ①Bearing outer ring integrated with housing, ②One-side inner ring integrated with hub shaft

Table 1 Examples of main activities related to steering systems

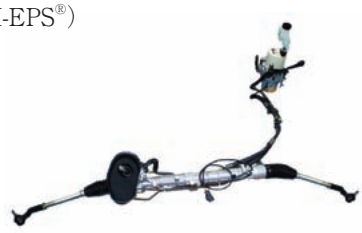
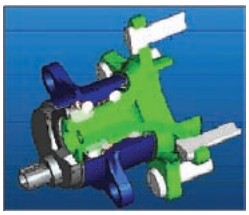
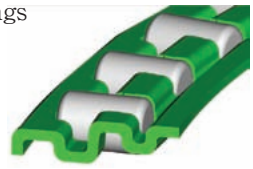
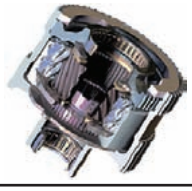
Systems		Development points and technologies	Eco-efficiency value	Environmental impact reduction ratio
Electric power steering systems	Column assist type (C-EPS®) 	■Compactness and light weight by integration of motorized tilt & telescopic mechanism ■Compactness and light weight by adoption of hall IC type torque sensor ■Compactness and light weight by adoption of brushless motor ★Mass: 30% reduction ★Torque loss: 22% reduction ★Energy consumption: 83% reduction	1.63	39%
	Pinion assist type (P-EPS®) 	■Compactness and light weight by integration of motor and controller ■Compactness and light weight by adoption of brushless motor ★Mass: 30% reduction ★Torque loss: 22% reduction ★Energy consumption: 83% reduction	1.64	39%
	Rack assist type (E-VGR® integration) 	■Compactness by integration of electronic variable-gear-ratio steering (E-VGR®) mechanism ■Compactness and high power by motor efficiency improvement ■Compactness and light weight by adoption of brushless motor ★Mass: 26% reduction ★Torque loss: 40% reduction ★Energy consumption: 83% reduction *Received the Automotive Component Award in the 4th Monozukuri Parts Prize in 2006 sponsored by the Nikkan Kogyo Shimbun, Ltd.	1.79	44%
Hydraulic-electric power steering systems	(H-EPS®) 	■Compactness and light weight by integration of motor and controller ■Energy saving by Idle & Go control ■High response by adoption of brushless motor ■High efficiency by gear pump ★Mass: 20% reduction ★Torque loss: 12% reduction ★Energy consumption: 67% reduction	1.4	29%
Hydraulic power steering systems	(HPS) 	■Rack weight reduction by friction welding ■Torque loss reduction by high flow rate valve and high flow rate pump ★Mass: 13% reduction ★Torque loss: 20% reduction ★Energy consumption: 17% reduction	1.20	17%

Table 2 Examples of main activities related to bearings & driveline products

Systems		Development points and technologies	Eco-efficiency value	Environmental impact reduction ratio
Engine	Ceramic bearings for turbochargers 	■Turbo efficiency improvement by replacing full float bearing with rolling bearing ■Further improvement of turbo efficiency by use of ceramic balls ★Energy consumption: 67% reduction	1.21	17%
Chassis	Lightweight, low-torque hub unit wheel bearings for mini-vehicles 	■Reduced bearing flange thickness and optimized to ball diameters ■Built-in ABS sensor ■Low torque and waterproof by optimizing contact pressure and contact width of dust seal lip ★Mass: 20% reduction ★Torque loss: 30% reduction	1.19	16%
Drive train	Intelligent torque controlled couplings (ITCC®) for 4WD vehicles 	■Pilot clutch wear reduction and temperature stabilization by developing exclusive oil for ITCC® ■Durability improvement by DLC-Si coating on pilot clutch surface ★Mass: 15% reduction ★Loading capacity: 2.1 times improvement *Received Minister of Economy, Trade and Industry's Award at 21st Chunichi Industrial Technology Awards in 2007 sponsored by Chunichi Shimbun	1.23	19%
	Super-low-torque tapered roller bearings (LFT®-Ⅲ) 	■Long fatigue life, low torque and high rigidity by optimization of internal specifications ■Size reduction by applying heat-treatment enabling long fatigue life ■Agitation resistance reduction by controlling incoming oil volume lower ★Mass: 40% reduction ★Torque loss: 80% reduction *Received 27th Minister of Economy, Trade and Industry's Award for Excellent Energy-Conserving Machinery from the Japan Machinery Federation	1.47	32%
Transmission/transfer	Low-torque thrust needle roller bearings 	■Light weight by adoption of new unique design retainer with high-accuracy pressing technology ■Reduction of sliding resistance between rollers and retainer by optimal retainer design ★Mass: 20-30% reduction ★Torque loss: 60% reduction	1.35	26%
	Compact TORSEN type C 	■Compactness and light weight by optimized design and integration of components ★Weight: 27% reduction	1.22	18%

4. Activities in Industrial Applications

Regarding machine tools and other types of industrial equipment, the JTEKT Group has been engaged in various development and design activities, placing emphasis on reducing the consumption of resources and electricity in order to prevent global warming. Concerning certain selected products, JTEKT conducts product assessments to grasp environmental impact in all product lifecycle stages from manufacture to disposal in order to supply products with minimal environmental impact on society.

