Cronitect®

New high performance corrosion-resistant steel for rolling bearings

SCHAEFFLER GROUP
INDUSTRIAL

Cronitect®

The new rolling bearing steel for special operating conditions

Figure 1 · Cronitect® hybrid deep groove ball bearing

Materials that are resistant to overrolling, wear and corrosion are a basic precondition for rolling bearings that must function reliably even under extreme operating conditions and in some cases under poor lubrication conditions (lubricant starvation) or even dry running. The new rolling bearing steel Cronitect® from the Schaeffler Group is the product of logical further development of solutions already offered in the Schaeffler product portfolio. Cronitect® indicates the combination of a martensitic hardening, corrosion-resistant steel that is generally available in most cases with a thermochemical surface layer treatment method and is characterised by very high corrosion resistance as well as high wear and overrolling resistance.

Introduction

In recent years, there has been a significant increase in the demand for rolling bearings that, even under extreme conditions, demonstrate their performance capacity and offer a long operating life. In particular, the requirement for bearings suitable for media lubrication or even dry running has accelerated the development of new technical solutions. The drivers of these developments include, on the one hand, more stringent legal conditions, for example in the food industry. On the other hand, the increased awareness of the sustainable use of resources and conservation of the environment as well as efforts to achieve energy-efficient, robust solutions play a decisive role. Accordingly, there is an increasing wish for reductions in the use of conventional lubricants and the avoidance of demanding sealing systems is becoming an objective.

In particular, media lubrication and dry running in combination with appropriate resistance to the specific environment place extreme mechanical, chemical and thermal requirements on rolling bearings.

There is a key role here in relation to the materials used for the various bearing components (rings, rolling elements, cage) and their interaction.

It is often only when rolling bearing steels resistant to corrosion and media are used that it becomes possible to move towards a bearing solution capable of dry running or media lubrication. The state of the art in terms of hardenable corrosion-resistant steels is represented on the one hand by the established X105CrMo17 (AISI440C), which represents a compromise between corrosion resistance and overrolling resistance but is limited in terms of its performance capacity and increasingly can no longer fulfil the current requirements.

On the other hand, the high end material X30CrMoN15-1 (Cronidur30) forms the upper limit of the state of the art. The use of Cronidur30 allows a significant increase in performance relative to the AISI440C.

Due to the high demands in terms of energy usage and machine technology involved in the production of Cronidur30, however, its availability is severely limited.

Figure 1 shows the implementation of the material solution in a hybrid deep groove ball bearing.

Requirements for the material

If a rolling bearing is to be used in a corrosive environment and must also run without the use of conventional lubricants, the rolling bearing steel used for the rings must fulfil three principal requirements:

- First of all, the material must have a high level of corrosion resistance in the hardened state. This requirement is achieved by a high proportion of dissolved chromium in the structure.
- Further, the requirement for a long rating life leads to the high overrolling resistance of the material.
  To this end, the material must demonstrate sufficient hardenability (hardness > 58 HRC) and a high degree of cleanliness.
- The effect of a corrosive environment may be associated with the ingress of moisture and other media into the bearing. As a result, the lubrication conditions under conventional lubrication become increasingly critical such that solid body friction becomes an inevitable consequence. Under media lubrication or dry running, this is the case right from the start. The material or material combination must therefore have high resistance to abrasive and adhesive wear.
  Resistance to abrasive wear can be achieved by high hardness – a slight tendency to adhesion results from the combination of materials with different types of bonds (e.g. steel – ceramic). The latter can be positively influenced by the formation of a stable, dense oxide layer on the steel.

Features of Cronitect®

As a result of the development work by the Schaeffler Group, the rolling bearing steel Cronitect® (**Chro**mium **Ni**trogen Pro**tect**ion) gives an extraordinarily effective combination of a steel almost in conformance with DIN-EN standards and a special thermochemical heat treatment process.

A surface layer is produced by means of appropriate process control. The process is similar to the case hardening of case hardening steels – in this case, however, on the basis of nitrogen. The surface layer of Cronitect® (*Figure 2*) is characterised by increased hardness, compressive stresses and a homogeneous, fine grained structure similar to that of the material Cronidur30. The precipitation of nitrides, carbides and carbonitrides in the surface layer is suppressed.
The increase in hardness is decisively determined by the dispersion of nitrogen.

