Höganäs

SPECIAL ISSUE
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POWDER NEWS

Best case scenario for Starmix®

The benefits of Starmix® are fully highlighted in an extensive new case study run under production conditions in cooperation with an Italian component manufacturer.

Using Starmix®, a mix bonded with organic binder, led to a substantial productivity and weight scatter improvement in a substitution programme for four belt pulleys.

The case study will be presented at PM2006 as *Reduced Weight Scatter with Bonded Powder Mixes* by Daniel Edman, Mats Larsson, Luigi Alzati (Höganäs AB) Riccardo Crosa (Höganäs Italia S.r.l.), Giovanni Pozzi and Carlo Frediani (Metalsinter S.r.l.).

This presentation examines a powder substitution programme involving successful cooperation between Höganäs and the Italian company, Metalsinter S.r.l. based in Seregno near Milan. Metalsinter was established in 1969 and specializes in shaped parts such as gears, pinions, flanges and pistons for a wide range of applications.

Starmix® was a replacement for the existing premix iron-copper-carbon material being used to produce belt pulleys. Metalsinter began producing belt pulleys made from a tailored Starmix® composition in the autumn of 2005 and is now using one new composition customized for different geometries in the family of components.

"I think this is one of the best test cases, if not the best, showing what can be achieved with Starmix®. It is a very ambitious study carried out under commercial manufacturing conditions with long production runs and examines a number of different components. It is unusual to have access to production data to this extent," says Mats Larsson of Höganäs, who will be giving the presentation in Busan.

Starmix®, an optimizable bonded mix, is increasingly replacing premixes by offering opportunities to improve efficiency and productivity as well as obtain tighter tolerances. Starmix® achieves this by bonding fine particular additives to reduce segregation and enhance filling performance.

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Substantial cost savings

As the study at Metalsinter examined a substitution programme in normal production, the number of parts analysed for each mix and component type varied between 2,500 and 24,000.

The bonding of light additives and optimization of Starmix® to avoid erractic flow patterns and bridging effects provided a weigh scatter reduction of more than 50%.

"For the fourth belt pulley a weight of +/-1.5% from nominal weight was acceptable," states Mats. "Based on experience, parts outside the range are considered as waste, due to tolerance and density demands. In a run of 24,000 compacted parts made from the premix, 2% were outside the acceptable range and therefore discarded. However, when using Starmix® all the parts were within the acceptable range. The reduction in scrap is a direct cost saving and the general quality improvement is an important competitive parameter."

In addition to cost savings due to better material utilization, the superior filling characteristics of Starmix® allowed a shorter filling sequence, which increased productivity.

"The parts made from Starmix® were pressed at 12 strokes per minute compared with 10 for the premix, representing a 20% productivity increase," explains Mats. "And if unplanned stops in production and rejected parts are factored in the productivity difference was actually even higher."

"These results confirm the improvements that can be made by switching to Starmix®," emphasizes Mats. "The combined benefit of increased productivity and better material utilization shows it is possible to make a considerable cost saving in the press operation."

Drawing of belt pulley produced by Metalsinter.

ENHANCE PERFORMANCE with high-temperature sintering

The latest sintering research from Höganäs gives a greater insight on atmosphere requirements and performance gains for chromium-alloyed materials sintered at a range of higher temperature levels.

High-temperature sintering has been shown to be especially effective for enhancing the properties of oxidation-sensitive chrome materials such as Astaloy CrM® and Astaloy CrL™ – materials that are attracting increasing interest from makers of components for high-performance applications.

A new study relating to this area: *Influence of Sintering Parameters on the Mechanical Performance of PM Steels Pre-alloyed with Chromium* by Ola Bergman, Sven Bengtsson (Höganäs AB) and Björn Lindqvist (Tech Center, Höganäs (China) Ltd) will be presented at PM2006.

"We want to support our customers both in terms of the process and material in order to help them achieve characteristics that are as good as possible," says Ola Bergman. "A lot of customers ask us about how different process parameters affect properties and this is the principal reason behind doing this new study on high-temperature sintering. As chrome-alloyed powders are newly developed, it is especially important to provide good process support for these materials."

"There has been previous research on high-temperature sintering of chromium-alloyed materials at 1120 and 1250° C, and our new paper extends our knowledge by showing the effects of sintering at intermediate temperatures," continues Ola. "Quite simply, we wanted to show what one can gain by moving away from the traditional sintering temperature for these materials of 1120° C to higher temperatures."

