NSK

SUPER-TF AND HI-TF BEARINGS

Outstanding toughness, performance, and cost savings: NSK technology sets a new standard for long service life.

Durability is a very important criterion for bearings used in automobiles, steel mills, and industrial machinery. The need for improved durability has become increasingly severe due to demand for greater cost performance, extended maintenance intervals, and compact component designs.

In response, NSK developed and supplied the marketplace with the TF series of bearing. However, to meet the customer's need for even greater efficiency, NSK developed a new material and a new heat-treatment process resulting in the newly developed series of Hi-TF Bearings and Super-TF Bearings, which are capable of exceeding the performance of our series of TF Bearings.

Super-TF Bearings have a longer service life combined with superior resistance against wear, seizure, and heat under contaminated lubrication conditions. The series of bearing was also developed to meet the anticipated needs of customers both now and in the future. This series is especially, suitable for applications requiring high durability. Hi-TF Bearings offer longer service life, provide superior resistance against wear and seizure under contaminated lubrication conditions, and ensures greater cost-performance. This series of bearing is suitable for applications requiring sufficient durability.

Super TF and Hi-TF Bearings

TF Technology, Hi-TF Bearings, Super-TF Bearings

In its quest for longer bearing service life, NSK has spent many years analyzing the mechanisms of fatigue in bearings and researching and developing materials, heat treatment processes and operating conditions. The range of approaches to achieving longer service life taken by our research team are shown in Fig. 1. The technology incorporated in our Hi-TF Bearings and Super-TF Bearings is designed to maximize service life under conditions where bearings are subject to surface-originating flaking.