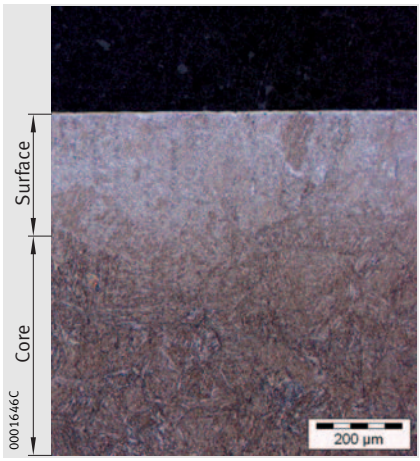

Figure 2 · Surface layer structure of Cronitect®

The increase in hardness to > 58 HRC ensures, in addition to the fundamental overrolling suitability for rolling bearings, the high abrasive wear resistance that is required. The high proportion of dissolved chromium after heat treatment leads to a completely formed and stable passive layer on the surface. The result of the passive layer is on the one hand an enormously high corrosion resistance, while on the other hand the oxide layer in combination with ceramic or steel rolling elements contributes – as shown – to a low adhesion tendency.

The features of Cronitect® are rounded off by the fact that the material has problem-free formability due to the low carbon content of approx. 0,2% as well as the uniform structural formation.

Performance capacity of Cronitect®

The excellent characteristics of Cronitect® were demonstrated in extensive test programmes:

- corrosion and media resistance
- overrolling resistance and thus full load carrying capacity
- long operating life under mixed friction conditions
- wear resistance under dry running running conditions
- given cold formability.

These are the outstanding features of Cronitect®. Solutions implemented accordingly using Cronitect® prove to be suitable for extreme operating conditions and offer the customer a long operating life even under difficult conditions.

The standardised test of the corrosion resistance of components is the salt spray test in accordance with DIN EN ISO 9 227 (formerly DIN 50 021).

In this case, Cronitect® achieves an anti-corrosion performance that at approx. 900 hours is only slightly lower than that of Cronidur30 and is significantly higher than that of AISI440C or rolling bearing steels with a coating of thin dense chromium (TDC), *Figure 3*.
The wear resistance of the material Cronitect® was investigated under dry running in special tests using angular contact ball bearings 7205. In the dry running tests, one of the major challenges was to prevent contamination of the test device by the test rig itself and by air containing oil. For this reason, the tests were carried out on a special dry running test rig in a separate, oil-free test chamber.
The maximum value of the difference between two raceway measurement traces (raceway transverse form) – in each case before the test lasting 300 hours and afterwards – was taken as representative of the wear. Tests were carried out on the materials 100Cr6, Cronidur30 and Cronitect® in combination with ceramic rolling elements and a cage material based on PEEK and specially developed for dry running rolling bearings.

After an identical running time, Cronitect® showed raceway wear almost twelve times lower compared to 100Cr6 and was thus at the level of Cronidur30, *Figure 4*, page 5.

In order to demonstrate the performance capacity under mixed friction conditions, the Schaeffler Group carried out rating life tests on a standard rolling bearing test rig and investigated material solutions on a comparative basis. The results are presented in *Figure 5*, page 5. The bearing rating life at a requisite reliability of 90% under the selected conditions for Cronitect® was higher by a factor of 9 than that of bearings made from AISI440C or the standard material 100Cr6.

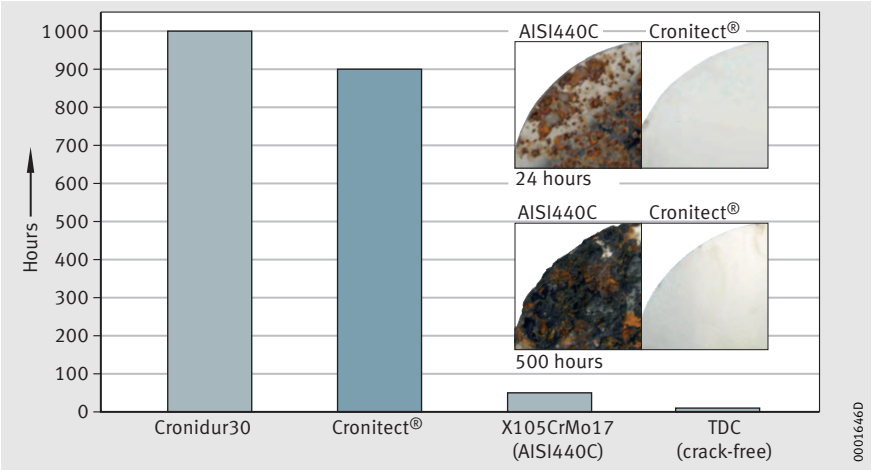

Figure 3 · Comparison of the anti-corrosion performance of corrosion-resistant steels and a thin dense chromium (TDC) coating, results obtained in the salt spray test in accordance with DIN EN ISO 9 227 (formerly DIN 50 021).

