

BEARING STEEL TECHNOLOGY

JOHN M. BESWICK

Editor

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John M. Beswick, editor

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Foreword

This publication, *Bearing Steel Technology*, contains papers presented at the symposium of the same name held in Phoenix, AZ., on 8–10 May 2001. The symposium was sponsored by ASTM International Committee A1 on Steel, Stainless Steel, and Related Alloys and its Subcommittee A1.28 on Bearing Steels. The symposium chairman was John M. Beswick, SKF Group Purchasing, Engineering and Research Centre, B. V., Nieuwegein, The Netherlands.

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Overview

This ASTM International Special Technical Publication represents the work of numerous rolling bearing experts who presented papers at the 6th International Symposium on Bearing Steels, held in Phoenix, 8–10 May, 2001. The almost traditional five-yearly cycle for the ASTM International bearing steel symposia resulted in the Phoenix location being selected for the third time in association with the ASTM International A1 committee week and the A1.28 subcommittee for bearing steel meetings. The remit for the subcommittee A1.28 on bearing steels is to have jurisdiction over the standards for steels commonly used for ball and roller bearings. This subcommittee is responsible for preparing, reviewing and maintaining these standards and assuring that they reflect current technology. Currently the A1.28 subcommittee is faced with many challenges, not the least of which is to keep the ASTM International specifications aligned with steel making processes changes. In addition, vindication of the current specifications in light of the economic pressure within the industry is an increasing requirement. It is generally recognized that many of the steel quality assessment methods and related specification limits, used within the industry, were developed for steel making methods, either obsolete or inappropriate to current methods or product functional requirements. Resistance to change is always present and product liability considerations, together with the related risk of litigation, place a high burden material, on engineers responsible for major specification changes. However the preparation and application of state-of-the-art, ASTM International bearing steel assessment methods and related acceptance limits (specifications) provides a professional forum for the introduction of progressive changes. Cross border joint-ventures or mergers are becoming increasingly common, within the rolling bearing industry, which adds to the requirement for up to date, state of the art bearing steel specifications.

The rolling bearing industry is truly global and bearing steels and rolling bearings are manufactured, and, or assembled in all industrialized countries. Some of the largest bearing steel producers have manufacturing facilities in more than one country and all of the largest rolling bearing producers have manufacturing plants located world-wide. The rolling bearing industry statistics are:

- Rolling bearings are a 20 billion U.S. dollar global business and rolling bearings are produced in 17 countries
- Approximately 500 rolling bearings are produced, per second, by about 30 manufactures
- More than 55 steel producers manufacture bearing steels
- In the Year 2000, 2.6 million tons of 1C-1.5Cr bearing steel was produced which represents about 0.5% of current global steel production
- Currently 37 different bearing steels are specified by ASTM International

The rolling bearing industry is characterized as investment intensive with a relatively low return on capital employed. In addition, the industry is highly competitive with, as previously shown, in excess of 55 bearing steel producers, about the same number of component producers and about 30 rolling bearing manufactures.

The economic use of materials and heat treatments can be identified as a key success factor for profitable rolling bearing manufacture. It therefore is appropriate to pursue an ASTM International

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symposium in which the state-of-the-art in bearing steel technology is reviewed. Such a review can provide a platform for the bearing steel purchasers and bearing users to analyze bearing industry trends and develop economic acquisition strategies.

A committee comprising representatives from bearing steel makers, "commercial" bearing manufacturers, aerospace bearing manufacturers, and the ASTM International symposium operations staff organized the 6th International Symposium on Bearing Steels, and the members of organization committee were as follows:

John Beswick,	SKF Group Purchasing, Nieuwegein, The Netherlands
Dorothy Fitzpatrick	ASTM, Conshohocken, PA
James Carosiello	The Timken Company, Canton, OH
Jeff Fuller,	Brenco, Petersburg, VA
Ronald Spitzer	MRC Bearings, Jamestown, NY
Paul Dimitry	Macsteel, Jackson, MI

This symposium, being the 6th in the series, was significant in that it enjoyed the best ever attendance and attracted 190 attendees from eleven nations. In addition, the event enjoyed a significant level of sponsorship from the following companies:

Aichi Steel Company	MRC Bearings	Saarstahl
Ascometal-Lucchini Group	Nedstaal B. V.	SKF AB
Aubert & Duval	Nippon Steel Corporation	SNR Roulements
Brenco	NSK Ltd	The Timken Company
Crucible Compaction	NTN Corporation	Timken Latrobe
FAG	Ovako Steel	The Torrington Company
Macsteel	Sanyo Special Steel	VSG

The global nature of the industry attracted 42 presentations at the symposium and the symposium program was divided into the nine technical sessions over three days. The presenters had the following affiliations:

• Rolling bearing producers	17
• Bearing steel producers	15
• University and R&D institutes	8
• Rolling bearing users	2

The broad goal of the symposium, and this book, was, and is to bring clarity into what is important in respect of rolling bearing steel technologies and the relevant disciplines are described in nine sections in this book. The 34 papers that were accepted for publication have been peer reviewed by 46 rolling bearing technology practitioners from 8 nationalities.

