The compact tapered bearing unit design principle

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1. Introduction

The key to safety and reliability, when specifically speaking tapered journal bearings, is a matter of bearing design. Design has further an impact on the life cycle cost. SKF has maintained a key focus in the conceptual development of new bearing designs with the ability to achieve the increased load capacities required by the global customer base. These tapered journal bearings are also known at Australia as "package bearings" and at North America as "cartridge bearings", in some other places they are called "wheelset roller bearings".

The compact tapered bearing unit (Compact TBU or CTBU) concept, when utilized, will require less maintenance costs, will provide higher safety and reliability and is pre-equipped with advanced component technologies that allow railway operators time to react if severe bearing conditions occur while in service.

2. Conventional TBU designs

Many types of railway vehicles are equipped with a TBU (tapered bearing unit) design. The conventional TBU design involves contacting rubber seals, known as garter seals, that ride on special seal wear rings. All parts are mounted in a ready-to-fit unit. This design is used especially for adapter solutions that involve direct exposure of the unit to the environment.

The conventional inch-sized design was standardised by the American Association of Railroads (AAR), for which SKF is fully approved since 1977. From the outset, AAR roller bearings were designed to substitute plain bearings. This required a relatively long axle that tended to bend in operation, causing additional wear on several parts of the bearing system, especially on the contacting surfaces of the seal wear ring. Fretting particles then could enter the bearing, reducing its useful life.

On the European market, full-bore axlebox housings are mainly used. The closed front cover protects the bearing system, and labyrinth seals with lower friction can be used. Various metric designs were developed to satisfy different customer demands. These designs mostly use a shorter axle length than those that meet AAR axle dimensions, but in certain applications a similar fretting process reduces service life.

3. Compact TBU design features

The primary aim of the new design concept was to achieve lower life-cycle costs by offering longer maintenance intervals.

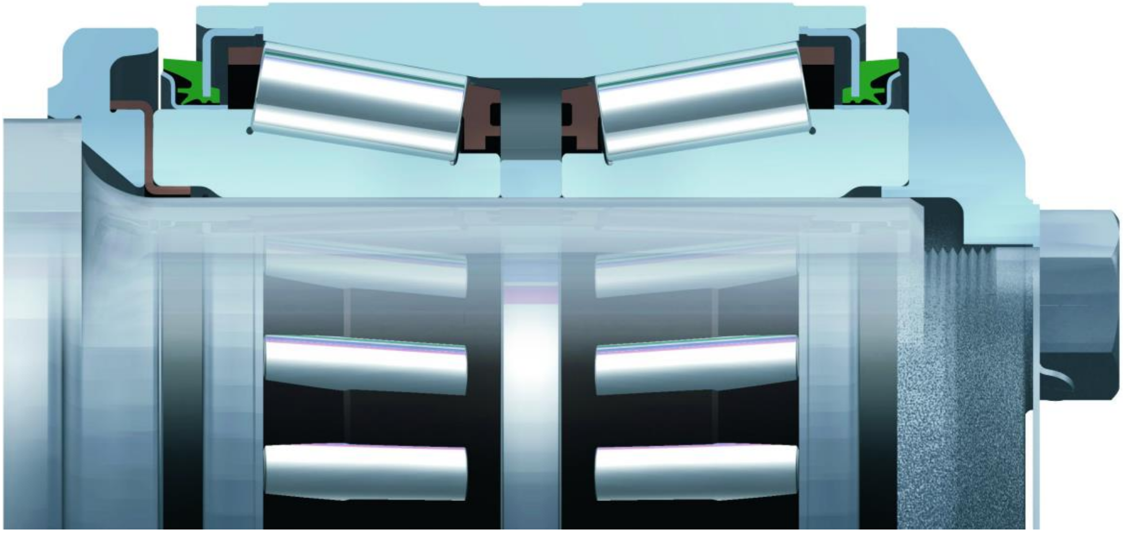

Fig.1 The compact tapered bearing unit design principle

3. 1 New integrated low torque seals

The new compact design principle makes additional spacers or seal wear rings unnecessary. The sealing function is integrated into the bearing unit between the outer ring and the inner ring. This feature helps save space and, as a result, minimises axle bending in many applications. The design is based on a low-friction rubber seal principle; the main features are a combination of labyrinth, lip and flinger elements. Improved protection against contamination extends service life.

