MOTION & CONTROL
NSK

Long Life Bearings for Steel Rolling Mills
WTF® Bearings

NSK's newly developed Water TF (WTF®) bearings are the result of combining special steel-melting technology used for aircraft bearing material, and our original, heat treatment technology. Our WTF (water-tough) bearings successfully resist premature flaking under severely contaminated conditions of water-infiltrated grease lubrication and powder debris (iron-oxide) contamination. Furthermore, our WTF bearings have a bearing life that is three times longer than our conventional bearings.

A new product that responds to customer needs for longer life in harsh environments.

Using NSK technology, we created WTF bearings to overcome premature flaking that results from conditions of water-infiltrated grease lubrication and powder debris or particulate contamination. WTF bearings achieve a service life three times longer under severe operating conditions.

Three Times Longer Life

Water-TF

1. Technology

Premature flaking is initiated by dents that are generated on bearing rolling surface areas, which are caused by particulate contamination. When the bearings are operated under such conditions with water-infiltrated grease lubrication, the strength of bearing steel is significantly weakened. This ultimately leads to a phenomenon called corrosion fatigue (Photo 1). By combining material and heat treatment technologies into what NSK calls Water TF (water-tough) technology, we can drastically prevent the onset of corrosion fatigue.

NSK's Water TF technology includes many proprietary technologies that have been patented (below) with many more pending approval.

USP6165289, GB2311998, USP5256213, USP5298323, JP2128328, USP4904094, GB2209058

Cracks lead to flaking and ultimately corrosion fatigue

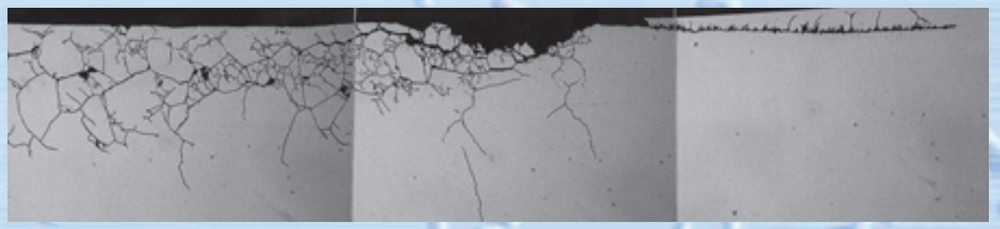


Photo 1. Water TF technology consists of an ultra-high clean-material technology for inhibiting the generation of cracks, and a chemical component design technology for restricting infiltration of water into any cracks that developed.

Nonmetallic inclusions (Photo 2) develop cracks below the bearing surface (Photo 3). Water in the grease lubricant infiltrates the cracks, and weakens the bearing material. Using a special steel-melting technology used for aircraft engine bearing material, we were able to restrict crack occurrence by reducing the amount of non-metallic inclusions in the raceway surface.

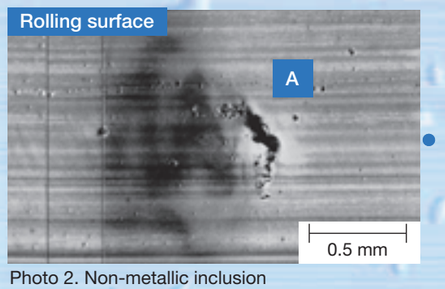


Photo 2. Non-metallic inclusion

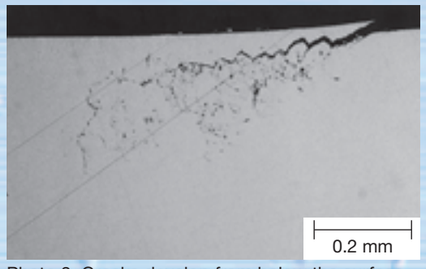


Photo 3. Cracks develop from below the surface

In order to inhibit the initial development of cracks along grain boundaries, we worked to achieve stronger grain boundaries (Photo 4) by developing an optimum alloy balance for bearing material.

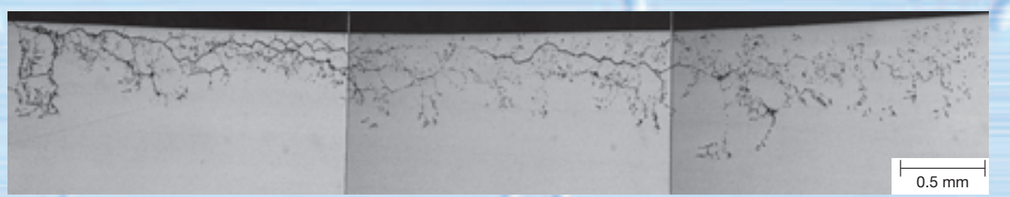


Photo 4. Cracks along grain boundary

NSK developed its Water TF technology by incorporating components of TF technology for enhanced service life under contaminated lubrication conditions.

Bearings used under contaminated lubrication conditions suffer from indentations that are generated on the raceways by foreign particles, which initiate surface originated flaking.
Stress concentration points around the edges of the surface indentations create cracks around the indentations, which progress into larger cracks that lead to flaking. Contact stress concentrations at the edges of an indentation (Figure 2) can be expressed by $[P/P_0 \propto (r/c)^{-0.24}]$, which is a function of r/c. This suggests that the larger the r/c, the smaller the stress concentration, which means an ultimately longer life.
NSK's research on bearing material confirms that as the amount of retained austenite increases, the r/c value becomes larger, and the reduction of stress concentrations is enhanced.
Our patented TF technology incorporates this principle for achieving longer life under contaminated lubrication conditions by maintaining optimum levels of retained austenite.

