Höganäs

SPECIAL ISSUE
EURO PM 2003
OCTOBER 20-22ND, VALENCIA

POWDER NEWS

The pursuit of high performance at low cost will be a prominent theme for Höganäs AB at Euro PM2003 held in Valencia, Spain, October 20-22.

Höganäs AB, the world's largest producer of metal powders, continues to be a major source of technical solutions that support the P/M industry's efforts to establish powder components in new areas, especially high performance applications such as gears.

Ralf Carlström, Marketing Manager of Höganäs AB says, "At Euro PM2003 we want to emphasise our capability to develop the material and process solutions to push the P/M industry forwards."

"We are working continually to develop new products and give our customers the lowest total cost. Our well-established Distaloy powders are breaking new ground too, selling better than ever as a competitive choice for new high-performance applications. In Valencia, we look forward to seeing existing customers and showing new contacts the cost-effective solutions we can offer."

The Höganäs Group's commitment to providing leading-edge knowledge on powders, properties and processes is clearly shown in an R&D budget that accounts for 4% of annual turnover. Latest findings on materials and methods to improve fatigue strength and rolling contact fatigue behaviour in high performance applications feature among the 7 presentations given in Valencia by the Group's R&D team. A general talk by Anders Bergmark will give an insight into Höganäs AB's unique knowledge bank on microstructure and fatigue performance.

Showcasing a major acquisition

The Euro PM2003 show also gives visitors a chance to discover the products and services available from Höganäs AB's latest major acquisition – SCM Metal Products, Inc., USA, a manufacturer of specialty iron and metal powders.

Acquiring SCM was an important strategic step in Höganäs AB's aim to become a full-range metal powder producer for the North American market. Find out more about SCM and its range of over 1,000 products at the Höganäs AB stand.

HIGH PERFORMANCE AT EURO PM2003

KEY KNOWLEDGE

Höganäs AB is at the forefront of fatigue research.

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OPTIMISED PROCESSES

The benefits of surface densification.

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PROVEN MATERIALS

Distaloys have enduring appeal for new high-performance parts.

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MAGNETIC PERFORMANCE

The latest advances in Soft Magnetic Composite design.

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FULL LIST

of the Group's presentations at EURO PM2003.

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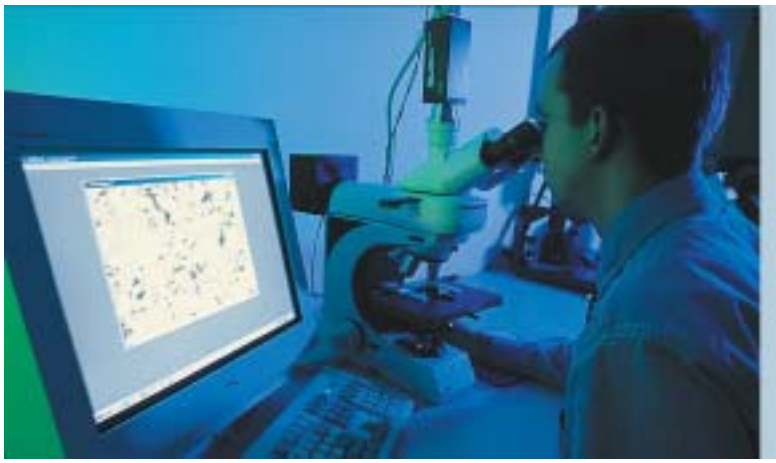


"We are at the forefront of knowledge on fatigue properties..."

IN-DEPTH INSIGHT ON

Höganäs AB has built up a unique knowledge bank on fatigue performance. The latest findings on chromium materials will be presented at Euro PM2003.

There is a clear trend towards the increased use of P/M steels in highly stressed applications such as gears, where high fatigue performance is required. Density and microstructure are the key parameters for the fatigue performance of P/M steels, and in-depth knowledge in these areas is an essential requirement if P/M components are to compete successfully with wrought steel in high performance applications.

A few years ago Höganäs AB embarked on an unprecedented project to map the microstructure and fatigue performance of its materials in the minutest detail.

The result is an unrivalled knowledge bank based on the work of the Fatigue Research Team, a group of four that works exclusively on fatigue-related research.

Sigurd Berg, Manager Product Development at Höganäs AB says: "We are at the forefront of knowledge on fatigue properties. We now have comprehensive knowledge on our materials' fatigue performance in density areas up to 7.3 g/cm^3."