Two water-atomized powder grades pre-alloyed with chromium and molybdenum, Astaloy CrM® and Astaloy CrL™, were studied at a range of sintering temperatures. The study found that the ultimate tensile strength of sinter-hardened Astaloy CrM® (with 0.6 wt% graphite added) at density 7.1 g/cm^3, increases from 1330 MPa after sintering for 30 minutes at 1150 °C to 1470 MPa after sintering for 30 minutes at 1250 °C.

Summing up the study's major findings, Ola says: "What we can conclude is that mechanical properties of the Cr-alloyed P/M grades are enhanced by a higher sintering temperature in the range 1120-1250 °C, due to the positive effects from pore rounding, increased density and more effective oxide reduction."

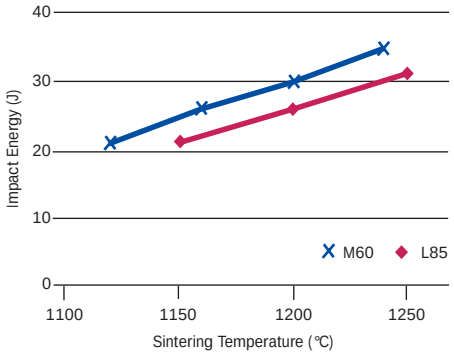
"Of course one can still get very good properties when you use the standard sintering temperature," stresses Ola. "High-temperature sintering is a very useful method if one wants to achieve even better properties for a high-performance component."

Creating the right atmosphere

Pre-alloyed chromium materials can be successfully sintered in conventional mesh-belt furnaces at 1120 °C in well-monitored atmospheres with low oxygen contents. The presentation also offers guidance, with the help of thermodynamic calculations, on sintering atmosphere requirements at higher temperatures.

Achieving the right atmosphere for high-temperature sintering is not a complicated matter, according to Ola: "Naturally, it is important that producers are aware of the conditions needed, but we can give recommendations to customers for optimizing the atmosphere for specific oven conditions to enable oxide reductions."

The study showed that at higher sintering temperatures more oxygen can be allowed into the atmosphere without creating oxidizing conditions. "One of the advantages of raising the sintering temperature is that you can use a more oxygen-rich atmosphere," Ola points out. "More oxygen means that the atmosphere is easier and less expensive for the component manufacturer to maintain during sintering."



Impact strength obtained after pressing to 7.0 g/cm^3 and sintering at different temperatures for 30 minutes in 90N2/10H2. M60 was sinter-hardened while conventional cooling was used for L85.
M60 = Astaloy CrM® + 0.6% graphite
L85 = Astaloy CrL™ + 0.85% graphite

Smart solutions for sharp notches

What is the best P/M material and process route for a target component with sharp notches? New insight on notch-friendly microstructures makes it easier than ever to find the optimum solution for specific applications.

Höganäs initiated focused activities on fatigue performance in 2001 and began to map the microstructure and fatigue behaviour of P/M materials in minute detail. Applied research work has progressed, building up a unique fatigue knowledge bank. Two years ago, fatigue testing started on notched bars in addition to un-notched bars. This new line of comparative research was based on the fact that many P/M parts have sharp notches, and an optimised material must be able to tolerate the high stress concentration in the notch root. Results from these tests are more relevant to component design, making it simpler and faster for customers to find the best material and process route for their requirements.

The latest notch-related fatigue findings from Höganäs will be revealed at the PM2006 World Congress in a technical presentation called: *Controlled Microstructure for Optimum Fatigue Performance* by Yoshinobu Takeda (HJKK Höganäs Japan) Anders Bergmark, Sven Bengtsson and Luigi Alzati (Höganäs AB).

This presentation examines specific notch radii applicable to important component groups: sharp notches below 0.25 mm notch radius (synchronizer hubs) and a larger notch radius of 1-3 mm (small spur gears and sprockets). The materials compared were the diffusion-alloyed powders, Distaloy® AE and HP, and the pre-alloyed products, Astaloy CrL™ and Astaloy CrM®.

Easier material selection

Yoshinobu Takeda of HJKK Höganäs Japan says: "In the past we have generated a lot of fatigue data, but our customers have not necessarily been able to automatically select the best material for their specific application from this."

"The new research on notch sensitivity has given us an insight on the materials and process routes that create the martensite gradient necessary for components with sharp notches," he continues. "This is very important in the Japanese market where customers are looking for solutions for complex, high-performance parts. We want to give our customers clear mapping or guidance to select the necessary microstructure, and our results provide the knowledge that can help us guide our customers to the right alloy for their target applications."

