# Rolling Bearing Application

Liu Zejiu He Shiquan Liu Hui

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This book briefly introduces the types of rolling bearings and their application, identification codes, tolerance and rotating accuracy, general international technical terms, dynamic and static capacity and life calculation, elastic and permanent deformation calculation, support arrangement, fit selection, radial internal clearance selection, rolling bearing vibration and noise, sliding friction in rolling bearings and lubricant, lubrication method selection, bearing mounting and dismounting and so on.

This would be a book reference for all kinds of the technical engineers and academia person who want to know the basic knowledge of rolling bearings and who are going to select a proper rolling bearing or who carry on bearing applied design. Also this book can be a reference book for all the persons who use rolling bearing and for the teachers and students of universities and colleges.

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# Preface

There have been three majar changes or corrections in technical term of China bearing industry since 1970:

1. The change of load capacity and life calculation method of rolling bearings:

Before 1970, China rolling bearing industry used the load capacity and life calculation method of the former Sovit Union. That is the working capacity factor method of rolling bearings, Its basic equation is: $C = (Qnh)^{0.3}$. Where, $C$—working capacity factor of a rolling bearing; for a specific rolling bearing, it is a constant. $Q$—actual load on a rolling bearing (kN). $n$—rolling bearing rotation speed (r/min). $h$—rolling bearing life (h).

G. Lundberg and A. Palmgren published two famous articles in1945 and 1952 respectively, and put forward a statistical probability method for rolling bearing capacity and life calculation. Its basic equation is: For ball bearing, $L = (C/P)^3$; For roller bearing, $L = (C/P)^{10/3}$. Where, $C$—rolling bearing basic dynamic rating; for a specific rolling bearing, it is a constant (kN). $P$—equivalent dynamic load (kN). $L$—rolling bearing life ($10^6$r).

Since the publishing of the two famous articles, many rolling bearing companies have carried on a lot of studying, testing, and verifying work about this new rolling bearing theory. The International Standard Organization, ISO, published two recommended standards:

ISO/R281—1962 Basic dynamic load rating of rolling bearings; ISO/R76—1962 static load rating of rolling bearings. Till 1970, most countries adopted the two ISO recommended standards. So China rolling bearing industry decided to adopt these two ISO standards in China, and stopped using the old rolling bearing calculation method. In 1975, the Rolling Bearing Sample Book was published by China Machine Press, in

which for the first time the parameters of $C$, $C_0$ and rotation speed limit $n$ for every rolling bearing were given out.

The change of rolling bearing life calculation method would affect many aspects. and all technical data about rolling bearings must be changed accordingly. Therefore, in 1978. we wrote the book *Rolling Bearing Load Rating and Life* and the book was published by China Machine Press, in 1982.

2. The identification code change of rolling bearings

Before 1990, China rolling bearing industry used the former Sovit Union's rolling bearing identification codes (designation) which was expressed by numbers. It was quite different from the common international rolling bearing identification code which was expressed by English letters and numbers. China government carried out the reform in 1978, and China rolling bearing export increased very quickly. But the difference rolling bearing identification codes seriously hurt Chinese rolling bearing export. Therefore, China rolling bearing industry decided to change the old identification code and adopted the commonly used international rolling bearing identification codes in 1990 and stipulated the new China National Standard GB/T272—1993: rolling bearing identification codes, and it took effect from the first of July, 1994. The identification code change of Chinese rolling bearings affected more comprehensive aspects. So, in 1994, we wrote the book *Rolling Bearing Application Handbook*, which was published by China Machine Press in 1996.

3. The technical standard revision of rolling bearings

The International Standard Organization (ISO) decided to restore Chinese membership in 1978. The China rolling bearing industry hold a meeting of ISO/TC4 (The Rolling Bearing Technical Committee, that is the fourth committee of ISO) in Hangzhou of China in April of 1986.

Since then, China rolling bearing technical standards have been revised synchronized with the international rolling bearing standards, Now most of the international rolling bearings standards have been adopted as the China National Standards equally or equivalently. So that, we wrote the book

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Rolling Bearing Application Handbook (2ed) and the book was published by China Machine Press, in January of 2006.

Based on latest information and development of rolling bearing, recently we wrote the book *Rolling Bearing Application*. This book briefly introduces the types of rolling bearing and their application, identification codes, tolerance and rotating accuracy, common international technical terms, dynamic and static capacity and life calculation, elastic and permanent deformation calculation, support arrangement, fit selection, radial internal clearance selection, rolling bearing vibration and noise, sliding friction in rolling bearings, lubricant, lubrication method selection, bearing mounting and dismounting and so on.

The Chinese edition of this book was written by Liu Zejiu (Chapter 1, 2, 4, 6), He Shiquan (Chapter 3, 7) and Liu Hui (Chapter 5). The English edition of this book was translated by the above authors.

It is hard job to produce this book in English version. We are very thankful to China Machine Press. We also did appreciate any valuable comments from all of readers.