"We can rank our materials from the starting point of structure," he continues. "This means that from the requirements of an application we can assist customers in rapidly selecting the right material and process route for a specific component."

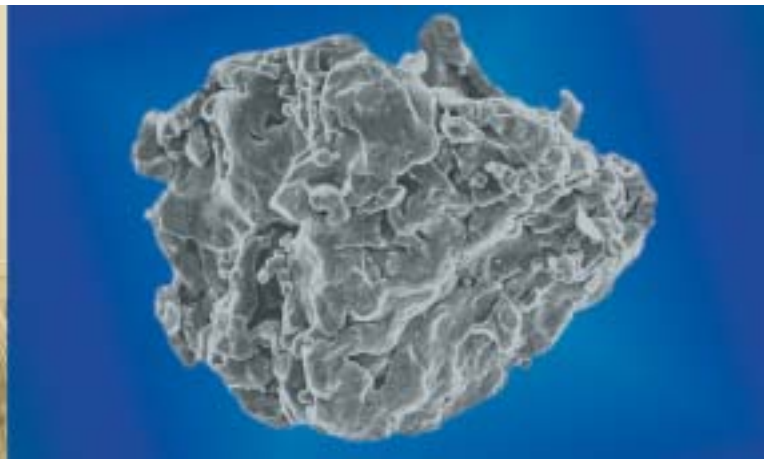
"Our knowledge, particularly the fatigue performance of our high-performance materials, is of great practical value and is underpinning efforts to expand the P/M market into the huge potential market for highly loaded gears in applications such as vehicle transmission and power train gears."

The role of nickel

Anders Bergmark, a member of the Fatigue Research Team, says the project has included a close study of nickel's ability to enhance fatigue limits.

"Traditionally, improved fatigue properties have been achieved by adding a little nickel to the mixture in order to raise the fatigue limit. However, powder mixes with small additions of nickel cannot fully utilize the nickel's performance, since the nickel particles are present as isolated islands of austenite surrounded by a border of martensite. It is not until a continuous network of martensite is formed that the fatigue properties really improve."

"Nickel and copper additions of around 4% and 2% respectively efficiently create this continuous network. But, at these high nickel levels, particle size segregation can be a severe problem, disturbing the continuity of the network. The remedy is to use diffusion-bonded grades, notably Distaloy AE and



FATIGUE PERFORMANCE

Distaloy HP, which exhibit a microstructure with a continuous network of martensite, and consequently have good fatigue properties."

Anders Bergmark will give a general talk at Valencia entitled **Microstructure Enhancement for Fatigue Improvement** based on the findings of the Fatigue Research Team.

Chromium for high performance

The latest deposit in the knowledge bank is a paper to be presented at Euro PM2003 by another member of the Fatigue Research Team, Ola Bergman.

His presentation: **Chromium-Alloyed PM Steels with Excellent Fatigue Properties Obtained by Different Process Routes** examines the fatigue properties of the pre-alloyed water-atomised chromium materials, Astaloy CrL and Astaloy CrM.

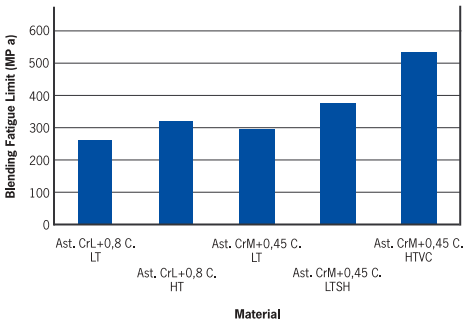
"We can show that these materials have the required properties for applications where high fatigue performance is essential," says Ola Bergman.

The bending fatigue limits at sintered density 7.1 g/cm^3 is around 260 MPa for Astaloy CrL + 0.8% graphite and around 290 MPa for Astaloy CrM + 0.45% graphite after conventional sintering at 1120 ºC in nitrogen-based atmosphere with low dew point.

Ola Bergman points out that "Even better results are achieved with high temperature sintering, which increases the fatigue limit of Astaloy CrL to 310 MPa. A combination of conventional sintering and rapid cooling improves the fatigue limit of Astaloy CrM to 380 MPa." The explanation for this considerable rise in fatigue performance lies in the microstructure shift from mainly bainitic to mainly martensitic structure, which occurs as a higher cooling rate is applied.

