CHINA STAR BULLET TRAIN ON TRACKT

COURTESY OF Machinery Lubrication

LUBRICANT SOLUTION HELPS BREAK SPEED RECORD AND INCREASES TRACTION MOTOR RELIABILITY

China's rapid economic development has created a great need for an improved and expanded railway system. Railway officials plan to lay 8,500 miles of track nationwide from 2002 to 2005, bringing its total network to more than 42,000 miles. More than 4,400 miles of the new track will provide service to new regions. Additional lines will also be added in areas with heavy traffic.

Railway expansion is critical because rail moves 54 percent of China's domestic trade (more than any other major country) and more than half its passenger travel. The national rail system expects to move 1.56 billion metric tons of freight this year, including 640 million tons of coal, plus 1.04 billion people.

The need for improved railroad efficiency prompted China's State Development Planning Commission and the Ministry of Railways to initiate the development of China's own bullet train technology. In conjunction with Zhuzhou Electric Locomotive Co., a major manufacturer of train engines in China, the China Star project began in early 2001 to develop a train with an average speed of more than 200 kilometers per hour (125 mph).

The trains will be powered by Zhuzhou Electric Locomotive's 1250 kw traction motors. The motors require the use of special insulated, resin-coated roller bearings, supplied by NSK Bearing Co. of Japan. Insulated bearings are needed to prevent electrical arcing through the bearing that severely damages the bearing's raceways and rolling elements. Each motor uses two of the special bearings. The unloaded bearing is a 170 mm (NH219) grease-lubricated bearing. The 280 mm (NU326) thrust bearing is lubricated by the same oil as the drive gear.

The lubricants for the traction motor were selected based on tests previously conducted at NSK's Tokyo research facility in its dedicated traction motor test equipment. Twenty-six different greases were evaluated including newly designed greases for the specially designed high-speed bearings. The candidate greases were subjected to extensive testing at high temperatures and high speeds for grease leaking, adhesion and grease life. Based on its superior performance in testing, a general-purpose lithium complex grease thickener was selected as the standard traction motor bearing grease for Japan's 300-series bullet trains.

Despite the care in selecting the grease, serious problems arose during testing. The greased motor bearing overheated at speeds above 160 km / hr, resulting in high vibrations and shortened bearing life. The project managers consulted with NSK to identify the problem and seek a solution. Various adjustments to the motor itself were tried but the technical team was unsuccessful in finding a mechanical solution. The breakthrough came when the team began focusing its attention on the grease, which provides the thin film of lubricant that the bearing relies on for proper operation. The team suspected that the grease was allowing bearing temperatures to rise above the grease's 500° F drop point (the temperature at which the thickener in the grease can no longer hold the lubricating oil in place), allowing the oil to run out of the bearing, leaving behind only the thickener. Extensive bearing damage would quickly follow.

Under the direction of Professor Gao, senior engineer with the China Locomotive Research Institute, a search was begun to find a grease that would enable the traction motor to run at higher speeds. After several unsuccessful efforts to find a suitable replacement grease, the team tried an aluminum complex EP grease (Royal Purple's Ultra-Performance Grease No. 2). This is a high-performance synthetic grease formulated with advanced additive chemistry that has had past success in reducing bearing temperatures and vibration.

Without making any other adjustments to the motor, the switch to the synthetic aluminum complex grease solved the overheating and premature bearing failures, enabling the train to immediately and reliably operate at speeds of 200 km / hr. Based on these results, Royal Purple was asked to recommend lubricants for the other lubricated components of the traction motor. Royal Purple recommended a multipurpose industrial oil with the additive Synerlec® for the 280 mm bearing and drive gear and a maximum-load synthetic lubricant for the gear coupling.

FIGURE 2 - NSK #NH219 170mm greased bearing after more than 80,000km of high-speed service.

FIGURE 3 - Inner race of same NH219 greased bearing after disassembly.

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The research institute sent a team to NSK's Tokyo lab in May 2002 to participate in a 20-day comparison test under the harshest conditions between the multipurpose industrial oil and the NSK-recommended mineral oil. In these tests, the industrial oil reduced operating temperatures by 20° C (36° F) while reducing bearing vibrations by 50 percent. Based on these test results, all parties agreed that these advanced new lubricants would be used in the traction motor.

Upon the team's return to China, high-speed motor tests were conducted using the newly selected lubricants. All of the motors performed flawlessly. Not only was a new China rail speed record of 321.5 km / hr (200 mph) set, but all lubricated bearings looked like new after 80,000 kilometers of high-speed testing.

The China Star project achieved rapid success because the team leaders quickly recognized that the motor's bearing problems were most likely caused by lubrication deficiencies. By focusing on a lubrication solution, rather than costly and time-consuming mechanical and design issues, the team quickly exceeded all of the project's speed and reliability goals.

FIGURE 4 - NSK #NU326 280mm oil-lubricated bearing after more than 80,000km of high-speed service.

FIGURE 5 - Inner race of same NU326 greased bearing after disassembly.