Liu Zejiu

# List of Symbols

| | |
|---|---|
| $A$ | minimum load Constant; Constant |
| $a$ | Semi-major axis of projected contact ellipse |
| $a_1$ | Life adjustment factor for reliability |
| $B$ | Bearing width |
| $b$ | Semi-minor axis of projected contact ellipse |
| $C$ | Dynamic load rating |
| $C_0$ | Static load rating |
| $C_a$ | Semi-major axis cofficient of projected contact ellipse |
| $C_b$ | Semi-minor axis cofficient of projected contact ellipse |
| $C_\sigma$ | Maximum contact stress coefficient |
| $C_\delta$ | Relative elastic approach coefficient |
| $D$ | Outside diameter of rolling bearing |
| $D_{pw}$ | Pitch diameter of rolling bearing |
| $D_m$ | Average diameter of rolling bearing |
| $D_w$ | Rolling element diameter |
| $d$ | Innerring diameter of rolling bearing |
| $E$ | Modulus of elasticity |
| $F$ | Applied load on support system |
| $F_A$ | Applied axial load on support system |
| $F_a$ | Applied axial load on rolling bearing |
| $F_r$ | Applied radial load on rolling bearing |
| $F_t$ | Gear drive circumference force |
| $F_s$ | Gear drive radial force |
| $f$ | Curvature radius coefficient of raceway groove |
| $i$ | Numbers of rolling element rows in rolling bearing |
| $J_a$ | Axial integral of load distribution |
| $J_r$ | Radial integral of load distribution |
| $J_1$ | Mean rolling element load integral of rotating ring |

$J_2$ Mean rolling element load integral of static ring

$K$ Elastic deformation constant

$L$ Rating life of rolling bearing

$L_s$ Fatigue life corresponding to survival probability

$L_{10}$ Basic rating life that 10% of a group of rolling bearings will endure

$L_m$ Median life that 50% of a group of rolling bearing will endure

$L_{na}$ Adjustied fatigue life of arbitrary condition

$L_{we}$ Effect roller length

$M$ Bending moment

$\frac{1}{m}$ Poisson's ratio

$N$ Drive power

$n$ Rotation speed of rolling bearing

$n_i$ Rotation speed of inner ring

$n_e$ Rotation speed of outer ring

$n_c$ Rotation speed of cage

$n_{ci}$ Cage rotation speed relative with inner ring

$n_{ec}$ Outer ring rotation speed relative with cage

$n_w$ Rolling element rotation speed around self-center axis, or rolling element self rotation speed

$O_i$ Inner ring curvature center of raceway groove

$O_e$ Outer ring curvature center of raceway groove

$P$ Equivalent dynamic load

$P_0$ Equivalent static load

$Q$ Rolling element load

$Q_c$ Rolling element load rating

$q$ Parameter of curvature center distance

$R$ Curvature center

$r$ Curvature radius of raceway groove

$S$ Probability of survival (reliability)

$G_r$ Radial clearance

$G_a$ Axial clearance

$V_i$ Line velocity of inner ring contact point

$V_e$ Line velocity of outer ring contact point

$V_c$ Line velocity of rolling element center

$X$ Radial factor

$X_0$ Static radial factor

$Y$ Axial factor

$Y_0$ Static axial factor

$z$ Numbers of rolling elements per row

$z_o$ Depth of maximum orthogonal shear stress

$\alpha$ Nominal contact angle

$\alpha_i$ Contact angle of rolling element with inner ring

$\alpha_e$ Contact angle of rolling element with outer ring

$\alpha_d$ Contact angle of rolling element end with ring rib

$\beta$ Load angle

$\gamma$ Bearing structure parameter

$\delta$ Relative approach of contact bodies

$\delta_e$ Relative approach at outer ring raceway contact

$\delta_i$ Relative approach at inner ring raceway contact

$\delta_a$ Relative axial displacement between inner ring and outer ring

$\delta_r$ Relative radial displacement between inner ring and outer ring

$\delta_s$ Plastic deformation

$\eta$ Reduction factor of dynamic rating load

$\lambda$ Reduction factor of dynamic rating load

$\theta$ Turn angle of axis

$\nu$ Adjustment factor of dynamic rating load

$\rho$ Curvature

$\rho_{\mathrm{I}1}$ curvature of body Ⅰ in plane 1

$\rho_{\mathrm{I}2}$ curvature of body Ⅰ in plane 2

$\rho_{\mathrm{II}1}$ curvature of body Ⅱ in plane 1

$\rho_{\mathrm{II}2}$ curvature of body Ⅱ in plane 2

$\Sigma_\rho$ Curvature sum

$F_{(\rho)}$ Curvature function

$\psi$ Angle of rolling bearing element with maximum loaded rolling element

$\psi_o$ Angle of rolling bearing load range

$\omega$ Angular speed

$\omega_i$ Inner ring angular speed

$\omega_e$ Outer ring angular speed

$\omega_w$ Self rotating angular speed of rolling element

**Subscripts**

i Inner ring

e Outer ring

c Cage

w Rolling element

a Axial

r Radial

p Central circle

m Average

min Minimum

max Maximum

# Contents



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