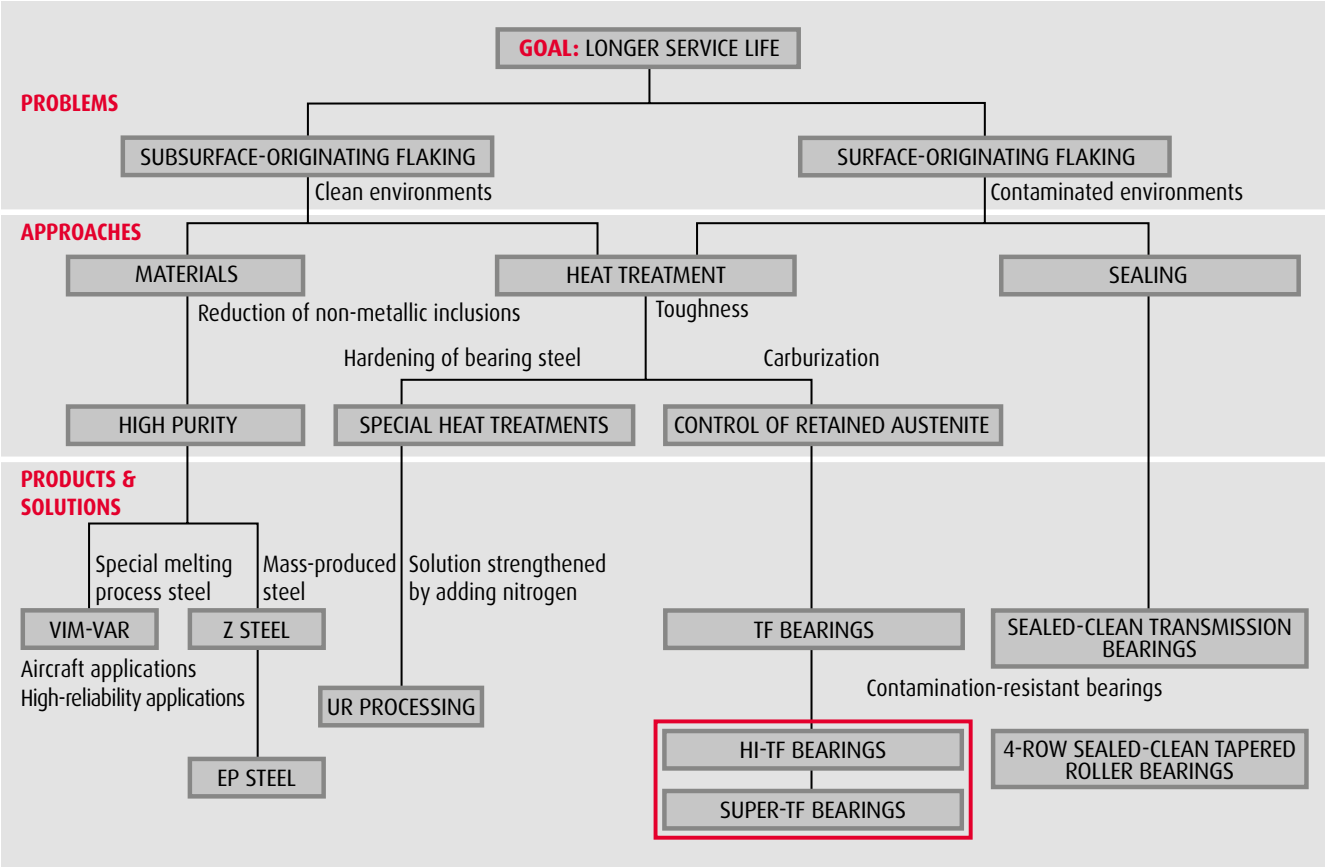

Fig. 1 Approaches to achieving longer service life in bearings

Hi-TF Bearings and Super-TF Bearings

TF Technology

The problem: Contaminated lubrication conditions

Bearings may be required to operate under clean or dirty conditions; under dirty conditions their lubricating oil is easily contaminated. Metal particles or casting sand in the lubricating oil make dents in the contact surfaces. As shown in Fig. 2, stress is concentrated around these dents and eventually leads to cracking and to surface-originating flaking. The concentration of stress around a dent is expressed by the equation [$P/P_0 \propto (r/c)^{-0.24}$], where "r" is the radius at the shoulder of the dent and "2*c*" is the shoulder-to-shoulder width of the dent. The greater the value of "*r*/*c*", the smaller the stress concentration and the longer the service life of the bearing.

