Koyo Production System and Machines & Equipments for Rolling Bearings

M. ISAKA

Bearings, one of highly matured and standardized industrial products, had been commonly and generally produced in a large lot with so-called mass-production method. However, considering the trends, such as diversified consumers' needs of automotive bearings, intensified competitions in the global market, and compliance with global environmental protection, bearing manufactures have now been strongly demanded to break away from the conventional concept of mass production method. In order to cope with these demands, the author herein presents Koyo's production method "KPS" (Koyo Production System), production innovation "PPI" (Product and Process Innovation), and machine & equipment specifications "SSF" (Simple Slim Flexible). In addition, Koyo's basic concept for establishing overseas factories and production machines & equipments are described.

**Key Words**: rolling bearing, production system, production innovation

1. Introduction

It was common practice that the production of technically matured and highly standardized rolling bearings used for the industrial market was made exclusively on dedicated production lines. These production lines were capable of producing large quantities. However, due to diversified customers' needs, intensified competitions in the global market, and compliance with the global environmental protection, more innovative production methods and equipments have recently been sought.

In this report, conventional production methods are reviewed and more innovative production methods, which we should consider from now and into the future, are discussed.

2. Trends of Production Methods and Equipments

The basic concept of Koyo's production system is based on KPS (Koyo Production System), which was originally based on "Just in Time" and "Automated Operation" under TPS (Toyota Production System).

Since 1978 (Fig. 1), this concept was systematically implemented and, before then, our production lines had been made similar to other standard products for industrial uses with the concept of mass production under such control as projected or planned production and production control by each process in a large lot. Now Koyo's production has been basically made with a "Fill-up System" philosophy. This philosophy has been used for all bearings except for bearings by order basis as special and large sizes.

Fig. 1 History of Koyo Production Systems for bearings

Concerning processing machines which are the cores of production lines, exclusively dedicated machines made domestically were mainly introduced to increase the quantity and the efficiency of each process. However, under the KPS, pursuit of efficiency for an individual process or machine results in an imbalance among processes. This imbalance causes the inability to observe the maximum performance on an overall basis. Ultimately we see such situations as the increased WIP (work in process) among the processes and a more complicated process flow (branches & confluences), as shown in the upper column of Fig. 2.

Fig. 2 Changes of configuration of machines & equipments

**Key Words**: rolling bearing, production system, production innovation
From the viewpoint of quality, process control, process history, etc., as shown in the lower column of Fig. 2, it is preferred that a work piece should be processed by one into each process.

According to Fig. 2, it appears that, since 1978, the process flow has remarkably been rectified, but still some concentrated processes actually exist. Even with the production lines of the full and complete processes connected with automatic conveyor systems, imbalances among processes due to different processing times has still been observed and we still have many production lines designed with multiple machines for one processing in an individual line.

In order to pursue more efficient production systems aiming "Production Innovation" mentioned later, future theme should be focused on the following points on machine-development and machine-set-up as the present stage being the time for change.

Table 1 Development of machines & equipments: Keys and subjects of layout

<table>
<thead>
<tr>
<th>Keys</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous flow processing</td>
<td>Zero quantity or reduction of work-in-process</td>
</tr>
<tr>
<td>In-line facilitated integrated process</td>
<td>Compact sized machines for metal forming and heat treatment, in-line facilitation</td>
</tr>
<tr>
<td>Mixed-flow facility</td>
<td>Coping with multiple types production</td>
</tr>
</tbody>
</table>


After reviewing excessive capital investment, luxurious specifications or complex structures and electric controls, etc. under the bubble economy, "Production Innovation" has started to come into picture in order to revive the manufacturing industry in Japan.

Japan cannot calmly sit back as China has continued to grow in the global markets, and each industry in Japan has been doing utmost to implement production and technology innovations even with the sequela of the bubble economy.

Without exception, Koyo at this stage has been in the middle of promoting "Product and Process Innovation" called PPI. The key words are "Change Process," "Change Machines," and "Change Products" which mean that "we create a completely new manufacturing technology by going back to the roots with deep analysis of history as well."

With this kind of concept and viewpoint, the goal is to create manufacturing innovations after reviewing current machines, equipments, and all processes.