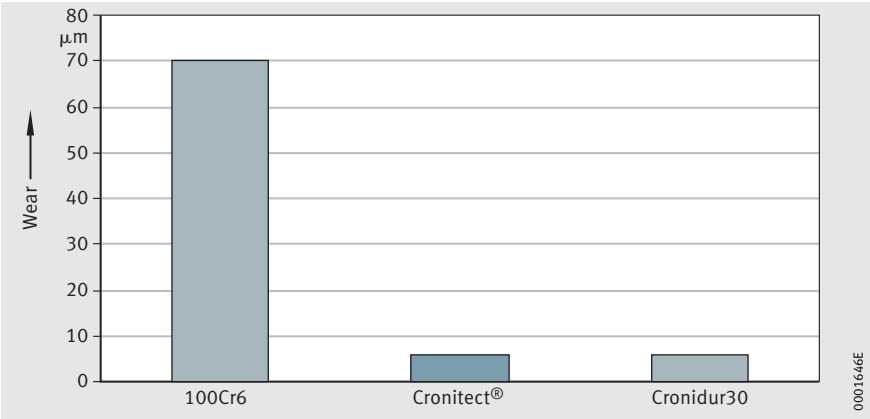

Figure 4 · Raceway wear after 300 hours of dry running (n = 1 000 min^{-1}, p = 1 350 MPa)

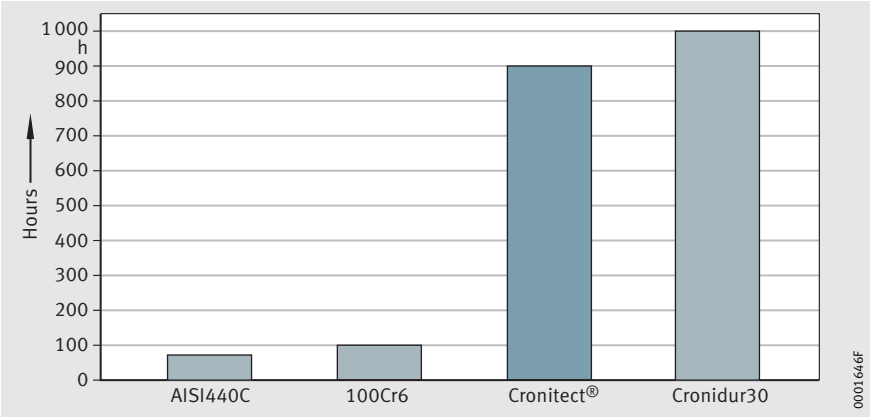

Figure 5 · Comparison of bearing rating life (requisite reliability 90%) of steels under mixed friction conditions

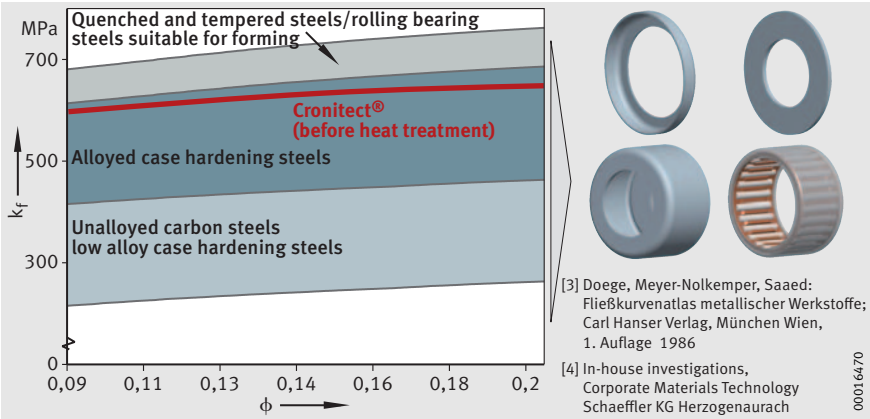

Figure 6 · Flow curves of various steels [3], [4]; bearings produced by forming

It is only with Cronidur30 that a further slight increase in performance can be achieved under mixed friction conditions.

In contrast to standard corrosion-resistant steels such AISI440C and the high end steel Cronidur30, Cronitect® makes it possible through its forming capability to expand the spectrum of corrosion-resistant rolling bearings with high hardness to cold formed bearing products for the first time. By means of Cronitect®, it is thus possible to achieve the balancing act between exceptional corrosion resistance and full load carrying capacity.

Figure 6 shows the forming capacity of Cronitect® in comparison with classic forming steels and some examples of products that can be realised in this way.

