Technical Trends of Oil/Air Lubrication for Steel Making Equipment

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Oil/air lubrication system is one of the lubrication methods for rolling bearings installed in steel making equipment. Recently, expansion of the application of this system has been accelerated not only for continuous casting machines but other applications because this system has been recognized by customers to be applicable to various conditions unique to steel making equipment. It has been confirmed that oil/air lubrication applied to continuous casting machines significantly reduces bearing wear. Also it is expected that the oil/air lubrication can contribute to energy saving due to minimum lubricant consumption and smaller starting and operating torque.

Based on considerable experience as a diversified bearing manufacturer, JTEKT has developed the optimum oil/air lubrication system for rolling bearings. This paper presents application examples and effectiveness of the oil/air lubrication system for steel making equipment.

***Key Words**: oil/air lubrication, continuous casting machine, steel making equipment, energy saving rolling bearing life*

1. Introduction

JTEKT began developing oil/air lubrication system in 1990 with the objective of improving the lubrication performance of rolling bearings for steel making equipment. Bearings for steel making equipment are often used in severe environments therefore, as a result of engaging in activities to solve various technical issues relating to oil/air lubrication together with our customers, we have had many successful application cases of bearings on various steel making equipment, including continuous casting machines, hot and cold strip mills. This paper presents application example and effectiveness of oil/air lubrication system for steel making equipment.

2. Overview of Oil/Air Lubrication

2. 1 The Principle of Oil/Air Lubrication

Figure 1 shows the transfer principle of the oil/air lubrication. The characteristics are as described below.

1) The oil is supplied into the pipe in droplets and transferred by air flow.
2) The oil supplied to the final lubrication point is in the form of droplets and enabling oil consumption to be kept to a minimum. This system has more promise of producing energy saving effects than other lubrication methods.
3) Moreover, because the air, which transfers the oil, is also supplied to lubrication points, the positive pressure is created inside the bearing and the sealing performance can be improved. In the steel making equipment, this sealing effect contributes significantly to improving bearing lubrication performance (life).

2. 2 Components of the Oil/Air Lubrication System

JTEKT's oil/air lubrication system is basically consisted of the devices shown in **Fig. 2**. **Table 1** describes the functions of each component. With this as our standard configuration, this oil/air system has a degree of freedom in its design, therefore it can be adjusted to suit the layout of the various steel making equipment.

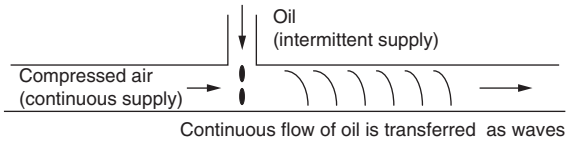

Fig. 1 Transfer principle of oil/air lubrication system

Table 1 Characteristics of each component in oil/air lubrication system

Device name	Component	Function	Oil/air system characteristics
Main unit	Pump unit	· Supplies air to the mixing device · Various monitoring functions for the oil lines	· Supports high viscosity oil → up to ISOVG680 · Auto-recovery function at fault occurrence → Auto-switchover to backup pump, etc
	Air unit	· Supplies air to the mixing device · Various monitoring functions for the air lines	· Supports a wide primary pressure range → 0.3 MPa or more possible · Supports air dryer
Mixing device (**Fig. 3**)		· Measures, distributes oil · Mixes oil and air (creating oil/air) · Pipe monitoring after mixing	· Oil/air pipe monitoring function → Monitors both leaks and blockages · Oil sight for visual checks → Able to visually check oil/air flow
Oil/air distributor (**Fig. 4**)		· Broad distribution of oil/air	· Fixed quantity distribution → 1 to 4 distribution (used for continuous casting machines, etc) · Non-fixed quantity distribution → 1 : 1 to 1 : 8 (used for strip mills, etc)
Collection tank unit		· Collects to the supply oil tank · Discharges supply air (into the open air)	· Exhaust air filter
Control unit		· Controls operation of each oil/air device · Monitors operation status · Sends and receives interface signals	· Initial oil filling function → Fills initial oil automatically · Displays breakdown recovery procedures → Displays breakdown recovery procedures on an operation panel

