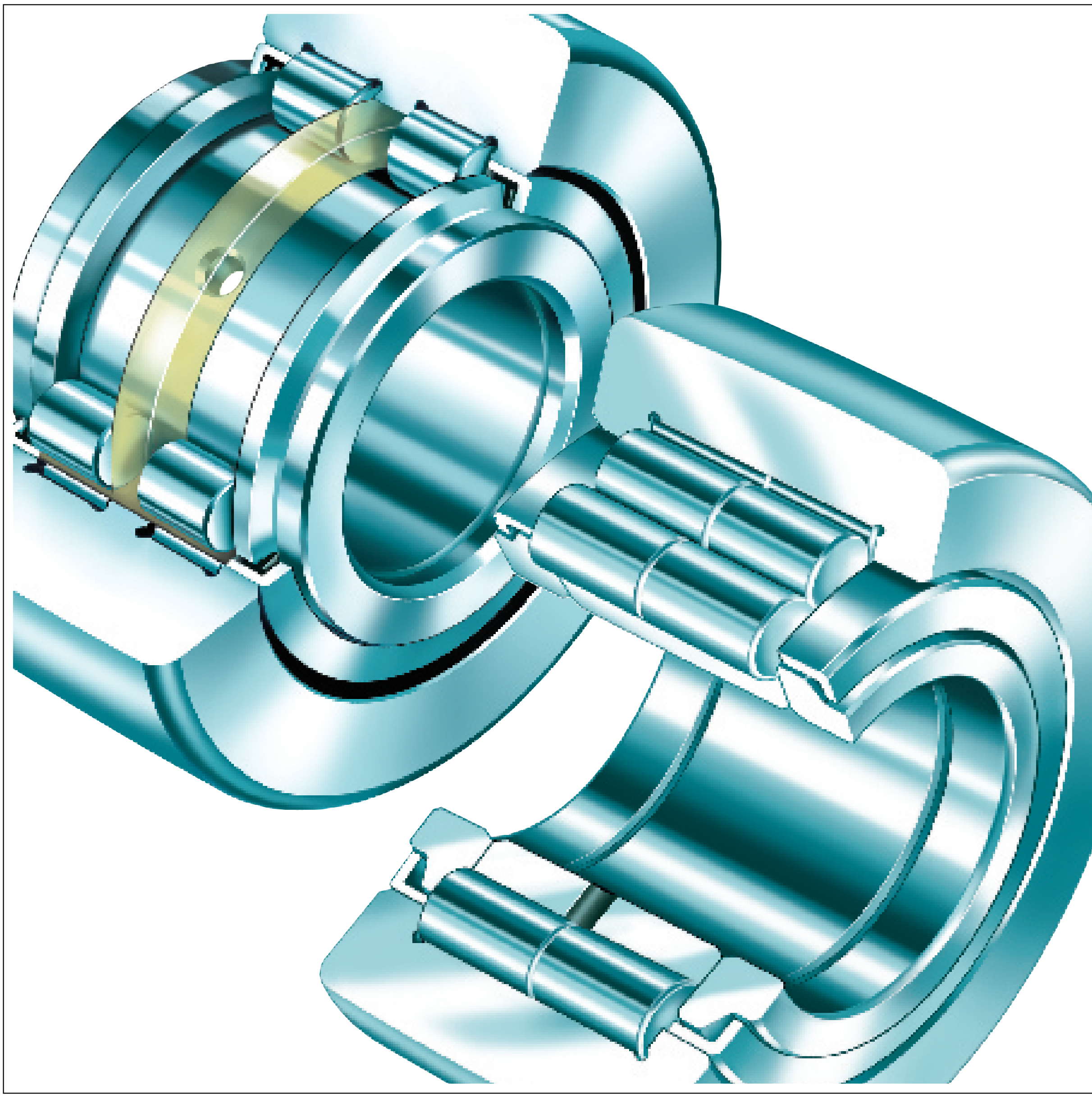

Optimized INA profile for yoke and stud type track rollers

Dipl.-Ing. (FH) Heinz Schäfers

INA reprint from “Der Konstrukteur”
Vol. No. 12, December 1997
Verlag für Technik und Wirtschaft, Mainz

A new generation of yoke and stud type track rollers

Optimized outer ring profile protects mating raceway

Dipl.-Ing. (FH) Heinz Schäfers

Yoke and stud type track rollers are widely used machine elements which, due to their thick-walled outer ring, can transmit high radial loads to the mating raceway, which is normally a cam plate or straight raceway. The outside surface of the track roller often has a curved profile in order to reduce Hertzian pressure and avoid additional edge loads arising from misalignment.