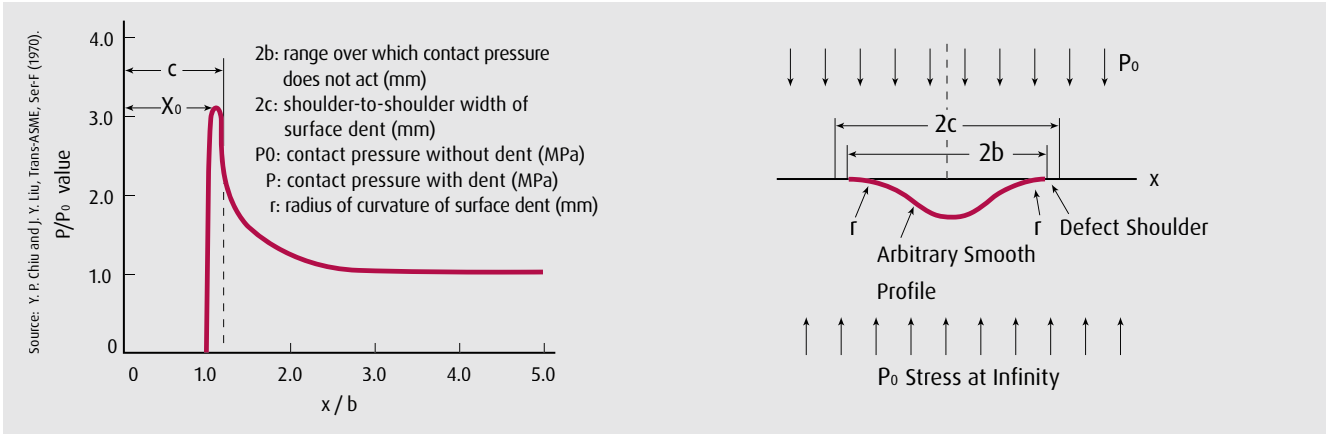

Fig. 2 Concentration of stress around a surface dent

The solution: TF technology

NSK is a world leader in the research and development of material properties to reduce the concentration of stress around surface dents. As shown in Fig. 3, our work has revealed that a high level of retained austenite is an extremely effective means of maximizing the r/c value around surface dents in the bearing material. TF technology is a unique heat treatment process developed by NSK to optimize the level of retained austenite in bearing materials.

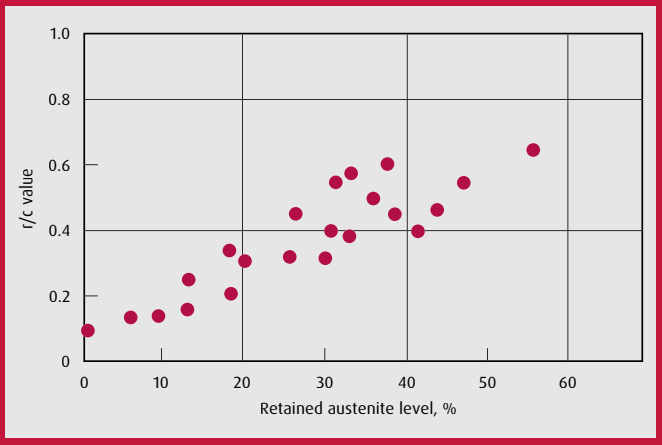

Fig. 3 Relationship of r/c value to retained austenite level

Material Properties of Hi-TF Bearings and Super-TF Bearings

NSK has developed the Hi-TF Bearings and Super-TF Bearings as two series of bearings that offer longer service life exceeding that of TF Bearings. As we have seen, the approach to achieving long service life taken in the Super-TF Bearings is to minimize the concentration of stress around the shoulders of surface dents. A high level of retained austenite helps to maximize the value of r/c and reduce the concentration of stress around the dents. However, austenite itself has a soft microstructure, and reduces the hardness of the bearing material. In order to meet the seemingly conflicting needs for greater hardness of the bearing material and a higher level of retained austenite, we decided to adopt a technique that would both promote the uniform distribution and reduce the diameter of carbide and carbonitride particles in the bearing material. To this end, our researchers have developed a new type of steel that has added the proper quantity of element used in the formation of carbides, and have developed the carbonitriding heat treatment to extract minute carbide and nitride compulsorily for the first time in the world. Hi-TF Bearings adopt a new type of steel named SAC1, which has a specific amount of chrome added to it. Super-TF Bearings adopt a new type of steel named SAC2, which has a specific amount of chrome and molybdenum added to it. Although Super-TF Bearings have a slightly higher product cost than conventional bearings, rise in product cost for the Hi-TF Bearings was avoided by using chrome manganese steel (SAC1) for the material. Figures 4 and 5 illustrate the image analysis results of carbide distribution in the structures of Super-TF Bearings and an ordinary carburized steel bearing. It is clear that the Super-TF Bearings has a greater amount of fine-size carbide and carbonitride particles. Fig. 6 shows that the formations of finer carbide and carbonitride particle give Hi-TF Bearings and Super-TF Bearings a greater degree of hardness and higher retained austenite levels than those of TF Bearings. As a result, Hi-TF Bearings and Super-TF Bearings achieve a higher r/c value. (Fig. 7)

