ADDITIVE MANUFACTURING @ RISE
-RESULTS AND UPCOMING ACTIVITIES

Seyed Hosseini, Manager Additive Manufacturing

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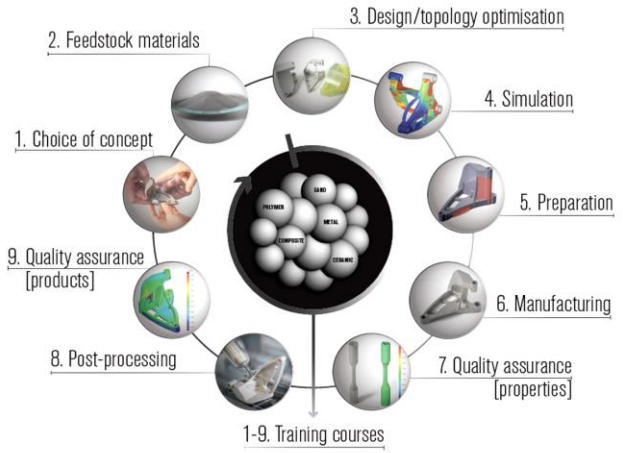


RISE Research Institutes of Sweden

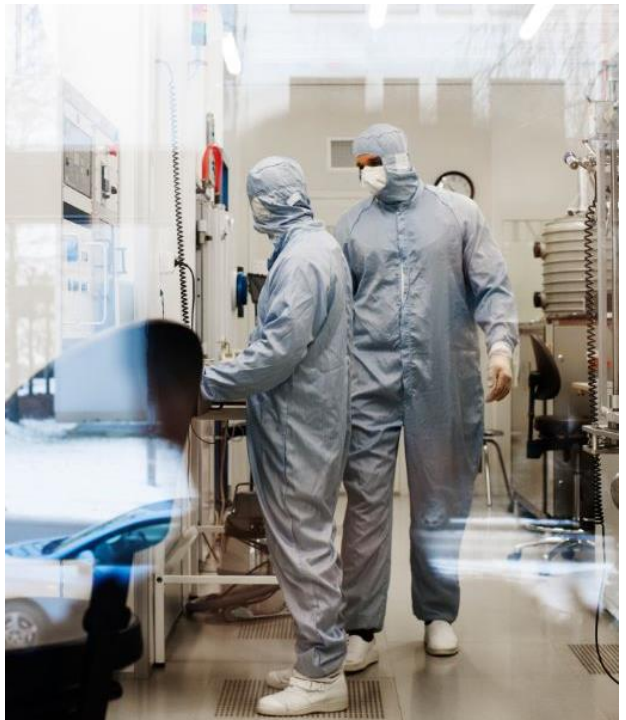
Material och Produktion

SWEREA AB part of RISE, Research Institute of Sweden

- **October 1 2018**, ***SWEREA IVF*** became part of ***RISE***, Research Institutes of Sweden. Together with SWEREA SICOMP, SWEREA SWECAST, and the corrosion area of SWEREA KIMAB we will mobilize our competences, capabilities and innovation infrastructure into RISE in order to become a stronger innovation partner for industry, academy and public sector. For a competitive and sustainable industry and society, in Sweden as well as globally.

RISE in brief

- Present across the whole of Sweden. And beyond.
- 2,700 employees, 30 % with a PhD.
- Turnover approx. SEK 2.7 billion (2017) (exclusive SWEREA AB)
- A large proportion of customers are SME clients, accounting for approx. 30 % industry turnover.
- Runs 100s of test and demonstration facilities, open for industry, SMEs, universities and institutes (RISE is owner and partner in 60 % of all Sweden's T&D facilities).



With our broad range of **competencies and unique expertise,** we create added value


Bioeconomy


Fire and safety


Cement and concrete


Certification


Circular economy


Design


Electronics


Energy and fuels


Packaging


Glass

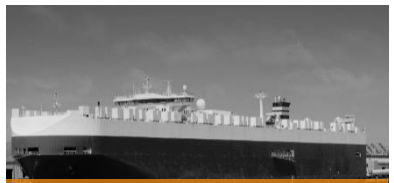

Health and Care


ICT and telecoms


Agriculture and food


Chemistry, materials and surfaces


Life Science


Maritime


Mechanical engineering


Mechanics


Metrology and measurement technology


Paper and Pulp


Process development


Built environment


Safety


Mobility

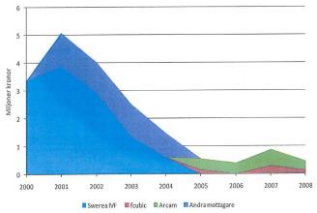

Wood


Water

Our journey in additive manufacturing…

Additive manufacturing research Lab. @ RISE IVF

90'
~8 MSEK 1990-1996



Siemens opens their first AM-lab 200 MSEK investment

Desktop Metal raised $34 Million in equity for a new AM-tech.