Bearing Steel Process Developments

In this section the global bearing steel making technologies were reviewed, at the symposium, and bearing steel purchasers find the potential price reduction due to the use of billet casting, of rolling bearing steels, very attractive. The reduced cost in billet casting and/or "hot charging" is primary due to the elimination of the rolling operations and/or reduction of the post casting thermal treatments such as the ingot or blooms "soak". In support of the technical information on this subject a paper was given describing a billet casting friendly steel grade. Another paper provided hitherto never published data on the relative segregation levels for ingot and continuously cast 1C-1.5Cr, bearing steel and the

effect of steel making processing parameters and soaking practice on the bearing steel segregation properties.

Steel Technology and Bearing Component Manufacture

For the first time at the ASTM International bearing steel symposia, a session was included on the rolling bearing component manufacturing aspects of bearing steel technologies. In one paper, the machinability parameters in bearing steels were reviewed and relevant testing methodologies described. In another paper, a modernistic steel technologies related to improved environmental aspects of the hardening heat treatment process was described. It was generally agreed that future ASTM International bearing steel symposia would benefit from having more papers on the bearing manufacturing aspects of bearing steel technologies.

Developments in Bearing Steel Quality Assessment and Correlation's with Bearing Life

The bearing steel industry is highly dependent upon the availability of clean steel making methods and the related techniques to assess steel cleanliness were reviewed. The use of statistics of extreme values (SEV) and a new method based on generalized Pareto distribution (GPD), when using optical microscopy, were presented. These technologies are being accepted as relevant methods for the new generation of rolling bearing steel specifications and the methods will be seriously considered in future ASTM International bearing steel specifications.

The attractiveness in the use of ultrasonic techniques, for internal cleanliness assessment, was covered in some papers. The use of an ultrasonic method was advocated at the first ASTM International bearing steel symposium in 1974, and it is significant that currently, all the top level bearing steel technologists are now applying advanced ultrasonic testing competencies in support of their product integrity guarantees.

Developments in Bearing Service Life Testing

Rolling bearing service life, as opposed to "pure" rolling contact fatigue life testing, was covered in some papers. Rolling bearing life tests for improved service life under hard particle contaminant in the lubricant, water ingress and dented raceways due to artificial indentations, were described. The challenges and opportunities in effective integration of bearing metallurgy, tribology and mechanical testing to perform meaningful service life tests were adequately demonstrated in these papers.

Bearing Metallurgy Developments for Improved Service Life

The technologies pertaining to new alloys, heat treatments and microstructure control for improved served life and extreme conditions were described in a number of presentations at the symposium. The use of steels alloyed with silicon to improve the service life, particularly for elevated temperature demanding applications, was a reoccurring theme in new rolling bearing steel developments.

Developments in High Alloy Steel for Improved High Temperature and Enhanced Corrosion Resistance Properties

The rolling bearing industry, particularly aerospace, demands for high temperature and corrosion resistance was addressed in some papers. The advantages of powder metallurgy for the creation of microstructures, not possible by conventional melting, to give elevated wear and corrosion resistant rolling bearing properties were presented. In addition, the relative properties of contemporary and new alloys for aerospace, as well as carburized and nitrogen alloyed steels were covered.

Microstructural Changes and its Relationships with Bearing Life and Life Time Predictions

The material physics aspects associated with the Hertzian contact cycle process in rolling bearing contacts were presented in some papers at the symposium. The well known aspects of microstructure change in the Hertzian contact zones of rolling bearing was treated in one paper, presented at the symposium, using a thermo-mechanical response model for the prediction bearing rolling contact fatigue life.

Material Factors in Bearing Life Calculations

Material factoring of rolling bearing life is known to be difficult, and at times emotive, when comparing different bearing steel and rolling bearing producer manufacturing philosophies. Eminent North American and Western European workers in the field of rolling bearing life modeling presented papers on the subject. The development of rolling bearing life endurance models were reviewed and new physically based endurance limit model, for life estimates on surface and through hardened rolling bearings were presented, as well as advanced testing and a modeling information on steel quality, life factors.

Bearing User Future Requirements

The future user requirements in respect of rolling bearing steel technologies were presented by representatives from prime user segments. The aerospace—aircraft engine rolling bearing steel requirements were reiterated as being improved service life for the rolling elements and cages in conditions of corrosion and lubricant contaminate, as well as “slow and graceful spall propagation rates when the bearing starts to fail.”

The high demands in the earthmoving industrial equipment, manufacturing segment were presented and the steel and rolling bearing technologist were challenged with an industry wish list of requirements for society and industry standards for basic parameters tests, and the ability to determine value of the enhancement in specific applications, and the ability to quantitatively rate suppliers enhanced product against other suppliers' products.

In the relatively short time, which has elapsed between the symposium, and the publication of this book, quite significant changes have occurred within the bearing steel and the rolling bearing manufacturing industries. The global economic down turn has necessitated cutbacks in the rolling bearing steel technology budgets resulting in some producer R&D facilities being downsized. These changes require increased diligence within the bearing steel technology fraternity in order to retain a competitive posture within the context of an ever increasingly price sensitive steel supply and bearing sales markets.

The ASTM International standardization committees, together with the ASTM International symposium and publications staff, have an important role to play to sustain growth within the rolling bearing industry. The ASTM International symposia are a neutral forum to address the “added value” relationship in rolling bearing steel technologies. Bearing steel technologies and purchasing managers, interested in utilizing the global bearing steel supply market opportunities, will benefit from a closer look at the information and wisdom contained in this publication.

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