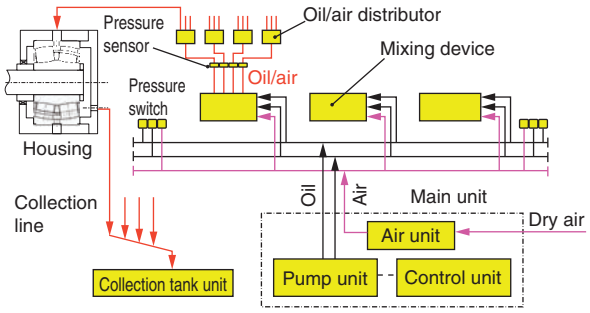

Fig. 2 Basic configuration of oil/air lubrication system

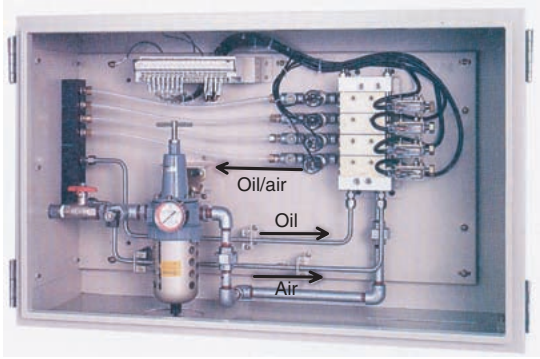

Fig. 3 Mixing device

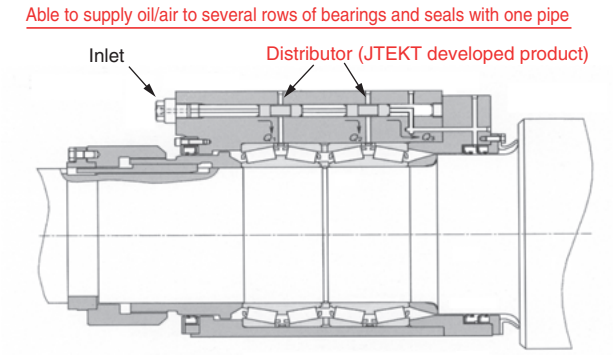

Fig. 4 Distributor in oil/air lubrication system

3. Examples of Application on Various Steel Making Equipment

3. 1 Application on Continuous Casting Machines

The bearings applied on the continuous casting machines use a grease lubrication method however, by applying the oil/air lubrication, the following merits can be expected.

1) Longer segment exchange interval due to significant alleviation of corrosion and wear on the bearings
2) Reduced unexpected incident ratio caused by the bearing damage due to significant alleviation of

corrosion and wear on bearings
3) Reduced operation cost due to lower lubrication consumption
4) Reduced maintenance cost due to less man-hours required for disassembly and cleaning of bearings
5) Friendlier on environment due to oil collection

The oil/air lubrication is particularly effective for improving the bearing life. Two examples of such improvement are given below.

Figure 5 shows the investigation results of the factors for the replacement of the bearings which are operated with the grease lubrication. Approximately 70% of the replacement is caused by the corrosion and the wear. The corrosion is mainly caused by the penetration of slab cooling water into the bearing. With the grease lubrication, the "breathing"[*1] of the seal creates the negative pressure inside the bearing, reducing sealing performance and allowing slab cooling water penetration. Meanwhile, with the oil/air lubrication, the positive pressure is maintained inside the bearing because of the constant air supply achieving high seal performance. As a result, the penetration of slab cooling water is suppressed and the corrosion is significantly reduced.

The wear occurrence is greatly affected by the strength of the oil film by the deterioration of the lubrication condition due to the penetration of cooling water. In the oil/air lubrication, the oil with high extreme-pressure property can be used and combined with stabilization of the lubrication condition due to the abovementioned high sealing performance, the wear is improved significantly.

*1 breathing of the seal

Pressure fluctuates inside bearing when air expands or contracts due to temperature rising or falling.

This fluctuation causes air to go back and forth from inside to outside of bearing.

Figures 6 and **7** show the results of the field tests. **Figure 6** gives the visual comparison results of the bearing between with the grease lubrication and with the oil/air lubrication. The oil/air lubricated bearing showed no corrosion had occurred, confirming it had excellent sealing performance. Furthermore, the amount of the wear on the outer raceway of the bearing was significantly reduced, as shown in **Fig. 7**. These field test results make it safe to assume that, in the case of continuous casting machines, the oil/air lubrication significantly contributes to improve the bearing life.