Investigations of the causes of failure in yoke and stud type track rollers in relation to the specific application (Figure 1) show that, in particular, the contact between the outside surface and the mating raceway may be subject to wear which shortens the operating life of the machine elements and thus of the cam or guidance systems.

These investigations were taken into consideration in the design of the "New Generation of Yoke and Stud Type Track Rollers" [1], as shown in Figures 2 and 3. The "Optimized INA profile" was developed using extensive computer simulations with the aim of minimizing wear as a cause of failure.

What are the factors influencing this wear? What measures can be taken to prevent or at least delay the onset of wear?

1 Cause and effect

One cause of this wear is the relative movement between the outer ring surface and the mating raceway, generally caused by severe acceleration and deceleration.

This occurs in linear guidance systems due to oscillating motion at the return points where the rollers change rotational direction or, where the roller is running in a U-shaped guideway channel, it changes rotational direction when moving from one side of the guideway to the other.

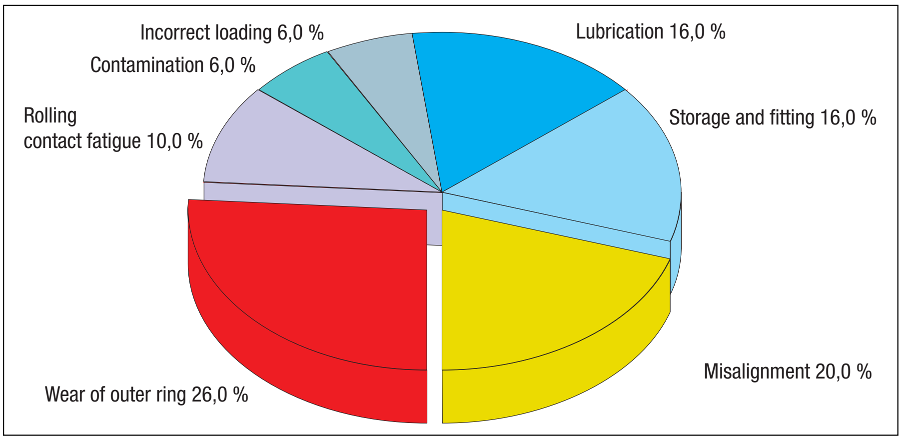

Figure 1 Yoke and stud type track rollers, causes of failure in relation to specific application