"What is significant here," emphasises Ola Bergman," is that you can optimise microstructure and heighten characteristics with high-temperature sintering or rapid cooling in a cost-effective single-stage process without secondary operations."

Fatigue limits in plane bending
(2 million cycles, R=-1)
for Cr-alloyed PM steels at density 7.1 g/cm^3
obtained by different sintering process routes.



LT=Conventionally sintered at 1120° C and cooled with 0,5-1° C/s

HT=High temperature sintered (1250° C)

HTVC=High temperature sintered (1300° C) and vacuum-carburised

LTSH=Conventional sintered (1120° C) and sinter hardened (2-3° C/s)

"Our knowledge, particularly the fatigue performance of our high-performance materials, is of great practical value..."

Dividends from sur

The cost and performance benefits of surface densification in P/M gear production are outlined in a new paper to be presented at Euro PM2003.

Highly loaded applications such as gears operate under rolling contact conditions. Rolling contact fatigue performance at the gear flanks of P/M components must achieve a comparable level to conventional steel if P/M materials are to be considered as an alternative for highly loaded gear applications.

Surface densification is one method that can be used to enhance the rolling fatigue performance of gears. The latest findings in this area will be presented at Valencia in the paper **Rolling Contact Fatigue Design Aspects of Surface Densified PM Components** by Linnéa Fordén and Sven Bengtsson of Höganäs AB.

Research for the paper has been carried out in cooperation with the Fraunhofer-Institute for Structural Durability LBF, Darmstadt, Germany.

Rolling contact fatigue investigations were done on molybdenum pre-alloyed P/M materials. The surface densification was performed by radial rolling in a two-roll burnishing machine at Escofier Technologie SA in France.

Radical Improvement

The paper concludes that the rolling contact fatigue behaviour of P/M materials is radically improved by surface densification and is very close to the level of wrought steels. It was also found that the more expensive powder forging procedure does not result in better rolling contact fatigue performance.

By FEM calculations and experiments, it was shown that surface-densified P/M components have a subsurface stress distribution under contact pressure that is very similar to wrought steel. “This means that the same guidelines regarding case depth, surface hardness, residual stresses and other design parameters can be used for surface-densified components as well as wrought steel,” points out Linnéa Fordén.

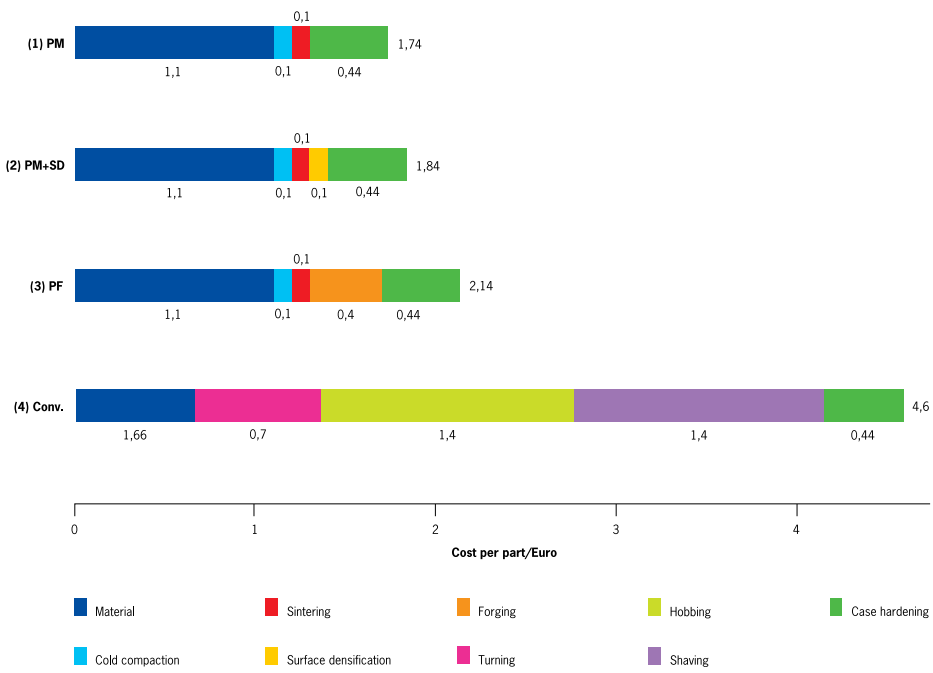
Lower gear production costs

The slight gap between P/M materials and wrought steel regarding rolling contact fatigue behaviour is more than compensated for by the cost angle. The paper shows that P/M technology and surface densification bring considerable costs savings compared to conventional gear manufacturing methods with wrought steel, which involve costly operations such as hobbing, turning and shaving (see chart).

