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## ROLLING BEARING CHARACTERISTICS FOR MAXIMISING THE LIFE OF CONVEYOR IDLER ROLLS

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The study of conveyor systems has shown that no matter how efficient the sealing devices, the environment can be so varied and hostile that they eventually become seriously damaged. This allows the debris to enter the rolling bearings. Ingress of debris into standard rolling bearings cause the bearings to be clogged whereupon they can no longer rotate. High friction could also develop, causing overheating and the possible risk of fire.

Page 316 of the Conveyor Equipment Manufacturers Association (CEMA) book entitled "Belt Conveyors for Bulk Materials", states under the heading "Maintenance" :

> "Although one stuck idler roll may not appear important, maintenance personnel should realise that under a high-speed belt handling abrasive material, its shell could soon wear through, presenting a knife edge which could severely damage an expensive belt"

Rolling bearings for conveyor idlers should, therefore, be designed therefore to ensure that the idler roll keeps on rolling even if the seals become damaged and debris enters the bearings.

A number of bearings of different type and design have been used in conveyor idlers. SKF has carried out extensive tests on these various bearings to investigate whether they have the most important characteristics required for maximising idler life - that is - resistance to seizure.

This paper endeavours to show that rolling bearings require some unique characteristics for maximising the life of conveyor idler rolls.

### THE STANDARDISED METHOD FOR CALCULATING BEARING LIFE

Bearing life is normally determined according to the well-known ISO formula :

$$L_{10} = \left(\frac{C}{P}\right)^p$$

where :

$L_{10}$ = basic rating life, millions of revolutions

$C$ = basic dynamic load rating, N

$P$ = equivalent dynamic bearing load, N

$p$ = exponent of the life equation

$p = 3$ for ball bearings

$p = \frac{10}{3}$ for roller bearings

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It is more convenient to express the basic rating life in operating hours. The equation used is :

$$L_{10h} = \frac{1000\,000}{60n} \left(\frac{C}{P}\right)^p$$

or

$$L_{10h} = \frac{1000\,000}{60n} L_{10}$$

where

$L_{10h}$ = basic rating life, operating hours

$n$ = rotational speed, r/min

The above equations are used to calculate the number of revolutions, or the number of operating hours at a given constant speed, which a bearing is capable of enduring before the first sign of fatigue (flaking, spalling) occurs on one of its rings or rolling elements.

It is common for users of idler rollers to specify a required $L_{10}$ life for idler roll bearings, i.e. bearings for idler rolls are selected according to their calculated fatigue life. Experience has shown that fatigue is **NEVER** encountered on an idler roll bearing.

The mode of failure, in almost every case, of bearing failure, is that the seals have collapsed, debris has entered the rolling surfaces and severe wear, or seizure of the bearing has taken place.

There is therefore little logic in using the ISO formulae for determining the life of bearings used in conveyor idler rolls. It is the effect of the contaminant and not the calculated fatigue life which determines the "effective life" of the bearing and the idler roller.

## MISALIGNMENT

In many bearing applications misalignment can be avoided entirely, or when it is present, bearings are chosen which can accommodate misalignment such as spherical roller bearings or self-aligning ball bearings.

Idler roll bearings should be able to accommodate a misalignment of up to 0,004 radians. This takes into account shaft deflection under load and manufacturing inaccuracies which cannot be avoided.

The figure of 0,004 radians is reasonable because misalignment above this value can have an adverse effect on many seal designs.

Spherical roller bearings are unacceptable for idler roll applications because of the large cost disadvantage. Self-aligning ball bearings are not suitable since the axial load, especially in the wing rolls, is too high for satisfactory operation.

## LUBRICATION

In South Africa, idler rolls are generally greased for life; the bearings receiving their one and only grease fill on assembly.

There are three reasons for this. The sheer number of idler rolls in a conveyor installation makes a relubrication routine impractical, or at the very least expensive. It is difficult to enforce the necessary safety measures during maintenance. It is also extremely difficult to pump grease through one grease nipple to three or more rollers. The pressures involved are extremely high and, if not carried out properly, this could result in the seals in the outer or first roller being subject to maximum pressure causing the seals to be blown out.

