Improvement in Palm Oil Mill Machinery Efficiency Through Self-Aligning Roller Bearings

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INTRODUCTION

Self-aligning roller bearings play a crucial role in enhancing the efficiency and longevity of equipment used in palm oil mills. These bearings are instrumental in reducing friction between moving parts, ensuring smoother operation and reducing wear and tear on machinery.

Self-aligning roller bearings significantly reduce friction; thus, they enable machinery to run at higher speeds and with greater precision. This increase in operational efficiency translates to higher throughput and productivity, allowing mills to process larger quantities of palm oil within shorter time frames. The smoother motion facilitated by roller bearings also leads to more consistent and reliable performance of critical equipment such as screw presses, crushers, and conveyors.

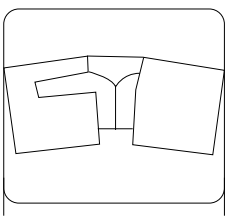
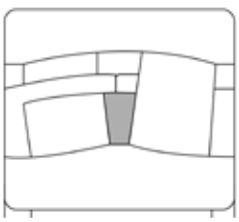
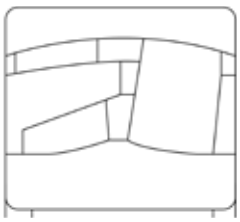
The bearings used in rotary mechanisms of industrial machines need to fulfill the requirements for bearings, which are bearing life, load capacity, speed performance and handling quality. Moreover, the dynamic characteristics of bearings significantly influence the performance of machines, especially in aero engines (Cui *et al.,* 2021). Recently, NTN innovated self-aligning roller bearings, which are the EA Type (pressed steel cage) and the EM Type (machined brass cage). Both bearings have fulfilled current industrial needs and offer many advantages.

STRUCTURE OF SELF-ALIGNING ROLLER BEARINGS

Recent industrial developments require self-aligning roller bearings to have longer lifespan and greater rigidity, in addition to high-speed capability. To meet these needs, bearing manufacturers have been developing bearing products with improved cage shapes and more amply sized rollers.

In order to cope with the requirement for higher load capacity bearing products, NTN has produced a unique self-aligning roller bearing based on Type B, with the inner ring center rib removed (*Table 1*). This design adopts the guide ring from Type C and Type E, in which the rollers are stabilised in terms of attitude with a resin cage. Therefore, the ULTAGE series of self-aligning roller bearings will be highlighted in this article.

TABLE 1. COMPARISON OF SELF-ALIGNING ROLLER BEARING

Type	Type B	Type C	Type E
Cross-sectional plan			
Roller	Asymmetric roller	Symmetrical roller	Symmetrical roller
Cage	Pressed steel	Pressed steel	Resin molding
Center rib	Yes	None	None

The ULTAGE series of self-aligning roller bearing has two variants, called Type EA and Type EM: *Figures 1* and *2* show the structure and features of the Type EA and EM bearings, respectively. The dimensions of the Type EA bearing are equivalent to those of the Type EM bearing. Both Types EA and EM employ symmetric rollers, where the diameter and length of the rollers have been maximised so that the bearings can withstand a much greater load. In addition, by adopting a novel cage featuring higher rigidity and a simplified form, it has become possible to eliminate the inner ring center rib and incorporate the maximum number of rollers of maximsed length.

Figure 3 shows the working mechanism of the Type EA bearing. Firstly, the window-type pressed steel cage in the Type EA bearing guides the rollers with both of its end faces. Next, four tabs (protrusions) situated in the cage pocket help stabilise the attitude of the rollers while the bearing is running and generate a smooth flow of lubricating oil within the bearing. Furthermore, the entire surface of the pressed steel cage is subjected to a special surface treatment to improve its wear resistance.

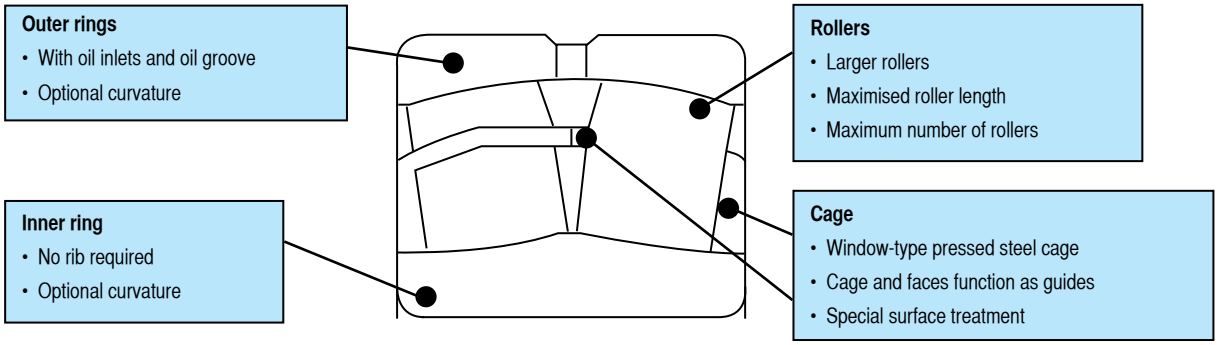


Figure 1. Self-aligning roller bearing for Type EA.