Since Koyo was founded, a conventional method was adopted, but now Koyo has started to take the following measures.

① Discontinue the "selective fitting" (To adjust internal clearance of a bearing by matching balls and races with their specific diameters)
② Change conveyor systems between equipments from three-dimensional connections to two-dimensional connections

Figure 3 shows an image illustration of two-dimensional connection of conveyor system.

![Image](image)

**Fig. 3 Image illustration of conveyor system**

There still exist many machines connected with three-dimensional conveyor systems. These system use upper spaces because of limited production area where the multiple machines for one processing, as shown in the upper column of Fig. 2, have to be connected and also there are some remains from the mass production of one particular size with the machine layout done by process during the first half of 1970s.

From now on, two-dimensional conveyor systems will be required in order to avoid the difficulties in maintenance and complicated works required for change-over, which is necessary in cases where different sizes are produced on the same line.

When such kind of new concept has to be spread within the company, "Consciousness Innovation" of all concerned is required. This consciousness innovation is a must for successful achievement of "Product and Process Innovation".

When a new plan for production machines is made, each time it is reviewed from the roots based on PPI concept, and in addition, what we need is the innovative facilities with reflection of modern concepts such as "Ergonomics" and "Universal Design."

"Ergonomics" and "Universal Design" are both indispensable concept from now on, which is gentle to human beings and also respect mankind.

Such innovative image of machines is shown in Fig. 4 and this is the facility with SSF (Simple Slim Flexible) reflected. So far, machine layout has been done by "process by function" and each machine has been designed to have the optimum efficiency itself, which ultimately has resulted in more processes, large-sized machines, machines with complicated control systems, etc. The operation has been relatively accepted while the constant orders with limited sizes have been coming in. However, under the present situation; including with frequent quick changes, these machines have less capability to comply with frequent changes in product type and quantity, which are the facilities to cope with a large burden of excessive cost of depreciation. Figure 4 is the simulation of the various stages from conventional facilities to SSF facilities.
For LCC (Leading Competitive Countries) like Thailand, China, etc., it is not acceptable to place machines equivalent to those used in Japan but without automated systems.

- Those machines are originally designed for automated systems and therefore not suitable for manual conveying operations
- Machine costs are too high compared with labor costs
- Problems in maintenance are unsolved as same as in Europe and America

These kinds of problems should be focused on.

Consequently, we have to make production facilities in LCC with top priority being for human being and try to leave out automated systems with the least numbers. This means that we must return to the roots of manufacturing with production lines with as possible as manual operations. After all, only when manual operations are impossible, we should apply automated systems for processes, equipments, and production lines.

For future consideration, it will be necessary for us to develop machines that include both global specifications and local specifications, which can change the rate of automated systems in accordance with the rate of labor cost by taking machines for LCC (China and ASEAN) as the standard base shown in Fig. 5. As the first step, Koyo plans to have a production model line in Thailand, a line with the rectified concept included, such as an image shown in Fig. 6 and the second step of plan is to have the same in China.

---

**Koyo Production System and Machines & Equipments for Rolling Bearings**

1. **Conventional**
   - Process separation, simplified & slimmed equipments
   - (Shortening of flow length) Simplified & slimmed conveyor

2. **SSF concept**
   - Simple : Simplifying and removal of the complicated structures and control systems
   - Slim : Small and compact size, specifications only with absolutely necessary capabilities
   - Flexible: Facilities in compliance with mixture line for wider use and the increased power for coping with different types and quantities

In order to have two-dimensional conveyor systems, changes of not only conveyors but also machines themselves are inevitable, and therefore SSF of machines is required.

### 4. Establishment in Overseas Factories and Production Facilities

Koyo’s first overseas production was started in the US in the early 1970s, when dumping case for bearings was presented by local manufacturers. This was considered to be one of the earliest Japanese trans-plant production manufacturing facilities in North America.

