MEETING THE MATERIAL CHALLENGES OF AM INDUSTRIALIZATION

WHO IS SANDVIK?

46,000
EMPLOYEES

SALES IN OVER
150
COUNTRIES
AROUND THE GLOBE

91
BILLION SEK
INVOICED SALES

60
R&D CENTERS
GLOBALLY

3
BILLION SEK
INTO R&D
EACH YEAR

8,000
ACTIVE PATENTS AND
OTHER IP RIGHTS
PORTFOLIO OF BUSINESSES

SANDVIK MACHINING SOLUTIONS
36% 57%

SANDVIK VENTURE
9% 5%

SANDVIK CONSTRUCTION
10% 3%

SANDVIK MINING
30% 28%

SANDVIK MATERIALS TECHNOLOGY
15% 7%

Share of Sandvik Group’s total invoicing 2015.
Share of Sandvik Group’s adjusted operating profit 2015, excluding Group activities.
WORLD LEADING POSITIONS
IN THE FOLLOWING AREAS

TOOLS AND TOOLING SYSTEMS
-as well as components in cemented carbide and other hard materials

EQUIPMENT AND TOOLS FOR THE MINING AND CONSTRUCTION INDUSTRIES
-as well as various types of processing systems

HIGH VALUE-ADDED PRODUCTS IN ADVANCED STAINLESS STEELS
-and special alloys, and titanium, as well as metallic and ceramic resistance materials...
WE ARE A CUTTING EDGE TECHNOLOGY ENGINEERING GROUP
Why target AM? –SANDVIK’S HERITAGE

- Founded 1862 in Sandviken, Sweden
- Göran Fredrik Göransson redesigned the Bessemer process from lab-scale to industrial production of steel
- A tradition for breakthrough and innovation started the company over 150 years ago, continues by the foundation of Sandvik AM Center

1862 - Founded in Sandviken.
1870 - Drill steel for rock drilling manufactured in Sandviken iron works.
1872 - Russia biggest market due to demand for railway materials.
1876 - Sandvik leading supplier of cold rolled strip steel and flat wire (used for umbrella ribs).
1886 - Seamless tubes are supplied to the new power industry.
1889 - Upgrading of cold-rolled strip steel into manufactured products such as saws.
1901 - Sandvik is introduced on the Stockholm Stock Exchange.
1919 - Subsidiary in the US.
1924 - Launch of the first seamless stainless tubes. Coromant brand established. Cemented-carbide coated rock drills are developed.
1931 - First order for nuclear fuel cladding tubes.
1958 - First stainless steel conveyor belts are manufactured.
1958 - Sandvik introduces the indexable insert technique with exchangeable cemented-carbide inserts in Europe.
1960 - Europe accounts for 66 percent of invoiced sales, North and South America for 23 percent and the rest of the world 11 percent.
1966 - The company has 40 subsidiaries in 34 countries and sales in 100 countries.
1967 - Sandvik acquires 65 percent of Seco Tools.
1967 - Acquires 20 percent of the Finnish rock drilling equipment manufacturer Tamrock.
1991 - Sandvik acquires 100 percent of the rock drilling equipment manufacturer Tamrock.
1997 - Acquires 100 percent of the Finnish rock drilling equipment manufacturer Tamrock.
2005 - China is now the 10th largest market.
2011 - New strategy aimed at improving profitability and enhancing the Groups position in attractive segment.
2012 - The new strategy implemented. 150-year anniversary.

Seamless tubes are to become Sandvik’s main product in the steel segment.
AM – POTENTIAL FOR IMPACT

AM is an enabling technology

• "Game changer" for materials technology
• Minimized material consumption
• More complex geometries - reduced number of components and operations
• More intelligent designs and improved functionalities
• Individual variation at (almost) no additional cost

![Diagram showing the potential of AM technology with axes for part complexity and manufacturing costs. The graph illustrates the transition from conventional design to design for additive manufacturing with a focus on minimizing costs.]
AM – A THREAT TO MACHINING INDUSTRY?

