Material data and qualification for AM Oerlikon AM

Mikkel Pedersen, Head of AM R&D, Oerlikon

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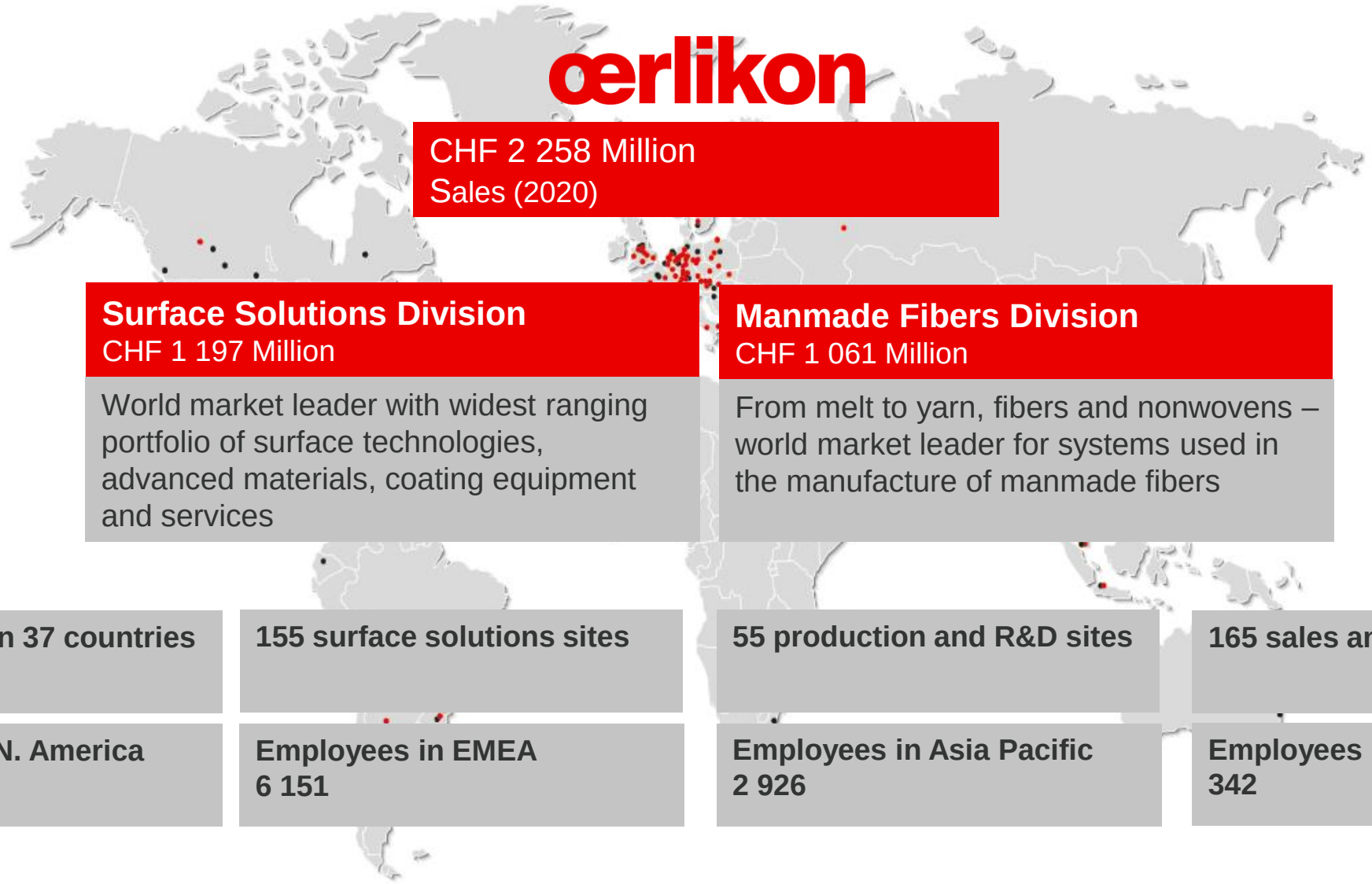
A Leading Global Presence to Serve our Customers Locally

oerlikon am



Surface Solutions Division
CHF 1 197 Million

World market leader with widest ranging portfolio of surface technologies, advanced materials, coating equipment and services