“Compared with conventional techniques, sintering plus surface densification offers between 30-50% savings. You can get comparable performance for a much lower cost.” says Linnéa Fordén

face densification

Cost comparison of gear manufacturing methods



Focus on surface densification

Originally used in conventional steel making, surface densification has become of increasing interest in P/M technology as a method to increase the load bearing capacity of P/M gears. Höganäs AB became involved with surface densification in the early 1980s, and since the mid-1990s it has been a prioritised R&D area. Surface densification merits serious investigation because it is one of the techniques that enables the production of high-performance P/M gears with a cost-effective edge on wrought steel.

Höganäs AB works on the development of the surface densification technique in close cooperation with partners in the powder component industry as well as external research institutions and universities.

These include:

Gear tests: WZL (Werkzeugmachinenlabor, Laboratory for Machine tools) RWTH University of Aachen, Aachen, Germany

Rolling contact fatigue testing: LBF Franhofer Institute for Structural Durability, Darmstadt, Germany

Rolling contact fatigue testing: V-Tech International, West Bend, WI, USA

Surface densification: Escofier Technologie SA, Chalon-sur-Saone, France

DISTALOYS ARE STILL OUTSTANDING PERFORMERS

Sales of the well-established Distaloy powders continue to grow, as this product group often provides the optimum material for today's new high-performance applications.

"Distaloys have proved to have an enduring appeal for the makers of new components. As they have a number of outstanding properties, plus robustness, they have fitted in very well with the trend towards more high-performance parts," explains Mats Larsson at Höganäs AB.

Höganäs AB introduced Distaloys, a family of diffusion-bonded powders, between the 1970s and 1990s, and the products has been marketed globally over the years with great success. In fact, sales are still rising steadily, and on average Distaloy volumes have more than doubled over the past 10 years.

Distaloy-based parts are typically used in power tools at a sintered density of around 7.0 g/cm^3. Heat treatment and new techniques such as warm compaction can be applied to improve gear strength.

There are 10 different Distaloys (see table). "In general, the family is characterised by high strength, in particular high fatigue strength. Distaloys are also a very robust product group delivering good characteristics even in less than perfect processing conditions," says Mats Larsson. "This applies in particular to Distaloy AE, which is the biggest selling Distaloy product."

This improving sales performance points to Distaloy AE's ability to meet the requirements of new, often high-performance components. Distaloy AE is used in applications such as helical gears for electrical machines, and has proved a popular choice for new P/M parts such as synchronising hubs and sprockets.

"The diffusion bonding of the alloying elements nickel, copper and molybdenum gives Distaloy AE good mechanical properties with maintained compressibility and minimal segregation, and this allows the tighter tolerances that are becoming increasingly important in today's market," comments Mats Larsson.

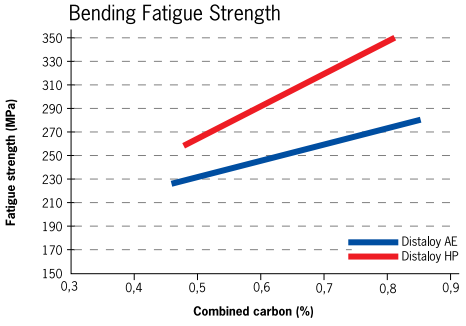
The fastest-growing Distaloys are the last three to be introduced, namely HP, DH and DC based on 1.5% pre-alloyed molybdenum material.

One of these fast-growing sellers, Distaloy DC (Dimensional Change), offers an important benefit for many applications. Mats Larsson describes it as: "A material that offers the same dimensional change irrespective of density. This solves problems where shape changes might otherwise occur due to density variations."

Distaloy HP (High Performance) as the name suggests offers the very high strength and fatigue strength that is increasingly in demand for enhancing component performance. "It has proved to be one of the best fatigue materials Höganäs AB produces," concludes Mats Larsson.