A NEW PARADIGM FOR MANUFACTURING

• A different manufacturing principle changes the rules of the game:
  - New geometries
  - New/different materials
  - New production chains

• Flexibility, versability, but also a new way of thinking:
  - Design
  - Material: is formed, - and can therefore be manipulated during the manufacturing process
  - Product development...!
  - Intellectual Property Rights (IPR)
  - The value creation in products and services
The additive process builds a material in the shape of a product. Properties depend on the process conditions. In conventional machining, successive removing of material costs time and money. In AM, successive addition of material costs time and money. AM decreases the need for machining but increases the value of the machining needed.
COMPETITION...

MAPAL is bringing more and more tools made by AM to the market, typical benefits are:

- Weight (and vibration) reductions
- Integrated cooling fluid channels

KENNAMETAL is filing patent claims...
NEED FOR KNOWLEDGE: SANDVIK AM CENTER

Industry-leading provider of high value-added products in advanced metallic materials for selected niches in the most demanding industries.

Holds a clear global leadership by offering productivity enhancing products and solutions for advanced industrial metal cutting.

Equipment, tools, service and technical solutions for exploration, excavation and processing of rock and minerals in the mining industry.

The world's widest range of rock drilling, rock excavation, rock processing, demolition and bulk-materials handling equipment, tools, services and technical solutions for the construction industry.

Unique customer offering within selected areas.

From Apr. 1st 2016
SANDVIK AM CENTER INITIATIVE - OBJECTIVES

• Establish Sandvik strategic AM research program.
• Develop an R&D team with leading competence.
• Build up an equipment park for investigation of the most relevant AM techniques.
• Keep close contact with all stakeholders, especially the Business Area R&D centers
• Support the Business Areas to apply AM technologies for existing and future products, product development as well as production
• Connect with key external partners.
• Identify new business opportunities based on AM.
AMC PRESENT PROCESS PORTFOLIO

POWDER BED FUSION

• Arcam
  − A2X
  − Commercial materials, Sandvik powders & composites...

• CONCEPTLaser
  − CL M2 Cusing & MLab
  − Commercial materials & Sandvik powders
AMC PRESENT PROCESS PORTFOLIO
BINDER JETTING

• ExOne
  - M-Flex, X1-lab & Innovent
  - Standard ExOne material systems
  - Suitable for composites and Sandvik *Hard* materials
  - “Special” alloys
A GENERAL THOUGHT: FROM MATERIAL TO PRODUCT AND MANUFACTURING
AM IMPLEMENTATION CHALLENGES

• Design and product development
  - Requires a new way of thinking and new skills
• AM industrial manufacturing process chain
  - AM integrated with conventional manufacturing technologies
• Supply chain:
  - Feedstock & material: Reliability, Quality control, Alloys not optimized for AM
• Process equipment often not designed for industrial production
  - Process speed
  - Machine cost
  - Work with the right partners…!
SANDVIK MATERIALS TECHNOLOGY

BUSINESS CONCEPT

• Product innovation, technology leadership and close, long-term customer relationships

• World leading metallurgy and R&D in materials technology

• High value-added products enabling customers to fulfill – and even exceed – their productivity and performance expectations
MATERIALS FOR AM: SANDVIK OSPREY

UNIQUE PRODUCT OFFERING TO THE ADDITIVE MANUFACTURING INDUSTRY

• Original powder manufacturer - Everything we sell is made by us
  – Complete control of product quality with excellent batch to batch
  – Ability to customise our product to meet the customers requirements

• Flexible operations allow us to support the full product life cycle, from initial R&D to full scale series production
  – Latent production capacity to support future market growth

• More than 15 years experience servicing the metals AM market
>2000 alloys in database

- Stainless Steels
  - 316L, 304L
  - 420, 430, 440C
  - 15-5PH & 17-4PH (SUS630)
- Duplex stainless steel
- Low alloy steel
- Tool Steel; M2, T15, SKD-11, H13
- Maraging steel 18Ni300 (1.2709)
- Nickel based super alloys
  - Inconel
  - Nimonic
  - Hastalloy & Triballoy

