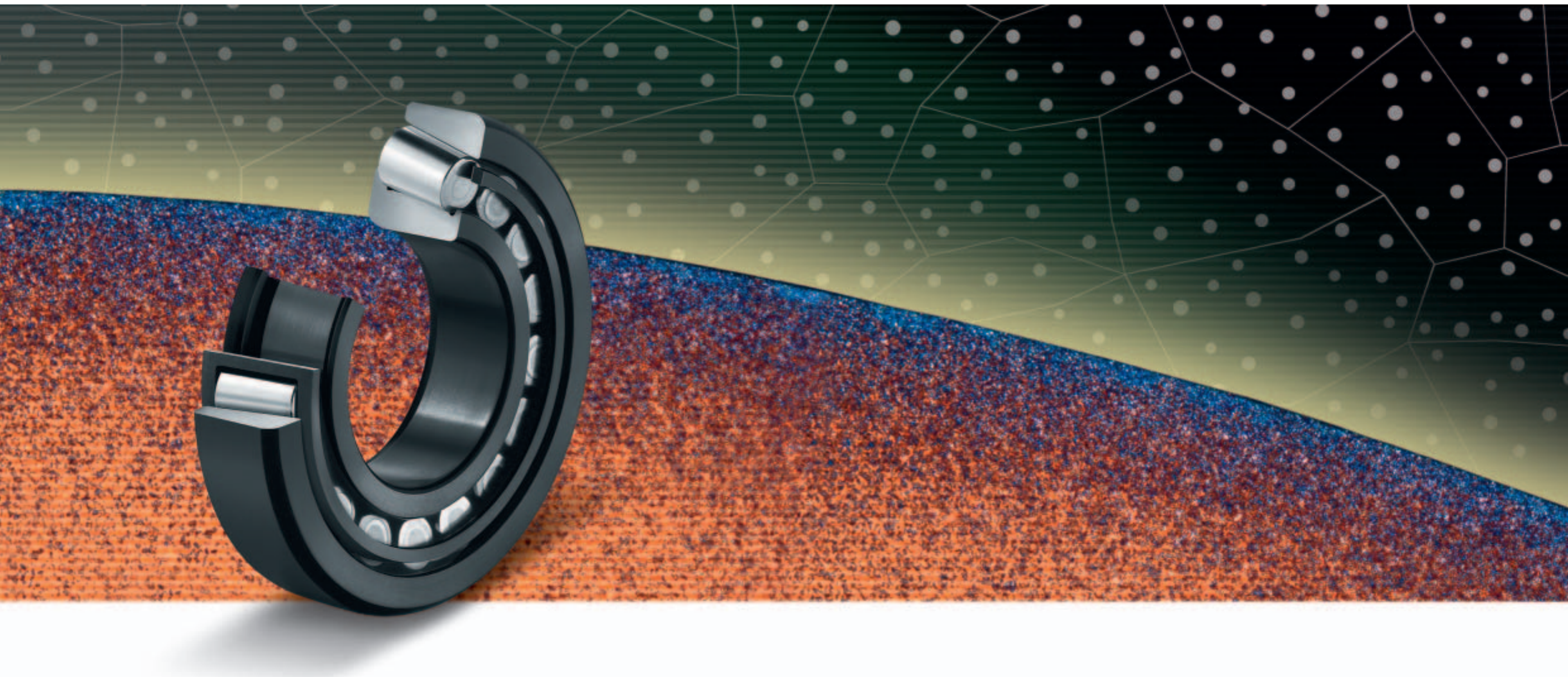

Carbonitrided Rolling Bearings

Longer operating life under boundary lubrication and contamination

Carbonitrided rolling bearings

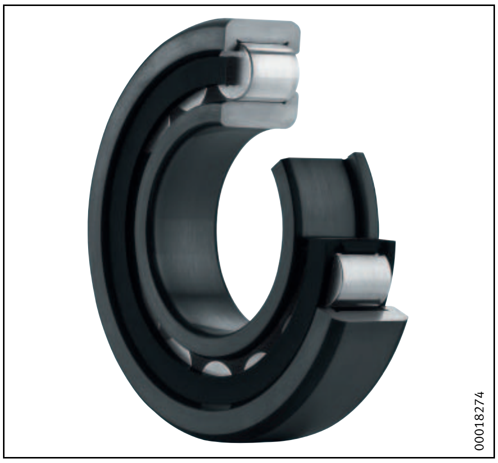

Figure 1: Carbonitrided rolling bearing with black oxide coated rings

The Schaeffler Group carries out ongoing research into new materials and methods for materials treatment in order to offer higher performance bearing solutions, *Figure 1*.

