Trends of Bearings for Steelmaking Applications

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Various types of rolling bearing are applied for steelmaking application depending on each equipment and its function.

Corresponding to the demand for more safety, higher quality and higher productivity, bearings have been more diversified and developed for special performance and this movement will be continued.

Here general description of the development at Koyo and representative bearings for roll necks of rolling mills, back-up rolls of multi-roll mills and continuous casting applications are presented with respective recent and future technical trends.

***Key Words**: rolling bearing, steelmaking, rolling mill, maintenance free, technical trend*

1. Introduction

Iron and steel are required in an amount of 0.8 billion tons or more a year in the world and the demand is still increasing with a rate of about 1%.

Iron and steel materials are used for extremely wide variety of fields and are a basic material indispensable for social progress, still showing the significance in the 21st century.

Iron and steel are made in iron foundries, where various facilities are provided for the manufacture. Such facilities require various bearings suitable for the function thereof. Thus, it is not too much to say that such facilities use various sizes of bearings ranging on their outer diameters from small to super large on the order of few meters. **Figure 1** shows the summary of the market trends and of the developments by Koyo regarding bearings for steelmaking applications.

There is no doubt that an iron-and-steel field, likewise other industrial fields amid the advance in the industrial reorganization, will be increasingly demanded of meeting the needs of "more safety", "higher quality", and "higher productivity".

2. Increasing Service Life on Large-size Bearings for Rolling Mills

A bearing having a longer life is required for satisfying the need for providing a maintenance-free bearing and for enabling a facility having higher function. Large-size bearings for the steelmaking application, typical example of which is roll neck bearings for rolling mills, show the end of the life thereof mainly by the flaking. Measures for increasing the life of such bearings include a common measure for improving the material and heat treatment, in addition to the improvement in an individual design and processing (accuracy).

