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Deutsche Bahn's new trains run more efficiently and longer with advanced technologies from SKF

Bearing design and integration expertise from SKF has helped Siemens and Bombardier to create a new generation of reliable, highly efficient passenger trains for Deutsche Bahn - Germany's national rail operator.

Gothenburg, Sweden, 08 June 2017: The ICE-4 passenger train will become the backbone of Deutsche Bahn's (DB) long distance network. The new train has been designed using a modular concept, allowing it to be reconfigured to suit a wide range of different applications on the German rail network. SKF has been involved in the €6 billion project since 2012, working directly with Siemens, the manufacturer of the new train, and with Bombardier, which supplies the trailer bogies and coaches.

Meeting the demanding performance and reliability specifications for the ICE-4, presented a host of technical challenges. The new train will operate routinely at 250kph. Naturally, every component used on the train must meet stringent safety criteria, but DB also needs to keep tight control over its operating costs. That required the designers to maximize energy efficiency and minimize routine maintenance requirements.

Smart sensor integration
The trailer bogies, supplied by Bombardier and named BOMBARDIER FLEXX Eco, use an inboard bearing arrangement enabling lower weight and energy consumption. For this application, SKF developed a special tapered roller bearing unit (TBU), with integrated sensors to monitor the speed and direction of rotation of each wheelset. Building the sensors into the bearing unit itself minimizes the space required for the whole assembly, an important characteristic in the inboard configuration, where space is limited. Used in the control of the train's braking system, the signals generated by the sensors have been customized specially to suit the requirements of the customer. The safety critical nature of this application calls for levels of redundancy. For this reason, both of the bearing units on each axle are equipped with dual sensors. An additional sensor in each bearing monitors its operating temperature, providing an important early warning indicator in the event of temperature increase.

"The inboard bearing configuration is a relatively new configuration in high speed rail applications, requiring a new technology," says Wolfgang Schatzer, Strategic Account Manager, Railway Industry at SKF. "The size of the axle, and the loads involved, require an unusually large bearing. The inner diameter is in the range of 180mm, compared to the 150mm size normally used in outboard bearing arrangements, but this is an area where SKF has a lot of experience and expertise."

Extended maintenance intervals
Modern intercity trains must meet highly demanding criteria for reliability, together with long intervals between maintenance. The customer specifications required a calculated bearing life of 3,3 million km. "The total operating life of the bearings is important, but to reduce cost of ownership, the period between maintenance operations can be even

more significant," says Schatzer. "Extending the maintenance intervals for rail bearings has been a major area of research and development for SKF in recent years, and we had confidence from our own testing and the use of our bearings technologies in the field that we would be able to fulfil the customer's requirements."

Key to extending the maintenance intervals in a tapered bearing unit (TBU) is to minimize friction and thereby reduce operating temperatures, which allows the lubricant inside the bearings to work for a longer time before replacement.

Supplying the bearings and sensors as a sealed and greased unit, has multiple benefits for the customer, both in development and production, with fewer, more clearly defined interfaces between the bearings, sensors and other parts of the train.

The motor bogies, developed by Siemens themselves, use a more conventional outboard bearing arrangement, an area where SKF also has extensive experience, including from some of the most demanding high-speed applications in the world. Again, the company opted for an integrated bearing unit solution, this time using cylindrical roller bearings. The motor bogies had even more stringent durability requirements, with customer specifying 1.65 million km before bearing service.

Well-coordinated test program

To prove their reliability and performance, all the new bearing units had to undergo a two year, multi-step testing and validation process. Validation began in a virtual environment, using computer simulation of the design. Then SKF used its in-house test center in the Netherlands, the largest facility of its type in Europe, to test the bearings in realistic operating conditions. Prototype bearing units were mounted in real ICE-4 axleboxes and ran for the equivalent of 800,000 km, during which the bearing temperature and performance was closely monitored. This test took around four months and was designed to emulate a wide range of operating conditions. Further testing of bearings fitted to prototype trains was conducted by Siemens at its test and validation center, in Wegberg-Wildenrath, Germany, followed by field tests on the DB network.

High-efficiency motor and gearbox components

In the traction units, SKF has also been selected to provide energy efficient taper roller bearings for the main gearbox output shafts, with a 240mm bore diameter. "Energy efficiency is an increasingly critical consideration for rail operators as they seek to control the lifecycle costs of their trains," says Jochen Baum, Manager Drive Systems Competence Center, Railway Industry at SKF. "The SKF solution uses a low-friction bearing, and it is the first time a bearing of this design is used in a railway application." The use of a low-friction bearing helps to improve the service life of the bearing, he explains. "Less friction leads to a lower operating temperature. During the customer's test cycle, we could show that our low-friction bearing operated at a temperature almost 30 degrees lower than a conventional bearing. The lower operating temperatures gives what could be described as a "temperature margin" which makes the bearing more robust to withstand unfavorable conditions raising temperatures, such as fluctuating torque/speed, hot ambient temperatures, and not ideal oil supply." SKF has also developed a specially modified deep groove ball bearing, designed to resist high axial shock loads, and supplies cylindrical roller bearings for use in the traction motors of the train.

Rolling out across the network
Siemens delivered the first prototype trains to DB in 2014, operational tests on the public network began in 2016 and the ICE-4 will formally enter service in 2017. SKF will work closely with Siemens and DB to monitor the performance of the bearings during the first few hundred thousand kilometers of operation, and, if they perform as well in operation as they did during the test period, the maintenance intervals will be gradually extended over time.

“In these kind of applications, it very important to be involved from the early stages,” says Schatzer. “That allowed us to provide input not only into the design of the bearings, but also the surrounding elements, which often have a significant impact on the overall performance of the system.”

Initially, the ICE-4 will replace DB’s existing Intercity and Eurocity fleets, some of which have been in operation since the 1970s. Over time, the train will also replace the company’s ICE1 and ICE2 units, eventually accounting for around 70 percent of the company’s inter-urban services by revenue[1]. DB has placed an initial order for 130 new trains, and it has entered a framework agreement with supplier Siemens mobility for eventual delivery of up to 300 trainsets.

Aktiebolaget SKF
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SKF is a leading global supplier of bearings, seals, mechatronics, lubrication systems, and services which include technical support, maintenance and reliability services, engineering consulting and training. SKF is represented in more than 130 countries and has around 17,000 distributor locations worldwide. Annual sales in 2016 were SEK 72 787 million and the number of employees was 44 868. www.skf.com

[1] http://www.siemens.com/press/en/feature/2015/mobility/2015-12-ice4.php?content[]=Corp&content[]=MO