Ricoh announced a binder jetting printer will be soon available

Daimler AG announces to start 3D print spare parts for Mercedes-Benz Trucks (polymer)

Siemens has majority shares in Materialize (software solution)

GE raises their bid on Arcam to $600 million and takes over Concept Laser

GE launches their new AM Division, GE Additive (10k machines in 10 years)

Siemens in collaboration with Stratasys and EOS to include in the NX platform

Daimler increases the activities in AM: Ricoh for polymer AM

GKN and SAAB collaborates for a number of components

CAM²

AMEXCI

2018-05-17 ABB and RISE IVF Launch of the new equipment

GE opens a $40 million AM Center

Alcoa enters a partnership with Airbus to provide 3D-printed parts for commercial aircraft

Netherlands announced an additional investment of €134 million into research projects in AM

Norsk Titanium announced a $1 billion investment for aerospace manufacturing facility

GE launches its $1.4 billion bid on taking over Arcam and SLM Solutions

Siemens announces a solution for AM-simulation included in the new NX - platform

Boeing (Chicago, Illinois) was granted a patent for a virtual library of parts that could be 3D-printed on demand to reduce physical inventory

Oerlikon opens up a new PM factory in Michigan

Daimler starts a new project with EOS, Prem. Aerotech

AM-Arena

Freemelt

fcubic free form fast

[2, 3, 4] Wohlers Report 2016, 2017, 2018

RI.SE

The AM-Team at @ RISE IVF

Ola L. | *Jan J.* | *Sven K.* | *Anton D.-J, PhD Student* | *Christophe L., PhD* | *Sebastian P., PhD Student* | *David O.* | *Magnus W.* | *Camille P., PhD* | *Klas B., PhD*

Lenny T. | *Sepehr H., PhD* | *Seyed H., PhD* | *Emil J.* | *Rolf A.* | *Taoran M., PhD* | *Amine Y., PhD* | *Johan B. , PhD* | *Charlotte I.* | *Erik A., PhD*

The AM-team

Additional experts/competences active in the AM-team

Materials/process steps @ RISE IVF

Material dev. & char.

Design for AM

Process opt. / mod.

Manufacturing & Post-processing

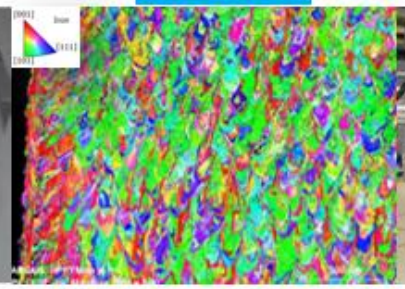
Quality assurance

Digitalization/ Industrialization

Selective laser melting (metals)

Stereo lithography (ceramic)

Fused deposition modeling (Polymers, composite, bio-based material)



AM Research Focus @ RISE

- **New materials**
  - Metals (magnetic – for electrification), bio-based polymers, ceramics for high temperature appl.
- **Improved process quality and productivity**
  - In-situ quality insp., higher output, less errors,
  - Post-processes such machining, heat treatment, etc.
  - Quality assurance and NDT
  - Material characterization
- **New AM-processes**
  - Hybrid processes, flexible cell strategy
- **Design and simulation**
  - Design for AM for increased/improved functionality
  - Simulation to minimize error and improve productivity
- **Large scale AM (green manufacturing)**
  - Polymers, bio-polymers and metals

https://www.bayut.com/mybayut/3d-printed-homes-future-dubai-real-estate/

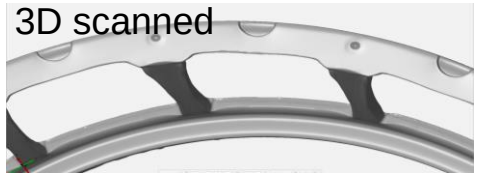
Results from on-going or finished project…

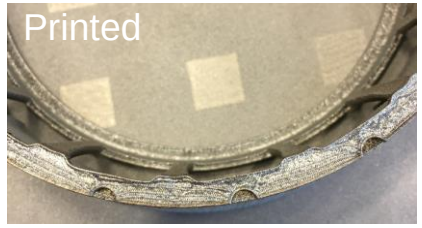
DigiAM: Faster Adoption of Additive Manufacturing by Digitalization of Quality Assurance and Material Stock

Coordinators: Sepehr Hatami / Camille Pallier

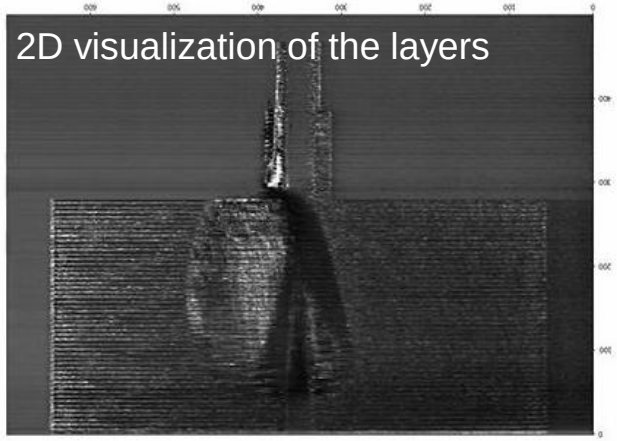
Budget: 6 785 000 kr (Bidrag Vinnova: 3 377 500 kr) // Duration: 2016-12-01 -> 2018-11-30

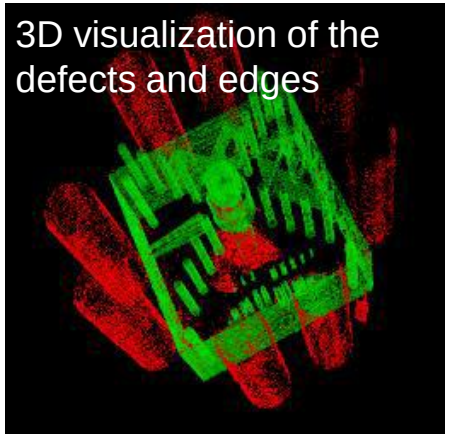
- Goal 1: digitalization of component stock
  - Store CAD files of components instead of real components
  - Production of component/spare parts when there are needs through AM