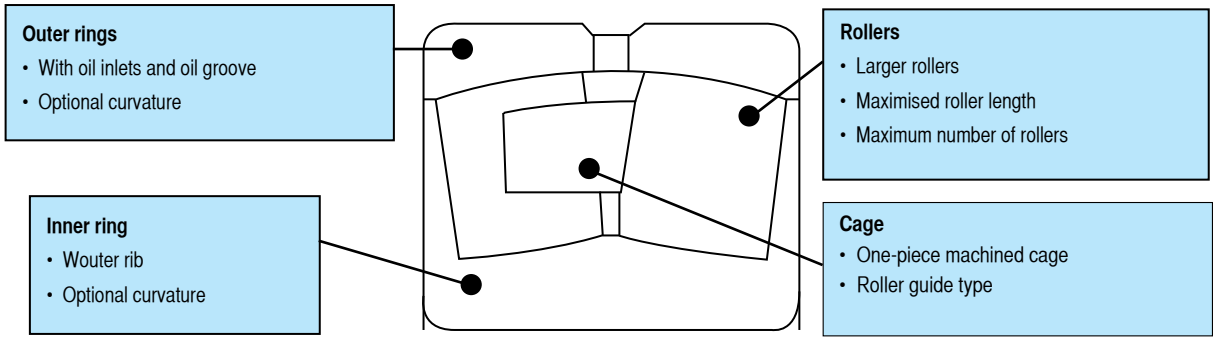


Figure 2. Self-aligning roller bearing for Type EM.

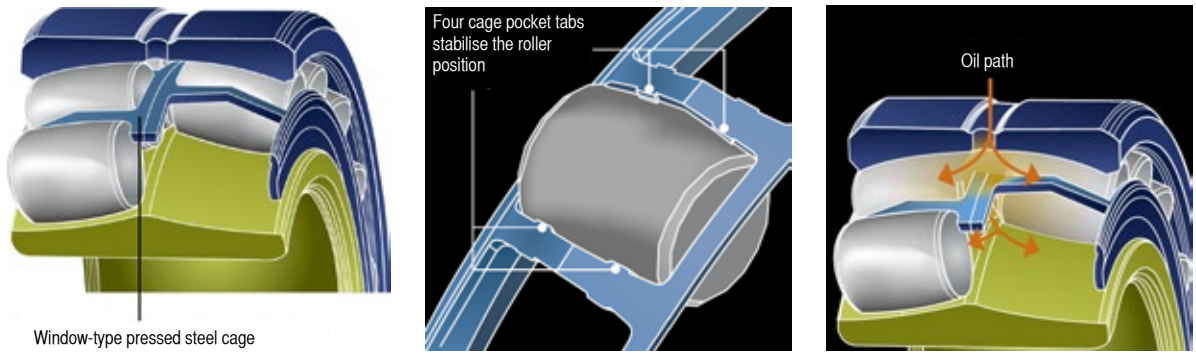


Figure 3. Working mechanism of the Type EA bearing.

Figure 4 shows the working mechanism of the Type EM bearing and illustrates the machined high-tensile brass cage. This cage adopts a roller guide type in order to stabilise the attitude of the rollers while the bearing is running. The cages are one-piece machined cages, and the inner ring features a rib to prevent the removal of the rollers. The Type EM bearing is particularly advantageous in applications subject to severe vibration and impact.

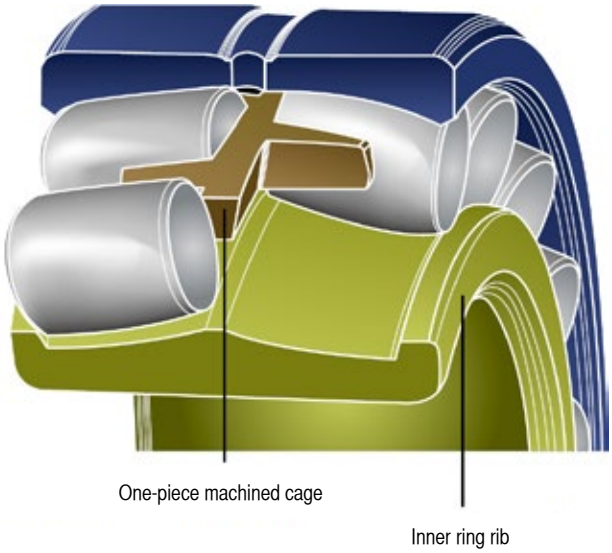


Figure 4. Working mechanism of the Type EM bearing.