Höganäs research on notched test bars has been particularly illuminating on the fatigue profile of Distaloy® AE and HP, as they perform better in notched condition in comparison to pre-alloyed materials.

"From these findings we are now in a position to recommend, for instance, that Distaloy® AE or HP would be highly suitable if a target component is a synchronizer hub with very sharp notches in the region of a 0.25mm notch radius," states Yoshinobu.

Anders Bergmark, a specialist on fatigue performance at Höganäs, adds: "The presentation at PM2006 World Congress will show that we can now deliver more component-related fatigue knowledge and we know from our customers that there is a demand for this. Research must be related to the reality of the customer."

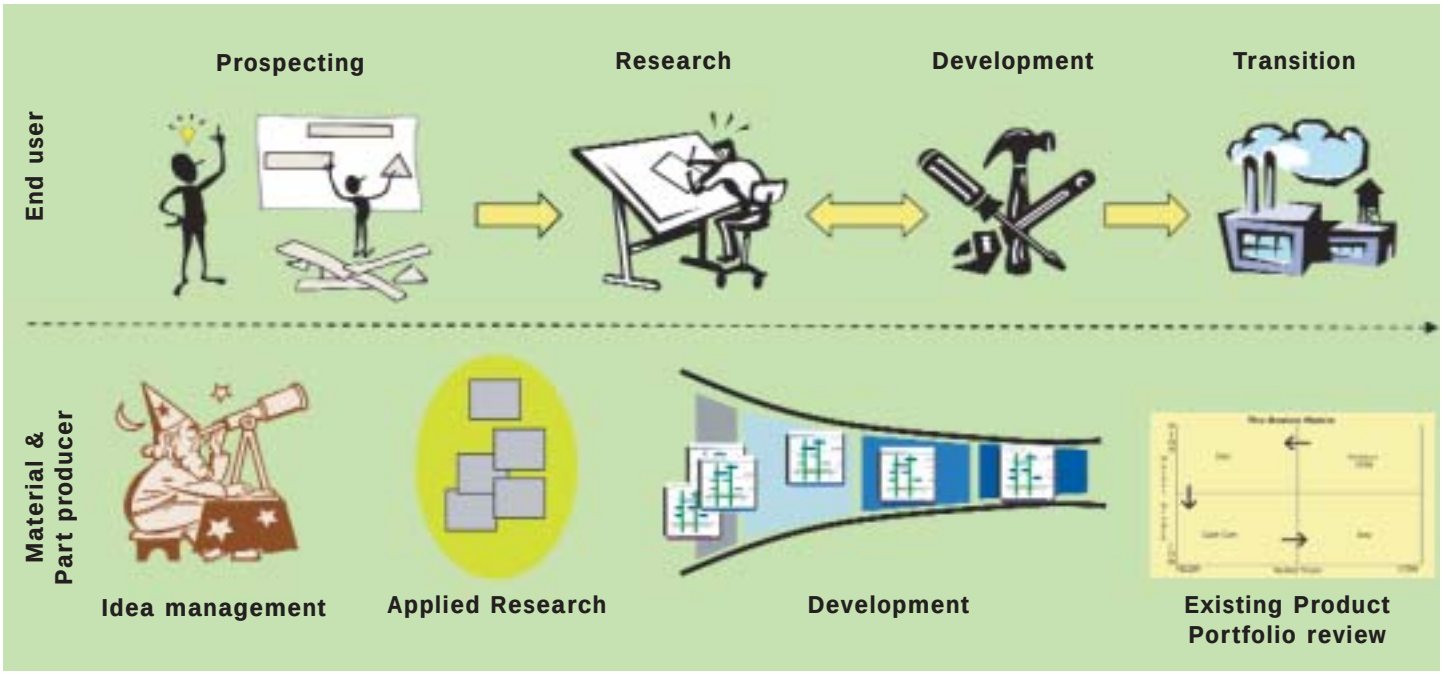
Key findings

- Diffusion-alloyed materials (Distaloy® AE and HP) can be used in as sintered condition, with no secondary operations, for parts with sharp notches such as synchronizer hubs.
- Pre-alloyed materials (Astaloy CrL™ and Astaloy CrM®) can be used for parts with sharp notches, but secondary operations, such as case hardening or shot peening, are recommended in order to create sheltering compressive residual surface stresses.
- Shot peening (SP) has also been shown to be very effective in improving the performance of diffusion-alloyed materials.