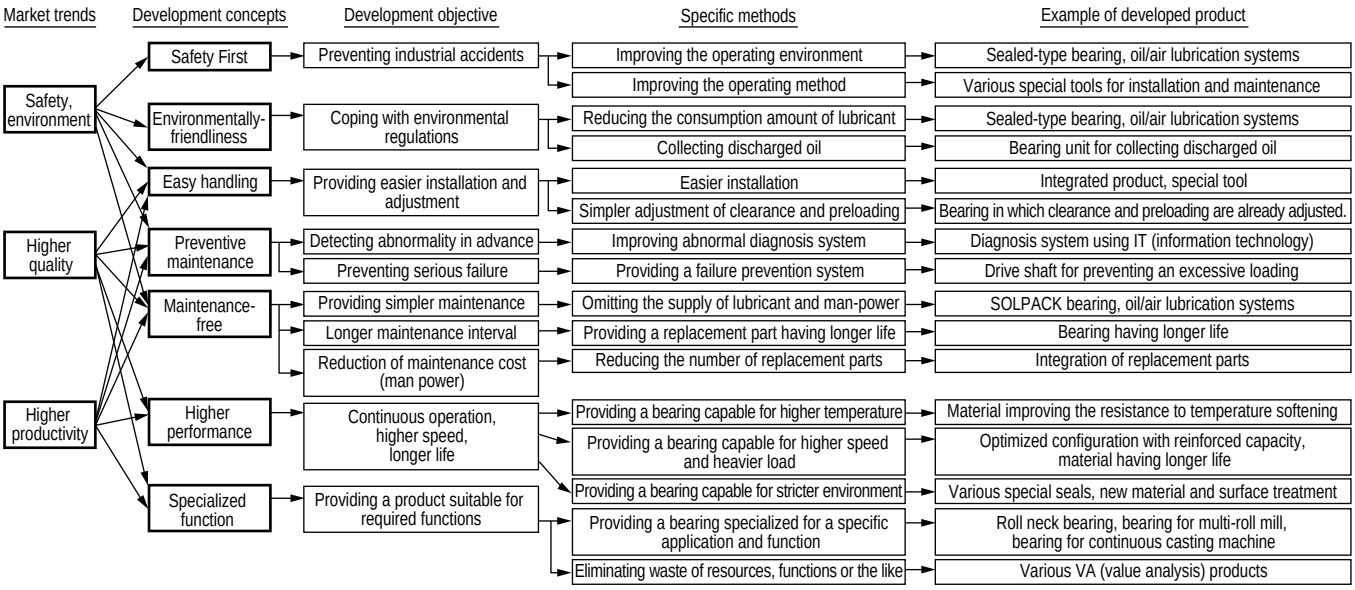


Fig. 1 Market trends and developed products at Koyo

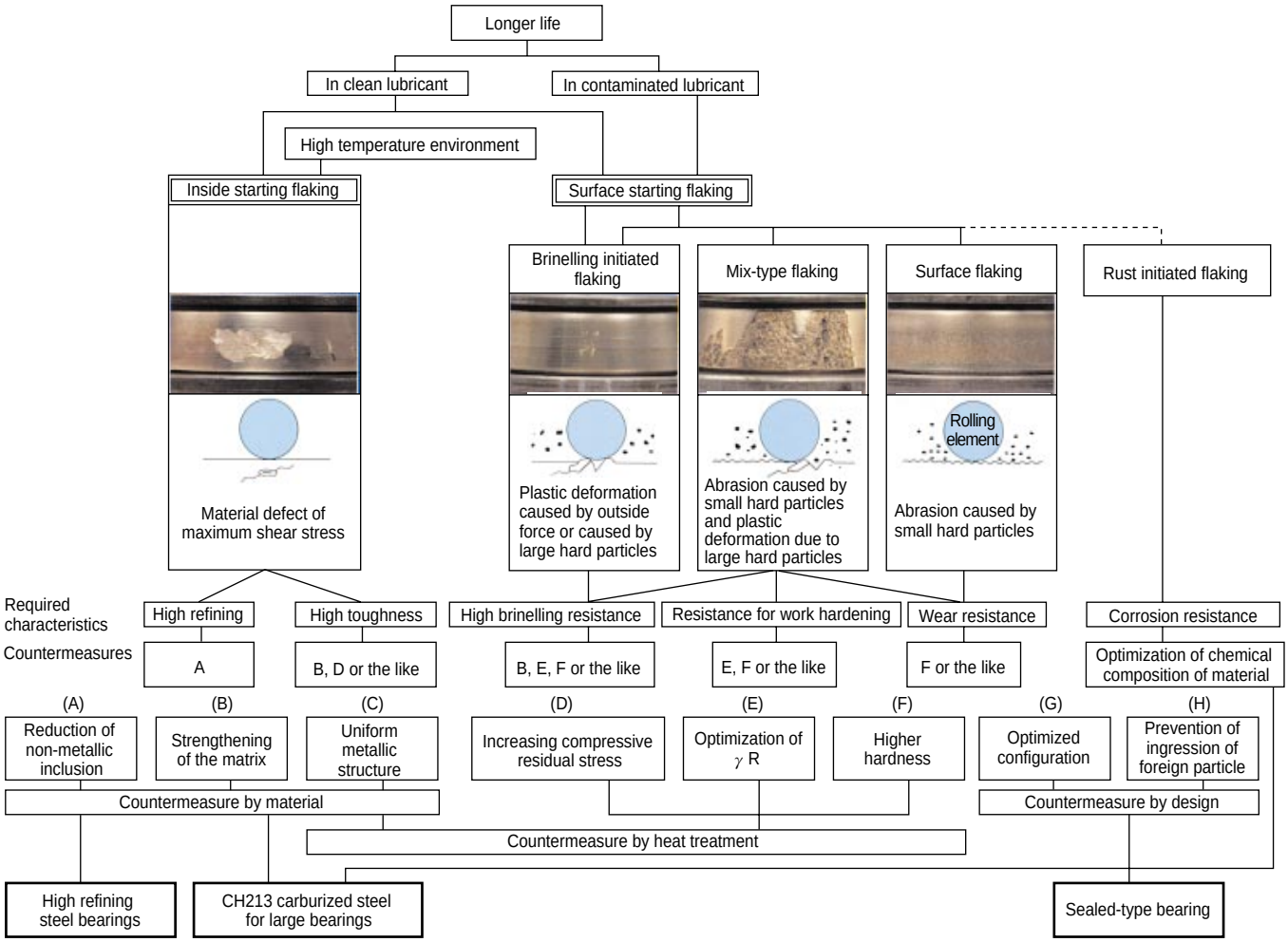


Fig. 2 CH213 carburized steel for large bearings having longer life

A typical mode of the flaking in a roll neck bearing for a rolling mill is an inside starting flaking developed from a crack caused by an internal defect in a subsurface layer under the rolling contact surface, or the matrix fatigue. The inside starting flaking also may be caused by the reduction in the hardness by the temperature rise. There is another mode of the flaking in a roll neck bearing which is caused by the damage on rolling surface due to the ingression of the rolling oil or oxide scales. Such a surface starting flaking caused by the damage on the rolling surface can be reduced by improving the sealing performance of the bearing.

Koyo has collected many examples in which such flaking was caused so that the causing process is examined. As a result, Koyo optimized the chemical composition of a material in a bearing for the purpose of ① strengthening the material matrix and ② improving the resistance to temperature softening. The result is the carburized steel CH213 for large-size bearings having longer life, which are already in service (**Fig. 2**)[1), 2)].

