Rolling bearings have contributed to the improvement in almost all industries as key mechanical elements of rotating mechanisms. Recently there has been an increased need for high accuracy, high performance and multi-functional products at lower prices. In production engineering, various new technologies have been developed to cope with these needs. Examples of these are reviewed in this article including some future trends and views such as environmentally friendly technology, shortening of development period etc.

**Key Words**: rolling bearing, product engineering, manufacturing products, trend, hub unit, high precision, module

1. Introduction

Rolling bearings and related unit products are indispensable machine elements and are widely used in various industries. There are various needs concerning performance and function, and requirements in design and precision also differ largely according to their applications and bearing types. In these circumstances, production engineers are confronted with the task of developing technologies capable of producing low-cost products that can satisfy these requirements.

In recent years Koyo has obtained ISO14001 certification in order to conform to preservation of the global environment. Complete elimination of the releasing of wastes into the environment, such as minimal consumption and recycling of energy and resources, are needed. There is also a pressing need to consider the assessment for life cycle of products. This is considered to be an important item not only for the products themselves, but also for the field of production engineering.

Shortening product development periods has also become increasingly important. We must proceed in the 21st century by considering product development, production engineering and process engineering in a comprehensive manner.

This paper details specific examples of production engineering developed for bearings and unit products as well as the future direction of such technologies regarding these circumstances.

2. Recent Trends in Production Engineering

2.1 Example of Precision Improvement in HDD Bearings

Rolling bearings have been dramatically improved in basic performance such as rotating accuracy, noise, high speed performance and life. This largely owes primarily to developments in machining equipment and technology, measurement technology, and quality control as well as technologies concerning materials and lubrication.

The representative example of precision products is the bearing for hard disk drives (HDD) of computer for which machining accuracy and bearing performance has been largely improved. This improvement has been needed from the movement of higher performance of computers. The required level of HDD memory capacity has been increased as shown in Fig. 1 in terms of exponential function.

Recent required Non Repeatable Run Out (NRRO) which is one of bearing accuracy items is one-twentieth or less as compared that in ten years before, as shown in Fig. 2.

As a result of focusing on development of technologies for machining and assembling of miniature ball bearings to cope with these needs, Koyo has achieved the world’s highest...
precision level and contributed to the information industry. Figure 3 shows an example of precision data for a bearing raceway. The highest level of precision, NRRO ≤ 0.05 µm, was achieved.

The high-precision machining technology developed for HDD bearings has been applied to other types of bearings.

2) Technology for simultaneous grinding of raceway, small end face and outer diameter of inner ring

Inner ring raceway must be positioned to a high degree of accuracy. Using the same type of formed rotary dresser as used for outer ring, high-accurate machining was achieved by angular grinding as shown in Fig. 6.

Precision stability

Simultaneous grinding of inner ring raceway, small end face and outer diameter

Fig. 6 Simultaneous grinding of inner ring raceway, small end face and outer diameter

2. 2 Unit Products (I) – Hub Unit as an Example

This section shows unit products for automobiles as other examples.

Unit products have been developed not only for easy assembling at customers and cost reduction but also for consolidating various functions into a single unit. They are being expanded for various components.

Machining technology for hub units used in wheel application for automobiles is described in the following sections.

2. 2. 1 First Generation Wheel Bearings

Figure 4 shows an example of a double-row angular contact ball bearing. This bearing consists of two inner rings and one outer ring. High accuracy for raceway pitch is required to ensure bearing preload when it is mounted to a wheel.

Fig. 4 Double-row angular contact ball bearing

1) Technology for simultaneous grinding of two raceways of outer ring

The outer ring is provided with two raceways. In order to enhance machining accuracy pitch, a grinding wheel was shaped using a formed rotary dresser shaped to high accurate dimensions as shown in Fig. 5. The desired high precision machining was achieved by means of technology of simultaneous grinding for raceways of the outer ring.

2) Technology for simultaneous grinding of raceway, small end face and outer diameter of inner ring

Inner ring raceway must be positioned to a high degree of accuracy. Using the same type of formed rotary dresser as used for outer ring, high-accurate machining was achieved by angular grinding as shown in Fig. 6.
2. 2. 2 Second Generation Hub Unit

The next type developed was the hub unit that includes the hub on outer ring for mounting the brake drum. The hub unit is shown in Fig. 7. The emphasis of the development of this unit was placed on quality assurance and minimizing lead-time. For this achievement, a sequent line was adopted for production of this units.

![Fig. 7 Second generation hub unit](image)

1) In-line hardening and tempering (High frequency)

With the first generation, hardening was performed in batches. With hub units, however, hardening by high-frequency heating within the line was used. An electric heater was originally used for tempering. Tempering required much space and time because of the large number of work pieces involved. The induction heating system shown in Fig. 8 was therefore used for the tempering process too. The system saves space and reduces lead-time.

![Fig. 8 Hardening and tempering process](image)

2) Turning after heat treatment

In order to save the additional time needed for grinding due to heat treatment distortion, a system of turning raceways with chucking once subsequent to heat treatment has been introduced to reduce stock removal for grinding. Figure 9 shows the type of cutting tools and their movements.

3) Coping with negative clearance

Koyo has succeeded in developing a technology for obtaining the most suitable preload (negative clearance) that can both improve wheel rigidity required for chassis of the automobile and get longer bearing life. As shown in Fig. 10, rigidity and life act opposite to an amount of the clearance. Technology for machining the most suitable clearance to satisfy both rigidity and life has been developed.