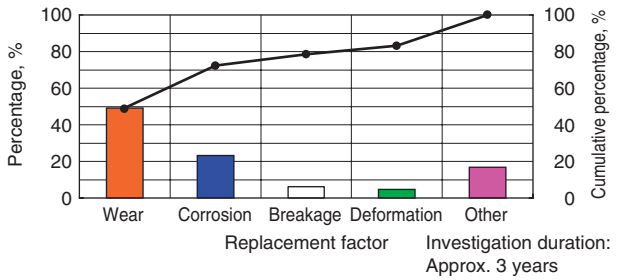

Fig. 5 Factors for replacement of spherical roller bearings

Aside from the oil/air devices, JTEKT, based on our experience as a bearing manufacturer, is involved in the design of oil/air systems including bearing peripheral devices. We engage in the three activities listed below in order to meet the various demands relating to continuous casting machines.

1) Layout Design Responding to Each Segment Configuration

The continuous casting machines are configured from multiple roll assembly units called "segments". The layout of the rolls within such segments is not completely identical. Moreover, as the rolls for slab continuous casting machines are separated into multiple parts, the several bearings are required to support them in various locations. JTEKT, by developing the oil/air distributor, has established the layout design for the correspondence of the diverse roll configuration in the segments (**Fig. 8**).