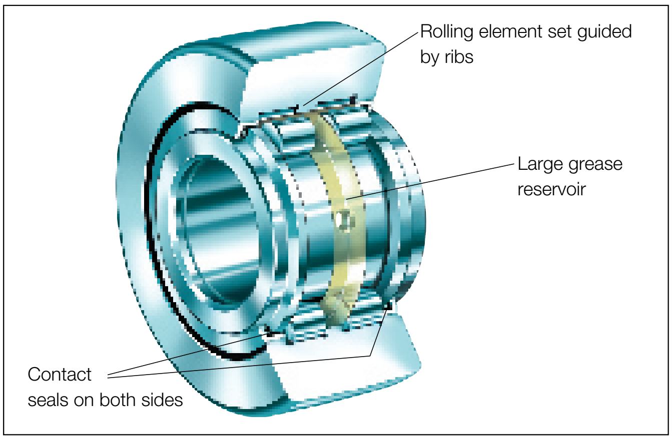

Figure 2 New generation yoke type track roller PWTR

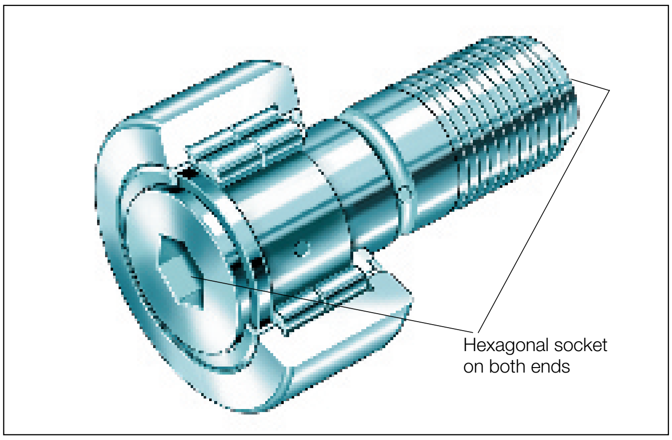

Figure 3 New generation stud type track roller NUKR

In cam control systems, acceleration/deceleration and load oscillations may be due to rough transitions between cam surfaces and by "inert masses". This slippage can be seen as a rough outer ring surface or the mating raceway, the effect being similar to sand blasting.

Improvement can be achieved by selecting an adequate minimum load or by changing rotational direction when the roller is stationary.

It is often beneficial to lubricate the contact zone by grease spray or an oil-soaked felt insert. However, a "flycatcher effect" can occur here, with an accumulation of contaminant in the contact zone which can lead to damage to the guidance system.

Furthermore, the use of any lubrication outside the roller is not permissible in a large number of applications, e.g. in the paper, printing and packaging sectors, and also for environmental reasons.

2 Reducing Hertzian pressure + preventing misalignment = minimizing wear

Selecting and maintaining the correct load is a decisive factor for achieving minimal wear. An adequate minimum load is required in order to prevent unwanted relative movement, while the permissible load is dependent on the material of the mating raceway. These influences are taken into consideration in the Hertzian pressure p_H.

Based on comprehensive investigations, permissible Hertzian pressure values are available [2], [3] for various mating raceway materials. The lower the maximum Hertzian pressure can be held, the less wear can be expected.

The maximum Hertzian pressure and resulting wear is influenced by misalignment (Figure 4), which is characterized as the angle of angular misalignment α and tilting angle β.

The failure characteristics of an excessively angle of angular misalignment α can be seen on the cylindrical wear profile of the outer ring surface together with flaking. An excessive tilting angle β shows a displaced raceway wear trace on the outer ring.

With little misalignment and adequate load ($C_{0w}/P < 60$ is generally assumed as a minimum load [3]), low-wear contact can be ensured even without lubrication. This can be seen in the matt grey appearance of the contact areas of both the track and the outer ring.