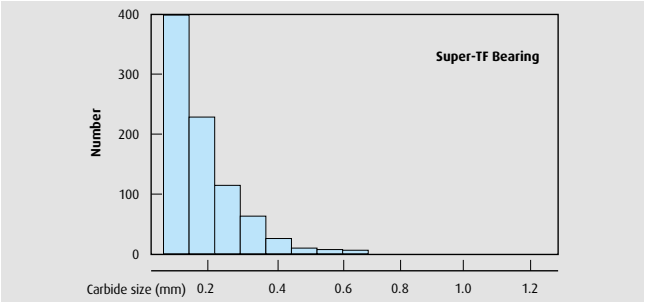

Fig. 4 Average diameter of carbide and carbonitride particles in a Super-TF Bearing

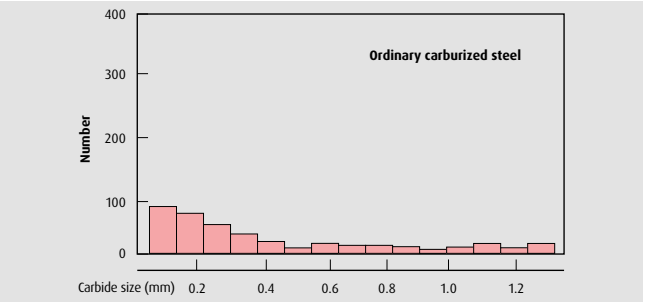

Fig. 5 Average diameter of carbide particles in an ordinary carburized steel bearing

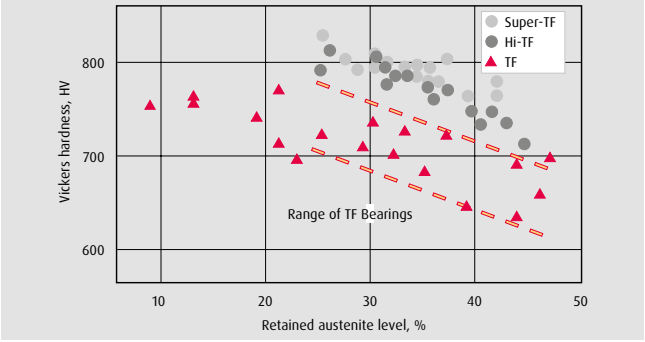

Fig. 6 Relationship of material hardness and retained austenite level

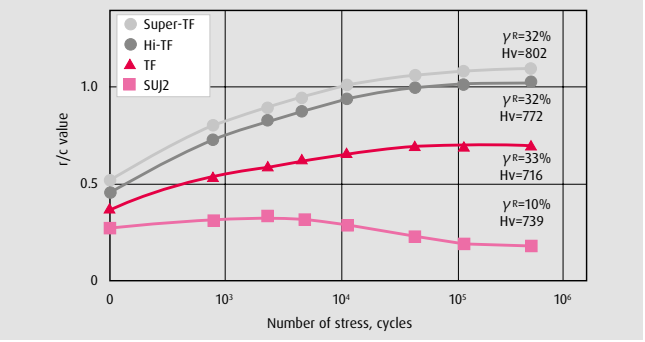

Fig. 7 Change of r/c value under repeated stress

Hi-TF Bearings and Super-TF Bearings

Service life under contaminated lubrication conditions

Table 1 and Fig. 9 show the results of service life tests conducted under contaminated lubrication conditions with NSK L44649/10 tapered roller bearings. If the service life of an ordinary carburized steel bearing of this type is taken as 1, then the L_{10} life of TF, Hi-TF, and Super-TF Bearings would be 4.5, 7.1, and 10.2 respectively (Table 1). Hi-TF Bearings and Super-TF Bearings thus offer over seven time and ten times the service life of ordinary carburized steel bearings. Service life is generally affected both by the conditions in which the bearing is used and by the amount of contamination in the lubricant. Under contaminated lubricated conditions, service life may fall to as little as 1/5 of the catalog life. As a result of attempting longer service life under contaminated lubrication, Hi-TF Bearings and Super-TF Bearings can achieve service life that exceeds the catalog life of existing products under contaminated lubrication for the first time.