Introduced here are main activities related to machine tools and other industrial equipment types, a summary of which is shown in **Table 3**.

Table 3 Examples of main activities for industrial applications

	Systems	Development points and technologies	Eco-efficiency	Environmental impact reduction
Machine tools	GL32J Cylindrical grinder 	■Development of high-rigidity wheel spindle for grinding part ■Energy-saving measures besides grinding part measures ・Sliding resistance reduction ・Coolant volume reduction ・Energy reduction of supply and cooling of wheel spindle bearing oil ★Energy consumption: 45% reduction ★CO_2 emissions: 10.5 tons reduction (in case of machining 200 000 workpieces per year)	1.26	21%
	TG5-100 Combination grinder 	■Size reduction by adoption of traverse for wheelhead ■Motor size reduction by adoption of linear guide to lower friction resistance of feeding slide ★Weight reduction: 20% ★Electricity consumption: 24% reduction	1.33	25%
Industrial equipment	Vacuum purge type box furnace (Koyo Thermo Systems Co., Ltd.) 	■Uniform heat distribution in furnace by separate temperature controls in three areas of bottom heater ■Heat dissipation reduction by adoption of semicircular bottom heater ■Two layers of heat insulating materials inside and outside of heating chamber ★Mass: 44% reduction ★Electricity consumption: 44% reduction	1.78	44%
	Spring type accumulator (Toyooki Kogyo Co., Ltd.) 	■Energy saving by stopping motor rotation with clamping pressure retained by spring ■High tegular type accumulator added ★Mass: 6% increase ★Electricity consumption: 63% reduction	1.82	45%
	CBN Grinding wheel for cylindrical grinder (Toyoda Van Moppes Ltd.) 	■Longer fatigue life by increased grinding layers ■Grinding resistance reduction by finer CBN abrasive grains ★Fatigue life: 3.2 times longer ★Grinding resistance: 20% reduction	1.64	39%
	Universal compact PLC (Koyo Electronics Industries Co., Ltd.) 	■Weight reduction by changing structure from I/O plug-in system to I/O connection system ■Electricity consumption reduction by changing power source from base built-in type to power-source module ★Mass: 61% reduction ★Electricity consumption: 58% reduction	1.75	59%

Among machine tools such as grinders, lathes, machining centers, JTEKT's main products (machines) are grinders, especially cylindrical grinders and combination grinders. From the perspective of product assessment, JTEKT has endeavored to reduce the environmental impact of grinding machines. With the GL32J cylindrical grinder, it became possible to grind workpieces using a grinding wheel 60mm in width (wider than conventional wheels), thanks to the development of high-rigidity wheel spindles and ecological grinding technologies such as sliding resistance reduction, coolant volume reduction and energy reduction in supply, and cooling of wheel spindle bearing oil. As a result, productivity was substantially improved with a 45% reduction in energy consumption per workpiece. This contributed to an environmental impact reduction ratio of 21%, which is equivalent to a 10.5 ton reduction of CO_2 emissions assuming the grinding of 200 000 workpieces a year.

For industrial applications, the JTEKT Group has a wide variety of products, such as semiconductor and liquid crystal display equipment, industrial heat-treatment furnaces, hydraulic devices like vane pumps, electronic devices, and CBN grinding wheels. Introduced here as a representative product is a hydraulic unit. Effective measures for energy savings in hydraulic units should be directed at the motor because it consumes much electricity. Electricity consumption of the spring-type accumulator shown in **Table 3** was reduced 63% by such measures as raising pressure only when necessary, lowering the circuit pressure and adopting a smaller motor, and adding a pressure retaining mechanism by a spring type accumulator. Although the accumulator itself caused a 6% mass increase, the environmental impact was reduced 45% because of reduced electricity consumption. Hydraulic units are expected to make a great contribution to energy savings because they are widely used in plant facilities and equipment.

5. Conclusion

This paper presented activities of the JTEKT Group related to the development and design of environmentally friendly products together with a visually manageable method of assessing development results based on environmental impact reduction ratios as an original and common index of JTEKT.

Since 2009, Japan's Ministry of Economy, Trade and Industry has been trying to introduce a carbon footprint system as a means of visually managing CO_2 emissions. This system adopts Life Cycle Assessment (LCA), in which calculations are made to quantitatively grasp environmental impact in all product lifecycle stages from material procurement to disposal or recycling, and greenhouse gas emissions are converted into CO_2 for comparison[8].

Environmental requirements will become increasingly severe. The JTEKT Group will continue efforts to develop environmental technologies and contribute to society as a manufacturing company friendly to the global environment. Regarding the environmental index, JTEKT is preparing to adopt the LCA method in addition to its original method currently in use in the JTEKT Group. JTEKT will closely cooperate with the Ministry of Economy, Trade and Industry as well as concerned industrial organizations to establish a common index based on a standardized equation and enable environmental impact to be visually monitored in the future.

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