- Cobalt Alloys – CoCrMo, CoCrMoW, CoCrW
- Pure Copper and Copper Alloys
- Binary Alloys - Fe-Si, Fe-Co & Fe-Ni
- Specialist Alloys:
  - Controlled Expansion Alloys - Invar & Kovar,
  - Soft Magnetic Alloys
  - Wear Resistant Alloys
  - Nickel Free Stainless Steel
- Titanium Alloys
  - CPTI, Ti6AL4V
- Aluminium Alloys
  - AlSi10Mg
- Magnesium Alloys
- Refractory Metals
SANDVIK OSPREY
GAS ATOMISED (GA) METAL POWDERS

- 6 Inert Gas Powder Production Plants
  - Capacity > 3,000MT/year
  - Lot size capability from 20 - 3000kgs
- Vacuum Melt capability for critical applications
  *(Sandviken, Sweden)*
- Nitrogen & Argon atomising
  - Extensive Alloy capability
- State-of-the-art Powder Sizing Equipment
  - Substantial Sieving and Classifying capacity
- Standard & Tailored powder size ranges
CHARACTERISTICS OF GAS ATOMISED METAL POWDERS

- Spherical shape
  - Good flow characteristics
  - Uniform layer properties
  - High tap density: >65% packing density

- Low oxide & impurity levels
  - Internal Cleanliness, enhanced mechanical properties

- Refined microstructures with isotropic properties

- Two typical powder size ranges available
  - Standard powders 40 µm < d50 < 90 µm
  - Fine powders d50<15 µm
SANDVIK CAPABILITIES

ATOMISING UNITS BEST SUITED TO ADDITIVE MANUFACTURING

- Osprey ‘fine’ suited to some laser beam Powder Bed Fusion (PBF) processes, (ex. 3D Systems)
- Osprey ‘conventional’ suited to other laser PBF (EOS, SLM, CL…) Directed Energy Deposition (DED)
- VIM facilities best suited to electron beam PBF (typically Arcam) and DED
ADDITIVE MANUFACTURING
COMPARING DIFFERENT POWDER MANUFACTURING METHODS
PM RESEARCH AND DEVELOPMENT

WORLD LEADING IN MATERIALS TECHNOLOGY

• Products developed in close co-operation with customers.

• Pilot powder production
  – Full characterization, testing and evaluation facilities

• Technical market support
  – Sandvik Powder Solutions
  – Sandvik Osprey

• Support all business areas regarding PM-based solutions

Sandvik Materials Technology

~900 materials for further processing into different niche applications

More than 250 employees at R&D Centers
LOOKING FOR THE BEST SOLUTIONS?
-START BY FINDING THE RIGHT PROBLEMS!

Motivated by application

New technology, industrial potential and future markets

Principal limitations within present technology

Take advantage of new technology for improvements

All industrial needs are not met

Take advantage of available technology

Presently applied technology, industrial needs and present market

Available technology

Improved technology

New technology

TRL
TRL1
TRL2
TRL3
TRL4
TRL5
TRL6
TRL7
TRL8
TRL9
EXAMPLE FROM ONGOING WORK AT SANDVIK

FEASABILITY STUDY: COROMILL 390

• “What can be achieved with a standard AM toolsteel and common AM design solutions?” - Redesign by Autodesk Within
FEASIBILITY STUDY: COROMILL 390

PRACTICAL TESTS:

• Decreased weight decreased the vibrations:
  – Double the cutting depth – Potential for doubled productivity!

• Fatigue cracks after 330 000 -340 000 revelations
AM IN INDUSTRIAL PRODUCTION

GREAT EXPECTATIONS - MANY CHALLENGES

Process and material are more coupled than conventional processes

• Many variables - requires standardization across the process chain
  – Material properties for each alloy needs to be mapped in respect to the different variables in the process window

• Different machine systems, different set-ups, different calibrations, and different conditions produces different results…, stability and traceability!
  – Variation in process variables for different feedstock batches

• Quality management, traceability, inspection and verification

• Process: Repeatability and reliability
It's not a tip of an iceberg we're seeing, -we're entering a new universe in manufacturing...
THANK YOU!
Any Questions?

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