Figure 3 shows the result of comparing a conventional steel SNCM815 and the presently-developed steel CH213 for the life in a rolling fatigue test. As can be seen from **Fig. 3**, CH213 shows the life four times longer than that of SNCM815.

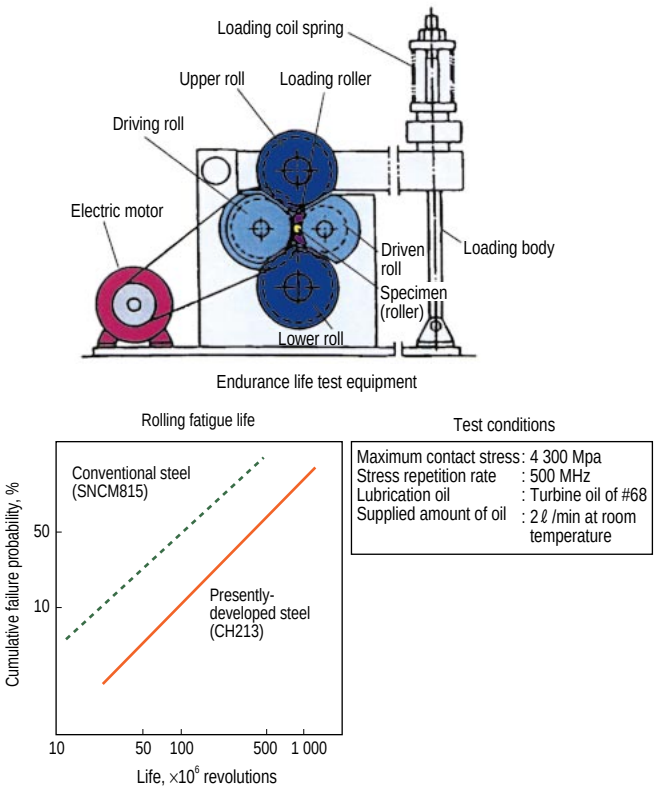


Fig. 3 Result of rolling fatigue test

Figure 4 shows the history of the improvement of a service life of bearings for work roll for hot strip mills used at customers. The service life of bearings have a remarkable increase thanks for an introduction of CH213.

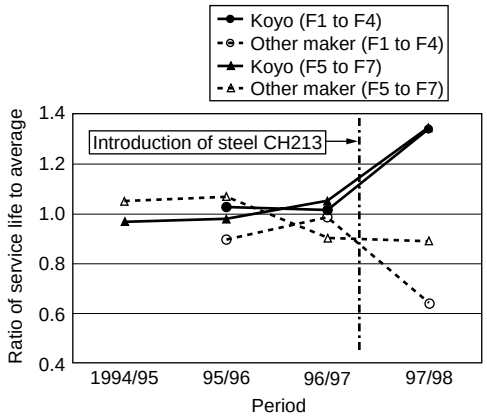


Fig. 4 Transition of service life of work roll bearings for hot strip mills

3. Rolling Bearings for Various Steelmaking Application

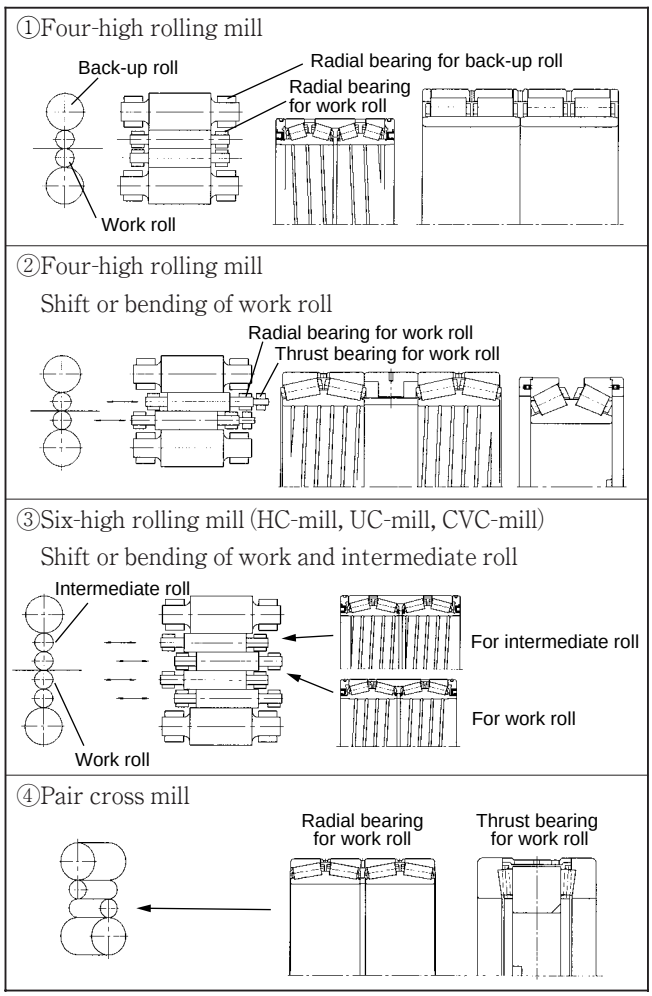
This section will describe typical rolling bearings used for steelmaking application with regards to the technical tasks and future trends.