Manmade Fibers Division
CHF 1 061 Million

From melt to yarn, fibers and nonwovens – world market leader for systems used in the manufacture of manmade fibers

179 locations in 37 countries	**155 surface solutions sites**	**55 production and R&D sites**	**165 sales and service sites**
Employees in N. America **1 273**	**Employees in EMEA** **6 151**	**Employees in Asia Pacific** **2 926**	**Employees in other regions** **342**

Global product development and manufacturing partner – enabling our customers to break performance barriers

oerlikon am

2015 founded

>200 employees

4 sites on 3 continents

USA, EU & China

MARKETS

AUTOMOTIVE

AEROSPACE/SPACE/DEFENSE

POWERGEN

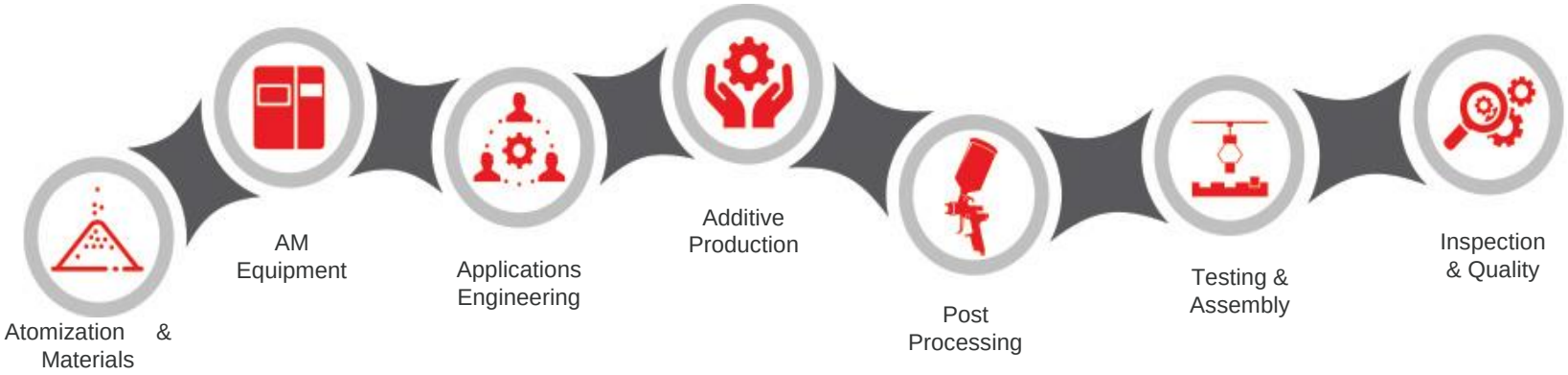
GENERAL INDUSTRY

R&D

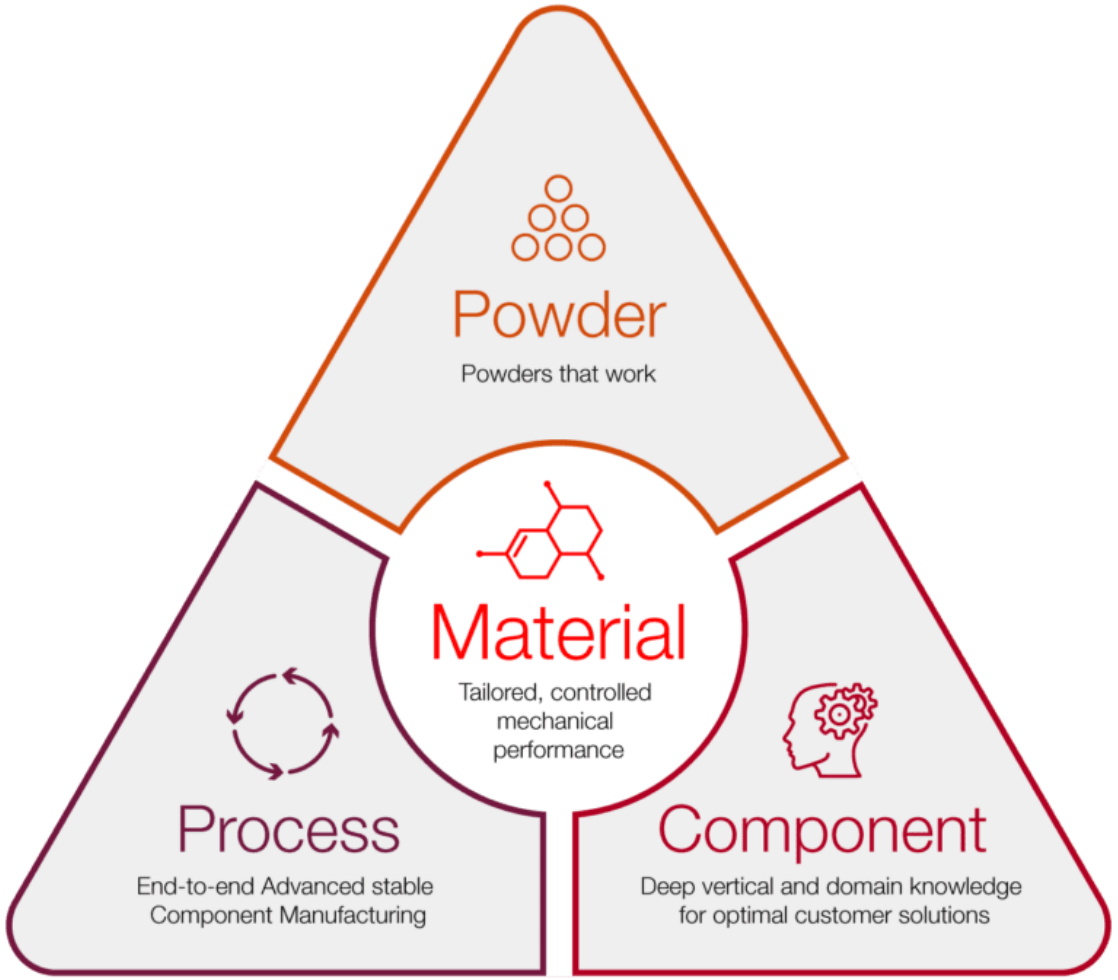
Component Development

Applications Engineering

INTEGRATING & SCALING THE ENTIRE AM VALUE CHAIN



The challenge of qualifying the material in AM

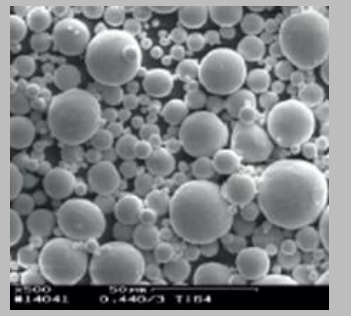


- The complexity of each of the individual elements defining the material and the interconnectivity
- Lack of industry data available compared to traditional manufacturing processes
- Material created using AM belongs to a new material group
- New material evaluation capability
- AM is in a transition from prototyping to large scale series production

Powder

What is needed:

- Mature and robust supply chain and supplier management
- Relevant sourcing and in-use specifications
- Robust handling and storage processes and equipment



What are the challenges:

- Production environment and the volume
- Powder in-use cycle
- Material segregation and cleanliness
- Traceability & Quality control

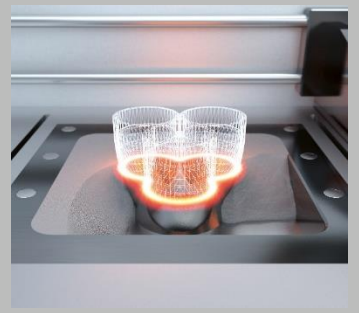
To Blend or not to blend

- Decisions made in the powder handling drives quality control
  - Powder sampling process
- Powder quality control with relevance to the process
  - Hall flow testing
- Environment
  - Drying powder