Friction torque is reduced by 75% compared with a garter seal arrangement. As a consequence, the operating temperature is reduced by 20°C, which contributes to longer grease life and energy savings. Results from the SKF seal test, which evaluates water and dust contamination, confirmed that the design was effective in excluding contamination. Long-term endurance tests have been conducted under very severe operating conditions. The new integrated seal has also passed all AAR approval tests.

3.2 Polymer spacer

Fretting corrosion between the backing ring and the cone side face is caused by journal bending during operation. This corrosion not only causes foreign particles to enter the bearing but also increases axial clearance, resulting in reduced performance and reliability. The development target was to avoid fretting corrosion by changing the steel-to-steel contact between backing ring and the cone side face to steel-to-polymer contact. A spacer of reinforced polymer material is clamped onto the bearing components. Extensive tests were conducted on the new bearing, in some cases subjecting it to the equivalent of 800.000 kilometres of operation. There was no trace of fretting corrosion.

3.3 New long life grease

For the Compact TBU a long-life multipurpose grease for a variety of axlebox applications was developed. Specifications considered the engineering requirements for high-speed operation as well as heavy loads.

The resulting new grease has passed all chemical, mechanical and tribology testing procedures in accordance with the European Standard EN 12081. Extended endurance and dynamic simulation tests are being carried out on SKF railway test rigs to confirm the expected high mechanical and thermal stability as well as resistance to corrosion. The new grease will therefore extend intervals for routine maintenance as well as complete overhaul cycles.

3. 4 Polyamide cage

SKF had begun to introduce polymer cages for TBU applications in 1990, and today has vast experience in various applications, including freight cars in operation in Europe and China. A variety of mass transit vehicles, multiple units and passenger coaches also are equipped with polymer cages, as are several high-speed trains. This refined cage is made of reinforced polymer and has demonstrated excellent performance. The main user benefits are reduced friction, roller slip, wear and operating temperature, and improved safety. Even under emergency running conditions, the unit operates without blocking. For the Compact TBU development project, the polymer cage design feature was refined even further to meet the tight space requirement.

3.5 Compact design

This principle offers decreased journal length opportunities and consequently lower axle bending which allows higher loads. The decreased distance between the rows of rollers improves internal loading sharing.