![Fig. 10 Negative clearance and rigidity/life](image)

2. 2. 3 Third Generation Hub Unit

In order to further reduce weight and cost of the unit, the inner ring and shaft have been consolidated into a single part and the same has been accomplished with the shaft and nut. Figure 11 shows the original third generation hub unit.

![Fig. 11 Third generation hub unit](image)

1) Machining technology of inner ring unit (Grinding and superfinishing)

The inner shaft includes the single inner ring of the second generation hub unit plus the shaft inserted in the hub unit. Figure 12 shows the method established for simultaneous grinding of the raceway, seal face, outer diameter and end face of inserting section for inner ring with formed rotary dresser.
a sensor, and they are mounted together on the hub unit. In order to facilitate mounting at the automobile assembly plant, a detection mechanism capable of guaranteeing output of the speed sensor already mounted on the bearing has been developed.

4) Shaft clinching

The inner ring used to be fixed on the shaft by means of a nut. Hoping to enhance bearing rigidity, reduce weight and cost, a technology has been established for clinching the inner shaft that can guarantee axial force of a bearing. Figure 14 shows the clinching process. Pressure is applied by a reciprocating tilted punch. The technology is able to obtain the most suitable axial force without deforming other parts such as the inner ring, balls and outer ring.

2. 3 Unit Product (Ⅲ) – Axle Unit

As previously stated, over the span of several years the hub unit has been improved from the first generation to the third generation. Amidst the recent trend to combine related parts into modules, we have also moved towards incorporating peripheral parts into units.

With an axle unit as an example, the efforts in enhancing precision for developing these units are described.

The objectives for the development are to reduce cost and enhance quality as an axle unit, incorporating peripheral parts into a hub unit and to enhance the precision of brake disk runout.

1) Set machining of axle, left and right

Figure 15 shows the axle. A total of 4 parts: front, rear, left and right is applied for one vehicle.

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**Fig. 12** Simultaneous grinding of inner shaft raceway, seal face, end face and outer diameter of inserting section for inner ring

2) Assembly (Matching)

First generation hub units are assembled with two parts: an outer ring and two inner rings. The third generation uses a combination of three parts. Because raceway dimensions of inner shaft are taken relative to the end face of the inserting section for inner ring, a new technology for measuring the dimensions has been developed.

3) ABS sensor output detection mechanism

Automobile manufacturers provide their vehicles with an ABS sensor to secure steering safety by preventing the wheels from locking when suddenly applying the brakes. As shown in Fig. 13, the ABS sensor consists of a rotor and
3. Future Direction of Development

As was previously stated, although there have been dramatic improvements in performance and design of bearings themselves, their basic configurations appear not to have changed so much.

Be that as it may, the position of bearings seems to be changed amidst the trend to use units and modules in place of separate parts seen in recent years. Up to now those in the industry have been able to cope with conventional technology and their extension. It has however become important to develop and establish technologies that have never been experienced or do not exist anywhere in the world. Effective use of resources on a global scale and environmental conservation have especially become required conditions, and innovative production technology must be developed to deal with them.

Effective use of human resources and time is also important. It is thought that items such as production preparations using electronic information will bring about a particularly significant change in the roles of production engineers.

3.1 Innovative Production Technology

This section describes items related to innovative production technologies that will probably be developed in the near future.

1) Total elimination of contaminants released into the environment

Product design used to be primarily concerned with performance and precision, but now product design should be done in a comprehensive view of all aspects including production technologies. An epoch-making system capable of high-precision plastic machining needs to be developed. A net shape that does not leave stock removal in subsequent processes, a combination of forging, press forming, roll forming and welding, plus a method of forming by docking also need to be developed.

2) Innovative cost reduction

Concerning cost reduction, bearing manufacturing processes from grinding to assembling have matured to a certain degree. The level of these processes needs to be raised in order to fully automate the process. In the field of materials, innovative cost reducing technologies such as special heat treatment and surface treatment technologies for improving low-cost materials to be as good as high-cost materials or integrating technologies of material, coating and heat treatment can be expected.

3) Environmental conservation

Among the various machining processes, heat treatment can be given as an epoch-making process for saving energy. Development of high-speed carburization technologies and saving energy by using regenerative burners will probably grow. Progress is being made in the recycling of waste such as scraps from grinding. Ultimately, taking all aspects of the product including recycling will probably become an item of importance.
3.2 Shortening of Product Development Periods

Along with customer satisfaction, dramatic reduction of development periods will be a theme of importance in order to effectively use manpower and time. This encompasses product development from design to production preparations, and is achieved by proceeding simultaneously within a common information framework, rather than having the design and production engineering departments, with their complicated relationship, proceed according to individual information items. In specific terms, Koyo hopes to dramatically reduce the total development period by conducting processes from design to production preparations simultaneously using 3D CAD.

![Diagram showing simultaneous process]

Fig. 18 Shortening of development period

4. Conclusion

Usually, the main effort of conventional production technology development used to be concentrated on how cheaply the manufacturer could produce better products based on design drawings. Now, however, we must significantly shift our attention from "production innovation" to development of production engineering, which is the driving force behind "product innovation."

For this reason, the production engineers must provide optimal product shape at the product concept and design stage and must be able to provide the best machining methods and materials for product functions.

The IT revolution is now said to be everything for corporate growth. IT however is a means, not an objective.

In other words, it will be necessary to create a single flow by using IT to change production engineering skills learned at the production site into digital data, and then putting the information in a database for product development and manufacturing method development so the various departments can share and use the data. By doing so, product development, production engineering development and stable mass production can all be carried out simultaneously.

The management of product technology and production technology development which can be carried out simultaneously on a single flow is now the theme of utmost importance.