"Greased-for-life" should mean that the grease life is equal to or greater than the life of the idler roll. We find that with the idler rolls, the $L_1$ grease life (i.e. the time period at which 99% of the bearings are still reliably lubricated) is typically 22 000 hours for ball bearings but only 7 000 hours for taper roller bearings.

This is one of the reasons why ball bearings are preferred to taper roller bearings in idler rolls. Idlers with ball bearings do not need relubricating and this is an accepted principle in South Africa and many other parts of the world.

## SEALING

Although seals for the idler rolls are of many varying designs, they can be placed into two categories; rubbing seals and labyrinth seals.

Rubbing seals have good dirt exclusion properties but unfortunately produce very high friction. When used in a contaminated environment, rubbing seals can be worn rather rapidly, reducing their effective life and efficiency.

Labyrinth seals are attractive in that there is no rubbing contact and hence little friction. Under adverse conditions, there will eventually be ingress of contamination into the seals and the bearings causing higher friction.

It now becomes clear that standard bearings used in conveyor idler rolls are prone to failure. Normally the failure is due to seizure. It has been shown that a 1 to 10 relationship exists between the percentage of seized idlers and the increase in power consumption. For example, a 10% rate of seized or near seized idlers, would demand an additional 100% of power consumption.

Idler rolls therefore need a purpose designed bearing, one that is capable of operating in a wear producing situation and does not seize even when worn. Such a bearing is the SKF Seize Resistant Bearing.

In response to requests from the British Mining Industry, the SKF Seize Resistant Bearing has been specifically designed as the bearing for bulk conveyor idler rolls and is insensitive to the ingress of contaminants and is seize resistant even with marginal sealing arrangements. Close to 100 million seize resistant bearings have been produced worldwide for use in all types of mining and mineral extraction industries. It is tried, tested and proven.

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The design parameters for the bearing were :

- it must be self-contained and require no adjustment
- it must accommodate misalignment
- it must be lubricated for life at the initial assembly
- it must continue to operate safely when contaminated
- it must permit the use of a seating system with low friction torque
- it must permit the use of simple, easy to assemble, low cost idlers.

Consequently the bearing has a number of distinguishing features :-

- The largest possible balls were selected for their enhanced ability to override particles, crush them and eject them.

- The raceways feature a special track form to improve the tolerance for misalignment; and a special surface finish to prevent skidding of the balls thus making the bearing seize resistant.

- The non-reinforced nylon cage is of a unique (patented) design. Its elastic flexing properties avoid the jamming of hard particles in the pockets and absorb extreme differential accelerations of the balls.

A further recognisable feature included in the open side of the cage moulding is a flexible wiper prong which prevents the ingress of large pieces of contaminant into this side of the bearings. The full annulus of the cage body protects the other side. The bearing can therefore be mounted either way with equal assurance of successful performance.

Since SKF have been marketing seize resistant ball bearings, a large amount of empirical data and a great deal of application experience has been accumulated.

The seize resistant ball bearing was designed and developed at the SKF product centre in the United Kingdom. The design was modified and optimised by an iterative process involving extensive testing. The bearings were subsequently tested at the SKF Engineering Research Centre (ERC) in Holland. The tests have included an in-depth analysis of the effect of dirt ingress on bearing turning friction, operating temperature and service life. Many different types of contaminant have been tested.

An identical test was used to compare the performance of standard deep groove ball bearings, taper roller bearings and seize resistant bearings. The test conditions were as follows :-

Rotating outer ring, no seal fitted.

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|---|---|---|
| Lubricant | : | Factory preservative only |
| Radial load | : | 734N |
| Rotational speed | : | 732 r/min |
| Misalignment | : | 0,004 radians |
| Contaminant, dry | : | Arizona road dust (course)<br>15g at start of test + 5g added every 24h |
| Failure criteria | : | Inner ring temperature 150 ° C<br>Friction torque 4 Nm<br>Radial play 1,5 mm<br>Excessive vibration - subjective analysis |

After extensive testing it was found that :

- The deep groove ball bearing performs slightly better than the taper roller bearing. The seize resistant ball bearing has a **10 times** longer life than the deep groove ball bearing.
- Both the taper roller bearing and deep groove ball bearing failed due to seizure.
- The seize resistant bearing failed by wear as it was designed to do.
- The seize resistant bearing had the lowest mean power consumption.