ADVANTAGES OF SELF-ALIGNING ROLLER BEARINGS

Load capacity

Based on bearing model 22216 (Dimension: ∅80 × ∅140 × 33), *Figures 5a* and *5b* show the results of the basic dynamic load rating (C_r) and the basic static load rating (C_{or}), respectively, for the Type EA bearing, in comparison with competitors. The basic dynamic load rating (C_r) and basic static load rating (C_{or}) of the Type EA bearing were 278 kN and 287 kN, respectively, which were the highest compared to its competitors. The maximised roller diameter and number of rollers help the Type EA and EM bearings achieve the highest load capacity.

Allowable speed

Based on bearing model 22216 (Dimension: ∅80 × ∅140 × 33), the Type EA and EM bearings showed the highest allowable speeds as compared with the competitors' bearings, as shown in *Figure 6*. The Type EA bearing reached 4600 min^{-1} and 3700 min^{-1} under oil and grease lubrication, respectively, due to its high rigidity and window-type pressed steel cage.

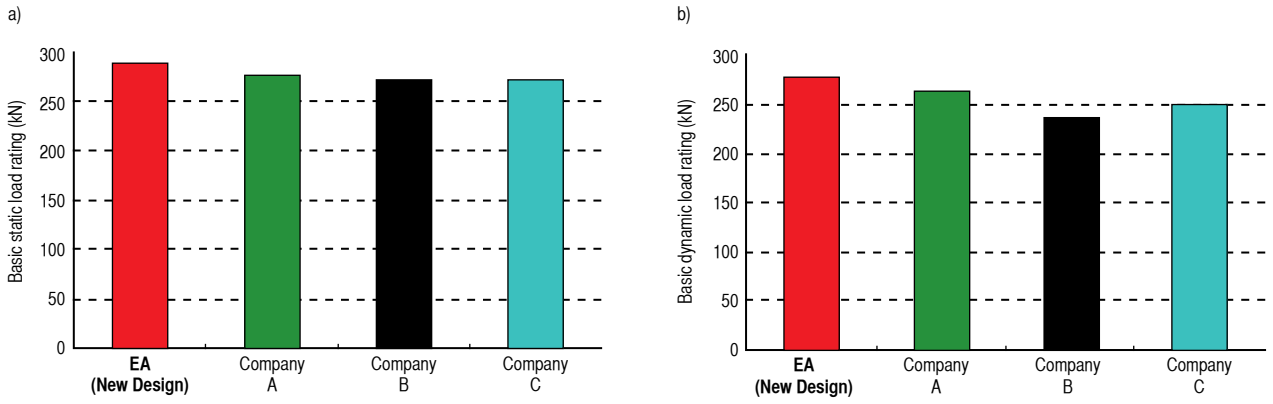


Figure 5. Comparison of basic dynamic load rating (Cr) (a) and basic static load rating (Cor) (b) between Type EA bearing and other companies.

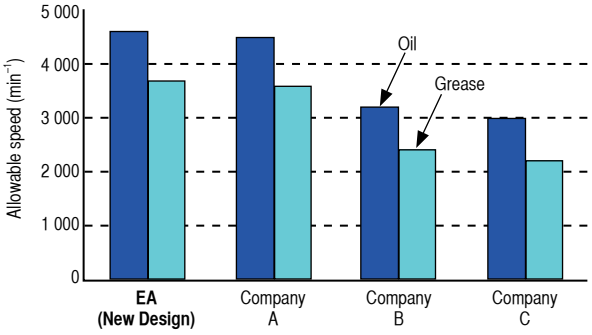


Figure 6. Allowable speed test of EA bearing compared with other companies.

Operating temperature range

Based on bearing model 22216 (Dimension: ∅80 × ∅140 × 33), *Figure 7* shows the effect of temperature rise on the bearing under lubrication circulation conditions. Apparently, the temperature increased in the competitors' bearings compared with the Type EA and EM bearings, while the running torque remained low. By adopting a special heat-treatment technique, the maximum operating temperature for Type EA and EM bearings is set as high as 200°C.

Design

The higher load capacity design technique helps this bearing achieve a compact and lightweight product. *Table 2* summarises NTN's efforts to reduce the size of the bearing. By applying a new design technique, the size of the conventional bearing model 22220B (Dimension: ∅100 × ∅180 × 46) can be reduced to the new size of bearing model 22217EA (∅85 × ∅150 × 36). This results in an overall size reduction of up to 20%, a mass ratio reduction by 48%, and a calculated operating life increase of 10%. NTN believes that this achievement will positively help machine designers in designing lighter and more compact industrial machines.

