NUMANOVA: materials for the new industrial revolution

Metal Powder production for the Additive Manufacturing

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NUMANOVA SpA
General Manager, Executive Director and co-founder
• The new frontier of metallurgy
• International market trends and actors
• Metal Powders as the reference raw material for the new industrial revolution
• AM materials: present and near future
• How to be among market leaders technically?
NUMANOVA is an Italian company active in the production of high quality metal powders obtained from ferrous metals and non ferrous alloys to be used in Additive Manufacturing (3D printing), Metal Injection Molding (MIM), Hot Isostatic Pressing (HIP), surface engineering, laser cladding, sintering, etc. for the most demanding industrial sectors such as aerospace, energy, automotive, mechanics, naval, biomedical, and luxury. The Company is equipped with the most advanced production technologies based on gas atomization, vacuum induction melting and ceramic-free melting. Plasma Arc technologies and Electron Beam Melting processes will be also introduced as part of a fully integrated Supply Chain.
INTERNATIONAL MARKET TRENDS AND ACTORS
The metal powder market has varied applications in transportation & logistics, industrial, construction, electrical & electronics, and others. The increase in demand for powder metallurgy manufactured components has driven the growth of the metal powder market. Growing demand for sustainable products due to the need for reducing the environmental impact of the metal industry has resulted in the increase in the demand for metal powder. The growing preference of metal powder for sustainable and innovative production and manufacturing technologies will also drive this market. Non-ferrous metal powder is expected to grow due to the demand from existing and emerging end-user industries.

The market for metal powder is observed to be matured in developing economies such as Europe and North America. The reason behind this is the high disposable income. The Asia-Pacific region is projected to be the fastest-growing market with the highest CAGR of 5.0% during the forecast period. North America accounted for the largest market a share of 40.4% in 2014. The global market for metal powder is projected to grow at a CAGR of 3.8% from 2015 to 2020 and is projected to reach USD 4,062 Million by 2020.

The metal powder market will be driven by the demand from end-use industries and technological advancements. The development of economies plays an essential role in increasing the demand for metal powder in the global market. The key parameters that determine the growth of metal powder in developing economies include:

- Demand from end-use industries
- Technological advancements
- Development of economies
- Growth in demand for sustainable products
- Increasing preference for innovative production and manufacturing technologies

### Metal Powder Market Size, by Type, 2015-2020 (USD Million)

<table>
<thead>
<tr>
<th>Type</th>
<th>2015-2020 CAGR</th>
<th>2015-2020 Market Size (USD Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferrous Metal</td>
<td>3.8%</td>
<td>2,000</td>
</tr>
<tr>
<td>Non-Ferrous Metal</td>
<td>5.0%</td>
<td>1,000</td>
</tr>
<tr>
<td>Others</td>
<td>2.8%</td>
<td>500</td>
</tr>
</tbody>
</table>

Note: E - Expected, P - Projected
Others include silver, platinum, and gold

Source: MarketandMarket Analysis
METAL POWDERS FOR AM

The boom in additive manufacturing will drive significant growth in the area of metal powders optimized for use with 3D printers, according to a new industry report and forecast titled “Additive Manufacturing Opportunities in the Metal Powders Industry”.

The metal powder industry, historically serving traditional powder metallurgy production techniques, is embracing additive manufacturing as a growing source of demand over the next ten years, with demand for metal powder used for 3D printers growing to 4.8 million kilos in 2023.

The expectations are that 3D printing/additive will consume around $520 million in metal powders by 2019 growing to $930 million by 2023. Leading the development of manufacturing metals parts with metal powders has been the aerospace industry, which expects to consume around $150 million in 3D metal powders by 2019. Meanwhile, the use of metal printers in service bureaus are creating more and more demand for metal powder material, as bureaus seek highest possible utilization rates for their printers to control manufacturing costs. By 2019, service bureaus are expected to consume almost $100 million in metal powders for 3D printing.

