

Bearing Steel Technology-

Advances and State of the Art in
Bearing Steel Quality
Assurance

John M. Beswick
editor

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and State of the Art
in Bearing Steel Quality Assurance:
7th Volume***

John M. Beswick, editor

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Foreword

This publication *Bearing Steel Technologies — State-of-the-Art and Advances in Bearing Steel Quality Assurance* contains papers presented at the symposium of the same name held in Reno, Nevada on 17 to 19 May, 2005. The symposium was sponsored by the ATM International Committee A01 on Steel, Stainless Steel, and Related Alloys and its Subcommittee A01.28 on Bearing Steels. The symposium chairman was John M. Beswick, of SKF Group Purchasing, located at the SKF Business & Technology Park, Nieuwegein, The Netherlands.

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Overview

At the beginning, the intention was to put together a symposium covering the global state-of-the-art and advances in bearing steel quality assurance; 7th International ASTM Bearing Steel Symposium. Given the competitive nature of the bearing steel and rolling bearing manufacturing industries, this was an ambitious target and we had no idea whether or not it would work.

In the papers presented during the three-day symposium May 17–19, 2005, in Reno, Nevada the industry technology trends and the characteristics of bearing steel quality assurance were debated. The approach of soliciting papers from global bearing steel producers and rolling bearing manufacturers seems to have worked and this approach has given us a better understanding of the related technologies.

The symposium, attended by 149 registered delegates representing organizations from 14 different countries, covered the nine sequential topics, with 45 presentations related to the theme of the symposium. Not all of the papers presented at the symposium were submitted for peer review, and publication, and this special technical publication (STP) contains 25 papers on the subject. Of these papers one was identified as award quality, by the ASTM paper review board.

Review of Global Bearing Steel and the Rolling Bearing Industry

In the first section of the symposium the global bearing steelmaking industry was reviewed. In the published paper from the Oy Ovako Ab Hofors plant, the origin of the Swedish bearing steel manufacturing was described from the ancient Swedish "Bergsman" to the present. The paper describes the impact of Swedish steel technology on bearing steel quality assurance, for example the Hofors micro inclusion rating scale, as applied in the JK rating scale from 1936, is the basis for the presently applied ASTM E45 micro inclusion rating methodology.

Developments in Global Bearing Steel Making Processes

The STP contains a paper from the Baosteel Group Shanghai Nr 5 Works in which the vacuum carbon de-oxidization methodology for low aluminium 1C-1.5Cr bearing steel production, was described. The paper claimed reduced production cost for such a process.

Advances in Steel Maker Testing and Quality Assurance

The advances in bearing steel quality assurance is dominated by ultrasonic testing technologies, with a paper on this subject from Schaeffler KG, Germany who compared the ASTM E588 standard method with the German SEP 1927 and defines the limitations. Sanyo Steel, Japan reviewed their quality assurance technologies and Ascometal, France presented a statistical analysis of the test volume considerations.

The use of pulse height distribution analysis (PDA) for rapid bearing steel micro cleanliness characterization, instead of optical microscopy, is proposed in a paper from NSK Japan. A significant, and highly appreciated, contribution is made by Acciaierie Venete, Italy in which radiation testing methodologies are presented. This is the first time that specific information was

made available on this topic; radiation testing being a pre-requisite for responsible steel and bearing manufacturing quality assurance.

The choice of metallurgical testing methods is clearly a compromise in the required defect tolerance limit, the necessary test volume, the reliability of the testing and the cost of testing.

Implementation and Use of Extreme Value Analysis Micro Inclusion Rating Methodology

The origin and the methodology behind the ASTM E2283 Extreme Value Analysis (EVA) for micro inclusion rating is described in a noteworthy paper by Dennis Hetzner of the Timken Company. This paper describes the details of the EVA methodology which was applied for bearing life prediction in papers from SNR France, SKF (authors located in The Netherlands) and an analysis from the European Structural Integrity Society (ESIS) Technical Committee 20 members.

The EVA methodology for bearing steel quality assurance has gained acceptance but the problem of representative sample sizes and the handling of outliers remains a challenge and its use in the ASTM bearing steel specifications, such as A295, has not yet been brought to fruition.

Bearing Steel Making and Bearing Manufacturing Metallurgy Quality Assurance

The influence of bearing steelmaking on heat treatment distortion is given in a comprehensive paper from SKF (author located in Germany). Data on the bearing steel casting method, alloy content/hardenability, forging symmetry and tube making is presented. The effect of the entire bearing component manufacturing chain is explained and the avoidance of uneven residual stress at every manufacturing stage, is identified as important.