4. Laboratory testing

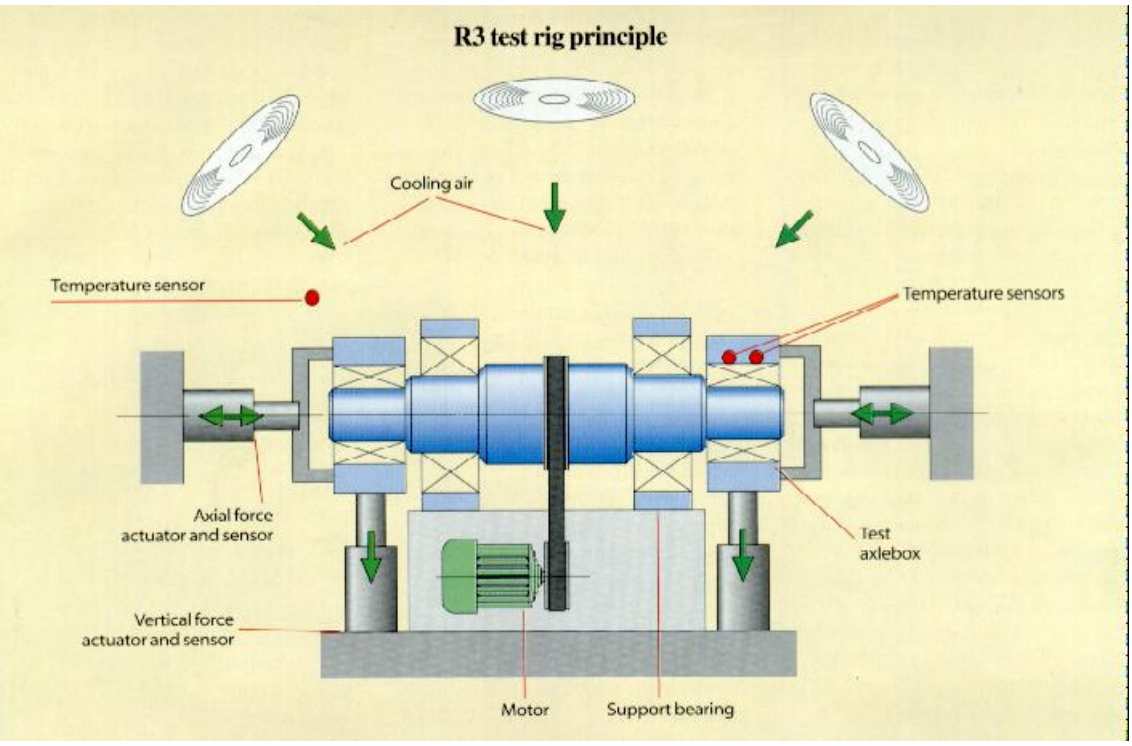

Fig. 2 SKF R3 test rig principle used for temperature testing

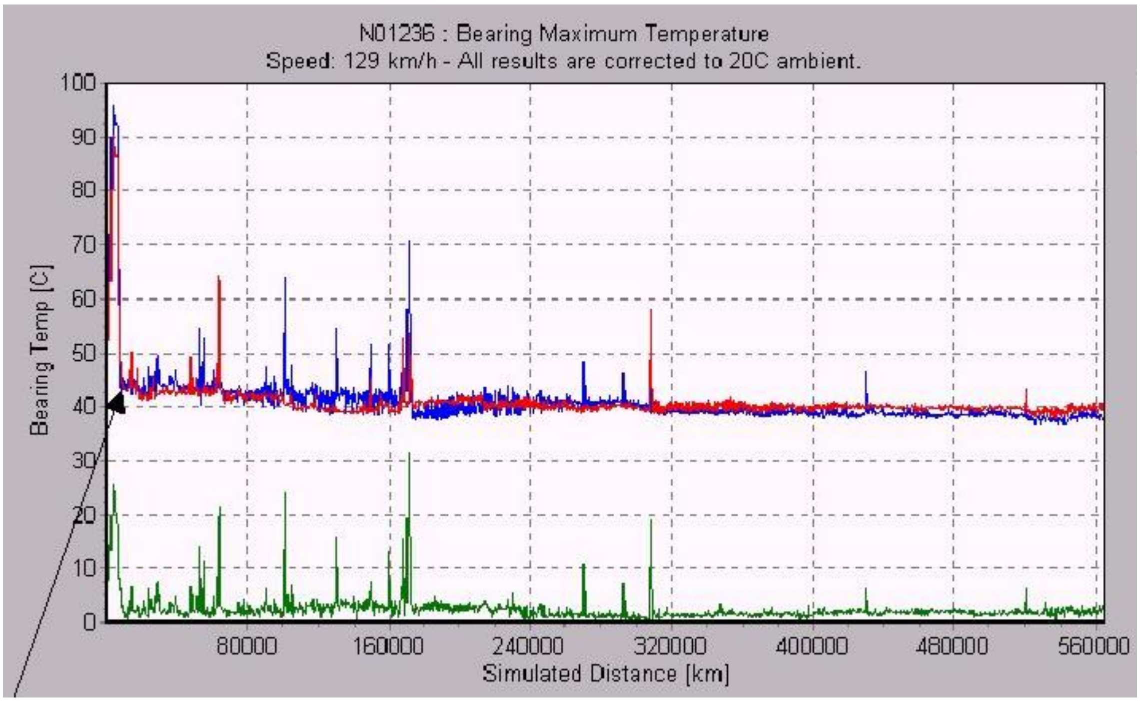

Fig. 3 Compact TBU temperature development over 560.000km, on top bearing temperature, below bearing temperature difference of the left and right side bearing of the test rig arrangement

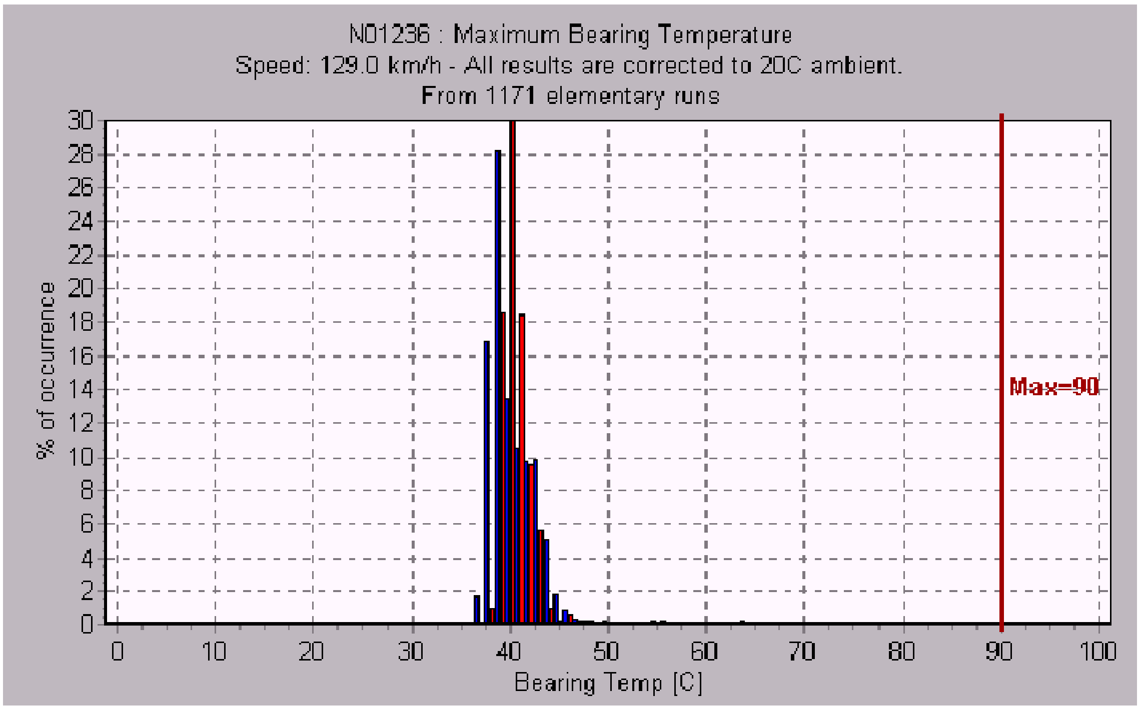

Fig 4 Mean Compact TBU temperature over the complete testing cycle which refers to 560.000km in field operation

The key for ensuring the long-term reliability and performance of railway rolling stock are rigorous testing procedures. Most of the facilities are located in the Railway Test Centre RTC inside the SKF group Engineering and Research Centre in the Netherlands. The life testing and other tests were done in accordance to relevant specifications such as the new European standard EN 12 082 and specifications of the AAR, Association of American Railroads. Based on these test results, the compact tapered bearing design for class K has reached a conditional approval from AAR.

