An X-life Solution by FAG for Spreader Rolls

FAG
Rolling Bearings

Examples of Application Engineering

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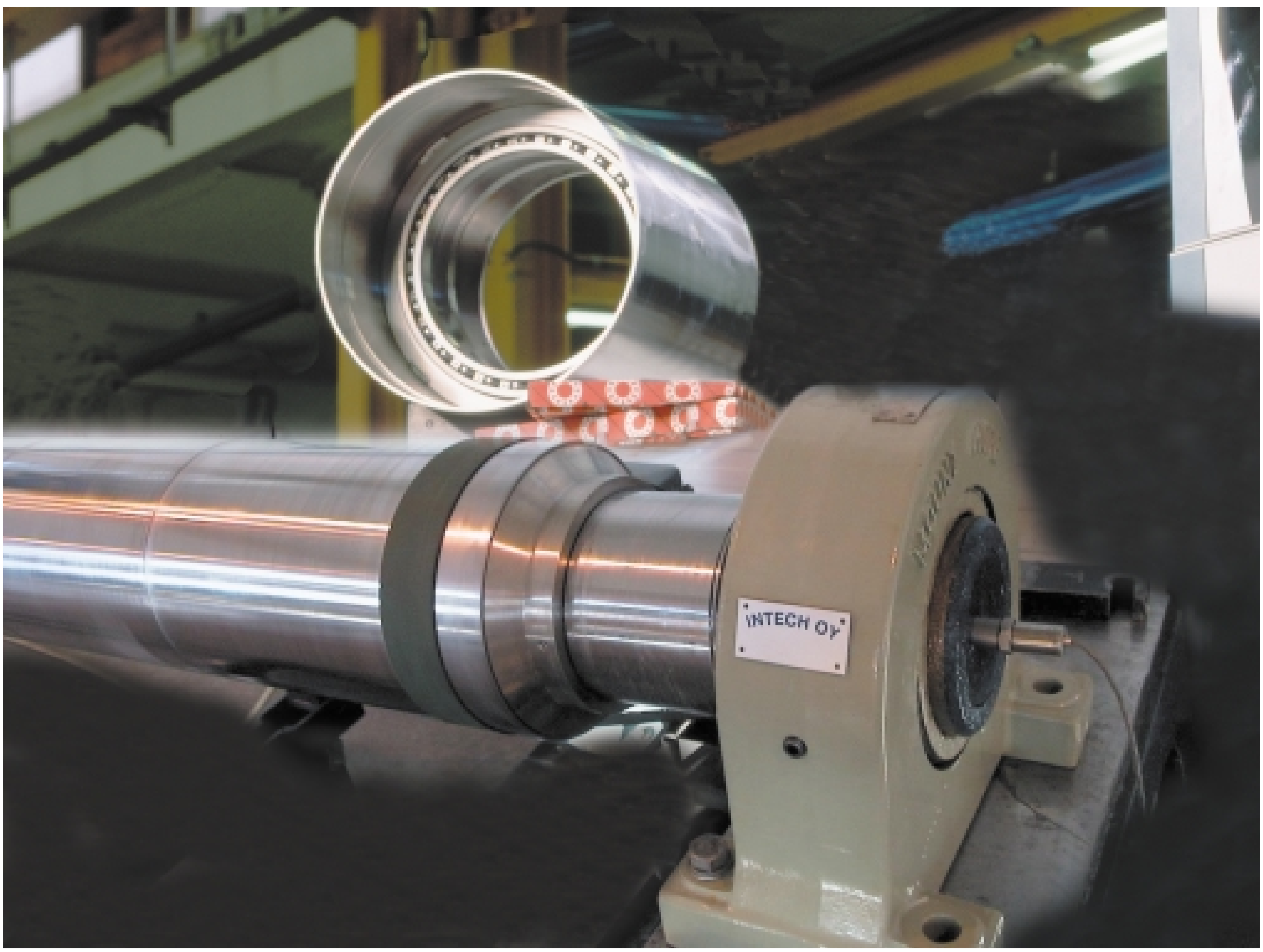