- Goal 2: Digitalization of the quality assurance
  - Explore the new in process monitoring possibilities for BPLD and PBF-LBM processes
  - Evaluate post process monitoring capabilities
  - Create a digital certificate of each component



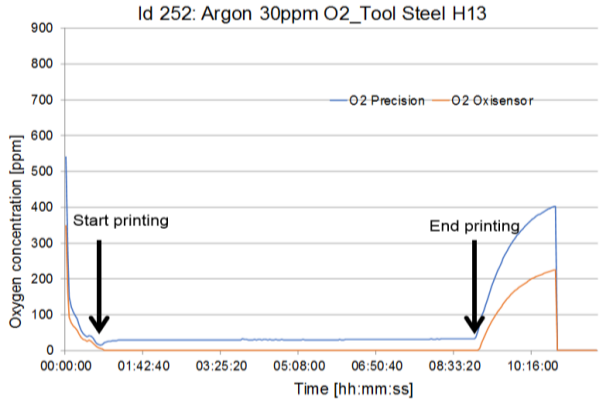


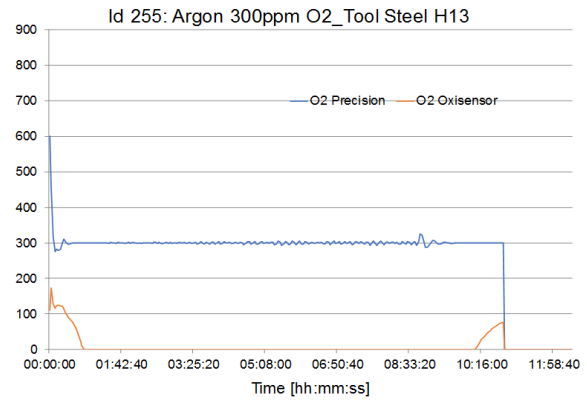
A Member of The Linde Group | AGA | Cascade | GKN | Höganäs | Högskolan Väst | SKF | Termisk Systemteknik | UNIBAP | RI.SE

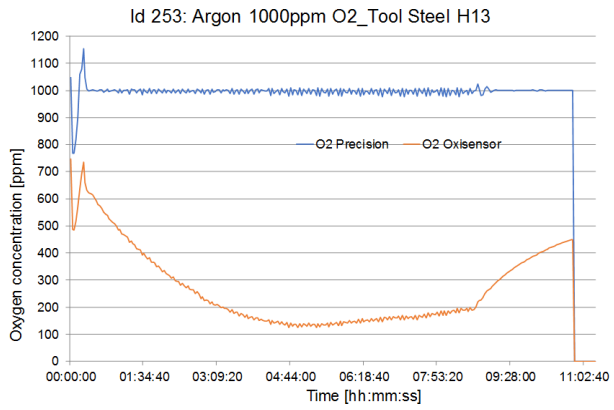
DigiAM: Faster Adoption of Additive Manufacturing by Digitalization of Quality Assurance and Material Stock

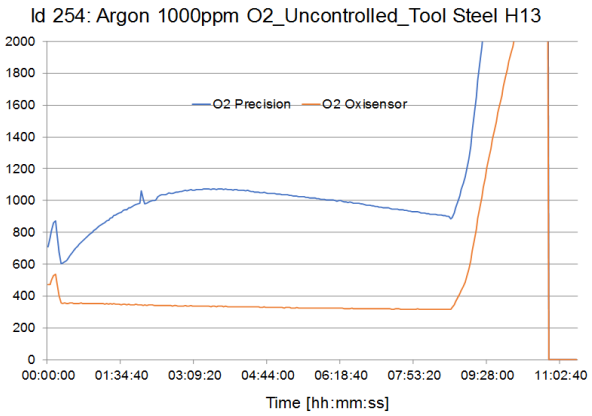
Coordinators: Sepehr Hatami / Camille Pallier

- Comparison between Addvance System & existing systems
  1. O_2 Oxisensor: Monitor O_2
  2. O_2 Precision (Addvance): Analyze and control atm (O2 and humidity (dew point))









Conclusion:

The O_2 oxisensor doesn't follow correctly the level of oxygen →
Not precise at low level of oxygen (< 1000 ppm)
O_2 Precision: control effectively the atmosphere →
O_2 level is maintained at the required value
Humidity decrease when O_2 level is low

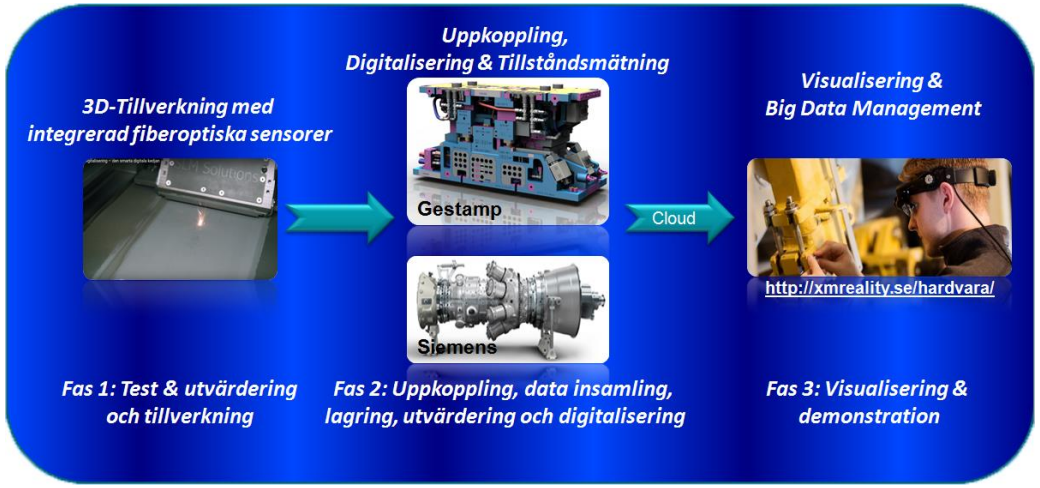
Effective tool for improving and following the printing process