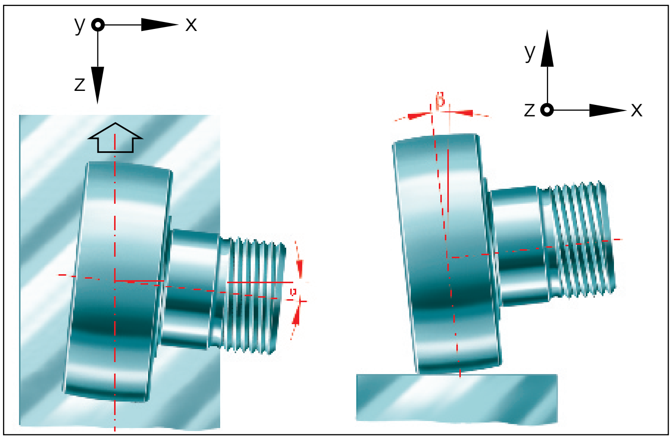

Figure 4 Angle of angular misalignment α and tilting angle β

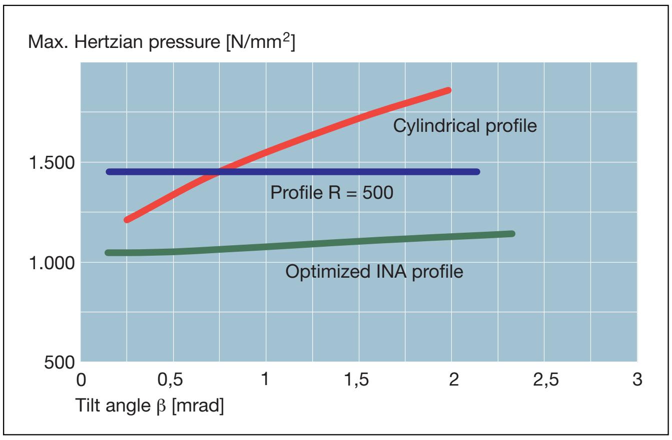

Figure 6 Maximum Hertzian pressure of stud type track roller NUKR 80, radial load F_r = 13 800 N, corresponding to C_w/P = 5

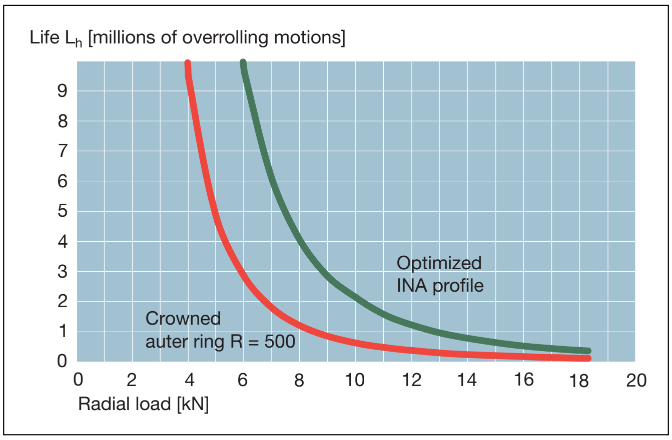

Figure 7 Basic rating life of mating raceway of yoke type track roller NUTR 15, mating raceway made from 42CrMo4V, hardness 350 HV

3 Influence of the profile on the Hertzian pressure

The outer ring profile has a decisive influence on the maximum Hertzian pressure and the behaviour of the track roller under misalignment.

3.1 Cylindrical profile

During untilted straight running, the cylindrical outer ring profile has a low maximum Hertzian pressure value. In this theoretical case, however, it is assumed that the edge stresses (which are often forgotten in such analysis) have been ignored (Figure 5). In cylindrical track rollers without profiling, even small tilt angles caused by manufacturing inaccuracies or deformation due to radial load result in extremely high edge stresses (Figure 6). This leads to damage in the contact zone and the internal structure of the track roller.

3.2 Profile R 500

Profiled outer ring surfaces are much less sensitive to tilted running (Figure 5).

The profile used previously has a 500 mm radius (R 500) and gives a constant maximum Hertzian pressure (Figure 6) under normal tilting angles. Even under tilting of 0,7 mrad and above, this is less than the values for the cylindrical roller.

All these values are, however, relatively high. A further reduction in this level, for either tilted or untilted running, was therefore required in order to achieve the objective of reduced wear in the contact zone.

3.3 Optimized INA profile

The new "Optimized INA profile", resulting from the computer-aided search for low Hertzian pressure, is a decisive step towards achieving this objective. In all cases, it has the lowest maximum values (Figures 5 and 6), which do not significantly increase even with increasing tilt angle b. This optimization gives a large radius which reduces the maximum Hertzian pressure and a profile which effectively limits edge stresses under tilting.