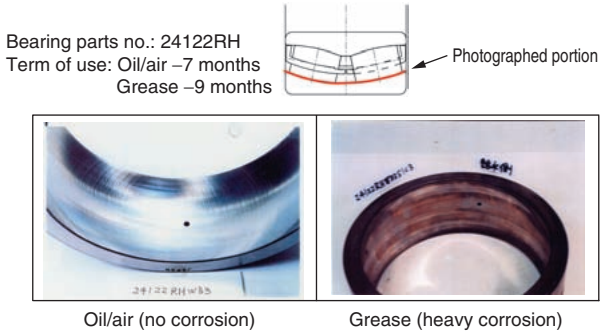

Fig. 6 Corrosion comparison after field test

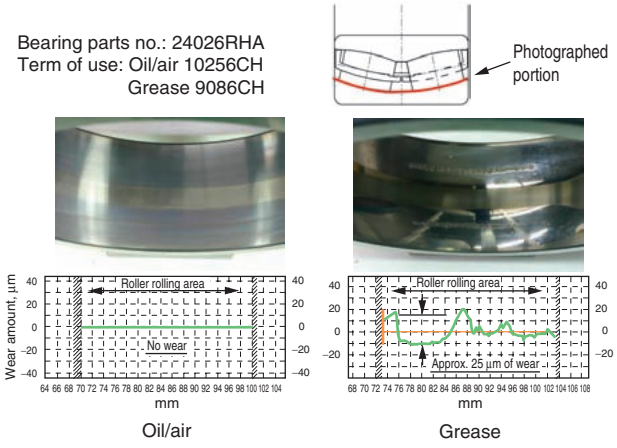

Fig. 7 Wear comparison after field test

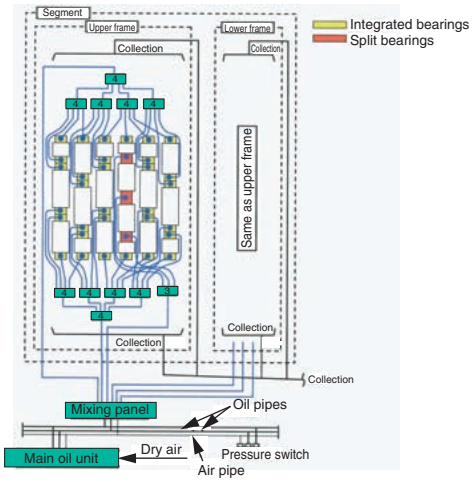

Fig. 8 Example of layout in segment

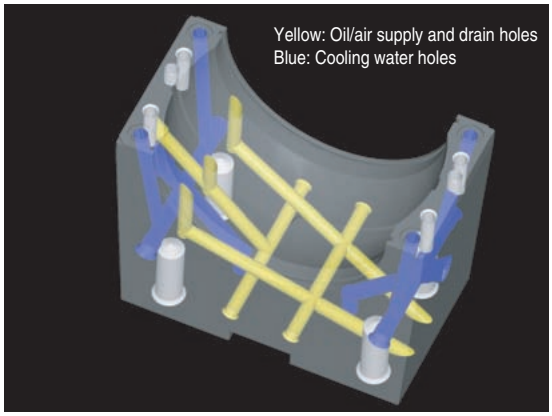

Fig. 9 Example of oil supply and drain holes on bearing housing

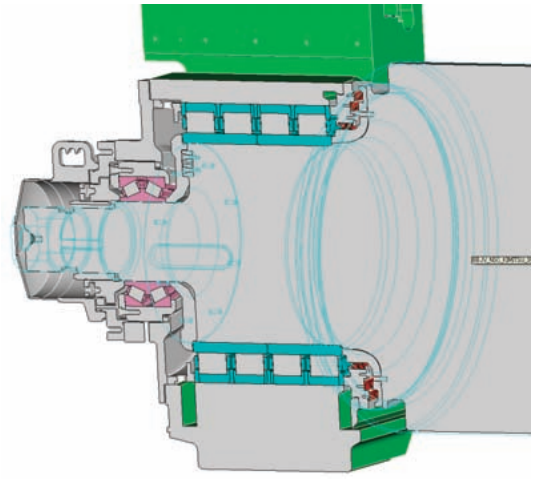

Fig. 10 Back up roll bearing for cold strip mill

2) Enhancement of Units Considering Maintainability

In the continuous casting machines, the segments are replaced periodically to maintain their condition. To make segment replacement work easier, JTEKT has also made developments for peripheral devices such as a multi-coupler allowing several pipes to be attached at one time and an oil filling device required for off-line maintenance work.

3) Design of Oil Supply and Drain Holes in Bearing Housing

In the oil/air lubrication, to maintain the lubrication ability of the bearing, it is necessary to secure the sufficient oil level inside the bearing. JTEKT has designed the optimal oil supply and drain holes in the bearing housing (**Fig. 9**).

3. 2 Application on Hot/Cold Strip Mills

In hot and cold strip mills, the rolling bearings are used in not only the strip mill itself, but also the accessory equipment such as guide rolls and transfer devices. The effectiveness of oil/air lubrication is examined for such application.

On the strip mill itself, the oil/air lubrication could be applied to the back up roll bearings which are not often replaced.

Currently, on the hot strip mills, many back up rolls use the oil film bearing. Moreover, large forced oil system is the main lubrication method, therefore the overall strip mill size becomes large. It will be effective in making equipment more compact if the rolling bearings will be used on the back up rolls and the oil/air lubrication will be adopted.

In case of cold strip mills, already many rolling bearings are used on the back up rolls (**Fig. 10**). The mainstream methods of the lubrication are the forced oil circulation systems and the oil mist, with hardly any examples of the oil/air lubrication. However, it is feasible that in the future a shift may occur from the oil mist to the oil/air lubrication in order to improve the environment and reduce operation costs.

Table 2 gives a comparison between the oil and air consumption of the oil mist and the oil/air lubrication. The table shows that the application of the oil/air lubrication could have an energy saving effect.

Apart from examples of application on strip mills themselves, there are also examples of the application with the transfer tables for the hot strip mills. The main objectives of applying the oil/air lubrication method in this case are the improvement of bearing life by better sealing performance and the reduction of motor power consumption due to low torque. Moreover, by collecting the supplied oil, it is possible to minimize equipment maintenance costs by reducing processing costs of the oil discharged around the equipment and so on. In the application example of **Fig. 11**, as well as constantly monitoring the oil supply condition, the system also collects the oil supplied, therefore providing both reliable lubrication and easy maintenance.