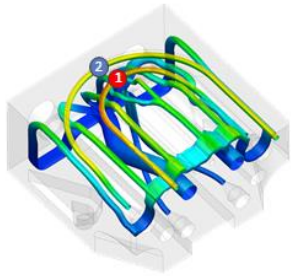
CoHM-3D: Connectivity and Health Monitoring of 3D-printed Components in Extreme Conditions

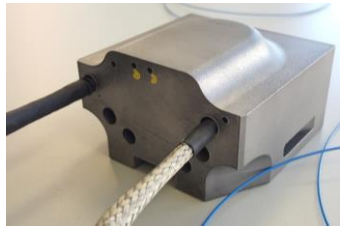
Coordinators: Seyed Hosseini/ Ola Lyckfeldt

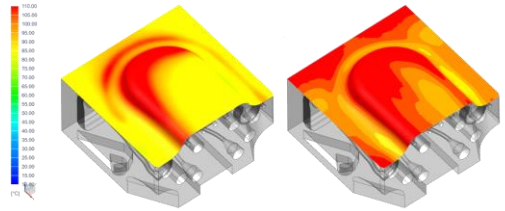
Budget : 9 850 000 kr (Bidrag Vinnova : 6 350 000 kr) // Duration : 2017-05-15 -> 2019-11-14

- Goals:
  - Combine additive manufacturing and fiber optic sensors to create sensor networks in metal components
  - Condition monitoring in extreme environments
  - Visualization of real time sensor data using AR/VR
- Demonstrate:
  - Embedded FBG sensors in AM produced components that measure temperature and strain
  - New visualization methods using AR/VR
  - Two industrial demonstrators:
    - Visualize the contact between a press hardening tool and the metal sheet during forming operation
    - Condition monitoring of gas burners used in industrial gas turbines









GESTAMP HARDTECH xmreality

SIEMENS brogren industries PROXIMION UDDEHOLM CARPENTER Powder Products RI.SE

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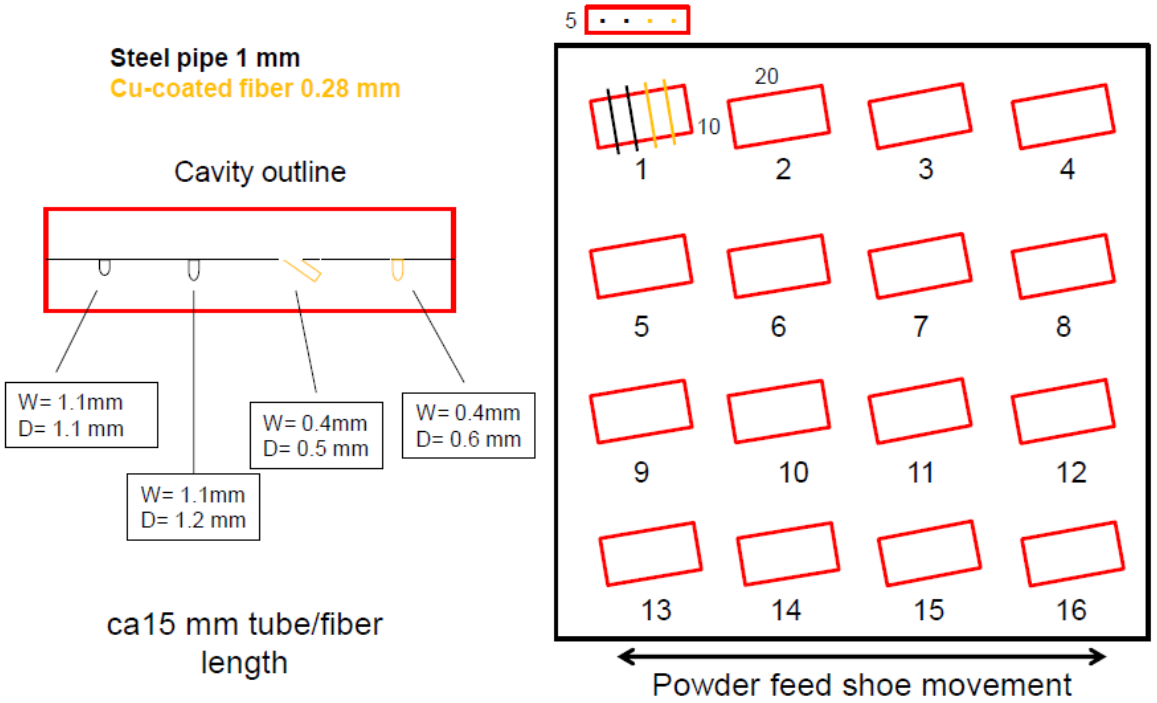
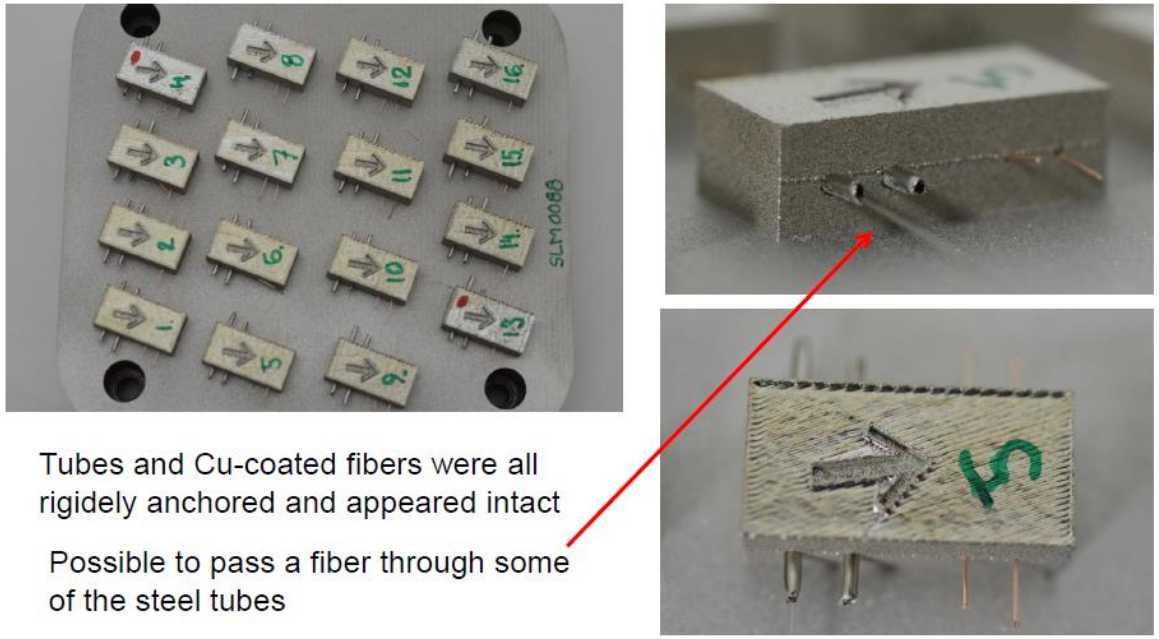
Coordinators: Seyed Hosseini/ Ola Lyckfeldt