The supply chain for metal powders for additive manufacturing is potentially robust, as production processes for metal powders have been utilized for decades, with hundreds of thousands of tons of powder being supplied to manufacturers across the globe each year. Despite the perception that 3D printable powders themselves are difficult to produce, powder suppliers actually understand the

The future is very encouraging for metal powders for use in 3D printing, however, as extensive investment in R&D for self-monitoring and reporting in metal 3D printers is taking place. This will lead to quicker qualification of metal parts printed via additive manufacturing in high value applications.

Total AM Metal Powder Demand by Industry (Kg)

Source: SmarTech Markets report “Additive Manufacturing Opportunities in the Metal Powders Industry”
**THE INTERNATIONAL ARENA**

**Leading Metal Powder Special Steel producer by Region**

<table>
<thead>
<tr>
<th>Region/Country</th>
<th>NA</th>
<th>STS</th>
<th>ATS &amp; HSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>ATI, CarTech, SMC</td>
<td>North American Höganäs, GKN Höganäs, CarTech</td>
<td>Crucible, CarTech</td>
</tr>
<tr>
<td>Europe</td>
<td>Aubert &amp; Duval, Erasteel, Sandvik/Metso</td>
<td>CarTech, Sandvik/Metso, Erasteel</td>
<td>Bonfer Uddeholm, Erasteel, Höganäs</td>
</tr>
<tr>
<td>Asia</td>
<td>Sanyo Special Steel, Metal Technology, Daido</td>
<td>Jiangxi Yuean Superfine, Advanced Technology Materials, Daido</td>
<td>Daido, Sanyo Special Steel, Hitachi Metals</td>
</tr>
<tr>
<td>ROW</td>
<td>Visc</td>
<td>DSS</td>
<td></td>
</tr>
</tbody>
</table>

Many special steels producers are active in the Powder Industry and are also investing downstream.

At the time being, NUMANOVA is the only Italian independent player active in this market.
METAL POWDERS AS THE REFERENCE RAW MATERIAL FOR THE NEW INDUSTRIAL REVOLUTION
A mixed bag.

Selection criteria are margin before volume, focus on specialties.
MATERIALS CUSTOMIZATION AND SPECIALISATION

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Courtesy: EPMA, EOS, GE, SLM Solutions, Erasteel, etc.
AM MATERIALS: PRESENT AND NEAR FUTURE
SPECIALTY METALS

- Ti and Ti-based alloys: grade 1, grade 2, grade 5 (Ti6Al4V, Ti-6-4 mod, Ti6Al7Nb), grade 23 ELI, TiAl (intermetallics)

- Al-based alloys: AlMg10Si (*automotive*), Al357 (*aeronautics*), high strength grades (Scalmalloy®) for both applications

- Co-based alloys: ASTM 75

- SS and Tool steels: 316L, 17-4 PH, 15-5 PH, DS and SDS, tool steels

- Ni-based alloys: In718, In625, In738, C-276

- Zr-based alloys: refractory alloys, CMC, MMC

- Nb-based alloys: pure Nb, C-103 (Nb-Hf)

Less than 40 alloys commercially available, more than 200 alloys of present interest for the industry (all possible apps) … much room for new metallurgy!
TITANIUM AND Ti-BASED ALLOYS

- Growth markets
  - Aerospace and medical (with AM and MIM)
  - Ti64, TiAl

- Expansion of powder manufacturing capacities globally
- Huge investments in AM by aerospace sector
TITANIUM AND TI-BASED ALLOYS (2)
Fuel nozzle for the LEAP aircraft engine being developed by CFM International, a 50/50 joint company of GE and Snecma (Safran) of France. The nozzle is made by GE. Additive manufacturing is used on its elaborate interior.

Borescope bosses for the PurePower® PW1100G-JM engine – the Pratt & Whitney engine to power the A320neo – are made by selective laser melting (SLM). The low-pressure turbine for this turbofan engine will be the first ever to come equipped with borescope bosses produced by additive manufacturing processes. The bosses form part of the turbine case and allow the blading to be inspected using a borescope. Photo: MTU Aero Engines.