Carbonitriding is an expanded heat treatment method. In addition, nitrogen is deposited in the surface layer of the bearing rings. This method increases the surface hardness and improves the wear resistance of the bearing.

Due to the harder surface, the bearing is less sensitive to contaminants in the lubricant and to damage through particle overrolling. If optimum lubrication is not present, a lubricant film separating the surfaces cannot be formed.

Under this boundary lubrication, mixed friction may occur and lead to bearing damage.

Carbonitriding increases the fatigue limit life under both these boundary lubrication conditions and under good lubrication conditions.

Alternatively, carbonitriding gives a means of achieving a given rating life even when using smaller bearings (downsizing).

New materials

For carbonitrided bearings, specially developed base materials are used that are matched to the heat treatment. These are through hardened steels or case hardened steels.

Changes to the molecular structure

Carbonitriding changes the molecular structure in the surface layer of the material, *Figure 2*.

During the carburising of steel, the carbide is distributed as coarse grains in the material.

It can be seen in the micrograph that the carbides adopt an elongated needle form. They are not only embedded but accumulate at the grain boundaries. This increases the risk of crack formation.

The process of carbonitriding influences the form and the distribution of the carbides. The carbides become smaller and spheroidal.
Their distribution is more homogenous and less concentrated at the grain boundaries. The risk of crack formation is reduced. With increasing carbon and nitrogen content in the rolling bearing steel, the martensite start point decreases. The heat treatment process leads to more thermally stable residual austenite. Due to the higher toughness of the residual austenite, the bearing rating life is increased.

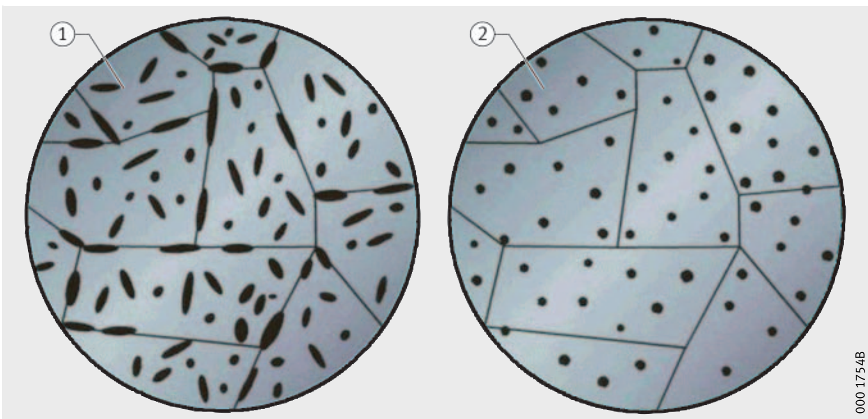

Figure 2: Micrographs of case 1 hardened steels and 2 carbonitrided steels

Contamination and particle overrolling

If there are particularly hard and sharp-edged contaminants in the rolling bearing greases, such as hardened metal particles or moulding sand fragments, these are pressed into the raceways by the overrolling action of the rolling element. The displaced material forms a rim around the indented depression. With each overrolling cycle, an area of increased stress is formed at the location of the rim and the rolling bearing steel undergoes rapid fatigue, *Figure 3*.

The carbonitriding leads to more stable residual austenite. Due to the higher toughness of the raceway surface, the rim is flattened again and crack formation is prevented, *Figure 4*.

Mixed friction

If lubrication is insufficient, a lubricant film separating the surfaces is not formed and undesirable steel-to-steel contact takes place. In addition to the increased bearing temperature, which leads to more rapid ageing of the lubricant, the raceway surface may undergo fusing and damage.

The heat treatments influence the compressive residual stresses near the surface such that the stresses generated through overrolling in operation are reduced. This allows higher load to be achieved with the same rating life or a longer rating life under the same load.

Longer rating life and downsizing

Carbonitrided bearings can therefore also be used under good lubrication conditions where a longer bearing rating life is required.

In those cases where there is no additional design space due to design restrictions, increased performance density is required. In some cases, the higher performance capacity of carbonitrided bearings allows the use of smaller bearing positions or so-called downsizing. Through this optimisation, the frictional torque can be significantly reduced, which leads to significant decreases in CO_2 emission.