3. 1 Roll neck Bearings for Rolling Mills

Products made by rolling mills (e.g., those for automobiles) are required to have increasingly higher quality on their surfaces. In order to satisfy such a strict requirement, various rolling mills are now being developed. **Table 1** shows the structure of a rolling mill which has been recently developed and the configuration of a roll neck bearing. Koyo satisfies such a requirement by sufficiently understanding the required function at the stages of planning and development of a rolling mill to commercialize a special bearing having a specialized function.

Conventionally, back-up rolls for four-high rolling mills mainly used oil film bearings. However, Koyo has performed actively to replace the oil film bearings to the rolling bearings, in order to contribute to the improvement of the surface quality of the products made by rolling mills (**Fig. 5**)[3]. For the replacement of the bearings, not only the bearings but also the rigidity of the rolls and chocks are examined by Koyo.

Table 1 Structure of recent rolling mills and roll neck bearings



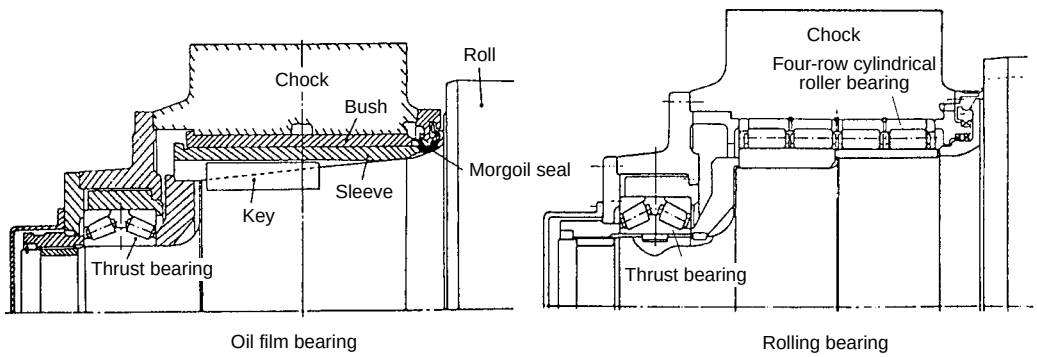


Fig. 5 Replacement of oil film bearing with rolling bearing for back-up roll of rolling mill

Four-row tapered roller bearings are generally used for reasons of compact and higher load capacity. Koyo has developed a sealed-type four-row tapered roller bearing for the purpose of preventing the roll neck bearing from the damage due to the ingression of the rolling oil containing a lot of water or oxide scales, which is now in service. In order to further enhance the function of this sealed-type bearing, Koyo has performed various improvements on the sealed-type bearing (**Fig. 6**).

One of the improvements is to adopt a compact seal, which allowed this sealed-type bearing with less reduction rate of load capacity as compared with that of an open-type bearing having the same boundary dimensions. Koyo also has developed a seal accommodating to a high-speed rolling and a seal having an improved sealing performance, further expanding the application of such a sealed-type bearing.

Future trends are that such a roll neck bearing will be capable of further heavier load and further high speed rolling conditions so as to contribute to higher productivity in a rolling process. The roll neck bearing will also be required to have further higher reliability in order to secure a high operation rate of the rolling.

In order to realize a bearing which keeps up with such a trend, Koyo not only applies a conventionally-used measures for providing a longer life but also develops such a bearing material and seal that can resist more to corrosion and wear even under the strict rolling conditions.

3. 2 Back-up Roll Bearings for Multi-roll Rolling Mills

Figure 7 shows the structure of a typical multi-roll rolling mill and the history of the change of the back-up roll bearings used therein. The feature is that the bearing is rotated at the outer ring, loaded on outer diameter surface of the outer ring and its lubrication oil has low viscosity. The outer ring of the bearing is required to have a high toughness enduring a shock load and a high rigidity enduring repeated tensile and compressive stress (**Fig. 8**).

To provide a bearing having such performances, Koyo adopted a special material and heat treatment to develop a bearing having a hardened zone with a sufficient depth and a mild zone in core, which is now in service (**Fig. 9**)[4].

