Hoeganaes Corporation: A global leader in metal powder production targets Additive Manufacturing

The growth in metal Additive Manufacturing has attracted a wide range of companies to enter the market to supply metal powders, however few have the track record of Hoeganaes Corporation in the production of powders for industrial parts production. In the following article the company reports on the development of gas atomised titanium powders for metal AM, along with the its ambitions to introduce more cost effective water atomised powders that have the potential to help the industry move towards higher volume production.

Hoeganaes Corporation is a recognised global leader in the production of metal powders for the production of structural components, with six metal powder manufacturing facilities in the United States, Europe and Asia. The company recently completed a $5 million investment in its Innovation Center in Cinnaminson, New Jersey, USA, with the primary purpose being the development of a new generation of advanced metal powders for Additive Manufacturing. State-of-the-art equipment, including a new gas atomisation facility, has been installed in the new Innovation Center as the company makes progress towards its goal of the development of long-term, sustainable production of high-quality cost effective powders for metal Additive Manufacturing.

Commenting on the main drivers behind the expansion into powders for metal Additive Manufacturing, Hoeganaes’ Global Director of Business Development for Additive Manufacturing, Richard Kallee, told Metal Additive Manufacturing magazine, “Hoeganaes Corporation continually benchmarks new technology for the use of metal powders. Following an evaluation of the technical challenges and market expectations, metal powders designed specifically for AM were identified as a growth market. Based on this analysis, we developed a strategy for the supply of powders for Additive Manufacturing.”

Fig. 1 Exterior view of the Hoeganaes Innovation Center in Cinnaminson, New Jersey
Hoeganaes believes that the combination of its new Innovation Center and long track record in metal powder production puts it in a strong position to serve the growing metal AM industry. Mike Marucci, Vice President for Advanced Engineering, commented, “We believe that the biggest advantage that the Innovation Center provides is the people. Hoeganaes has been a leading powder manufacturer for decades and our Innovation Center has people that have worked in developing powders driving various markets for more than 40 years. Additionally, a new wave of engineers are now in the process of working with various AM platforms to better support our customers. These people and their experience provide a formidable support team for launching products into a new market such as AM.”

The new Innovation Center not only includes water and gas atomisers, but also state-of-the-art AM production equipment and a laboratory that includes advanced image analysis systems and scanning electron microscopy as well as mechanical and chemical testing. Marucci stated, “Hoeganaes is working with several industry leaders on materials development for selective laser melting, electron beam melting, and binder-based AM technologies. However, as AM process development will be primarily part-specific, we believe our customers will work on developing the process to suit their product and Hoeganaes can provide the support to develop the powder properties and ideal alloys required.”

**Titanium powders for AM**

Thanks to high levels of interest from the aerospace and medical sectors, titanium is proving to be one of the leading materials behind the surge in the growth of metal Additive Manufacturing. Additive Manufacturing is recognised as a key technology that can take advantage of titanium’s unique properties such as its high strength to weight ratio, excellent corrosion resistance and biocompatibility, whilst bypassing the high cost of machining complex shapes from wrought material. Titanium powder, however, is challenging to produce and metal Additive Manufacturing not only requires powder with extremely high levels of purity, but also powder with specific shape and size specifications to enable the stable and repeatable production of the highest quality parts.

Hoeganaes introduced its AncorTi™ titanium powder earlier this year. AncorTi is a gas atomised spherical Ti6Al4V powder for Additive Manufacturing applications, however it is also suitable for Metal Injection Moulding (MIM) and Hot Isostatic Pressing (HIP) processing. Titanium’s high strength to weight ratio, corrosion resistance and biocompatibility makes it a perfect candidate to manufacture parts for aerospace, medical, chemical and marine applications. “Ti6Al4V is the most commonly used titanium alloy and is offered by Hoeganaes in a range of particle sizes and purities including those that meet ASTM specifications. Of course, all our products are subjected to rigorous quality testing,” stated Marucci.

Hoeganaes is currently offering...
AncorTi in Grades 5 and 23, with three particle size distributions engineered for Selective Laser Melting (SLM) and Electron Beam Melting (EBM) AM platforms and customer applications. Commercially Pure (CP) titanium is also available. “We are currently focused on supplying the aerospace and medical markets with our AncorTi products. We see both of these industries as the main drivers of metal AM manufacturing and we are excited to collaborate with them to develop a new standard for these powders and processes,” stated Kallee. “Our experience of meeting the high demands for quality in the automotive industry gives us a decided advantage in supplying mission-critical materials to these markets. To that end, Hoeganaes will be AS9100 certified by the end of 2015.”

Quality control in Additive Manufacturing

When it comes to metal Additive Manufacturing processes, Hoeganaes believes that there needs to be a much more holistic approach to understanding and improving process quality. “It is crucial to have a comprehensive understanding of the complete process chain, from powder manufacturing through to AM processing and product performance evaluation,” stated Kallee. “Since Hoeganaes has over fifty years of experience in the development of metal powder for part production, our research engineers have the depth of understanding to develop optimal manufacturing methods for AM powders, from melting and atomising through to shape control, screening and classification.”

Hoeganaes has identified a number of key quality issues that needed to be addressed by the industry in relation to the metal powders used in AM. The issues include unexpected alloy inclusions, gas inclusions, particle size variations and alloy content deterioration. The company has also cited storage and transportation dependent shelf life variations, as well as humidity and climate variation, as important factors.

These issues, state Hoeganaes, can cause inconsistent spreadability in powder bed AM systems, leading to process instability, inclusions or pores, gas entrapments causing pores directly or indirectly by laser scattering in smoke, and certain element inclusions causing crack initiation sites during fatigue cycling.