Since then, factories have been established in various countries including UK, Thailand, etc. to comply with demands from Japanese car manufacturers that are our major customers. Basically production systems and equipments are close to 100% equivalent to those of factories in Japan. By these days, Koyo had established each factory by each type of bearings in Japan, and therefore the technology and the equipments was transferred from each parent factory to each trans-plant in overseas countries. Automated equipments placed in Thailand and China were slightly lower level than those in Europe and America. European and American equipments were equivalent to those in Japanese factories, including conveyor systems. However, it is difficult to perform the same level of maintenance as in Japan, which leads to lower operation rate of machines. This is the most reflective point for the production engineers. It is important to enhance the systems of education and maintenance, but it is more important to give it priority to develop easy-in-maintenance machines, that is, simple machines as mentioned above.

---

**Note:** No. of figure indicates process No.

**Fig. 4** Example of SSF concept

---

**Fig. 5** Machines & equipments by overseas factories

**Fig. 6** Example of rectified production line in Thailand (image illustration)
5. Summary

The future themes for machines, equipments and process flows were reviewed on the past history of production systems and structures of equipments as a whole, our working on PPI “Product and Process Innovation”, and the planning of machines & equipments by country. Taking all in mind, followings are the summary for machines & equipments to be required from now.

1) Machines by which we can process piece by piece with the speed required
2) Processes and equipments which are simple, slim, and flexible
   - Simple machines or machines without any complicated structures and controls
   - Machines with small & compact size, and specifications only with absolutely necessary capabilities
   - Facilities in compliance with mixture lines for wider use and the increased power for coping with different types and quantities
3) Machines & equipments with consideration of peculiarity of each country or region
   - Rate of automated systems and capital investment for machines to be determined depending on rate of labor cost
   - Consideration for easy operation and maintenance

These are the agenda for the production engineers to develop these machines, equipments and processes as discussed.

Last subject of this report is to think over what should be an aim from now in order to maintain production facilities in Japan while continuing to comply with the requests from the customers, particularly car manufacturers, for establishing factories in overseas countries.

Basically Koyo will produce and supply from local factory where the demand exists while Japanese facilities will continue to produce high-function products and high-value added products.

Therefore, the products, parts, and processes with core technologies have to be produced in Japan or in the optimum production site. However, in order to offset higher labor cost in Japan, production lines for the highly functional products and core parts must be intensively automated (unmanned) and also well rectified by new concept.

When a consideration is made on the optimum production site, there are some informative cases, created by Japanese car manufacturers, which are the relationship between body plants and unit plants and also the establishment of plants on a global scale. Normally one set of plants consisting of a body plant, paint plant and assembly plant has been established in each country but unit parts like engines or transmissions are not produced simply in every country. Every car manufacturer has gradually established the optimum production site for unit parts or core parts in North America, European continent, and Asian or ASEAN countries while at the same time carrying out the production allotment by type of car.

Concerning bearings, core technologies and parts are within the raw material processes, surface treatment processes and rolling element processes. These are the core processes or parts which should be hereafter still produced in Japan. However, in case of raw materials, if such materials for bearings with required quality become available in other some countries, the circumstances would change and the production facilities could be shifted to each country, in view of supply chain and logistics getting advantageous situation, even though the core technology is included.

In order to prepare ourselves for such opportunity, the thinking should be started to determine on production facilities and processes with consideration of different equipments by regions and SSF concept, and at the same time to develop local suppliers in each region.

For the final process of bearing production, the assembling process, it is needless to say that the operation must be completed in the each region where demand exists. In car manufacturers’ plants, recently, such new movements as “in-house outsourcing,” “suppliers park,” and “satellite plant” have been introduced and, with regard to bearings, it is hoped to develop machines with high operational availability which include the technology of one-touch change-over systems and also accommodate a mixture line located side by side of car assembly lines in compliance with different requirements coming from different types of cars in single line.

6. Conclusion

With the basis of KPS, effort is carried out for Product and Process Innovation with PPI concept where Koyo creates the innovation on the process, machine & equipment, and line facilities as a whole in order to make our factory comply and follow diversified needs of our customers, which means that the factory enables to extend the highest level of products and services to the customers instead of producing products just honestly following the drawings based on purchase orders.

Moreover, by pursuing “Product and Process Innovation,” it is believed to have created the additional effect of obtaining the improved design innovation on each product which will ultimately satisfy the customers, and endeavor to arrive at the new stage for manufacturing.

* Managing Officer responsible for Production Engineering Division