Budget : 9 850 000 kr (Bidrag Vinnova : 6 350 000 kr) // Duration : 2017-05-15 -> 2019-11-14

Cavity design and machine set-up



SLM processed specimens



Tubes and Cu-coated fibers were all rigidely anchored and appeared intact

Possible to pass a fiber through some of the steel tubes

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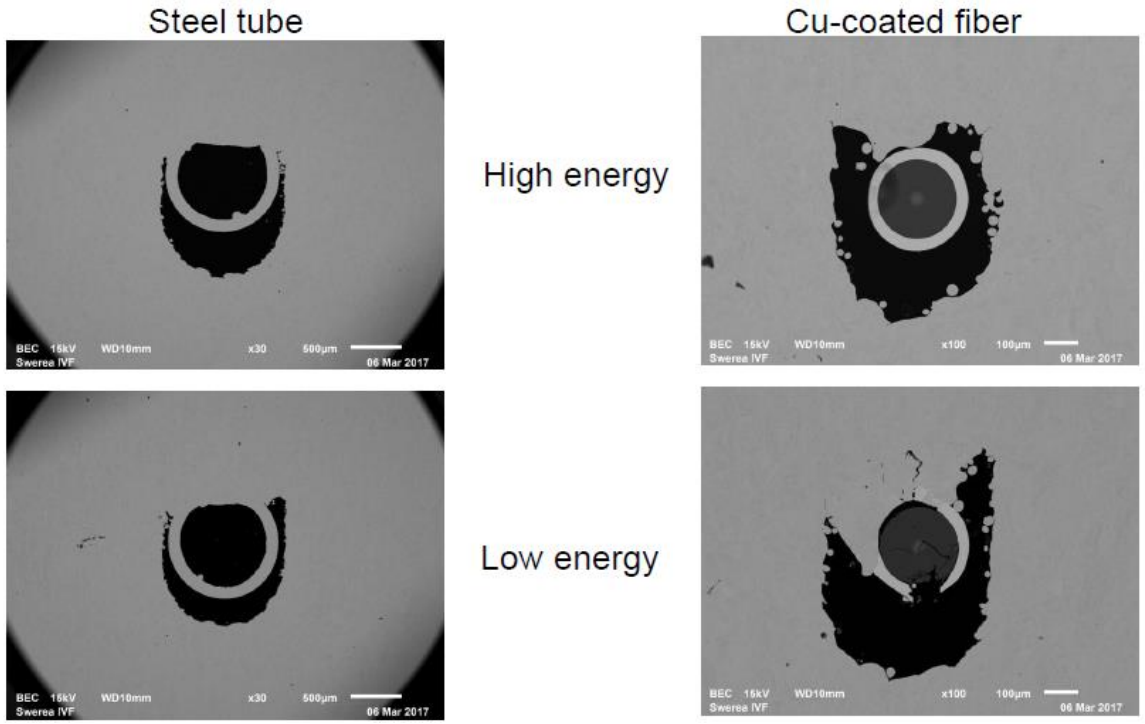