Beyond this quasi static testing method the behaviour of the compact tapered bearing unit was evaluated additionally under realistic operating conditions. SKF has used a high sophisticated test rig called THISBE (test rig for high speed train bearings), which can simulate dynamic load conditions. Here the bearing and axlebox are fitted in part of an actual bogie frame, including the suspension system with springs and dampers. The rig is controlled by a computer using signals obtained by recording and analysing actual loads, acceleration and displacements on axleboxes in service.

5. Applications

A further target of the project was to develop a product range suitable for most market requirements. The new product range offers a more focused assortment, which is of benefit to OEM customers and meets aftermarket requirements as well. Further Compact TBU sizes can be developed on customer request. The width of the outer rings of the Compact TBU is the same as for standard TBU's; only minor modifications are needed on the backing ring and front cover to upgrade existing applications.

Very soon after the market introduction main OEM customers as well as railway operators were interested in the Compact TBU design principle. First applications were selected to be equipped with the new axlebox bearing generation.

- The Siemens modular Desiro train generation, which can be applied for long distance service as well as for suburban and commuter systems, is equipped with CTBU 130 x 230 bearing units.

- One main Siemens Desiro application are the commuter trains for UK, which are running at maximum speed of 160km/h with 18 tonnes axle load. These Desiro trains are equipped with high sophisticated axleboxes developed and designed by SKF.

- Another European application are the Portuguese CP 2000 suburban trains which are equipped as well with CTBU 130 x 230.

- For European freight cars the CTBU 130 x 240 are in use at several operators. The standard axle load at Europe for the new freight car designs is more and more 25 tonnes at a maximum speed of 120km/h.

- The CTBU class K has reached a conditional approval form AAR. E.g. the Southern Company Coal Service has CTBU class K service. An average mileage of 500.000km is reached up to now. The axle load is 31,2 tonnes at a speed of 130km/h.

In total more than 10.000 Compact TBU's are delivered word wide.

6. Field experience

At Australia Compact TBU's class G are under field test on Bradken trial iron ore freight wagons at Robe River, operating from Pannawonica to the Western Australian coast at Cape Lambert. The CTBU’s have been in service for approximately 3 years from January 2000 to February 2003 and have completed 570,000 km.

The bearings were found to be in excellent condition with no signs of fretting corrosion between the backing ring and the cone side face.

Fig. 5 CTBU class G after 570.000km service before dismantling

Fig. 6 CTBU class G after 570.000km service backing ring shoulder

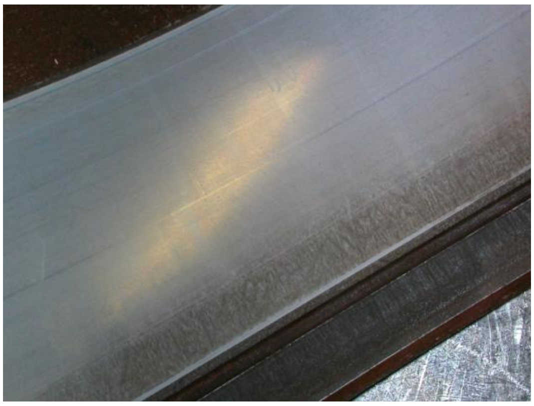

Fig. 7 CTBU class G after 570.000km service bearing cup raceway

Fig. 8 CTBU class G after 570.000km service bearing cone rollers

7. Summary

Extensive rig testing for freight and passenger operational parameters confirms the expectations of the new compact tapered roller bearing unit design. A larger range of different metric and inch sizes has been developed to meet the requirements of different axle loads. Today there are already several modern railway vehicles for passenger and freight service in full bore axlebox applications as well as typical AAR adapter applications at Europe, North America and Australia equipped with Compact TBU's.

The tear down inspection of the Compact TBU class G at Australia after 570.000km mileage confirmed the design principle.

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