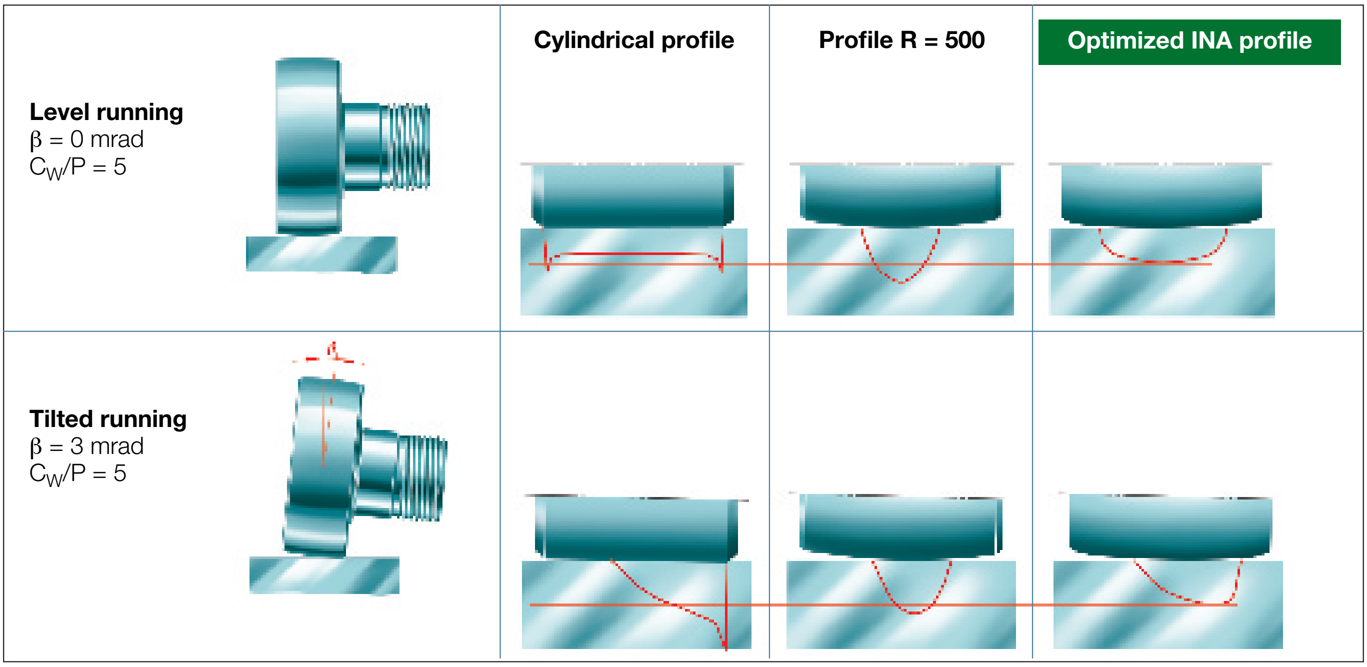

Figure 5 Influence of profile on Hertzian pressure – Optimized INA outer ring profile compared with conventional profiles

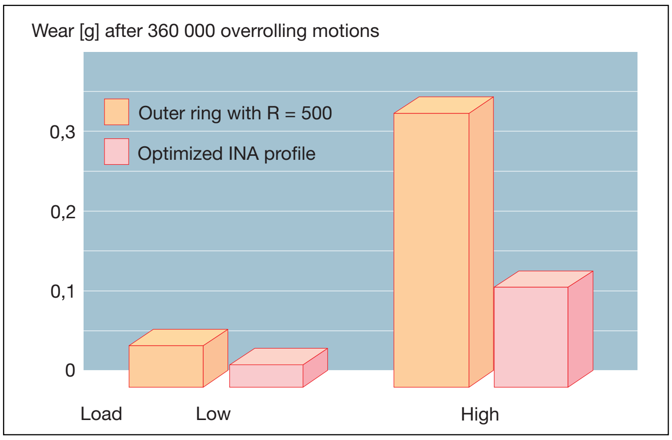

Figure 8 Wear of mating raceway made from GGG-50. The results are mean values from several test runs each of 360 000 overrolling motions without tilting

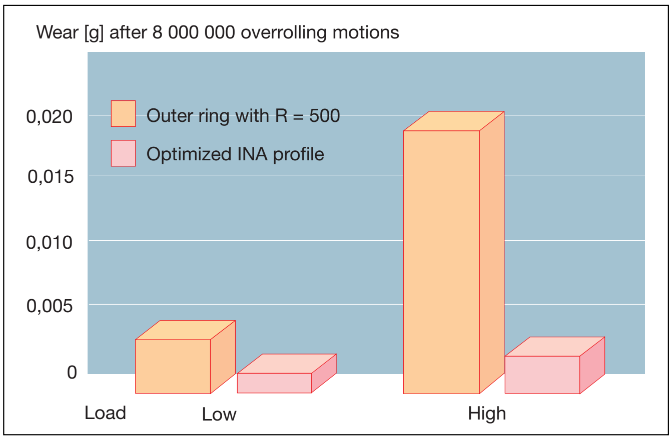

Figure 9 Wear of mating raceway made from 58CrV4. The results are mean values from several test runs each of 8 000 000 overrolling motions without tilting