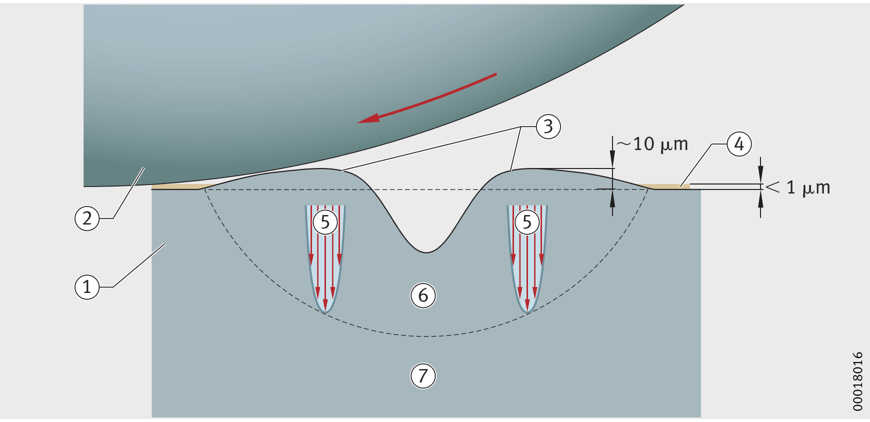

Figure 3: Schematic of the stress increase zone
1 Raceway, 2 Rolling element, 3 Raised edge due to indented particle, 4 Lubricant film thickness, 5 Stress increase, 6 Plastic deformation, strain hardening, 7 Residual stress buildup

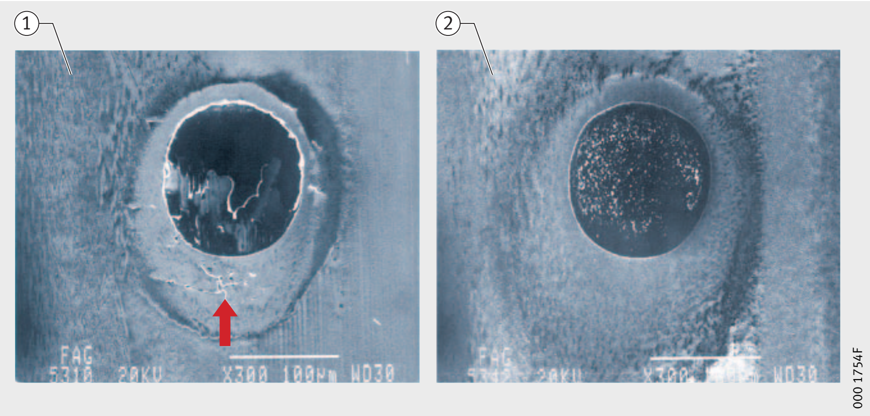

Figure 4: 1 After 40 hours of overrolling, a crack is formed at the indentation point without carbonitriding
2 After 1 500 hours of overrolling, there is still no sign of a crack in carbonitrided bearings

Application examples

Carbonitrided bearings are particularly suitable where long rating life and high machine availability are to be achieved despite difficult operating conditions.

This performance capacity is demonstrated by carbonitrided bearings in many applications:

- gearboxes in agricultural and construction machinery, cars, commercial vehicle and wind turbines
- pumps and compressors
- connecting rods in internal combustion engines
- rolling mill equipment
- marine propulsion systems.

Application examples

	Wear due to mixed friction	Rating life	Contamination and particle overrolling	Downsizing
Gearboxes	–	■	–	■
Pumps and compressors	■	■	–	■
Connecting rods	–	■	–	■
Steel, rolling mills	■	■	■	–
Marine propulsion systems	–	■	–	■

Summary

Carbonitrided rolling bearings are the result of intensive research work and offer customers advantages over standard bearings in many respects.

The increased residual austenite content improves the resistance of the bearing to contaminants in the lubricant. Carbonitriding changes the molecular structure in the surface layer of the material. The finer microstructure gives increased material toughness.

The rims formed due to particle indentation are flattened again in subsequent overrolling. Cracks are not formed and material fatigue is delayed by a considerable margin.

Carbonitriding leads to finer and more spheroidal carbides that are distributed more uniformly in the material.
As a result, the raceway surface is harder and more resistant to wear. In tests, carbonitrided bearings achieved a rating life two to six times longer than standard bearings even under full lubrication, *Figure 5*.

In difficult conditions or under heavy loads, mixed friction may occur if lubrication is insufficient. The wear occurring as a result can be counteracted by the higher surface hardness in conjunction with black oxide coating of the running surfaces using Durotect® B, in order to prevent slippage damage. Carbonitrided bearings thus achieve a longer operating life even under particularly adverse and challenging operating conditions, *Figure 6*.

Carbonitrided rolling bearings offer the customer high reliability and machine availability.

Further information is available from our employees in Sales, External Sales and the relevant Applications functions.

