SKF

Invitation to the inauguration of:

SKF University Technology Centre for Steels

From 14.30, Thursday 9 June 2011

The Babbage Lecture Theatre, University of Cambridge, New Museum Site, Pembroke Street, Cambridge CB2 3QZ

The centre's objective is to rapidly advance SKF's knowledge of the physical metallurgy of bearing steels leading to a range of new and improved products.

SKF have identified and selected a number of steel technology R&D topics for the University staff to work on, that will lead to a better understanding of:

- How to manage the detailed microstructure and exploit this knowledge to enhance bearing properties
- How modifications to steel composition can enable complex operational demands to be mitigated
- How to predict the performance relative to the steel and heat treatment selection

Leading the team is Professor Harry Bhadeshia, a recognised world expert in the physical metallurgy of steels and whose previous work has resulted in a number of innovative steel compositions.

Programme of events

Registration

- 14.30 – 15.00
  The Babbage Lecture Theatre

Welcome and introduction

Keynote presentations

- 15.00 – 17.00
  Professor Lindsay Greer, Head of Department, Materials Science and Metallurgy, University of Cambridge
- Professor Sir Leszek Borysiewicz, Vice Chancellor, University of Cambridge

The SKF Group

- Tom Johnstone, President and CEO

SKF Research and Development

- Dr Alan Begg, SVP, Group Technology and Development

Research overview (synopsis overleaf)

- Professor Harry Bhadeshia, Professor of Metallurgy, University of Cambridge

Tour of facilities

- 17.00 – 18.00
  Visits to three major activities:
  - The highest resolution electron optics
  - Mechanical testing and simulation facilities
  - Scanning electron microscopy

En route to these facilities, we will also encounter:

- The discovery of the electron
- The structure of DNA
- The fact that an atom has a nucleus
- That electricity and magnetism are one

The Cambridge site is possibly the most densely populated in terms of academic achievement anywhere in the world, and created the foundations for today's physics and computer science.

UNIVERSITY OF CAMBRIDGE

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Research overview

Professor Harry Bhadeshia

UNIVERSITY OF CAMBRIDGE

The steels that form critical bearing components are today manufactured to the highest of technological standards. This is because they have to sustain considerable trauma in terms of contact stresses, from environmental effects and in difficult engineering scenarios from unpredictable and large variations in loads.

There has been quite remarkable and well-documented progress in the performance of these steels, largely due to enhanced purity, clever processing and metallurgical understanding.

It nevertheless remains the case that with few exceptions, the vast majority of the several million tonnes of bearing steel produced annually relies on a composition originating from materials developed as tool steels. These have microstructures that consist of undissolved carbides in a matrix which is either mildly tempered martensite or bainite generated by isothermal transformation.

Further purification and modification of inclusion content is possible, but the table below shows what might be the limits of achievable purity in a commercial scenario. The current generation of bearing steels is not far from the stated values as far as oxygen and hydrogen concentrations are concerned. It follows that if the influence of nonmetallic inclusions is diminished, then other brittle factors within the structure begin to play the determining role; the two prominent culprits might be undissolved carbides, and embrittled austenite grain boundaries.

Table 1. Approximate dissolved impurity levels achievable in commercial steels. The oxygen concentration is the total value and the concentrations are stated in parts per million by weight. After A. G. Cramb, Impurities in Engineering Materials: impact, reliability and control, Marcel Dekker AG.

Solute	P	C	S	N	H	O
Concentration / ppmw	10	5	5	10	<1	3

Imagine now, that it becomes possible to create a steel which has no carbides. But instead, it possesses the largest density of interfaces ever reported for commercially viable alloys.

These interfaces are so closely spaced that the material is hard, the first requirement of a bearing steel. The interfaces are interesting in that they separate ferrite and highly stable austenite; and yet, the material is cheap to manufacture, can be made in quantity using conventional techniques, can be large in all dimensions, does not require rapid heat treatment, nor are the tightly packed boundaries generated by deformation, and has tenacious austenite grain surfaces.

Think now of hydrogen, an element which is detested in bearing steels; there are countless reports on how it dramatically makes the steel more tired than it should be. And reducing the hydrogen content during manufacture is not the complete answer, since the element can penetrate the steel via a variety of pernicious mechanisms during the course of service.

Think now of a method which copes with this scenario, by trapping the diffusible hydrogen at carefully designed locations in order to render it harmless. This is another risky project that the UTC is pursuing.

Rolling contact fatigue models are of two kinds, the first is in extensive use and originates from the classical work initiated in 1924 by Arvid Palmgren, Head of Engineering at SKF. Developments from which, in combination with experimental data form the basis of bearing life estimates. The second approach involves detail and hence is limited in application but provides insight which may or may not lead to new technology. The UTC is undertaking a new look at the damage associated with rolling contact fatigue. To explain this, consider thermodynamics which is a science of large numbers and defines equilibrium as a state where nothing changes no matter how long one observes. Kinetics on the other hand deals with change driven by the need to achieve equilibrium, is usually highly non-linear and complex. In between these two scenarios is irreversible thermodynamics where the steady-state is treated, i.e. a condition were change occurs but is not seen to occur by an appropriately located observer. The UTC is developing a model for estimating the changes in the residual stress profile as a function of structural detail. The residual stress profile can hopefully be linked to life. These are early days, the length scales need to be defined and so does the evolution of damage. But it may be possible to use such a framework to optimise structure.

Mathematical models can be naive; we intend to use the panoply of techniques available in Cambridge University to validate aspects of the model. These techniques include high-resolution, microscopic mechanical testing, quantitative characterisation and some which we will have to develop ourselves.

There are many other ideas which I will mention briefly, which are on the shelf, waiting for the right opportunity. Some of these will involve partners, and others will fall by the wayside. What is exciting is the opportunity that lies ahead in order to make a difference to the field.

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