In such a bearing, the outer diameter surface of the outer ring is directly supported by a work roll or an intermediate roll contacting on their surfaces, thus causing the accuracy and roughness on the outer diameter surface of the outer ring have a significant influence on the accuracy of the surface of the rolled products. To provide a clean surface of a product, the outer diameter surface of the outer ring is regularly ground. In order to improve the rotation accuracy and the productivity of a bearing which has been subjected to this grinding processing, Koyo has developed various grinding tools (**Table 2**).

Future trends for a back-up roll bearing are similar to those for roll neck bearings. Specifically, a back-up roll bearing will be required that are compatible with further heavier load and further high speed rolling conditions. In addition, in order to effectively serve for longer period of time, the back-up roll bearing is required to set more grinding stock on the outer diameter surface of the outer ring prior to scrapping.

Koyo tries to keep up with such a trend by a bearing having an appropriate material and an improved surface.

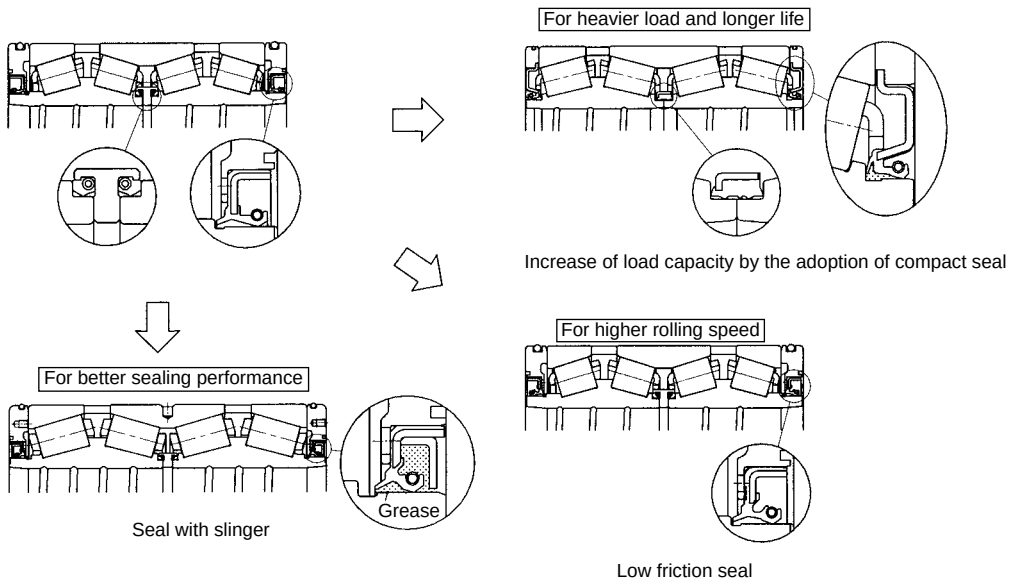


Fig. 6 Transition of sealed-type tapered roller bearings for roll neck application