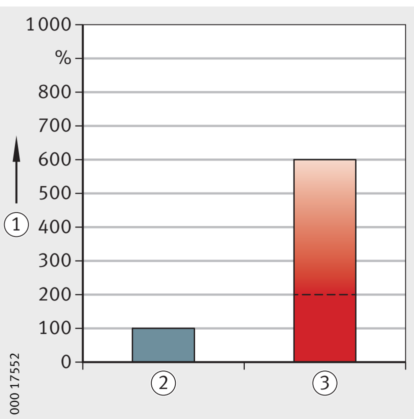

Figure 5: 1 Bearing rating life – full lubrication, 2 Standard, 3 Carbonitrided

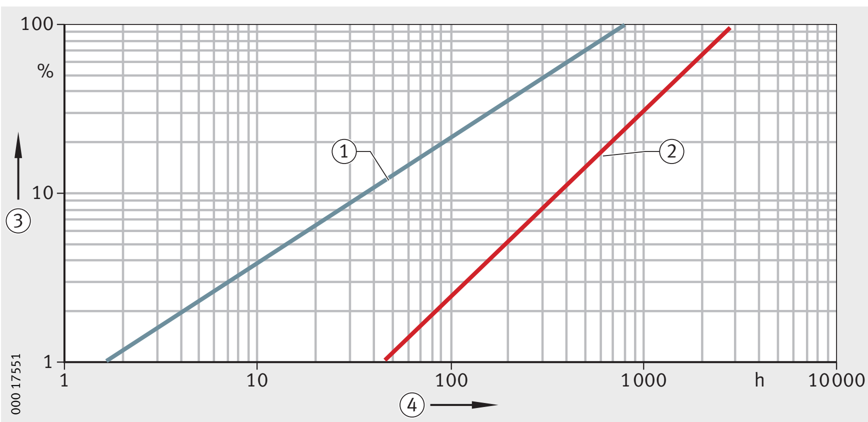

Figure 6: Rating life test under mixed friction. 1 Bearing with conventional heat treatment, 2 Carbonitrided rolling bearing steel, 3 Probability of failure (%), 4 Running duration (h)

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Enquiry form

Mounting location:

Rolling bearing type	______________
Machine type	______________
Mounting location	______________
Country, region	______________

Designation:		**Symbol:**
Force in	x direction	F_x
	y direction	F_y
	z direction	F_z
Moment about	x axis	M_x
	y axis	M_y
	z axis	M_z

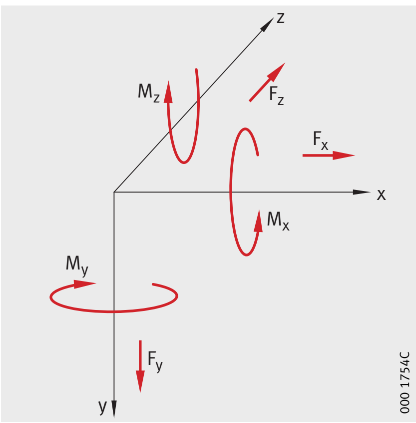

Figure 7: Forces and moments

Operating conditions

Load case 1:

Axial force	F_x	______________	[N]
Radial force	F_y	______________	[N]
	F_z	______________	[N]
Bending moment	M_x	______________	[Nm]
	M_y	______________	[Nm]
	M_z	______________	[Nm]
Speed		______________	[rpm]

Time periods:

q_1 = %

Load case 2:

Axial force	F_x	______________	[N]
Radial force	F_y	______________	[N]
	F_z	______________	[N]
Bending moment	M_x	______________	[Nm]
	M_y	______________	[Nm]
	M_z	______________	[Nm]
Speed		______________	[rpm]

Time periods:

q_2 = %

Load case 3:

Axial force	F_x	______________	[N]
Radial force	F_y	______________	[N]
	F_z	______________	[N]
Bending moment	M_x	______________	[Nm]
	M_y	______________	[Nm]
	M_z	______________	[Nm]
Speed		______________	[rpm]

Time periods:

q_3 = %

Operating conditions – continued

What is rotating?
- ❑ Outer ring (AR)
- ❑ Inner ring (IR)

Fits:

Shaft ____________

Housing bore ____________

Material:

Shaft ____________

Housing bore ____________

Type of lubrication
- ❑ Oil sump
- ❑ Recirculating oil
- ❑ Grease

Operating temperature ____________ [°C]

Temperature difference between AR, IR ____________ [K]

Internal clearance in fitted condition ____________ [μm]

Viscosity (ISO VG) ____________ [mm^2/s]

Lubricant manufacturer ____________

Lubricant designation ____________

Oil inlet temperature ____________ [°C]

Oil outlet temperature ____________ [°C]

Filter rate ____________

Oil sump temperature ____________ [°C]

Grease quantity ____________ [g]

Relubrication intervals ____________ [h]

Sender:

Company name ____________

Street ____________

Town, post code ____________

Country, region ____________

Telephone ____________

Fax ____________

E-mail ____________

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