The Distaloy Family

	Base	Cu	Ni	Mo	Benefit
Distaloy AB	Atomized	1.5	1.75	0.5	
Distaloy AE	Atomized	1.5	4.0	0.5	High strength, robust
Distaloy AF	Atomized	2.0	5.0	1.0	
Distaloy SA	Sponge iron	1.5	1.75	0.5	Better edge strength
Distaloy DC	Atomized pre-alloyed with Mo	-	2.0	1.5	Dimensional change independent of density
Distaloy DH	Atomized pre-alloyed with Mo	2.0	-	1.5	
Distaloy HP	Atomized pre-alloyed with Mo	2.0	4.0	1.5	Very high strength and fatigue strength
Distaloy Cu	Sponge	10			Cu master Distaloy, better dimensional control
Distaloy Acu	Atomized	10	-	-	Same
Distaloy MH	Sponge	25	-	-	Same



THE LATEST ON THE SMC REVOLUTION

Recent developments in SMC technology including new ideas for SMC–Laminate hybrid motors will be spotlighted in a paper presented in Valencia.

The isotropic properties of Soft Magnetic Composites (SMC) open up possibilities to produce innovative 3-D designs for electric motors, but what direction should SMC technology take?

In their presentation at Euro PM2003, **Soft Magnetic Iron Powder Materials AC Properties and their Application in Electrical Machines**, Lars-Olov Pennander of Höganäs AB and Alan Jack of the Drives and Machines Group, University of Newcastle upon Tyne, U.K. will give a highly informative overview on the progress of the SMC revolution.

Lars-Olov Pennander says: "The aim of the paper is to provide a general and useful introduction to the SMC concept and its benefits for electric motor designers."

The core of the paper looks at three possible directions for SMC technology in electric motor design.

Firstly, a universal motor for a standard vacuum cleaner is used as an example to show how SMC can replace lamination in existing designs.

"In general, it is better to design for SMC from the "outside in", that is from the wider perspective of the complete system, rather than taking the "inside out" approach of just looking at laminate component replacement. But, there are cases where even this can bring improvements."

"For this universal motor, we could show that even though the iron core weighed more in the SMC design this was more than compensated for by a considerable reduction of the copper needed for the winding."

Secondly, SMC can be used in unique designs not suitable for the lamination technique such as claw-pole motors, and thus extend the applications of these motors into new areas.

Thirdly, SMC materials can be used in hybrid concepts together with lamination to exploit the unique benefits of both techniques. One cited example is a Hybrid SMC-Laminate switched reluctance motor (SRM) in which the SMC rotor and stator core-back is used for the connection of flux in between the two laminated stator and rotor sections.

"Designers are familiar with laminate solutions and switching to an SMC solution is a big shift," says Lars-Olov Pennander. "The hybrid area is very promising for SMC technology as it offers designers an easier entry into this new field, and perhaps it gives SMC materials a greater chance of inclusion in a system."

Hybrid motor

The paper also touches on the recent commercial breakthrough for SMC applications in Japan in ABS-type brake systems produced by Aisin Seiki Co Ltd. The motor is an example of successful optimisation obtained by choosing SMC materials, which brought benefits such as flux concentration, weight reduction and a more integrated design with fewer parts.