## FRICTION TORQUE TEST RESULTS

Standard quantiites of grease and various types of contaminants were used to compare the friction torque of seize resistant ball bearings with the friction torque of deep groove ball bearings.

The large balls and raceway geometry give the seize resistant bearing a slightly higher turning torque in clean and preserved conditions.

Adding stone dust or coal dust to the lubricant makes virtually no difference to the turning torque of the seize resistant ball bearing.

For the standard deep groove ball bearing, however, turning torque rises by a factor of 3 with the introduction of contaminant.

## NEW CONVEYOR IDLER BEARINGS ON THE SOUTH AFRICAN MARKET

Two bearing types have recently been introduced in South Africa. The first is similar to the SKF seize resistant bearing in that its external dimensions are identical. This bearing is imported from China.

The other bearing type which is now manufactured locally by SKF, conforms to the German specification DIN 22112.

To evaluate these bearings they were subject to the same test that was previously used to compare the performance of the seize resistant bearing, the deep groove ball and the taper roller bearing.

## PERFORMANCE OF THE 'COPY' OF THE SKF SEIZE RESISTANT BALL BEARING

We have already mentioned that the external dimensions of this bearing is identical to the SKF seize resistant ball bearing, but this is where the similarity ends.

It was found that the life of the South African manufactured seize resistant ball bearing exceeded the life of the "copy" by a **factor of 15**

In all the tests carried out on the "copy" seize resistant ball bearing, the mode of failure was seizure. We therefere refer to this bearing as the imitation seize resistant ball bearing.

## PERFORMANCE OF THE BEARINGS MANUFACTURED TO DIN 22112

DIN 22112 states that bearings used in conveyor idler rolls must be deep groove ball bearings with a radial internal clearance of C4 (this means that the radial internal clearance of the bearing is relatively large). In addition, the cage of the bearing must be manufactured from glass-fibre reinforced polyamide 6.6.

The bearing is in all respects identical to a standard deep groove ball bearing except for the cage material and construction. The performance comparison between the seize resistant ball bearing and the deep groove ball bearing described previously refers to deep groove ball bearings with pressed steel cages. There is therefore a difference between the deep groove ball bearing manufactured to DIN 22112 and a standard deep groove ball bearing.

It must be noted that the deep groove ball bearing manufactured to DIN 22112 has proven to be extremely successful as an idler roll bearing in Germany and many parts of the world. The test results were therefore very interesting.

It was found that the seize resistant ball bearing exceeded the life of the deep groove ball bearing manufactured to DIN 22112 by a factor of 2,5.

The deep groove ball bearing did exhibit seize resistant characteristics but often failed due to excessive temperature. It was not specifically designed for wear like the seize resistant ball bearing.

The life of the bearing to the DIN specification was, however, far longer than that of standard bearing, as well as the imitation seize resistant ball bearing. This showed why it has proved to be a successful bearing in conveyor idler rolls. It is possible that this bearing will be increasingly used in idler rolls in South Africa.

DIN 22112 is interesting in that it does not specify a required bearing life. It states that the bearings **and seals** of the conveyor idler roll must be so designed that at a maximum speed of 650 r/min, the roller will have a life of at least 20 000 hours.

## BENEFITS OF USING A PURPOSE DESIGNED BEARING

It has been shown that only two bearing types are suitable for use in conveyor idler rolls

- the deep groove ball bearing manufactured to DIN 22112
- the seize resistant ball bearing

The seize resistant ball bearing is preferred in difficult and dirty applications.

To sum up the benefits of these two bearing for the conveyor user :

- Reduced maintenance, replacement and downtime.
- Improved productivity
- Significant energy savings.

Both these bearings are designed for a purpose and are performance proved.