Figure 1. Relation between *r/c* value and levels of retained austenite

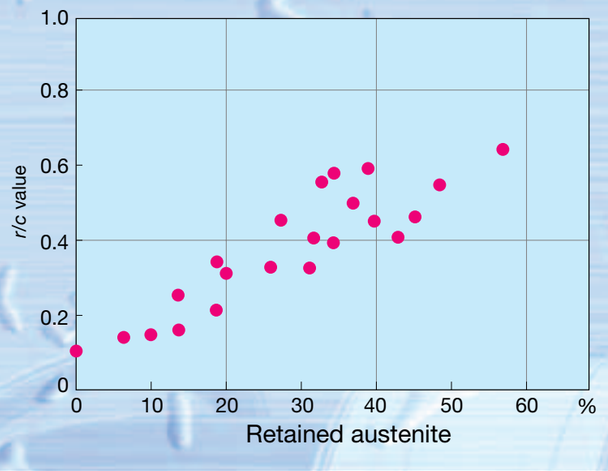
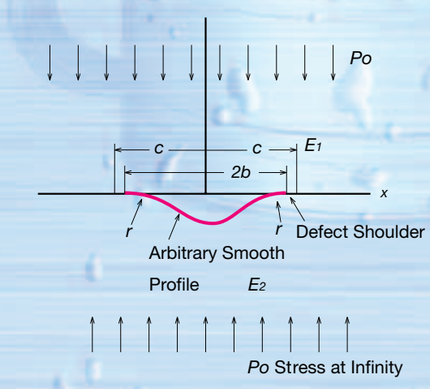
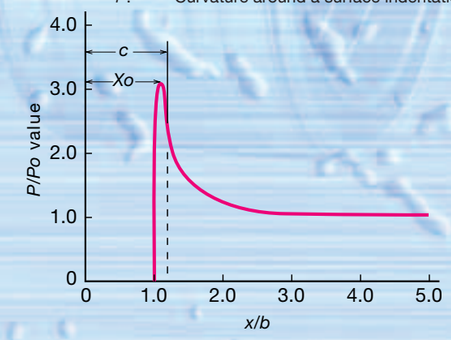


Figure 2. Stress concentrations at the edges of surface indentations [Y.P.chiu Trans-asme, Ser-F, (1970)]



2*b*: Range over which contact pressure does not act, mm
2*c*: Shoulder-to-shoulder width of surface dent, mm
E_1, E_2: Elastic modulus, MPa
P_0: Contact pressure without dent, MPa
P: Contact pressure with dent, MPa
r : Curvature around a surface indentation, mm



2. WTF technology among other NSK long life technologies

Example of bearing number: WTF 343 KVS 4551

- WTF: Water TF
- 343: Bore diameter
- KVS: Bearing type symbol
- 4551: Outside diameter

Purpose

Long Life

Challenge

- Subsurface originated flaking (for clean environments)
- Surface originated flaking (for water-infiltrated environments)
- Surface originated flaking (for particulate contaminated lubrication environments)

Measures

- Material
  - High cleanliness (mass-produced melting)
    - Z steel
    - EP steel
  - Ultra-high cleanliness (special melting)
    - Resistance to crack generation caused by corrosion fatigue due to water infiltration
    - Aircraft engine bearings
  - Chemical component design technology
    - Resistance to crack propagation caused by corrosion fatigue due to water infiltration
    - Water TF bearing
- Heat treatment
  - Control of retained austenite
    - TF bearing
      - Improvement of foreign particle resistance
      - Hi-TF steel
      - Measures against particulate contamination
      - Super TF bearing
  - Special heat treatment
    - UR bearing
- Bearing seal
  - Sealed four-row tapered roller bearing (E-CAPA series)
  - T/M sealed clean bearing
- Measures against water infiltration

3. Life of WTF bearings

Bearing life test results under contaminated lubrication conditions of grease, water, and fine iron powder simulating the market are described in Figure 3. Trial usage results of actual cold rolling mills are described in Figure 4. Both results show a bearing life three times longer than that of conventional bearings.

Figure 3. Test results of tapered roller bearing life under contaminated lubrication conditions of grease, water, and fine iron powder simulating market conditions

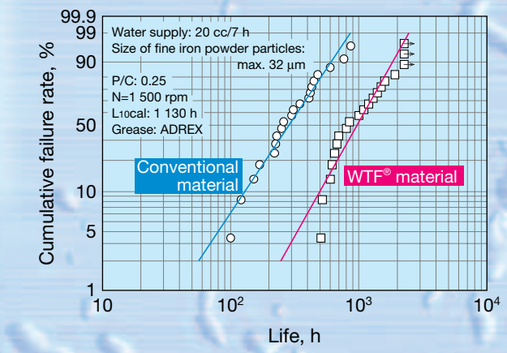


Figure 4. Trial usage results of WTF bearings in an actual cold rolling mill

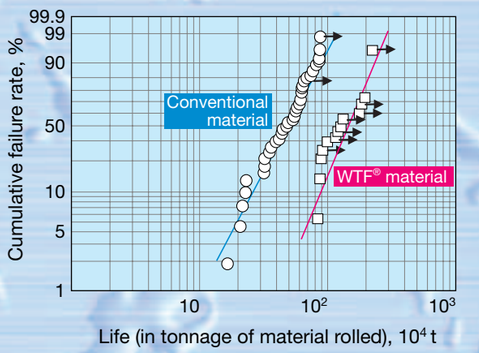


Figure 5. WTF bearing dimensions (example)