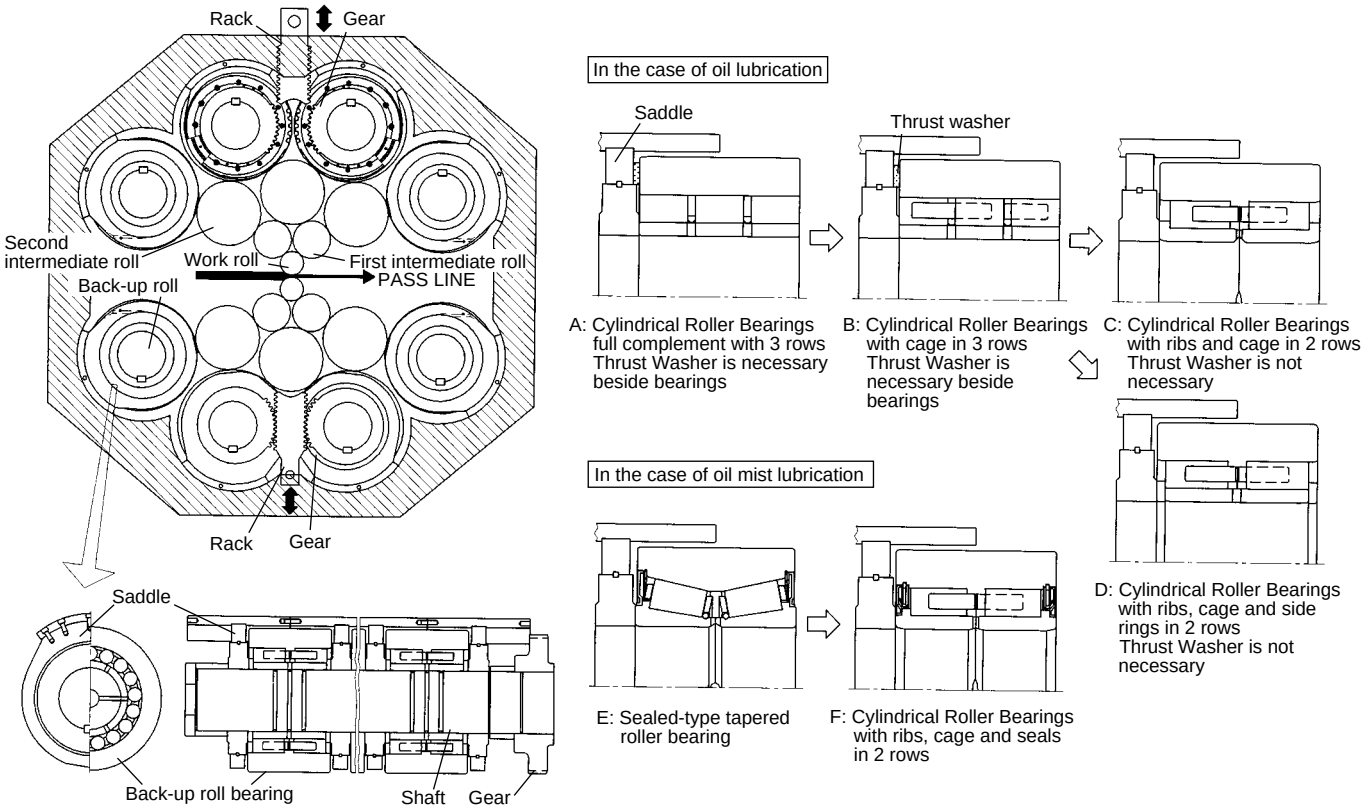


Fig. 7 Structure of multi-roll mill and transition of back-up roll bearings

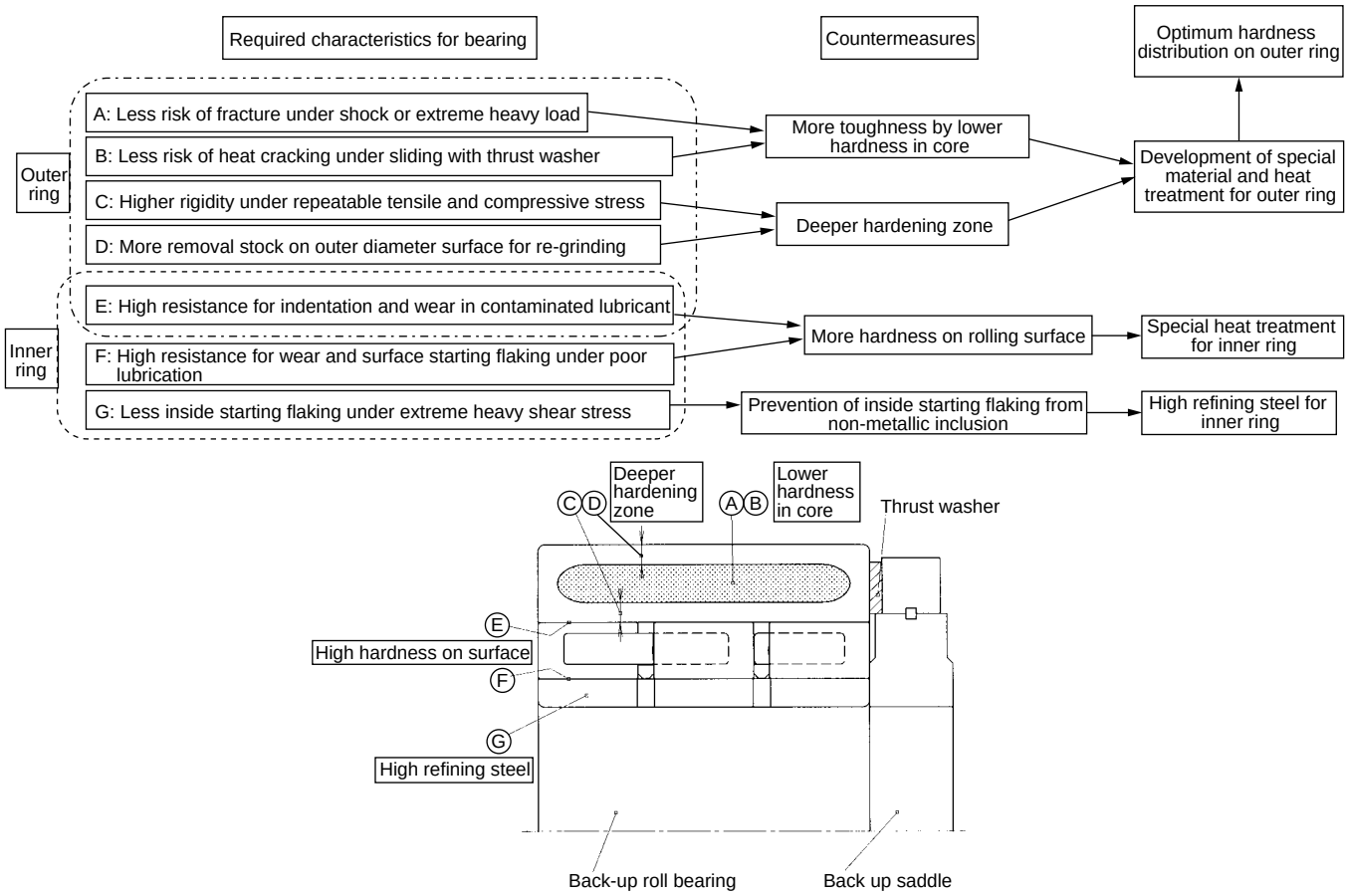
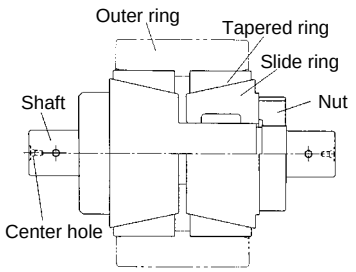
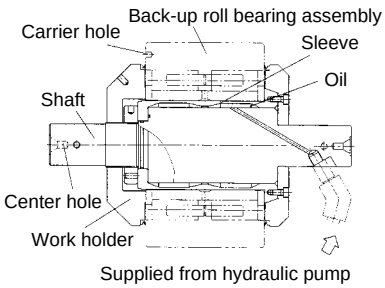
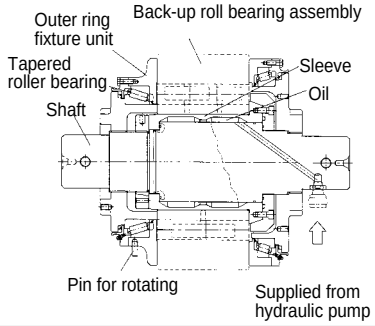


