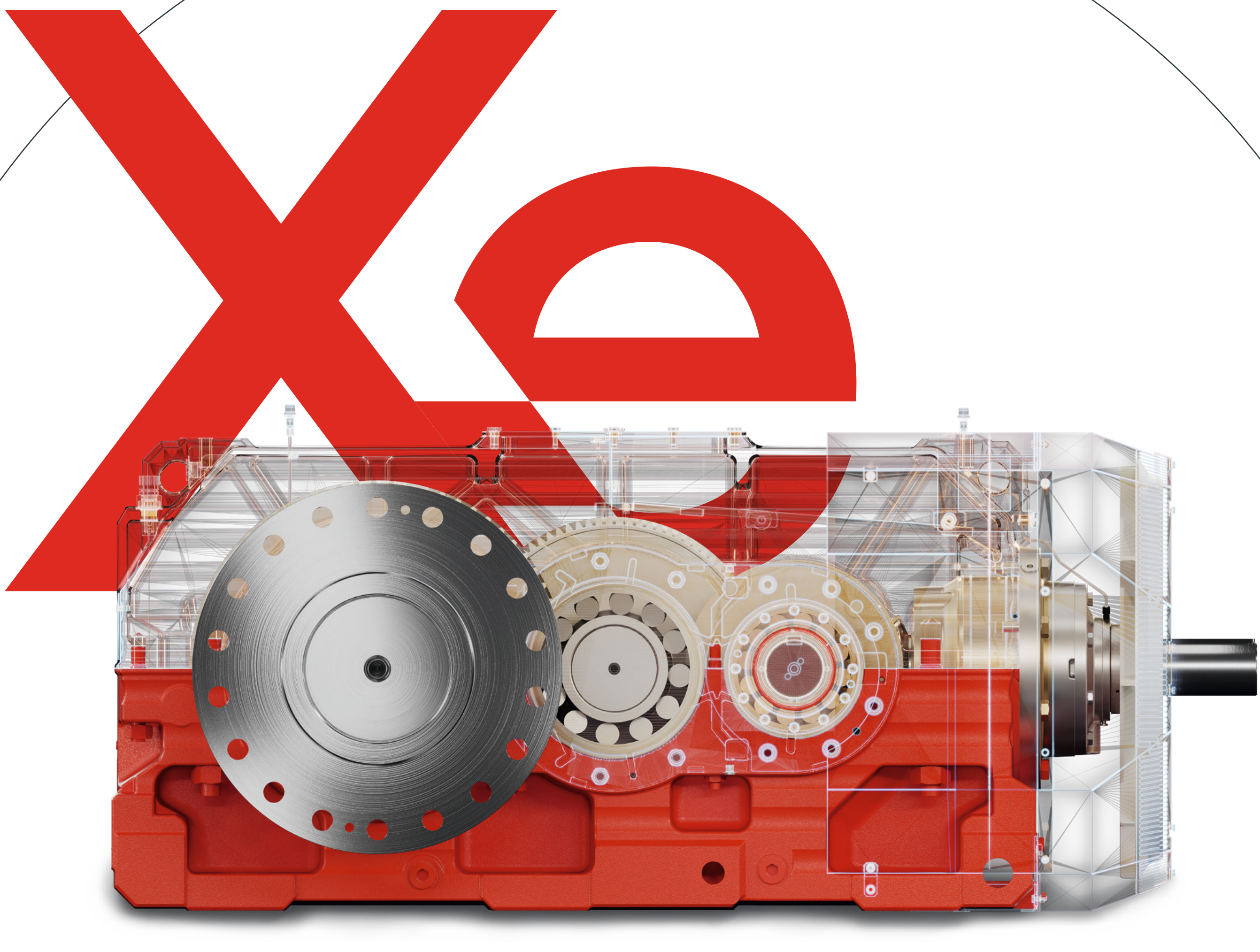
X.e CASE STUDY: SERVICE LIFE OF A CONVEYOR BELT DRIVE



OPTIMIZING THE SERVICE LIFE OF A CONVEYOR BELT DRIVE – A CASE STUDY

Besides the oil seals, the shaft-hub connection and the lubricant used, the key factors in determining the service life of an industrial gear unit are the rolling bearings, the loads placed on them and the gearing's load capacity for reliably transferring the torque.