Low Alloy Bearing Steels and Heat Treatments for Improved Bearing Quality

In a paper from Ascometal France and FAG Germany, through hardened rolling bearing steel temper resistance is presented as the key to improved raceway resistance to lubricant contaminant damage. Vanadium alloying is presented by POSCO and FAG Korea as the key to longer life case carburized rolling bearing steels. NTN Japan present information on ultrasonic high frequency structural fatigue strength decrease by diffusion hydrogen, indicating a correlation between 1C-1.5Cr bearing steel hydrogen, content and structural fatigue.

The physical metallurgy low alloy bearing steels in respect of alloy optimisation, residual element content and related heat treatments, remains a challenging premise for rolling bearing performance improvement. Future bearing steel symposia will undoubtedly continue to expand on this theme.

High Alloy Bearing Steels and Heat Treatments for Improved Bearing Quality

Papers on high alloyed bearing steels covered duplex hardened steel, plasma heat treatment, nitrided high temperature steel compared to M50, continued developments of high speed alloyed steel and austenitic stainless steel. The ubiquitous nitrogen alloyed stainless bearing steel was covered in a paper in which the wear resistance of M50 steel, was compared to the Boehler Edelstahl Austria, nitrogen alloyed stainless steel.

Microstructure Transformation and Use in Advanced Rolling Bearing Performance Predication and Quality Assurance

Microstructural transformation mechanisms in bearing steel were described in papers from SKF (authors located in The Netherlands) and Sanyo Steel, Japan. A 10 μ m micro x-ray diffraction spot size is demonstrated in the SKF paper for improved spatial resolution for use in residual stress profiling for rolling bearing contact fatigue studies. The contact fatigue flaking mechanism in powder metallurgy parts is described in the Sanyo Steel paper; the hydrostatic compressive region being localized with remarkable clarity.

Good quality microstructure characterization, be it by light optical, electron optical microscopy or using x-ray micro diffraction remain key competencies for understanding the physical metallurgy of bearing steels and their application performance.

Advances in Material Quality Factors in Life Prediction

Papers on multi-axial fatigue criteria and micro plastic material models support the advances in material quality factoring for bearing life prediction. The models are clearly more and more sophisticated but the problem remains of a lack of reliable material test data on the parameters influencing the contact fatigue life of rolling bearing steels. Short-crack fracture mechanics test data on hardened bearing steels are clearly a major challenge for the experimentalist as is the strain-hardening effect in hardened, high carbon bearing steel microstructures.

The papers indicated that no magic formula exists for quality assurance in steel rolling bearings. Without profound knowledge of the application loads and environment, and without state-of-the-art knowledge of steel technology and its relevance to the applied testing methodologies, quality assurance cannot be realized. For example, a low quality steel, from a low cost process, used in a low load application could be perfectly acceptable and commercially sensible. The ultrasonic testing, metallographic and statistical treatment methods presented in the symposium are proving to be essential tools in the knowledge gathering process for effective steel grade and related heat treatment selection against application requirements.

The steelmakers producing rolling bearing steel grades have traditionally developed quality assurance knowledge and the bearing producers have traditionally driven the requirements. However for economic reasons low cost region bearing component production is being increasingly applied in global rolling bearing manufacturing. As this trend continues, the component producers in these regions, and also the purchasers will need to develop state-of-the-art steel technology knowledge such that suitable steel qualities are applied relative to the rolling bearing end use.

The organizer is especially indebted to the generosity and support of the many sponsors representing the steelmakers, component producers and rolling bearing producers. Macsteel organized, and funded, a reception during symposium and in addition the following companies subsidized the event:

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Ltd
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Timken Latrobe Steel

The tradition, since 1974 of the ASTM committee A01 and the subcommittee A01.28 bearing steel symposia and paper publication (in book form) serving the industry is commendable and will, in all probability, continue. The frequency of every four to five years with several days formal presentations may need to change to a more frequent workshop format, inline with current industry practice. The future of peer-reviewed publications is totally dependant upon the cooperation of both authors and peer reviewers, the latter proving to be increasingly problematic. Without the support of my friends and colleagues the peer reviews would not have been possible. However, whatever the future holds it has been an honour, and privilege, for the author to organize the 7th International ASTM Bearing Steel Symposium and contribute to this ASTM Special Technical Publication (STP) 1465.

John Beswick
SKF Group Purchasing
SKF Business & Technology Park
Kelvinbaan 16, P.O. Box 2350
3430 DT Nieuwegein, The Netherlands



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