Process

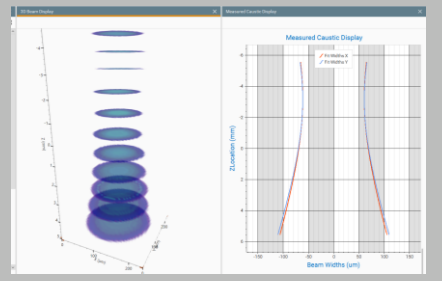
What is needed:

- Acceptable ranges of variation for key process parameters
- Standards and specifications for machine qualification, accreditation and operation
- Thermal post processing matching the microstructure



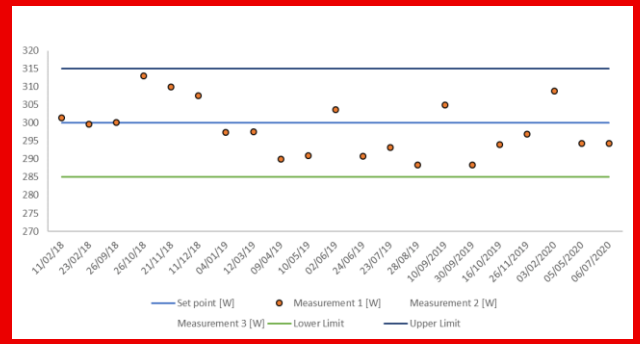
What are the challenges:

- High number of process variables, many of which are not independent
- Quality control and monitoring of KPVs
- Fast development and ‘black box’ technology
- Variability: Spatial, build-to-build, machine-to-machine



Process control

- ‘Normal’ machine performance
  - Sub-system performance
  - Bridging the gap machine-to-machine
- Monitoring capability
  - Sensors and measurement techniques
  - In-situ monitoring
- Statistical process control



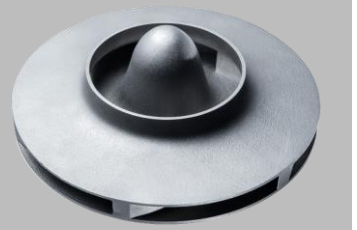
Component

What is needed:

- Design or material allowables / target values
- Process parameters relevant for the application, geometry or feature
- Defect/artifact acceptance criteria

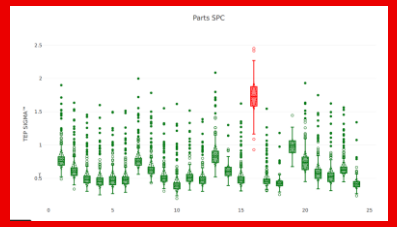
What are the challenges:

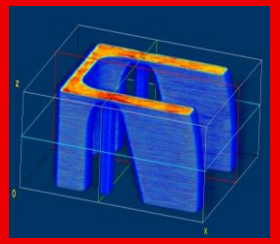
- Material and component are created at the same time
- NDI capability
- Influence of geometry and e.g. surface area, support structure



Application requirements

- Defect/artifact acceptance criteria
  - Can it be the same as for other manufacturing processes?
  - What is unique to AM
- NDI
  - Probability of detection
  - In-process monitoring as NDI

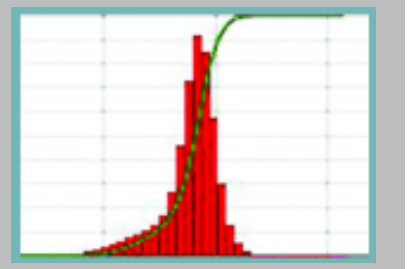




Material

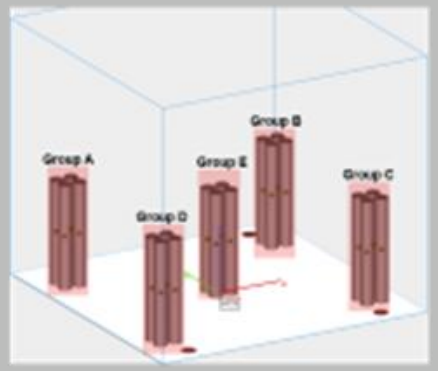
What is needed:

- Understanding of key failure mechanisms and material artifacts
- Standards and specifications for qualifying materials
- Material data available to industry



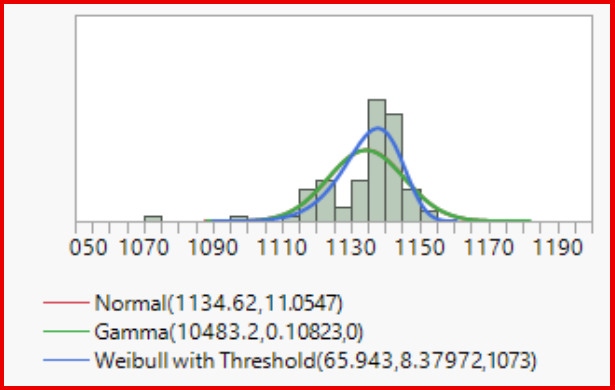
What are the challenges:

- New material artifacts from AM
- Recreating relevant and realistic artifacts in material testing
- Material testing and detectability
- Speed of material development
- Variability / combining data



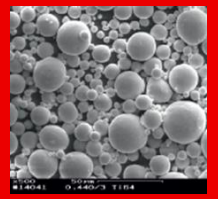
Testing and data analysis

- Coupon geometry
  - Single specimen preforms or multiple specimen blocks
  - Machined/Unmachined
- Material failure mechanisms
  - Creating or seeding of defects
- Data populations and combinability



What Oerlikon is doing to address these points

Powder

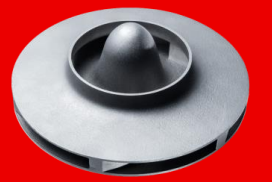


- Powder specifications (sourcing and In-use)
  - Defining key characteristics
  - Tracking and testing changes of powder in-use
  - Developing testing methodologies
- Powder handling
  - Processes and in-use cycles
  - Equipment
  - Batch tracking and traceability
- Working with our internal powder producers to optimise the products for AM

Process

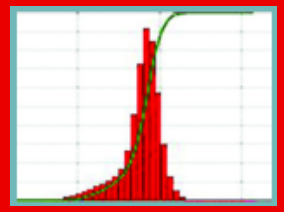
- Statistical process control
  - Process parameter tolerances and natural variability
  - How to track or measure parameters
- Machine and process qualifications
  - Machine critical items
  - Sub-system performance
  - Maintenance, calibration and health checks
  - Meeting requirements from new standards
- Heat treatment and HIP optimisation

Component



- Developing parameters for specific applications
  - Increase productivity
  - Increase quality and microstructure
- Improving surface finish
  - Within the AM process
  - Post-processing

Material



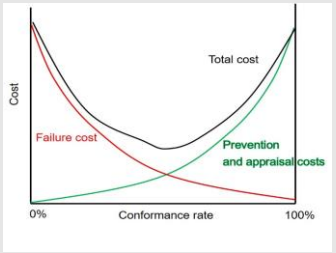
- Evaluating physical and mechanical properties
- Developing understanding of microstructure and artifacts
  - Definition and detectability of defects in AM
- New alloy development
  - Modifying existing materials to enable or improve performance when printed
  - Novel material development e.g. High Entropy Alloys

Where Oerlikon would like more collaboration within the industry

Industry material performance targets

- Turbomachinery is an ecosystem consisting of many different players with different interests and needs for their applications can be organised in subgroups
- Define a new material class that is AM and define the benchmark(s)
- Combine the single interests to create a larger market/voice and drive it through industry standards

Industry standards



- The route to qualified material and allowables is by addressing variability which is best addressed through common standards and processes
- Enables broad application of the data we create rather than single customer and increases the pool of combinable and comparable data available
- Means of introducing well-known and established processes from industry
- Challenge todays proprietary vs. commodity type technology path

Roadmap for Materials

- Part substitution is the main business today so here the materials are expected to look and perform the same
- Next generation parts will be designed for AM which includes new use of materials (functionally graded, variable density etc.)
- Novel material development and adaption to process
- Defining new processes for material evaluation and part certification

Close to you –

Anywhere in the world

THANK YOU.

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