Fig. 8 Characteristics required for back-up roll bearings for multi-roll mills

Table 2 Grinding tools for back-up bearings for multi-roll mill

Type	Tapered ring-type grinding tool only for outer ring only	Hydraulic type grinding tool for complete bearing assembly	Hydraulic type grinding tool for complete bearing assembly with clamping outer ring
Applicable Type of Bearing	Conventional 3-row cylindrical roller bearing, 2-row cylindrical roller bearing with rib	2-row cylindrical roller bearing with rib	Conventional 3-row cylindrical roller bearing, 2-row cylindrical roller bearing with or without rib
Structure			
Features	1) Tapered ring and slide ring are tightened by nuts to fix an outer ring for grinding on outer diameter surface. 2) Rotation accuracy of the bearing after grinding depends on the eccentricity between the outer ring and the tool because the outer ring is rotated for the grinding with rotating tool integrally. 3) Lifting tool is additionally required for assembly/disassembly.	1) Sleeve is hydraulically expanded to reduce the internal clearance in the bearing to zero. 2) Only outer ring is rotated without rotating the tool and thus the rotation accuracy of the bearing after grinding is high. 3) Requires carrier hole for outer ring.	1) Outer ring is clamped in the axial direction by the fixture unit so that the sleeve is hydraulically expanded to reduce the internal clearance in the bearing to zero. 2) Only outer ring is rotated without rotating the tool and thus the rotation accuracy of the bearing after grinding is high. 3) Requires carrier hole for outer ring.

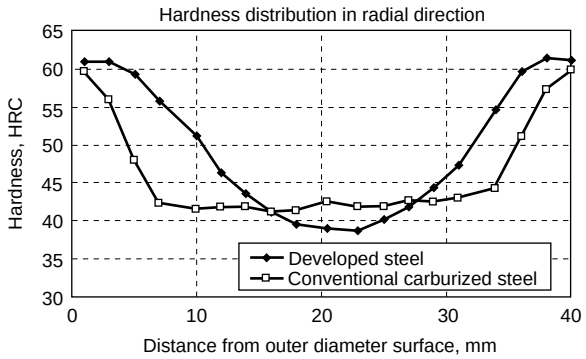


Fig. 9 Hardness distribution on outer ring

3. 3 Bearings for Continuous Casting Facilities

Figure 10 shows the structure of a continuous casting machine and the history of the transition of the roll structure. As can be seen from **Fig. 10**, an old-type roll has a large diameter while a new-type one has small diameters with a shorter distance therebetween.

A bearing for a continuous casting machine has a feature in that the bearing is applied with a high load under a high temperature condition while the inner ring is rotated with a low speed. Thus, the damage caused in the bearing for a continuous casting machine typically includes those caused by wear and deformation and does not include those caused by rolling fatigue observed on rolling bearings.