Ordinary carburized steel	TF	Hi-TF	Super-TF
1	4.5	7.1	10.2

Table 1 Comparison of service life of L44649/10 tapered roller bearings

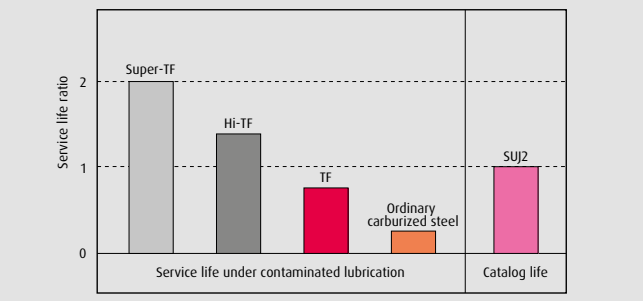

Fig. 8 Comparison of service life under contaminated lubrication

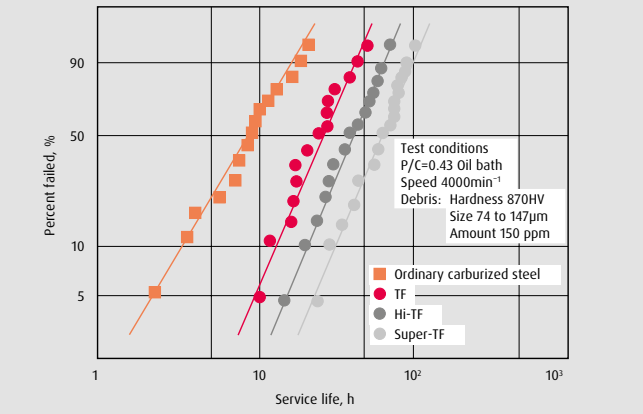

Fig. 9 Service life of L44649/10 bearings under contaminated lubrication

Service life under clean lubrication conditions

Fig. 10 shows the result of service life tests under clean lubrication conditions using 6206 deep groove ball bearings. Under clean lubrication, Hi-TF Bearings and Super-TF Bearings show a slightly longer service life than those made of SUJ2. The most important factor is the cleanliness of the steel from which the bearing is made. Material with a greater degree of purity offers a greater degree of long-life performance.

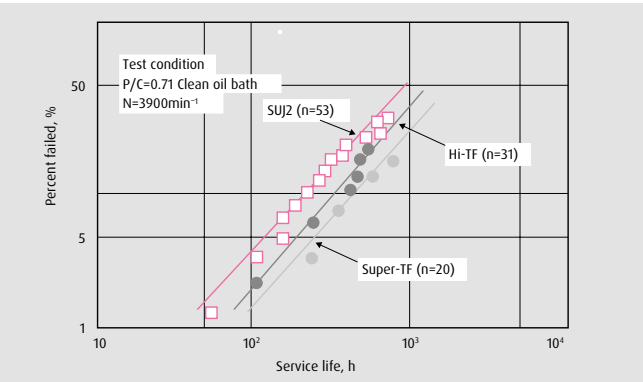

Fig. 10 Service life tests of 6206 bearings under clean lubrication

Service life under boundary lubrication conditions

Under boundary lubrication conditions where there is an insufficient amount of EHL film, metal-to-metal contact occurs, thus reducing bearing life. Fig. 11 shows the results of service life tests conducted under conditions where oil film parameter Λ, which represents the ratio of the thickness of the oil film to the roughness of the surface, is very small (Λ=0.3). When Λ is very small, peeling damage occurs (Fig. 12), but in Hi-TF Bearings and Super-TF Bearings, the concentration of stress around the projections of the contact area is reduced, giving a service life approximately 4.7 times and 5.5 times greater than that of ordinary carburized steel bearings.