Ferrous powder grades: reducing costs with advanced water atomisation technology

Hoeganaes has been involved in the gas atomisation of metal powders since the 1960s, making alloys for applications such as thermal spray, powder coating, brazing and filters.

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### Table 1 AncorTi Ti6Al4V chemical analysis (weight %)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Grade 5</th>
<th>Grade 23</th>
<th>Grade 5</th>
<th>Grade 23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>5.50-</td>
<td>5.50-</td>
<td>3.50-</td>
<td>3.50-</td>
</tr>
<tr>
<td>V</td>
<td>6.75</td>
<td>4.50</td>
<td>6.75</td>
<td>4.50</td>
</tr>
<tr>
<td>C</td>
<td>0.08</td>
<td>Max</td>
<td>0.08</td>
<td>Max</td>
</tr>
<tr>
<td>Fe</td>
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<td>Max</td>
<td>0.40</td>
<td>Max</td>
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<tr>
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<td>Max</td>
<td>0.05</td>
<td>Max</td>
</tr>
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<td>Max</td>
<td>0.015</td>
<td>Max</td>
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<tr>
<td>O</td>
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<td>Max</td>
<td>0.015</td>
<td>Max</td>
</tr>
<tr>
<td>Ti</td>
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<td>Max</td>
<td>0.13</td>
<td>Bal.</td>
</tr>
<tr>
<td>Bal.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### Table 2 Particle Size Distribution of AncorTi Ti6Al4V (particle size measurements were performed using Sympatec Laser Particle Size Determination)

<table>
<thead>
<tr>
<th>Particle Size Distribution (micrometers)</th>
<th>Grade A</th>
<th>Grade B</th>
<th>Grade C</th>
</tr>
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<tbody>
<tr>
<td>d_10</td>
<td>7-17</td>
<td>29-34</td>
<td>48-58</td>
</tr>
<tr>
<td>d_50</td>
<td>27-37</td>
<td>41-46</td>
<td>68-87</td>
</tr>
<tr>
<td>d_90</td>
<td>40-50</td>
<td>55-60</td>
<td>97-125</td>
</tr>
</tbody>
</table>

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It is crucial to have a comprehensive understanding of the complete process chain, from powder manufacturing through to AM processing and product performance evaluation.”

Hoeganaes indicates that it has already developed standardised tests for issues such as powder internal porosity, powder cleanliness (i.e. non-metallic inclusions), contamination, flowability and shape. “All of these process developments will help support the advances that are being made in 3D platforms for printing metals. As machine processing times continue to improve and new technologies are introduced for in-process inspection, we believe that it is essential that metal powder producers also maintain rapid product development at the vital powder end of the equation.”

Since the late 1990s, however, the company has produced finer powders that were conventionally made by gas atomisation through a proprietary high-pressure water atomisation process. As water causes surface oxidation during the atomisation process, which is removed from the powders during a post process, the technology is most suitable for iron-based material in the automotive industry.

Generally, gas atomised powders have been preferred for Additive Manufacturing because of the spherical nature of the particulate.
Water atomisation is, however, the most common and economical technique to produce metal powders. Water atomisation, due to the rapid cooling rate, produces powders that are irregular in shape. In addition, the high water pressures impact more energy into the molten metal stream leading to the rough shape of the powder particles. This irregular shape is less desirable for AM because it increases the flow time and possibly reduces the packing density. However, if a low water to metal ratio is used in the water atomisation process, along with a high pressure, a spherical powder with a particle size distribution optimised for Additive Manufacturing can be produced [1].

Hoeganaes works with its customers to determine the correct parameters necessary for a powder to allow it to work for each manufacturing platform. The company has seen powders from 15 micron to 60 micron, both irregular and spherical, all successfully used in AM processes. It believes that the key is to ensure the economics exist from powder production through to part production and the successful introduction of a final product to market. “The key is to work together to determine the characteristics of the powder that work best,” stated Kallee.

“Hoeganaes is currently supplying a range of water atomised powders to the AM industry as the various AM processes require powders with different properties, including powders that are nearly as spherical as gas-atomised powders. In general, water atomised powders are lower cost than gas atomised powders, but each application is different and the AM industry is still defining the optimum particle size and properties. Eventually, this will dictate the final value of water atomised powders based on the yield that can be achieved,” stated Marucci. “Many powders that had been gas atomised are now made through this process, such as powders for Metal Injection Molding and Metal Matrix Composites, and now some powders for Additive Manufacturing.”

Outlook

As a leading supplier to the global automotive industry, Hoeganaes is keen to advance the development of water atomisation technology for AM iron powders and it has launched research programs with key customers. However, Hoeganaes states that the business cases for automotive applications require a step-change improvement in processing to make the commercial benefits of water atomisation substantial enough to drive the market beyond low volume production.

Marucci concluded, “We have the powders, technology, quality systems and people to work on demanding application programs with world class customers, both for gas atomised powders such as titanium and for advanced water atomised powders. We are already established as a market leader in metal powder production, with the knowledge base, global network and commitment to high-quality, sustainable AM powder. We believe that this makes us an ideal solution provider at the forefront of this innovative and rapidly growing AM industry.”

Contact

Paul Taylor
Account Manager, Specialty Products
Hoeganaes Corporation
1001 Taylors Lane, Cinnaminson, NJ 08077
USA
Tel: + 1 610 927 7294
Email: paul.taylor@hoeganaes.com
www.hoeganaes.com

References


Fig. 4 (a) SEM image of water atomised iron powder and (b) typical particle size distribution of iron powder for Additive Manufacturing [1]