Based on the analysis on the forms of damages on bearings, Koyo performed the following approaches of:

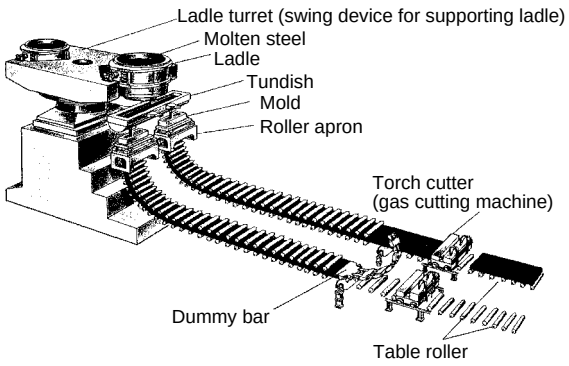
① the adoption of an optimal type of a bearing;
② the increase in the load capacity of the bearing; and
③ the modification of the sealing structure of the surrounding of the bearing.

As a result, Koyo has developed a special functional bearing suitable for a continuous casting machine (**Fig. 11**).

Future trends for a bearing for a continuous casting machine are that it will be required of enduring further heavier load conditions. Such a bearing also will be required to provide a higher reliability so that the continuous casting machine does not require frequent maintenance for saving the maintenance cost.

To keep up with such a trend, Koyo not only applies a conventionally-used measures for providing a longer life but also develops a bearing material and seal that can resist more to corrosion and wear even under strict rolling conditions.

1. Structure of continuous caster



2. Transition of the roll

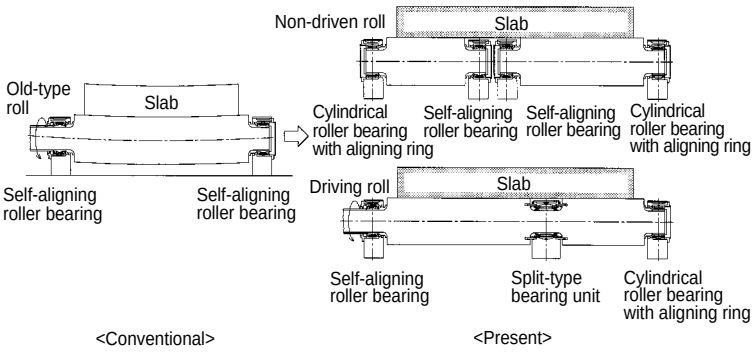
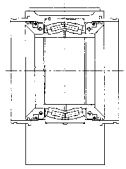
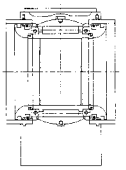
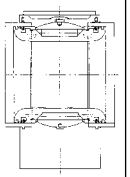
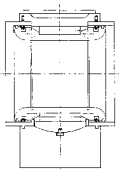


Fig. 10 Structure of continuous casting machine and transition of rolls

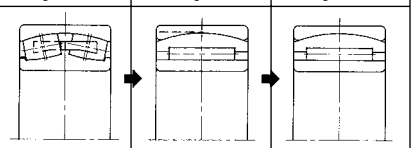
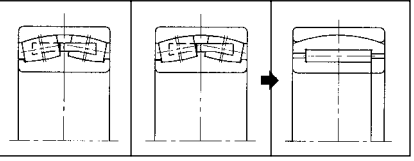
Bearing for the center of roll

	First generation	Second generation	Third generation	Fourth generation
Structure				
Type	Clamping ring-type with self-aligning roller bearing	Clamping ring-type with cylindrical roller bearing with aligning ring	Full ring-type	Half ring-type

Features

- Improved assembling of bearing
- Movement in the axial direction is easily absorbed.
- Deflection of the roll is smoothly absorbed.
- Having bigger load capacity and longer life
- Structure for superior sealing performance

Bearing for the end of roll

	First generation	Second generation	Third generation
Free side			
Fixed side			

Features

- Movement in the axial direction is easily absorbed.
- Deflection of the roll is smoothly absorbed.
- Having bigger load capacity and longer life
- Keeping the same boundary dimensions as that of self-aligning roller bearing

Fig. 11 Transition of bearings for continuous casting machine

4. Conclusion

Currently, an iron and steel field is experiencing a major shift from a conventional manufacture style requiring a huge amount of resources and energy to a new style in which less resources and energy are consumed.

To keep up with the speed of such a shift, Koyo sets the following three key words as an important philosophy for the development of future bearings.

① bearing capable of contributing to the reduction of cost for maintenance (i.e., maintenance-free bearing);
② bearing capable of contributing to preventive maintenance (i.e., intelligent bearing); and
③ bearing capable of coping with environmental regulations.

With the above philosophy in mind, Koyo will strive for the development of a bearing keeping up with the market trends.

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