By developing the Types EA and EM bearings, NTN has achieved the following improvements over its conventional designs: a 50% increase in basic dynamic load rating, a 35% increase in static load rating, a 20% increase in allowable speed, and up to 3.7 times longer operating life.

Handling quality

The Type EA bearing features a simple, window-type shaped pressed steel cage. The design facilitates the disassembly and reassembly procedure, as the projection of the rollers from the cage is small, therefore allowing the rollers to smoothly return to their normal state (*Figure 8*). The cage also makes greasing easier to apply to the roller surfaces (*Figure 9*).

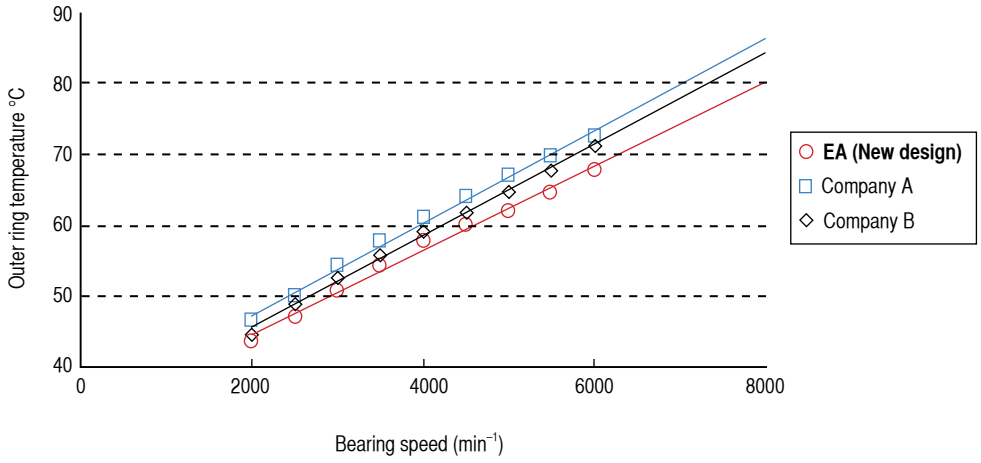


Figure 7. Effect of outer ring temperature on bearing speed.

Model Number	Basic dynamic load rating kN	Basic static Load rating	Primary Dimensions mm	Mass Kg	Life ratio
22220B	315	415	∅100 × ∅180 × 46	4.95	1
22217EA	324	330	∅85 × ∅150 × 36	2.59	1.1
			△ 20%	△ 48%	10%

Figure 8. Assembly and disassembly procedure of self-aligning roller bearings.

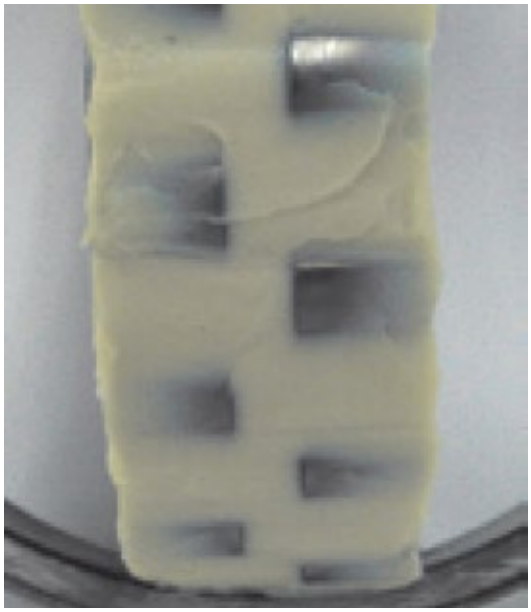


Figure 9. Grease dispersion on roller surfaces.

CONCLUSION

In conclusion, self-aligning roller bearings are a critical component in palm oil mills, providing benefits that enhance efficiency, reduce maintenance needs, save energy, and improve product quality. Their adoption leads to more sustainable and cost-effective palm oil production, which is vital for the industry's growth and competitiveness. NTN believes that the new bearing products in the ULTAGE series boast greater load capacity, higher speed, and longer operating life. Thus, NTN will continue to improve its products to fulfil market demands.

REFERENCES

Cui, Y; Deng, S; Deng, K, Liao, H and Zhang, W. 2021. Experimental study on impact of roller imbalance on cage stability. *Chinese Journal of Aeronautics, 34(*10): 248-264

Jat, A and Tiwari, J. 2020. Multi-objective optimization of spherical roller bearings based on fatigue and wear using evolutionary algorithm. *Journal of King Saud University-Engineering Sciences 32*: 58-68

Tsumori, Y. 2009. New ULTAGE series-EA and EM types of spherical roller bearings. NTN Technical Review 77: 81-85