Conclusions

- Basically the trials indicated that the concept of shaping cavities and embed either steel tubes or Cu-coated fiber is feasible, however, it is crucial to ensure proper positioning to control and optimize the concept
- Naked fiber is difficult to place and embed by SLM without cause damaging
- Further trials have to be conducted to evaluate the impact of the different laser energy setting applying more controlled positioning
- Variation in powder layer thickness on top of the fiber or tube diminishing evaluation of the effect of laser energy variation
- Overall, the conditions for succeed the embedding of fibers with retained function by accurately control positioning and machine parameters is considered to be good

DIGI-3D: Verifierad digital optimeringsarena för verktygsproduktion genom 3D-metallprintning (DIGI-3D)

Coordinator: Nader Asnafi

Budget: 8 000 000 kr (Bidrag Vinnova: 4 000 000 kr) // Duration: 2016-12-01 -> 2018-11-30

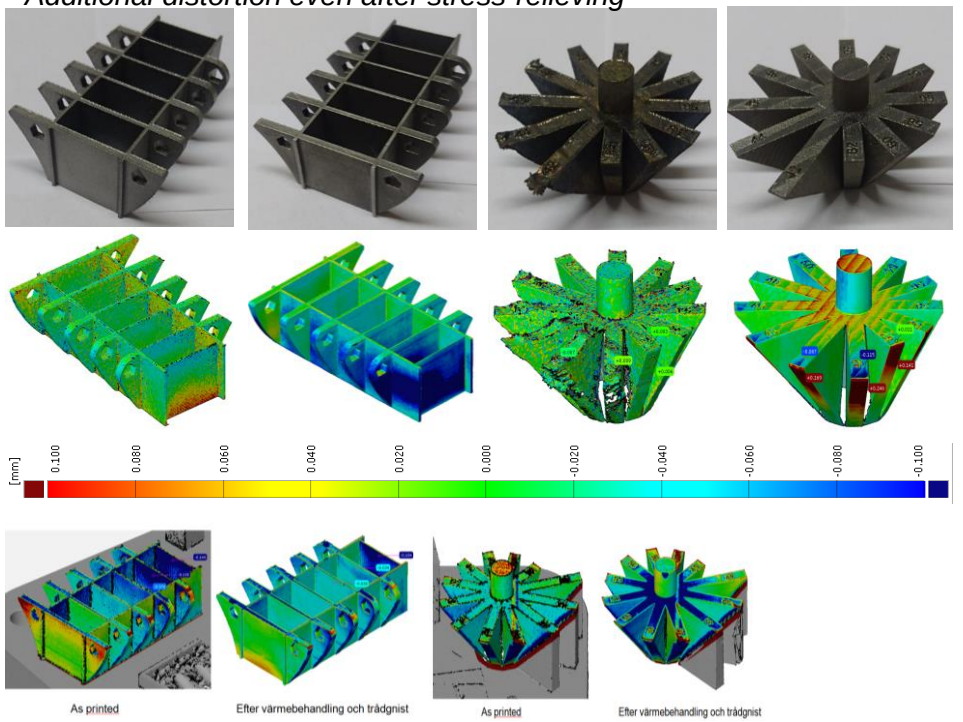
- Aim:
  - Reduce the lead-time for tool manufacturing
  - Reduce the weight by some 30%
  - Equal or reduce the costs by at least 20%
  - Reduce material waste by 30%

- Sub-wp: investigate potential differences between different systems
  - SLM Solutions Group AG (SLM 125HL)
  - 3Dsystems (ProX DMP 300)

- Microstrucutre, hardness, porosity, distortion, powder, mechanical properties (tensile, impact, etc.) and corrosion

Geometrical deviation:

Thin-walled components: SLM 125HL outputs components within the set tolerances
ProX DMP 300 allows printing of parts with greater tilting angle without failure
Additional distortion even after stress-relieving



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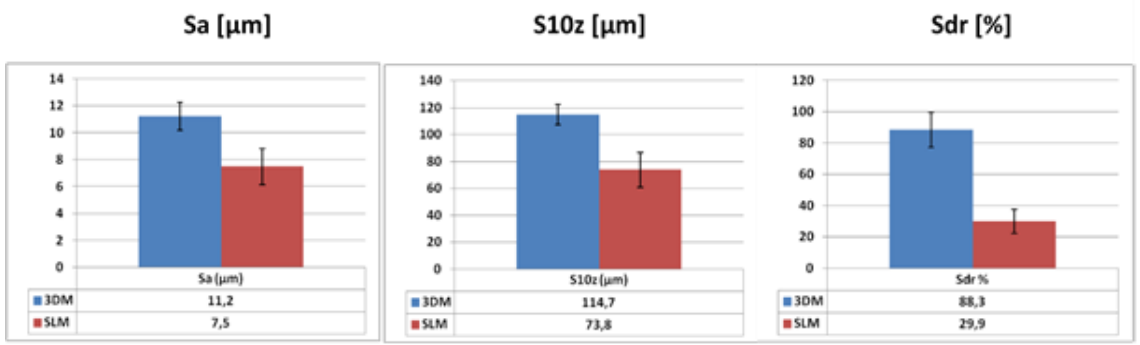
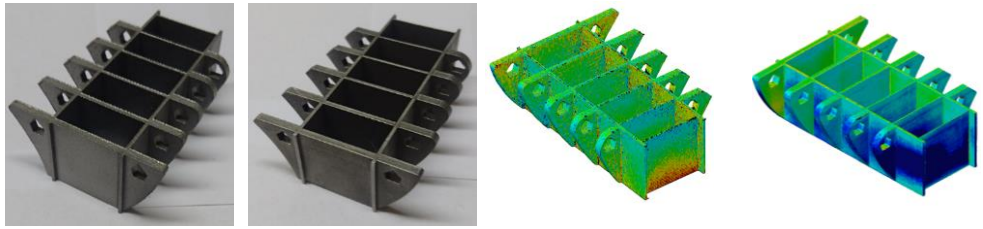
Coordinator: Nader Asnafi