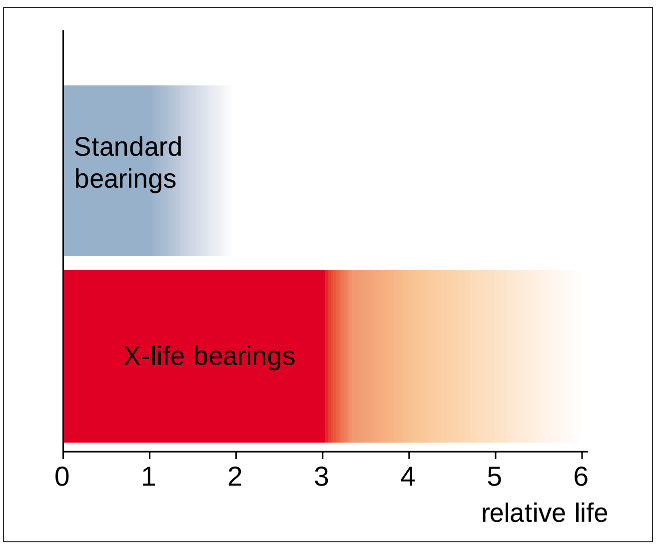
Spreader roll with hybrid deep groove ball bearings

Courtesy: Metalspray-Intech

Spreader rolls are found both in the wet section and in the dryer section of paper machines and in finishing machines.
Special bearing designs, in combination with specially designed lubrication and sealing systems, permit long rolling bearing lives to be reached even under the difficult conditions prevailing in paper machines, consequently ensuring a high cost-effectiveness.
FAG now offers a custom-tailored X-life solution for spreader rolls.

Hybrid deep groove ball bearings (rings of rolling bearing steel, combined with ceramic balls) in spreader rolls reach at least three times the service life of standard deep groove ball bearings.

Paper machines, as a rule, are in operation 24 hours a day and more than 350 days per year. This requires an extraordinary degree of reliability. For every unscheduled standstill of a paper machine costs the paper mill tens of thousands of deutschmarks per hour.
A particularly high degree of reliability and long service lives are also required of the rolling bearings installed in paper machines. Fatigue lives far in excess of 100 000 hours were calculated for conventional deep groove ball bearings in spreader rolls. In practice, however, service lives of clearly less than 20 000 hours are often reached.
In paper, textile and foil production, spreader rolls have to guide the web smoothly and without creases.
In the wet section, the rolls operate at approx. 40 °C, in the dryer section they are exposed to ambient temperatures of up to 180 °C (sections where the web is infrared-dried).
Usually the rolls are driven by the web running over them, reaching today speeds of up to 2 200 m/min (future speeds in the finishing sector up to 3 600 m/min). This makes speed indices ($n \cdot d_m$) in the order of ca. $2 \cdot 10^5$ to 10^6 $min^{-1} \cdot mm$ possible.

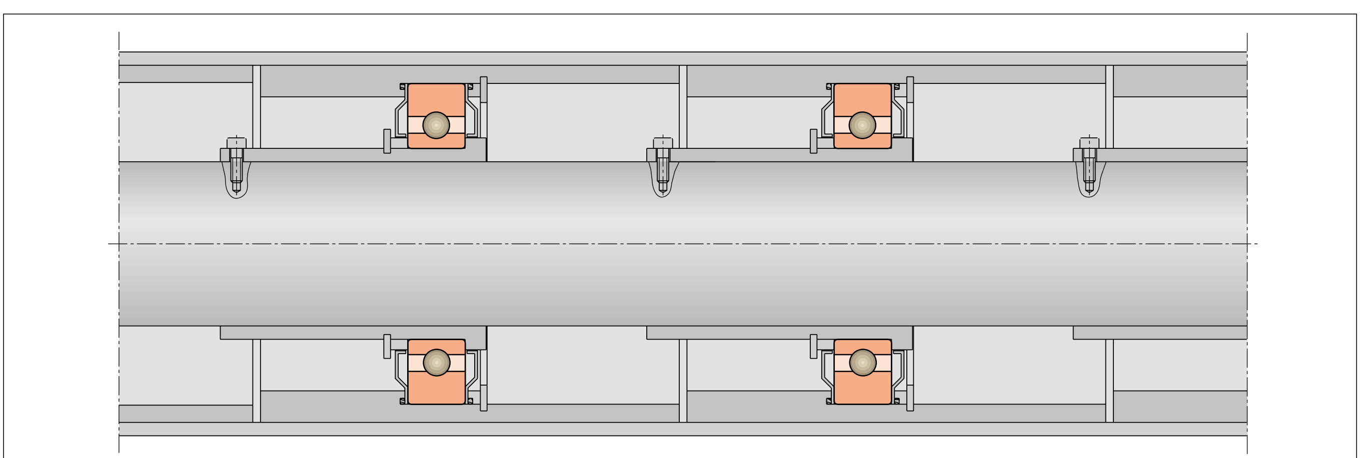


An X-life bearing in a spreader roll reaches at least three times the service life of a standard bearing