Material	UN	N0.9	N0.25
Distaloy® AE+0.8C	275 (10)	212 (4)	168 (<3)
+SP	322 (10)	306 (12)	284 (9)
Distaloy® HP+0.8C	322 (10)	243 (12)	188 (6)
+SP	397 (17)	355 (33)	339 (<5)
Astaloy CrL™+0.8C	296 (21)	190 (<5)	117 (<4)
+SP	335 (<8)	298 (<5)	285 (11)
Astaloy CrM®+0.45C 1250° C, SH	NA*	NA*	145 (8)
Astaloy CrM®+0.45C 1120° C (+methane) SH	437 (14)	308 (20)	234 (7)

* Not Available

Fatigue limits of un-notched and notched test bars [MPa].
Standard deviations are given within brackets.
SP: shot peening
SH: sinter hardening cooling rate approx. 2oC/sec.



Three-way cooperation is vital FOR P/M INDUSTRY GROWTH

The growth potential of P/M steels in new component applications can be fully realized if there is increased cooperation on development projects between powder suppliers, component makers and end users.

There is a wealth of evidence already available on the excellent performance of P/M steels. However, this seems insufficient to persuade some end users to switch from wrought steel. New efforts and cooperative initiatives are needed to convince component users that P/M steels are the best choice for specific applications. This is the theme of *PM Steels Approaching the Performance of Wrought Steels,* a presentation by Jan Tengzelius at the PM2006 World Congress.

"The issue we should be addressing is not whether P/M steels can reach the strengths of conventional steels," says Jan. "High performance from P/M steels has been proved by a vast amount of data supplied not only by us, but also by other organizations and research institutions. The question we should be asking is why more end users are not taking advantage of the data and using these materials in day-to-day production."

"We know that powder metallurgy manufacturing technology does not only achieve high strength levels, but can do it as a cost-efficient process in long production series," Jan continues. "We want to work to a greater extent on new applications that can generate growth and we believe cooperation is the key. The potential is there for substantial expansion, but we have to make efforts to establish the right conditions for growth".

Jan has identified four conditions for growth through cooperation:

Close cooperation between designers, part manufacturers and powder producers.
"It is essential to work in close cooperation within the whole chain from the powder supplier and component maker to the end user. It is clear that the best results come from three-way cooperation. In particular, getting component end users involved in three-way development projects means they can gain confidence in P/M solutions for specific applications."

Cooperative development at an early stage.
"Getting involved early in component development is crucial. The design potential of P/M technology should be considered at an early stage in development. At a later stage in the design process there are only limited opportunities to influence the design and utilize the advantages of P/M technology."

Focusing on specific applications.
"By focusing on specific applications we can concentrate on benefits relevant to the component rather than general arguments. Making a comparison with wrought steel solutions can be complex and the value of P/M for a new application may vary from case to case. Cooperation enables us to show and deliver project-specific advantages. The P/M advantage might be cost-efficient high-performance, a design solution only possible using P/M steel or the total cost comparison with an alternative technology. It could be a combination of all these."

Establish reliable component design data.
"If we get involved early in a project and can focus on a specific application, we are then in a position to generate the data that a designer needs for the target component. Again, the best way to achieve this is cooperation, by talking to the designer and finding out what he really needs to do his job. By working closely with the component maker and powder producer, the designer can then optimize the design and manufacturing process to achieve the desired level of quality".

REDESIGN REVEALS
SMC benefits for BLDC motors

A new study shows the competitive advantages gained from redesigning the stator of a BLDC motor using SMC technology.

The isotropic nature of Soft Magnetic Composites (SMC) opens up new 3-D design possibilities for designers of magnetic circuits in electrical machines. SMC technology is now being used in a wide range of commercial electric motors, and a new study shows how it can be successfully applied to improve the design of a laminated BLDC motor for a scroll-compressor application.

This collaborative study between Höganäs and the Dept. of Electrical and Electronic Engineering at the University of Newcastle upon Tyne, is the latest in a series on SMC-based BLDC motors.

"In the past our research has pointed to the opportunities and benefits of SMC-based BLDC motors in general terms," says Mats Persson, Area Manager – Market Development SMC Technology for Höganäs. "Now, we are moving on to benchmark Somaloy® technology in a specific commercial application. We have taken a state-of-the-art commercial motor in widespread use – a high-performance laminated BLDC unit – and improved it using SMC design to make it more competitive. I think the results will be of great interest to the designers and makers of BLDC motors."