4 What are the advantages of the "Optimized INA profile"?

4.1 Life

Under optimum contact conditions, the mating raceway life can be calculated in a similar way to that of a rolling bearing. However, this calculation requires knowledge of EHD lubrication theory and use of a mating raceway with the characteristics of rolling bearing steel.

Since these conditions are not generally fulfilled, life calculation is usually not carried out. If calculation is nevertheless carried out, the "Optimized INA profile" gives a longer mating raceway life than the R 500 profile (Figure 7).

4.2 Delayed wear means extended operating life

The operating life depends on the wear of the outer ring and mating raceway as well as the failure criteria of the specific application. While symptoms of wear may be tolerated in some applications without impairing the function, others are subject to more stringent criteria.
In general, the later occurrence of wear means a longer operating life.

Unfortunately, wear cannot be calculated definitively. Tests [4], [5] can give a clear picture here: Figures 8 and 9 show a comparison of the mating raceway wear for different materials with outer ring profiles of R 500 and "Optimized INA profile".

Figure 8 shows the average wear quantity in g of the mating raceway material GGG-50 after 360 000 overrolling motions.

Figure 9 shows the average wear quantity in g of the mating raceway material 58 CrV4 after 8 000 000 overrolling motions.

The "Optimized INA profile" shows far lower wear than the R 500 profile previously used as standard, both under low load (corresponding to about 1000 N/mm^2 Hertzian pressure with R 500) and high load (about 1500 N/mm^2 Hertzian pressure with R 500).

These test results more than satisfy the expectations placed on the "Optimized INA profile" developed by calculation. Even under tilted running, the "Optimized INA profile" has clear advantages due to the lower maximum Hertzian pressure, giving a decisive improvement in the operating life of the track roller and mating raceway.

4.3 Rigidity

The "Optimized INA profile" has the additional benefit of a rigidity increase of about 10% over the conventional R 500 profile (Figure 10).

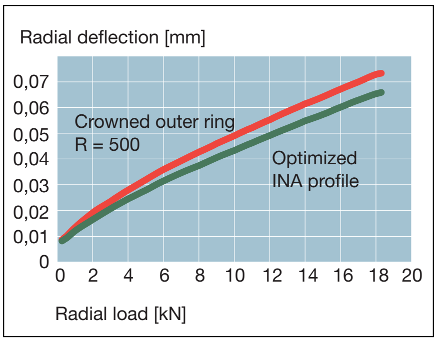

Figure 10 Radial deflection of outer ring and rolling element set with NUTR 15

Literature

[1] Bode, H.: A new generation of yoke and stud type track rollers, Der Konstrukteur, special issue ASB, April 1997

[2] INA catalogue 307: "Needle roller bearings, Cylindrical roller bearings", 1998

[3] INA publication LFR: "Track rollers", Herzogenaurach, 1996

[4] Welter, R. und Miko, J.: "Track roller with optimized function and running characteristics", "Konstruktionspraxis", no. 3 and 4, March and April 1995

[5] INA test report VA 67 802: "Wear of mating raceway in yoke and stud type track rollers", Herzogenaurach 1997

About the author:

Dipl.-Ing. (FH) Heinz Schäfers is Product Manager for Yoke and Stud Type Track Rollers in the Industrial Sector Management for Production Machinery and Systems at INA Wälzlager Schaeffler oHG, Herzogenaurach (Germany)

INA Wälzlager Schaeffler oHG

91072 Herzogenaurach · Germany
Telephone (+49 91 32) 82-0
Fax (+49 91 32) 82-49 50
Internet: www.ina.com

Sach-Nr. 006-956-548/OPS GB-D 07002 · Printed in Germany