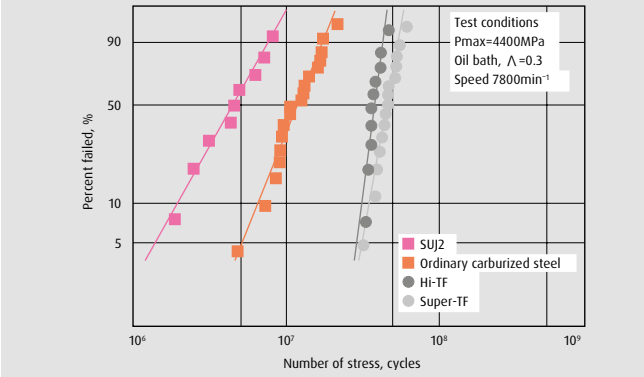

Fig. 11 Service life tests under boundary lubrication conditions

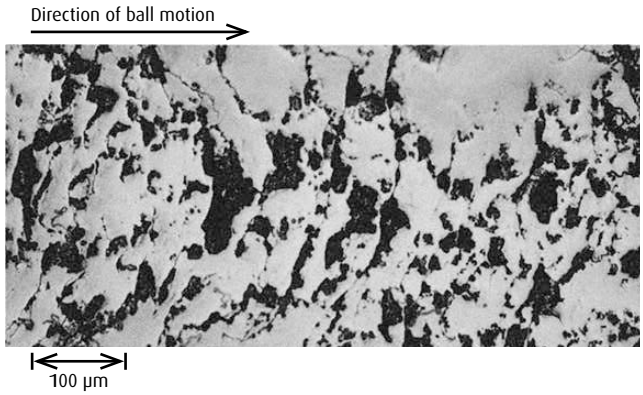

Fig. 12 Peeling damage

Wear and seizure resistance

Besides extending service life under contaminated lubrication conditions, another goal is to increase the bearing's resistance to wear and seizure by ensuring the dispersion of a large number of fine carbides and nitrides in the bearing material. Fig. 13 presents the results of a Sawin-type wear test, showing the degree of wear and the seizure limit for different types of bearing material. The test reveals that Hi-TF Bearings and Super-TF Bearings have superior wear resistance to both SUJ2 steel and TF Bearings. Hi-TF Bearings and Super-TF Bearings are also 20 % and 40 % more resistant to seizure than both SUJ2 steel and TF Bearings.

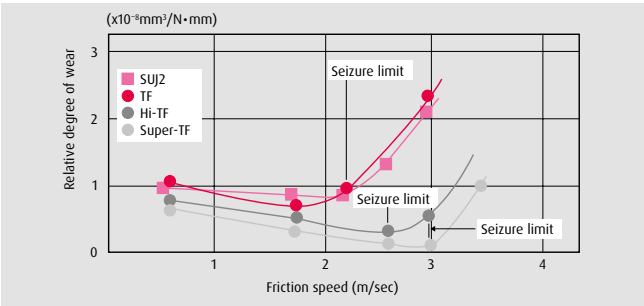

Fig. 13 Comparison of wear resistance

Heat resistance

Fig. 14 shows the results of service life tests conducted with 6206 ball bearings at 160°C under clean lubrication conditions. Test results reveal that Super-TF Bearings (heat-resistant specifications) have approximately 4 times the service life of SUJ2X26 steel bearings.

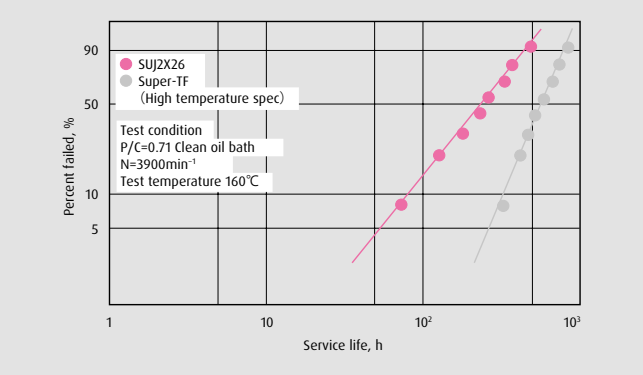

Fig. 14 Service life test of 6206 under high temperature clean lubrication

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