These loads primarily result from the torques and the radial and axial forces that affect the output shaft of the gear unit during operation and are consequently transferred to the bearings. Other factors that influence the bearing service life are the type of gear oil, the oil level in the gear unit and the application's ambient conditions.

When optimizing the service life of a gear unit to suit a given application, the first thing you need to do is consider the bearing service life.

1

BEARING SERVICE LIFE

The bearing service life corresponds to the number of revolutions or operating hours that a bearing can withstand at a constant speed without sustaining damage – and without material fatigue.

According to the ISO 281 standard, the **nominal bearing service life L_{10h}** is the service life achieved by 90% of bearings tested under the same conditions. In this context, the figure 10 stands for a failure probability of 10% and is calculated from the dynamic load rating C_r and a dynamically equivalent load P.

To calculate the **reference value for nominal bearing service life L_{10r}** as per ISO/TS 16281, the load of the individual rolling elements, the tilting of the bearing rings, the forces caused by the thermal expansion of the materials, and crossover influences from other gear unit stages are taken into account alongside the dynamic load rating C_r.

2

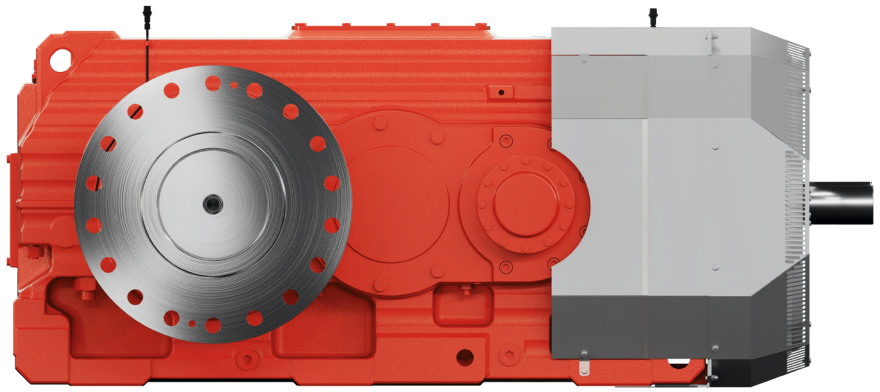
POWER LOSS IN THE GEAR UNIT

Due to hydraulic effects in the gear unit oil, and due to the seal, gearing and bearing, there is a certain percentage of loss in gear units during the conversion of rotational speed and torque on the output side compared to the drive power delivered by the motor. To optimize a gear unit for an application, it is important to cut down this power loss P_{loss} as much as possible.

CASE STUDY – CONVEYOR BELT DRIVE IN A SAUDI-ARABIAN CEMENT PLANT

CUSTOMER REQUIREMENTS (APPLICATION CONDITIONS)

- Input speed: 1485 min^{-1}, output speed: 65 min^{-1} (corresponds to a gear ratio of i = 22.85)
- Output torque M_{K2}: 76.5 kNm (operating torque)
- Service factor $F_s \geq 2$ (operation involving impacts and shocks)
- Oil bath temperature ≤ 90 °C (an external cooling system is not desired)
- Start using fluid coupling: starting factor = 1.6 (corresponds to a peak torque of 160%)
- Ambient temperatures of -5 °C to +40 °C
- Requested operating period of 10 years

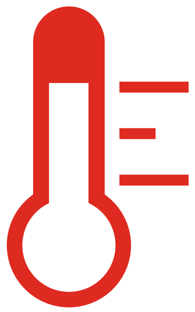


OUR SOLUTION:

- Generation X.e bevel-helical gear unit
- Nominal torque M_{N2} = 156 kNm
- Gear ratio i = 23.44

STARTING POINT – EXTERNAL COOLING SYSTEM

When using an external cooling system under the aforementioned application conditions, the expected oil bath temperature is 81 °C. For L_{10h}, the calculation of the bearing service life produces a value of 51 000 operating hours. The reference service life L_{10r} is 6000 hours longer, amounting to 57 000 operating hours. The power loss P_{loss} is 17.9 kW.