Spreader rolls consist of a stationary axle which is bent symmetrically to its longitudinal axis; the roll shell rotates around this axle. To enable the roll shell to follow the bent axle, it consists of several tube-shaped steel sections with identical diameters. Every tube element is supported by a deep groove ball bearing in such a way that it can rotate freely and has angular freedom. The outer ring of these bearings rotates.
Special seals at the roll ends protect the bearings inside from moisture and dust.
Depending on the specific application, the individual sections are provided with a shared flexible rubber coating. They are relatively light and – at a max. wrap angle of 30 degrees - only slightly loaded by the web tension.
Where the web wraps around the lower part of the spreader roll, i.e. where the web moves upward, the bearing load is reduced even more.
With standard rolling bearings, the slight load favours the generation of slippage. The resulting sliding of the balls, without rotation, is the technical challenge these bearings have to meet.
Due to the insufficient Hertzian pressure between balls and bearing ring, the driving forces decrease until they do not suffice to rotate the balls.
Slippage and brief periods in which no separating lubricating film is maintained cause starved lubrication. In standard deep groove ball bearings with steel balls, the generation of wear is favoured by the pronounced adhesiveness of the steel/steel combination, which clearly reduces the bearings' service life.

Technical data

Roll diameter	285 mm
Roll length	8 150 mm
Section length	380 mm
Section weight	15 kg
Web speed	1300 m/min
Rotation of roll shell	1145 min^{-1}
Web tension	2 kN/m
Wrap angle	30°
Roll temperature	150 °C



Spreader roll bearing arrangement. Every tube element is supported by a hybrid deep groove ball bearing.

Load, speed

The bearing load is the result of:
• roll weight = 0.15 kN and
• web tension = 2 · 2 kN · sin15°
The equivalent dynamic load of the bearing
P = 1.18 kN.
If the bearings are used at speeds of
v = 3 600 m/min, the speed index ($n \times d_m$) is
860 000 $min^{-1} \cdot mm$.

Bearing selection

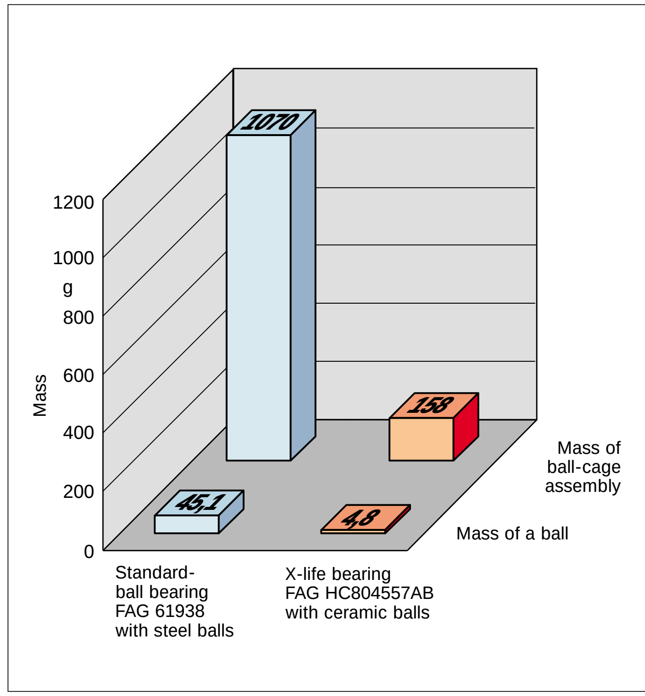
In order to achieve a satisfactory service life under the difficult operating conditions, hybrid deep groove ball bearings are used.

Requirements on the bearings:
• Smooth running (as slight masses to be accelerated as possible)
• Avoidance of slippage
• Utilization of standardized bearing components

Every tube element of the spreader roll is supported by a special deep groove ball bearing FAG HC804557AB.

The bearing dimensions are 190x260x33 mm.
Unlike a standard bearing, it features a thin inner ring, a solid outer ring, small ceramic balls (silicon nitride Si_3N_4) and a pressed steel cage.
The solid outer ring offers the advantage of lending the thin roll shell additional rigidity and form accuracy.

Hybrid deep groove ball bearing (rings of rolling bearing steel, balls of silicon nitride) – an X-life product of FAG



Comparison of the masses of a single ball and ball-cage assembly for the full number of standard steel balls and half the number of small ceramic balls

In order to reduce the revolving masses (ball-cage assembly), only half the number of balls was provided.
This means that every single ceramic balls takes up a higher load, which reduces the risk of slippage.