Profile of characteristics of hardened corrosion-resistant rolling bearing steels

Characteristic	AISI440C	Cronidur30	Cronitect®
Corrosion resistance	○	++	++
Wear resistance (adhesion and abrasion)	○	+	+
Overrolling resistance (mixed friction)	○	++	++
Overrolling resistance (EHD)	+	++	+
Dimensional stability	○	++	++
Compressive stresses (surface layer)	–	○	+
Cold forming capacity (unhardened)	––	(––)	+
Raw material availability	–	––	+

++ Very good
+ Good
○ Moderate
– Poor
–– Very poor

The table Profile of characteristics of hardened corrosion-resistant rolling bearing steels shows the qualitative characteristics profile of the corrosion-resistant steels established in the market for rolling bearings in comparison with Cronitect®. It is clear from this that Cronitect® achieves the performance capacity of Cronidur30, is significantly superior to the standard corrosion-resistant steel AISI440C and combines the very good characteristics with far better raw material availability.

Application examples

The extremely high corrosion resistance, suitability for dry running and the long rating life under mixed friction make Cronitect® of interest for applications in almost all industrial sectors.

Examples include packaging and food equipment, conveying, electronic component manufacture, power transmission, heavy machinery, fluid handling and pneumatics as well as sport and fitness.

It is possible to use Cronitect® across the whole spectrum of bearing solutions, from conventional rolling bearings of all types (deep groove ball bearings, needle roller bearings, stud type track rollers, etc.) to classical linear guidance systems.

For the Schaeffler Group as a technological leader in the field of actively and passively guided motion, sustainable use of resources and energy efficiency through reduced friction have always stood at the heart of product development.

The characteristics portfolio and the resulting robustness of Cronitect® open up new possibilities in bearing design. Depending on customer requirements or the possible bearing concept, the omission of contact seals is for example a highly promising approach for minimising bearing friction and making a contribution to increased efficiency.

Furthermore, the Cronitect® bearing can symbolically be moved closer to the environment and thus contribute to the simplification of customer products. This approach also takes account of the concepts of resource conservation and efficiency.

For professional and ambitious amateur cyclists, friction in areas of racing cycles such as the wheel hubs and the botttom bracket bearings plays a decisive role. It thus has a significant influence on the purchasing decision. Until now, bottom bracket bearings have predominantly been fitted with ball bearings made from 100Cr6, sealed on one side and lubricated with grease.

In partnership with a well-known manufacturer of cycle components, Schaeffler Group Industrial has developed a new concept – specifically optimised for low bearing friction – for this application.

The new Cronitect® hybrid bearing (*Figure 1*, page 2) does not have a contact seal; a low viscosity oil is used in place of grease, while a specially designed bearing cage ensures protection against coarse contamination. A comparative measurement of frictional torque carried out on the loaded bearing between the previous solution and the new Cronitect® hybrid bearing gives an indication of the level of the friction saving achieved.

With the new bearing concept, the bearing friction could be reduced by up to 75%, *Figure 7*. The solution described has been used successfully in volume for a year and has already achieved numerous successes in well-known cycle racing tours.

Bearing solutions based on this concept can also offer inline skaters decisive customer advantages. The new low-friction and maintenance-free Cronitect® hybrid bearings give the decisive impetus here for even more dynamic activity, ease of motion and enjoyment in skating.

In conjunction with just five high performance ceramic rolling elements, this gives a bearing that, with a weight saving of more than 12%, is significantly lighter than conventional solutions and exhibits a 49% reduction in friction. In this application too, the high tech plastic bearing cage also acts as a non-contact seal on one side. The result is excellent free-running characteristics due to minimal friction with minimal mass.

Due to the use of high performance materials for the bearnig components, use in the rain or cleaning with water also present no problems of any type.

The materials used – above all Cronitect® – and their extremely corrosion resistance allow practically maintenance-free use.

Among professional sportspeople, the new bearings have already awoken major interest and, due to their detectable running characteristics, are already referred to as “Magic Bearings”.

The new Cronitect® hybrid bearings are available in size 608, the one most frequently used for inline skates, *Figure 8*.