Budget: 8 000 000 kr (Bidrag Vinnova: 4 000 000 kr) // Duration: 2016-12-01 -> 2018-11-30

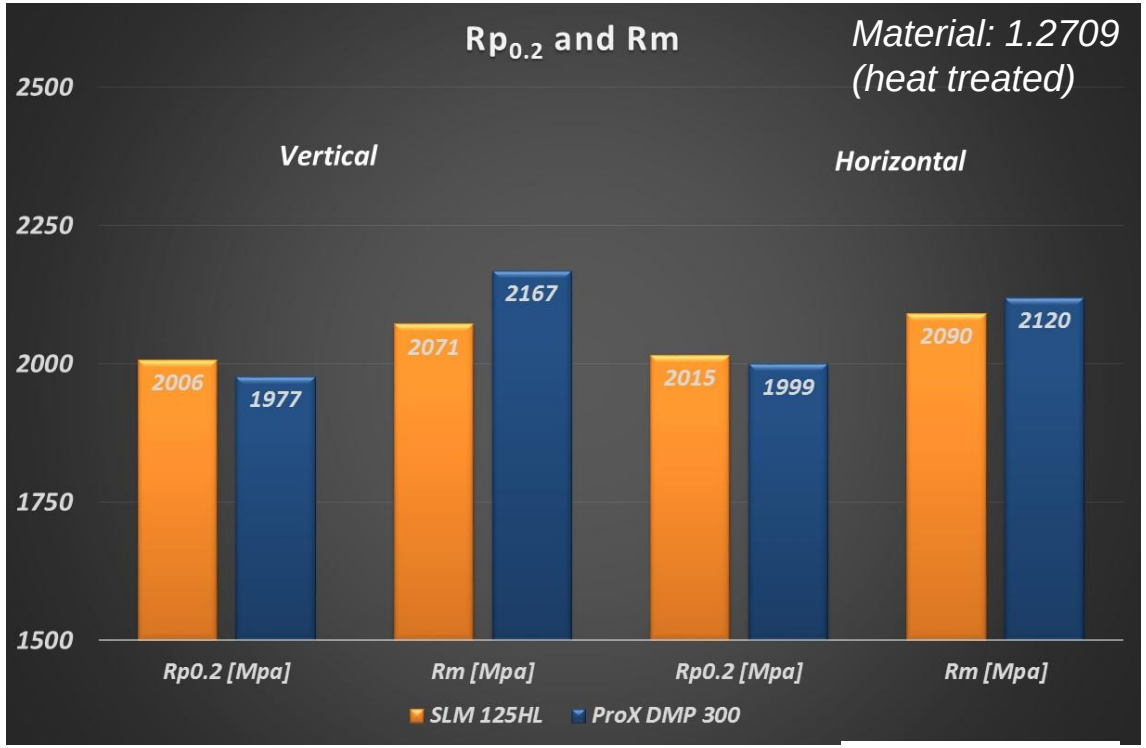
Surface roughness…





- Although the data from 3D-scanning indicates that the printed parts from ProX system appears to be better, when using a confocal microscopy to measure the surfaces the results are the opposite… Challenge of how to measure the surfaces AM-printed parts in good and acceptable way