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CALCULATION 1: REPLACING THE EXTERNAL COOLING SYSTEM WITH A FAN

Besides significantly lowering investment costs, dispensing with an external cooling system and switching to an axial fan can also cut the power loss by 8%. The main reason for this is a reduction in the bearing load, which no longer exhibits such high friction losses thanks to the warmer oil. The oil bath temperature then rises to 93 °C, with the reference service life L_{10r} remaining unchanged at 57 000 operating hours.

–8%

POWER LOSS

2

CALCULATION 2: REDUCING THE OIL LEVEL

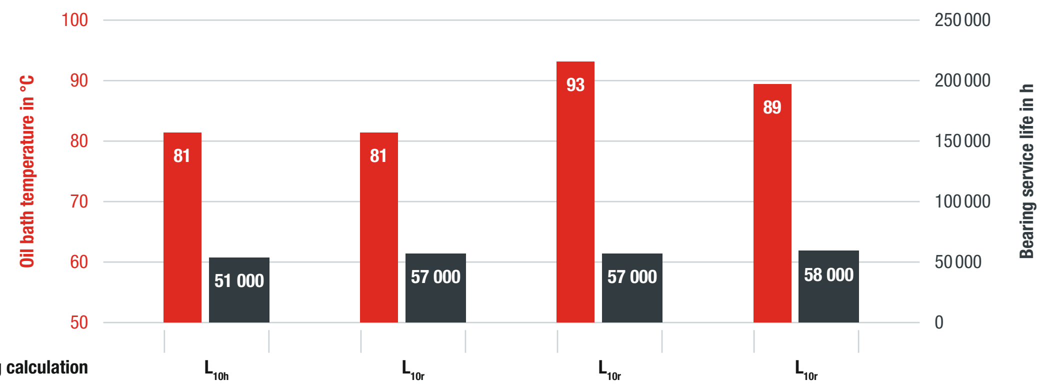
Reducing the oil level has a more significant impact on power loss. By implementing this measure and using a fan instead of the external cooling system, power loss declines by 24%. Due to the lower oil level in the gear unit, the oil bath temperature also falls back down to the requested 90 °C limit. The reference service life increases to 58 000 operating hours.

–24%

POWER LOSS

INTERIM RESULT:

- Total reduction in power loss: -24%
- Oil bath temperature: 89 °C
- Reference bearing service life: 58 000 operating hours
- **Additional advantage: Thanks to the measures taken, it is possible to meet the customer requirements without using a costly external cooling system.**



Bearing calculation	L_{10h}	L_{10r}	L_{10r}	L_{10r}
Cooling system	External cooling system	External cooling system	Axial fan Ø 780 mm	Axial fan Ø 780 mm
Oil level	Normal	Normal	Normal	Reduced
Bearing preload	Normal	Normal	Normal	Normal

3

CALCULATION 3:
MORE ACCURATE APPLICATION DATA AND THUS CUSTOM BEARING PRELOAD

Besides the starting factor of 1.6, the number of starting sequences (frequency with which the peak torque is reached) also comes into play. When operated continuously throughout the year, there are around 10 peak events on the conveyor belt in the customer's system every hour. Apart from this, there are no events of note that could lead to further peak loads. The equivalent permitted torque that now needs to be taken into account can thus be set at a much lower value. Based on this, it is possible to set a custom bearing preload.

– 28 %

POWER LOSS

210 000 h

OPERATING HOURS

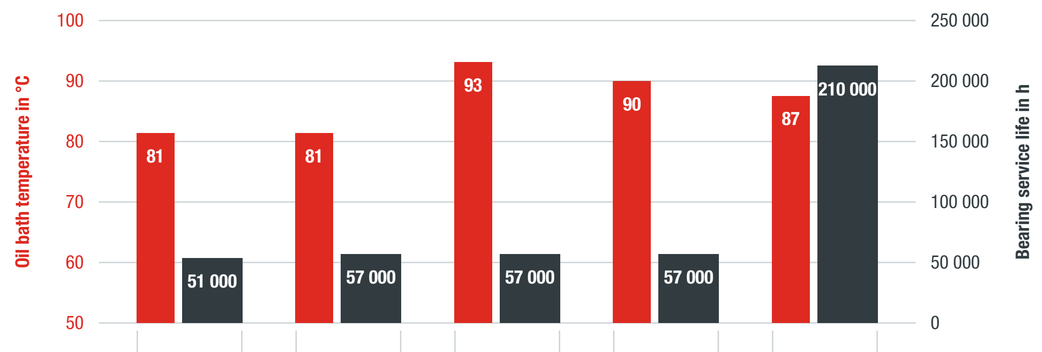
REFERENCE BEARING SERVICE LIFE

INTERIM RESULT:

- Total reduction in power loss: -28%
- Oil bath temperature: 87 °C
- Reference bearing service life: 210 000 operating hours
- **Additional advantage: significant increase in bearing service life thanks to custom assembly clearance values.**

CONCLUSION:

- The dominant share of losses attributable to the bearings can be significantly reduced.
- The lower bearing preload increases the bearing service life by a factor of 3.7.



Bearing calculation	L_{10h}	L_{10r}	L_{10r}	L_{10r}	L_{10r}
Cooling system	External cooling system	External cooling system	Axial fan Ø 780 mm	Axial fan Ø 780 mm	Axial fan Ø 780 mm
Oil level	Normal	Normal	Normal	Reduced	Reduced
Bearing preload	Normal	Normal	Normal	Normal	Custom

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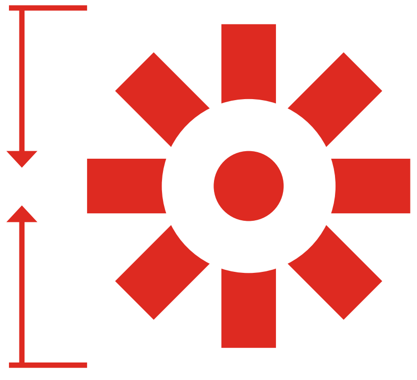
CALCULATION 4:
ADAPTING THE AMBIENT TEMPERATURE AND USING A CORRESPONDINGLY SMALLER FAN

After examining the local climate more closely, the ambient temperature range stipulated by the customer can be limited to +10 °C to +32 °C. A new thermal and mechanical calculation reveals that a smaller fan measuring 680 mm in diameter would suffice. Alternatively, it is possible to proceed with the design process using the fan already installed, which has a diameter of 780 mm. The oil bath temperature would then be reduced to 81 °C.

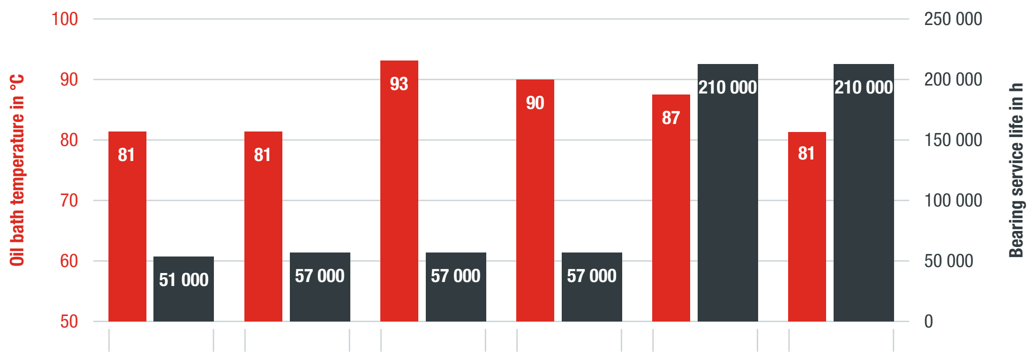


END RESULT:

- Total reduction in power loss: -28%
- Oil bath temperature: 81 °C
- Reference bearing service life: 210 000 operating hours
- **Additional advantage: reduced fan costs and lower noise level.**

CONCLUSION:

Thanks to the new opportunities offered by Generation X.e, the drive can be tailored precisely to the customer's stipulations and the requirements of their application. The more information SEW-EURODRIVE receives about the customer application and the installation site, the more accurately and cost effectively the drive can be designed.



Bearing calculation	L_{10h}	L_{10r}	L_{10r}	L_{10r}	L_{10r}	L_{10r}
Cooling system	External cooling system	External cooling system	Axial fan Ø 780 mm	Axial fan Ø 780 mm	Axial fan Ø 780 mm	Axial fan Ø 780 mm
Oil level	Normal	Normal	Normal	Reduced	Reduced	Reduced
Bearing preload	Normal	Normal	Normal	Normal	Custom	Custom

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