Furthermore – Cronitect® hybrid bearings are used not only in inline skates, cycle wheel hubs or bottom bracket bearings: their sophisticated characteristics make them the ideal rolling bearing in

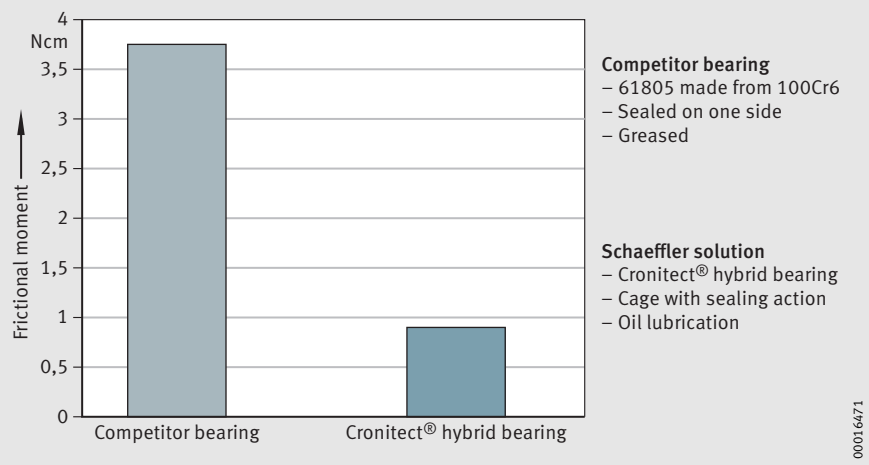

Figure 7 · Comparative frictional torque measurement of the deep groove ball bearing; application: bottom bracket bearing for cycle racing ($n = 100\ min^{-1}$)

Figure 8 · Cronitect® hybrid bearing for inline skates

numerous types of sports and fitness equipment, for example for high quality pedals, sliding seat rowing boats, fishing reels and yacht windlasses. There are also areas of application in food equipment. In this case, the focus is less on the requirement for minimised friction and more on avoiding the use of lubricants.

The reason for this requirement is to prevent contamination of the foodstuffs to be processed. For the cam control system of a bottle closing machine, the standard stud type track roller in an oil bath that was previously used was replaced by a specially developed track roller in which the roller stud and outer ring are made from Cronitect® and the moulded part is produced from a media-resistant plastic, *Figure 9*. The solution is greased for life and sealed against external influences by a meadi-resistant seal.

The balls in this case are made from corrosion-resistant steel. Since the system is therefore completely free from oil at the customer, this not only eliminates the risk of contamination of foodstuffs but the new bearing solution is also completely maintenance-free since it is no longer necessary to carry out relubrication.

The stud type track roller also offers extremely high media and corrosion resistance. The increased hygiene safety goes hand in hand with a cost saving due to reduced maintenance outlay and higher machine availability.

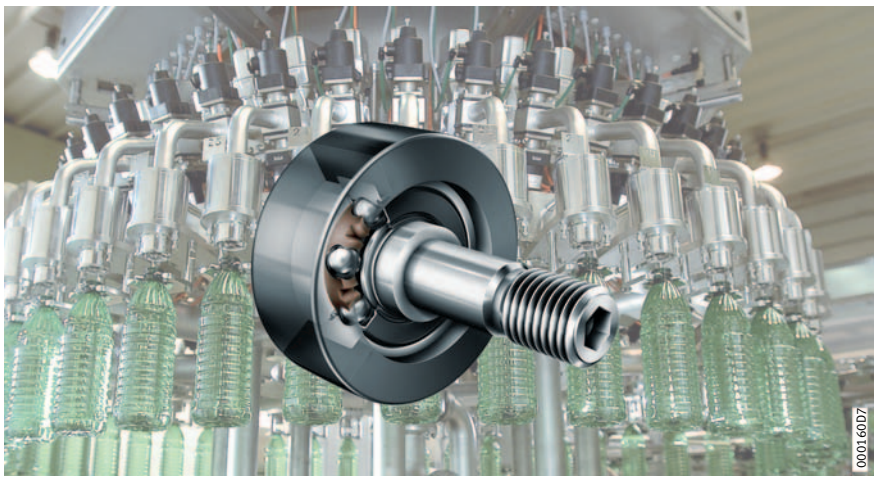

Figure 9 · Cronitect® track roller, e.g. for applications in the food industry

Summary

With the development of Cronitect®, the Schaeffler Group has succeeded in achieving targeted improvements compared to current standard solutions in the area of corrosion-resistant rolling bearing steels for extreme rolling bearing applications.

This article presents the characteristics of Cronitect®, especially its corrosion resistance, its suitability for mixed friction and dry running as well as the wear and overrolling resistance on the basis of representative test results and highlights its advantages compared to the state of the art.

Cronitect® is the solution to the requirements that will be placed on rolling bearings in future as a result of the sharper awareness of sustainable resource use, the will to preserve the environment and the efforts made towards energy-efficient, robust solutions.

Further information can be obtained from our employees in Commercial, External Sales and the relevant Application Engineers in the Business Units of Schaeffler KG.

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