Yield strength and estimate tensile strength

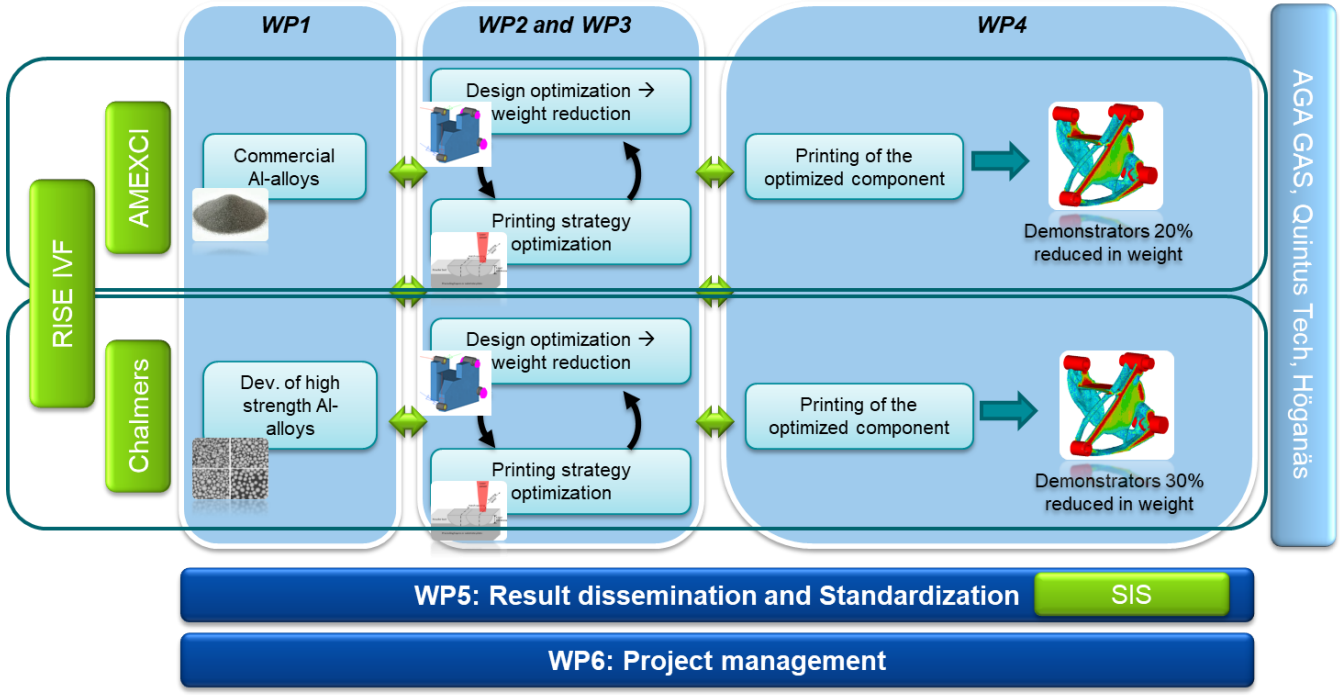


Upcoming activities…

ALL-LIGHT: Lighter components through additive manufacturing of aluminium alloys

Coordinator: Camille Pallier

- Aim:
  - Development of high strength aluminium (Al) alloys for additive manufacturing (AM)
  - Design for AM for weight optimization of components used in aerospace and industrial applications



- FoI project from 2018-10-15 to 2021-10-14
- Lighter goals:
  - Weight reduction of at least 20 % with improved mechanical strength
  - Reduced development time by at least 20 %
  - Technology and knowledge platform for Al AM

AMEXCI A Member of The Linde Group | AGA Quintus Technologies Höganäs | SWEDISH STANDARDS INSTITUTE | CHALMERS UNIVERSITY OF TECHNOLOGY | RI. SE

AM-LIGHT: Design and Material Performance for Lightweight in Powder Bed Metal Additive Manufacturing

METALLISKA MATERIAL

Coordinator: Lars Nyborg

- Scope :
  - Mechanical properties and surface properties with respect to sample orientation and dimension in the building process
  - Tuning of powder solutions to match the performance criteria
  - Combined good strength and smoother in-process and / or sub-process surface control
  - Development of design for manufacture rules for achieving optimized 316L, Ni-base and Al-alloy parts

- WP2 : Design for manufacture and build capacity : Al-alloy (end user : SAAB)
  - Verify surface finish capabilities
  - Tune surface characteristics by different methods (post treatment…)
  - Provide a benchmark on the outcome depending on choice for post-processing surface preparation

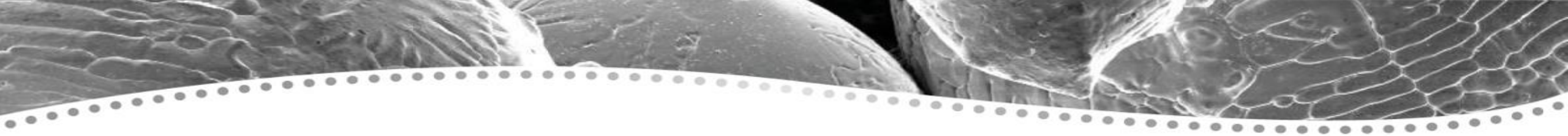
- FoI project from 2018-06-01 to 2021-05-30

SAAB ALFA LAVAL SIEMENS Ingenuity for life EDR MEDESO Höganäs LUNDS UNIVERSITET CHALMERS UNIVERSITY OF TECHNOLOGY RI. SE

2nd Conference on Additive Intelligence 4.0

8-9th April 2019 @ Chalmers / RISE IVF

https://www.swerea.se/kalender/2nd-conference-on-additive-intelligence-40

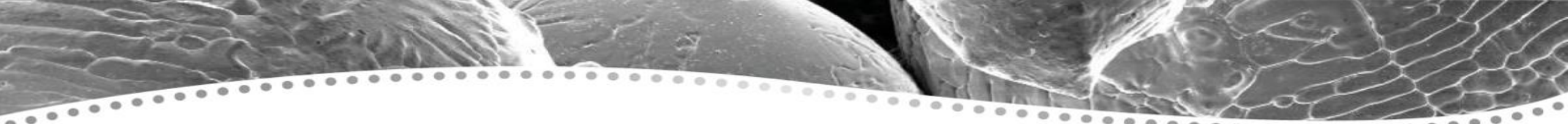


The Swedish Arena for Additive Manufacturing of Metals

contributes
to the development of technology and knowledge
to reach the full potential of Additive Manufacturing

- Network and meeting venues
- Competence development
- Technology development
- Infrastructure
- Coordinate project initiatives

Coordinate the implementation of the roadmap



Industry

3D MetPrint AB
ABB
AIM Sweden AB
Alfa Laval AB
Atlas Copco
Brogen Industries AB
Carpenter Powder Products AB
Duroc Laser Coating AB
Exmet
Freemelt
Höganäs Sweden AB
Kanthal AB
Quintus Technologies AB
Scania
Siemens Industrial Turbomachinery AB
TRUMPF Maskin AB
Uddeholms AB
VBN Components

Hultsfreds kommun, Hultsfred

Research partners

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Karlstad University
KTH
Linköping University
Luleå University
Lund University
Jönköping University, School of Engineering
Mid Sweden University
RISE IVF
RISE SWECAST
Swerim AB
University West
Uppsala University
Örebro University

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