ROLLING BEARING LIFE ESTIMATION CONSIDERING LUBRICATING CONDITIONS

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ABSTRACT
There is a great deal of oil film parameters Λ, or oil contamination effects on rolling contact fatigue life of bearings. A new life estimation method was developed which takes into account a factor of lubrication condition. The estimated results showed an agreement with the experimental results.

INTRODUCTION
Lundberg-Palmgren’s (L-P) life theory \(^1\) is well known as the fundamental estimation method for rolling bearings. Its failure mode assumption is that cracks initiate below rolling contact surface. Therefore, modification is required to predict surface originated flaking life under boundary lubrication conditions, or under contaminated oil lubrication. A new life estimation method \(^3\), which can also be applied to surface originated flaking, is described. This comprises the calculation of a volume element life, which is related to the local stress below the contact area, and then calculating the total life of the contact stressed region.

LIFE CALCULATION
This method’s model is basically L-P bearing life theory, except the stress volume is subdivided to consider the local stress concentration on the bearing raceway surface. Equation (1) is the basic life calculation equation which indicates the probability of survival \(\Delta S_i\) of a volume element \(\Delta V_i\), \(\sigma_i\) is the von-Mises stress at each subdivided stress volume. Equation (2) shows the life of each volume element life \(\Delta L_i\). The total life of stress volume \(L\) is calculated by equation (3).

\[
\ln \frac{1}{\Delta S_i} \propto \frac{N_i}{\sigma_i} \cdot \Delta V_i \quad \ldots \quad (1)
\]

\[
\Delta L_i = \Delta N_i \propto (\sigma_i^{-e} \cdot \Delta V_i^{-1} \cdot x_i^{h})^{1/e} \quad \ldots \quad (2)
\]

\[
L = (\Delta L_i^1 + \Delta L_i^2 + \ldots + \Delta L_i^n)^{1/e} \quad \ldots \quad (3)
\]

In this method, if \(\sigma_i\) is corresponds to an endurance limit, \(\Delta L_i\) shall be deemed infinite. In this way, the estimation can deal with not only consideration of lubricating conditions but also bearing fatigue limit life.

LOCAL STRESS
For point contact, the local stress is determined as the von-Mises stress, and its value was calculated by Muro’s program \(^3\). The calculation to obtain the local stress in his program was based on K. L. Johnson’s method \(^4\). And, for line contact, the local stress value was calculated by Smith-Liu’s equation \(^5\).

EFFECT OF OIL FILM PARAMETER Λ
Under low Λ condition, there must be the stress concentration on the contact surface due to the metal-to-metal contact of rolling elements surface asperities. The estimation model includes this stress concentration on the surface elements with the ingenious assumptions. The estimated life shows the agreement with Skurka’s experimental data \(^6\).

EFFECT OF OIL CONTAMINATION
It is assumed that the stress concentration around the dents due to oil contamination will inevitably occur when the rolling element rolls over the dent. The estimation model includes this stress concentration on the surface elements corresponds to dent’s size. The estimated life’s agreement is shown in Fig.1.

REFERENCE
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BIOGRAPHY
Hiromasa Tanaka has been an R&D engineer at NTN Corporation. His field in research involves rolling contact fatigue life of bearing. Currently, he is general manager of R&D Center.