Bearing clearance, fit tolerances

Differences in the web tension can cause the individual roll sections to tilt relative to each other. The required radial clearance C3 permits a sufficiently large tilting clearance even at higher speeds.
The rotating outer ring is fitted tightly in the tube with tolerance M6.
The inner ring is fitted loosely (tolerance h7) on the stationary axle for easy mounting.

Lubrication, sealing

Due to the small mass and the favourable contact geometry of the ceramic balls, the lubricant is subject to only slight stressing. A low-friction FAG rolling bearing grease Arcanol, for example L75, which is suitable for constant temperatures ≤ 80 °C, reaches a long service life.
With the rotating outer ring – depending on the grease type – there is a risk of the base oil being centrifuged from the lubricating grease. Field-proven sealing elements of a particularly good oil tightness keep the separated base oil reliably within the bearing.

Hybrid bearings: steel rings / ceramic balls

<u>Advantages of the hybrid bearings</u>:

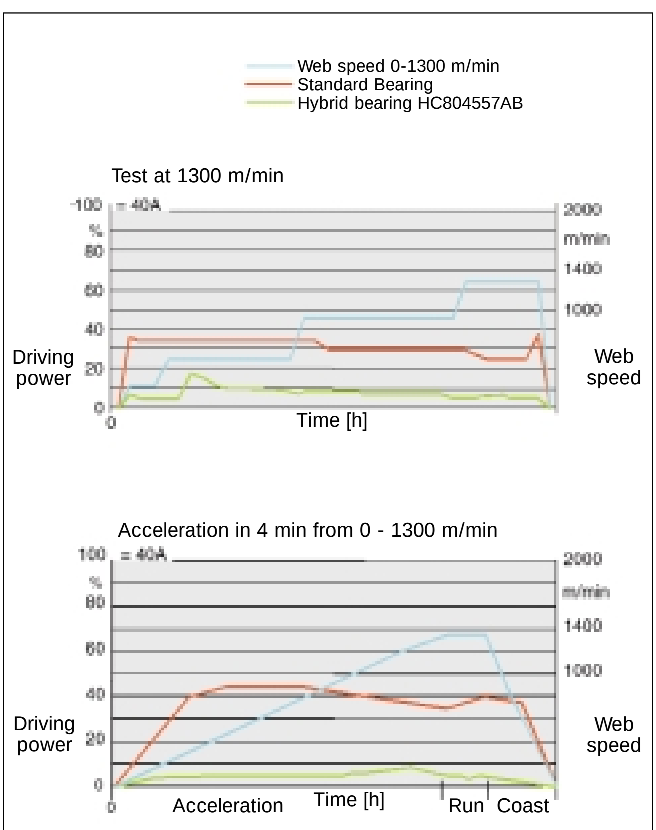
- Performance not impaired by slippage because of better tribological properties due to the favourable combination of materials
- Lower friction; as a result, considerably less driv-ing power is required (see acceleration charts)
- Higher accelerations and speeds due to slighter gravitational forces
- Considerably less vibration
- Longer grease lives due to lower friction and lower temperature

Favourable tribological properties of ceramic balls

- Ceramic balls are less affected by lubricating film breakdown and starved lubrication than steel balls as the parts in rolling contact display a clearly slighter tendency to adhesive wear.
- The mass of the ceramic balls is about 2.5 times slighter than that of steel balls, resulting in considerably slighter gravitational forces of the ball-cage assembly. This creates considerably more favourable conditions for slippage-free acceleration. Moreover, the centrifugal force of a smaller ceramic ball is only ca. 10.5 % that of a steel ball of the original size.
- The modulus of elasticity of silicon nitride is ca. 1.5 times that of rolling bearing steel. This results in a smaller contact area for the ceramic balls. The smaller contact ellipse causes less friction. Less heat is generated in the bearing. Due to the smaller contact area, combined with the specially machined raceways, the shares of sliding friction are reduced. Moreover, the supply with lubricant is improved. All told, a longer grease service life is achieved.

Greater cost-effectiveness due to X-life

The system cost is not only determined by the ac-quisition cost of the bearings and by the cost of providing suitable adjacent parts. The operating cost, repair cost and the cost caused by downtimes are also of considerable importance.
Minimal power consumption and reduced mainte-nance cost contribute to a low operating cost.
The operating periods of spreader rolls are consid-erably increased by the utilization of these special hybrid ball bearings. The bearings have to be replaced considerably less frequently, increasing the maintenance intervals and reducing the cost of machine downtimes, roll change and roll repair.



Driving power and speed during gradual and continuous acceleration for standard deep groove ball bearings and hybrid bearings

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