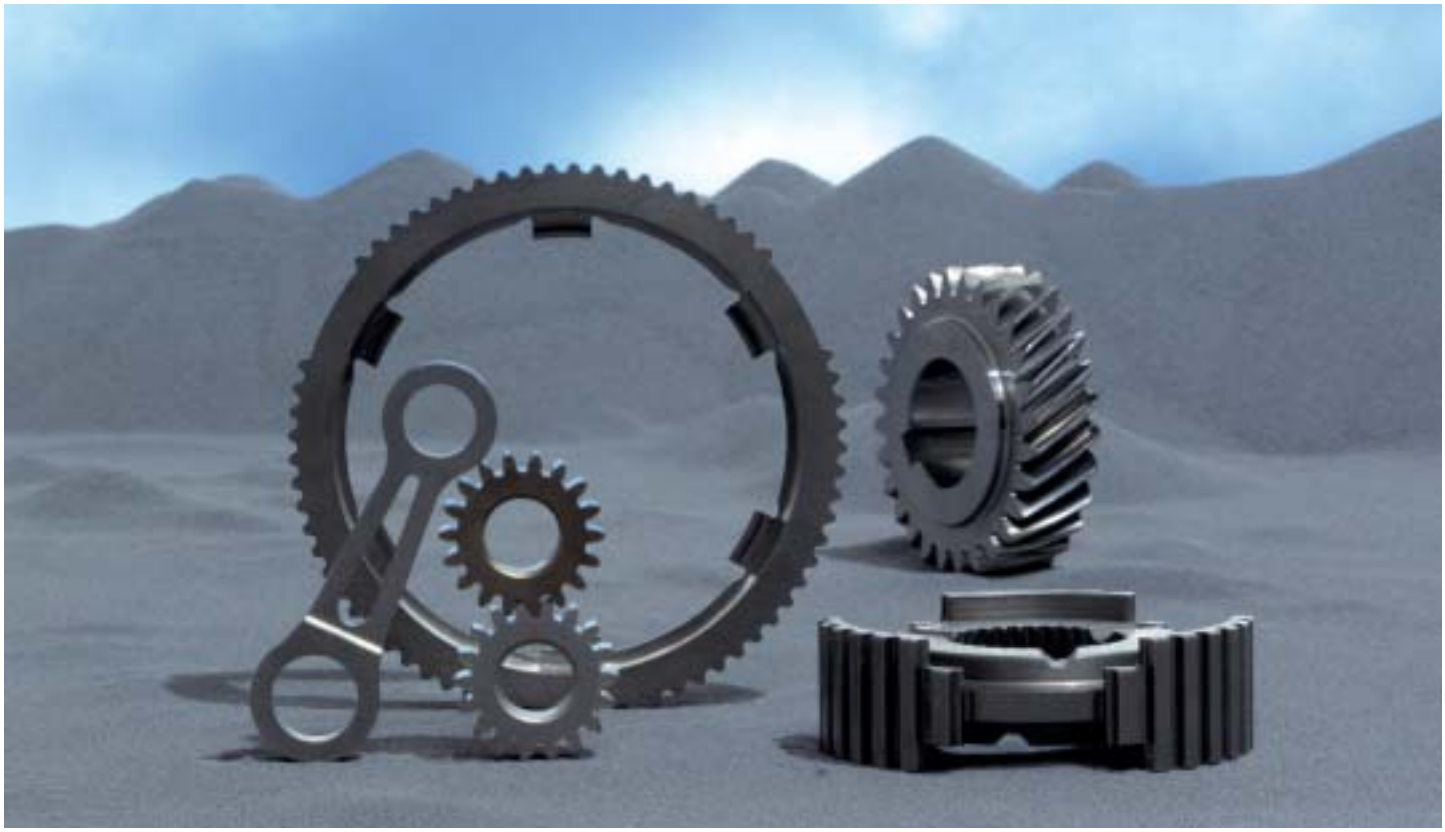
"This breakthrough in Japan shows the willingness of that market to embrace new technology. In Europe, SMC technology is also moving forwards and I hope that our paper will further stimulate that progress by showing the new possibilities that SMC materials offer," concludes Lars-Olov Pennander.

Focus on SMC technology

Höganäs AB launched the first SMC materials in 1993 and has been the leading R&D force in this specialised field ever since.

The Group is driving SMC technology forward through technical development of materials and processes for new components. Cooperation with end users is considered an essential element in establishing SMC technology.

The Höganäs Group is currently involved in more than 40 projects with manufacturers of electrical machines, primarily motor producers.



TECHNICAL PRESENTATIONS

AT THE EURO PM2003 CONFERENCE, VALENCIA, OCTOBER 20-22

MONDAY OCTOBER 20

Ferritic Stainless Steel for High Density Applications
Höganäs AB
Ricardo Canto Leyton

Press Capacity Improvements Utilizing Starmix Powder
Höganäs AB
Daniel Edman
Hilmar Vidarsson

TUESDAY OCTOBER 21

Chromium-Alloyed PM Steels with Excellent Fatigue Properties Obtained by Different Process Routes
Höganäs AB
Ola Bergman

Rolling Contact Fatigue Design Aspects of Surface Densified PM Components
Höganäs AB
Linnea Fordén
Sven Bengtsson
Fraunhofer-Inst. Darmstadt
Klaus Lipp, C.M. Sonsino

Soft Magnetic Iron Powder Materials AC Properties and their Application in Electrical Machines
Höganäs AB
Lars Olov Pennander
University of Newcastle
Alan G Jack

Microstructure Enhancement for Fatigue Improvement
Höganäs AB
Anders Bergmark

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Published by Höganäs AB, SE-263 83 Höganäs, Sweden, Phone +46 42 33 80 00, Fax +46 42 33 81 50, www.hoganas.com