This short pipe section connects two parts of a gas turbine. The fluid transition from round to square is easier to achieve with 3D printing than with conventional methods. Photo: Siemens.
Bevel gear-forming die model (45 mm x 35 mm x 11 mm)
HOW TO BE AMONG MARKET LEADERS TECHNICALLY?
Electrode Induction-Melting Inert Gas Atomization

- Advanced process for the production of metal powders from Titanium and Aluminum alloys, refractory materials, ceramics and precious metal alloys for Additive Manufacturing and special applications (e.g. HIP, MIM, PTA)
- Super clean metal powders thanks to induction-type ceramic-free melting technology (without contact with the crucible) starting from highly refined electrodes
- Metal powder of spherical morphology thanks to high pressure atomization with high density inert gas.
- Typical particle size distribution not exceeding 100 microns.
- Highly replicable process, proven technology.
- Nominal maximum daily capacity: 800 kg
- Plant size: 6m x 12m, H=10m
Vacuum Induction-Melting Inert Gas Atomization

- Advanced process for the production of ferrous metal powders (e.g. stainless steel) and super alloys based on Nickel, Cobalt and Zirconium for Additive Manufacturing and special applications (e.g. HIP, MIM, PTA).
- Capacity of alloying and refining of new metal alloys for metallurgical design requirements starting from selected raw materials and by-products.
- Metal powder of spherical morphology thanks to high pressure atomization with high density inert gas.
- Typical particle size distribution not exceeding 100 microns.
- Highly replicable process, proven technology.
- Nominal maximum daily capacity: 1,600 kg
- Plant size: 11m x 10m, H=11m
Inert Gas Shielded Multi-Frequency Sieving

- State-of-the-art sieving technology for metal and non metal powders
- Multi-frequency vibration
- Acceleration up to 500G
- Fully inert gas shielded, FDA and ATEX certified
- PM granulometry in the range 6 ÷ 150 microns
- Highly replicable process, proven technology.
- Nominal maximum flow: up to 250 kg/h (depending on metal powder grade)
- Plant size: φ=1200 mm, H=2m
Inert Gas Shielded High-Speed Blending

- State-of-the-art blending technology for metal and non metal powders
- Fast mixing times (from 30 sec to 5 minutes)
- Strict control in temperature
- Fully inert gas shielded, FDA and ATEX certified
- PM granulometry in the range 6 ÷ 150 microns
- Highly replicable process, proven technology.
- Nominal maximum size: up to 200 liters
- Plant size (various, case by case)
Inert Gas production by liquid and recycling

- State-of-the-art Ar gasification by liquid storage (I step), recycling (II step) and purified gas re-utilization (III step)
- Ar purity: 5.0 or higher (also after recycling)
- High and low pressure adduction lines
- Remotized control in liquid level, gas pressure, flow rate and temperature at the intake
- O₂, N₂ and other impurities control by sensoring and feedforward
- Nominal yearly consumption: up to 6 ML Nm³
- Nominal daily peak consumption: up to 20,000 Nm³
• Raw material management at VIGA through inertized silos, alloy addition controlled by process PC, automatic basket loading and weighing by load cells, assisted charge adduction to VIM crucible

• Automatic alloying system during melting for secondary metallurgy purposes (e.g. wires) in strict vacuum control, connected to process PCs level I and II

• Antistatic flooring at production plants footprint and laboratories

• Circular economy (liquid → recycling → purification → re-use)

• ... and much more
- Proprietary process control systems, related modeling, and operator guide systems at II and III level to be installed and used in the metal shop,

- Proprietary solution and know-how in the gas atomizing process and technology, based on complex modeling of the gas-molten fluid interaction system

- Proprietary mother alloys to be patented and used for PM production

- Develop and qualify the Supply Chain and Suppliers

- Develop and structure the Value Chain and Customers

- Apply to national and EU calls and funding schemes for collaborative R&D initiatives

- Perform room and on-the-job training of future Numanova’s operators and technologists
THANX FOR YOUR ATTENTION

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