Table 2 Comparison of oil/air consumption for back up roll bearing of cold strip mill

Examined bearing	Oil consumption, cm^3/hour		Air consumption, L/minute	
	Oil/air lubrication	Oil mist lubrication	Oil/air lubrication	Oil mist lubrication
$\phi820\times\phi1\,130\times800$ 4-row cylindrical roller bearing (radial bearing)	28.9	98.3	77	422
$\phi400\times\phi650\times240$ Double row tapered roller bearing (axial bearing)	7.8	24.6	30	105
Total	36.7	122.9	107	527

(Oil supply per bearing)

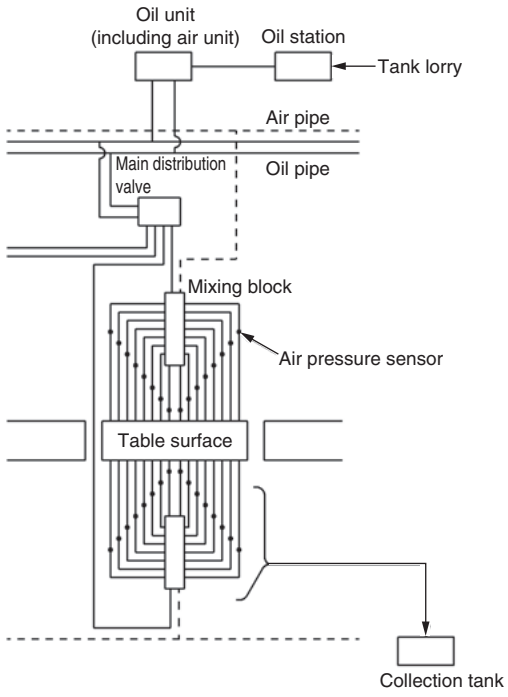

Fig. 11 Application example for transfer table

Another example of the oil/air lubrication being applied to the cold strip equipment is on the auxiliary rolls in the strip stand periphery. The spherical roller bearings are widely used for this application. By using the oil/air lubrication, high speed performance is improved compared with the conventional grease lubrication method. And there are expectations that the strip speed can be increased and the maintenance interval can be extended. Regarding the high speed aspect, the results of bench test showed that oil/air lubrication could achieve rotational speed as 400 000 dmN (equivalent to strip speed of 2 800 m/min) (**Fig. 12**).

3. 3 Application on Strip Mills of Nonferrous Metal

The same effects as mentioned above can be expected when the oil/air lubrication is applied to strip mills nonferrous metal, for example aluminum and copper rolling mills. The below is an example of how oil/air lubrication responds to the particular requirements of nonferrous metals.

Particularly, as the products of the foil strip mills are required to have a lustrous surface finish, it is necessary to suppress the friction loss with rolls as much as possible. That is a reason why light contact seals and non-contact seals are sometimes applied to lower the rotational torque of guide rolls, etc. The trade-off, however, is that the lubricant leakages may occur. In the normal oil/air lubrication, as the air supply causes oil leakages from the seal area easily, an ejector pump is used to suck the oil/air to prevent the oil lerkage.

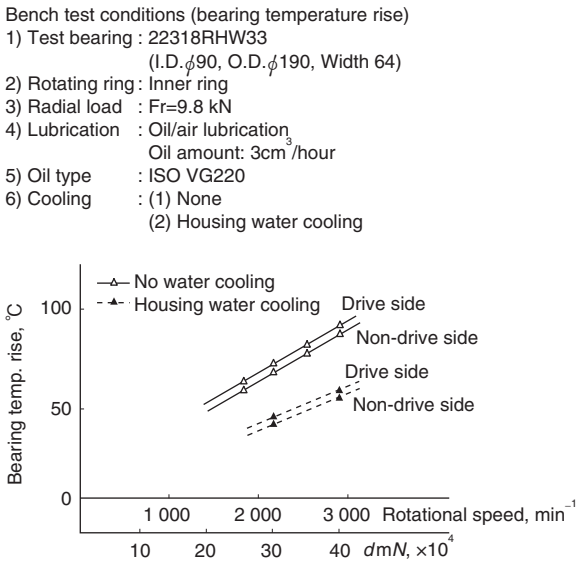

Fig. 12 Bearing temperature rise results

4. Conclusion

JTEKT has studied the effectiveness of the oil/air lubrication for the bearings on the steel making equipment while developing various technologies. As a result, many customers that deal with steel making equipment, especially continuous casting machines, are very satisfied with the benefits to be gained. JTEKT, in order to meet the customer's various demands, would like to continue to improve the oil/air lubrication technology and the product appeal from the lubrication method (oil/air lubrication) and the lubrication target (bearings) point of view. And we would like to develop the oil/air lubrication system which can further contribute to the stable operation of the equipment and the energy saving.

References

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