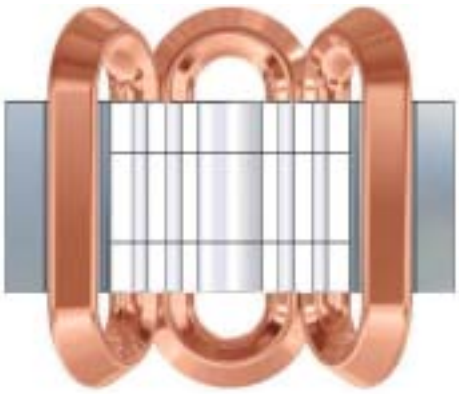
The results are released for the first time in a presentation at PM2006 entitled *Development of Somaloy Components for a BLDC Motor in a Scroll Compressor Application* by Mats Persson, Göran Nord, Lars-Olov Pennander (Höganäs AB) Glynn Atkinson and Alan Jack (Dept. of Electrical and Electronic Engineering, University of Newcastle upon Tyne)

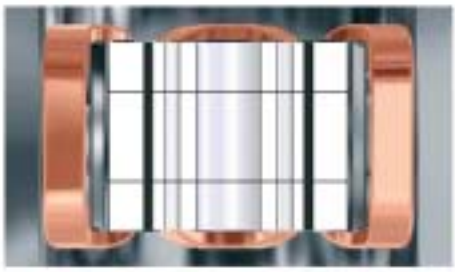
A successful outcome

Electric scroll-compressor drives, commonly used in home appliance cooling units and increasingly in vehicle air conditioning systems, require a highly efficient motor.

The basis of the study was to use the same rotor technology as the original laminated motor and then identify an SMC stator design that would at least match it within the same size of envelope. A successful outcome was judged to be achieving equal or better performance with a smaller motor.

Comparison of laminated and Somaloy® motors. The cut view illustrates the compactness of the Somaloy® design.





Somaloy® materials, including the newly developed Somaloy® 3P material, were used in the design process for the SMC-based machine.

Operating at 3360rpm, the laminated motor delivered 2.1 Nm of torque at an efficiency of 91.2%. The SMC version was designed to match this speed, torque and efficiency. In addition, it was possible through the design possibilities of SMC to shorten the total axial length from 95mm to 60mm and reduce the copper mass from 762g to 533g.

"This is a particularly good target application for SMC technology as there is good growth potential for BLDC motors in air conditioning compressors," says Mats. "However, it was also a challenging application as the high-grade laminates in the existing motor meant the core losses were already quite low. The motor's low electrical frequency of 112 Hz also presented a challenge, as in general SMC solutions become more competitive at higher frequencies."

"Despite these challenges, we have succeeded in achieving the key objectives. The study has shown that a 3-D SMC design matched the performance of the laminated original, but in a smaller envelope," concludes Mats.

Key findings

Redesigning the laminated stator of a high-performance magnet motor using Somaloy® materials and the 3-D possibilities of SMC design:

- delivered better or equal performance
- produced a motor 30% shorter in length
- used 30% less copper in the winding.

TECHNICAL PRESENTATIONS

AT THE PM2006 WORLD CONGRESS, BUSAN, SEPTEMBER 25-27

Monday September 25

Controlled Microstructure for Optimum Fatigue Performance

Höganäs Japan KK
Yoshinobu Takeda

Höganäs AB
Luigi Alzati, Anders Bergmark, Sven Bengtsson

Tuesday September 26

Influence of Sintering Parameters on the Mechanical Performance of PM Steels Pre-Alloyed with Chromium

Höganäs AB
Ola Bergman, Sven Bengtsson

Höganäs China Ltd
Björn Lindqvist

Correlation between Component Fatigue Performance and Results from Plane Bending Fatigue Tests on Notched Samples

Höganäs AB
Anders Bergmark, Senad Dizdar, Sven Bengtsson

PM Steels Approaching the Performance of Wrought Steels

Höganäs AB
JanTengzelius

Wednesday September 27

Reduced Weight Scatter with Bonded Powder Mixes

Höganäs AB
Daniel Edman, Mats Larsson, Luigi Alzati

Höganäs Italia S.r.l.
Riccardo Crosa

Metalsinter S.r.l.
Giovanni Pozzi, Carlo Frediani

Improved Consistency and Productivity by Aeration Filling Technology and High Performance Powder Mixes

Höganäs Japan KK
Yoshinobu Takeda

Höganäs AB
Mats Larsson, Naghi Solimanjad, Mikael Dahlberg,

Toyota Central R&D Labs.
Mikio Kondoh

Development of Somaloy® Components for a BLDC Motor in a Scroll Compressor Application

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Mats Persson,Göran Nord, Lars-Olov Pennander

University of Newcastle Upon Tyne
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