3D printing with Steel

The INSIDE Metal AM project

Today's setting

2 parts:
- Main lessons learned of the project
- (Cost of) Certification and future challenges

Break at 14h45

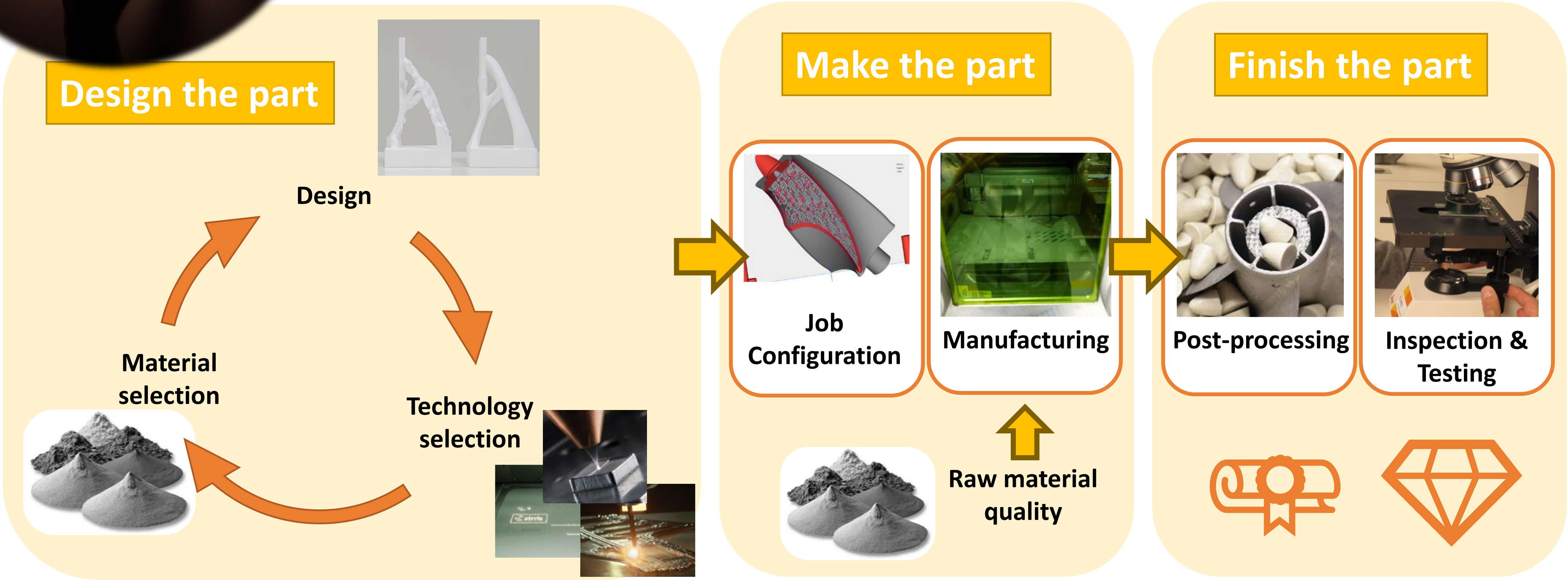
Feedback from the audience:
- Poll questions, integrated in Zoom
- Q&A via chat

Recording/slides made available

More info: *https://www.sirris.be/inside-metal-additive-manufacturing*

The successful application of metal AM is a journey

AM Roadmap


Design the part
Design
Material selection
Technology selection
Make the part
Job Configuration
Manufacturing
Raw material quality
Finish the part
Post-processing
Inspection & Testing

What is the most suitable technology?

What material to choose?

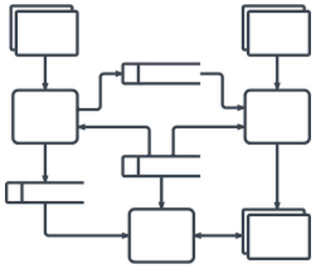
What material properties to use in my design?

Is heat treatment required?

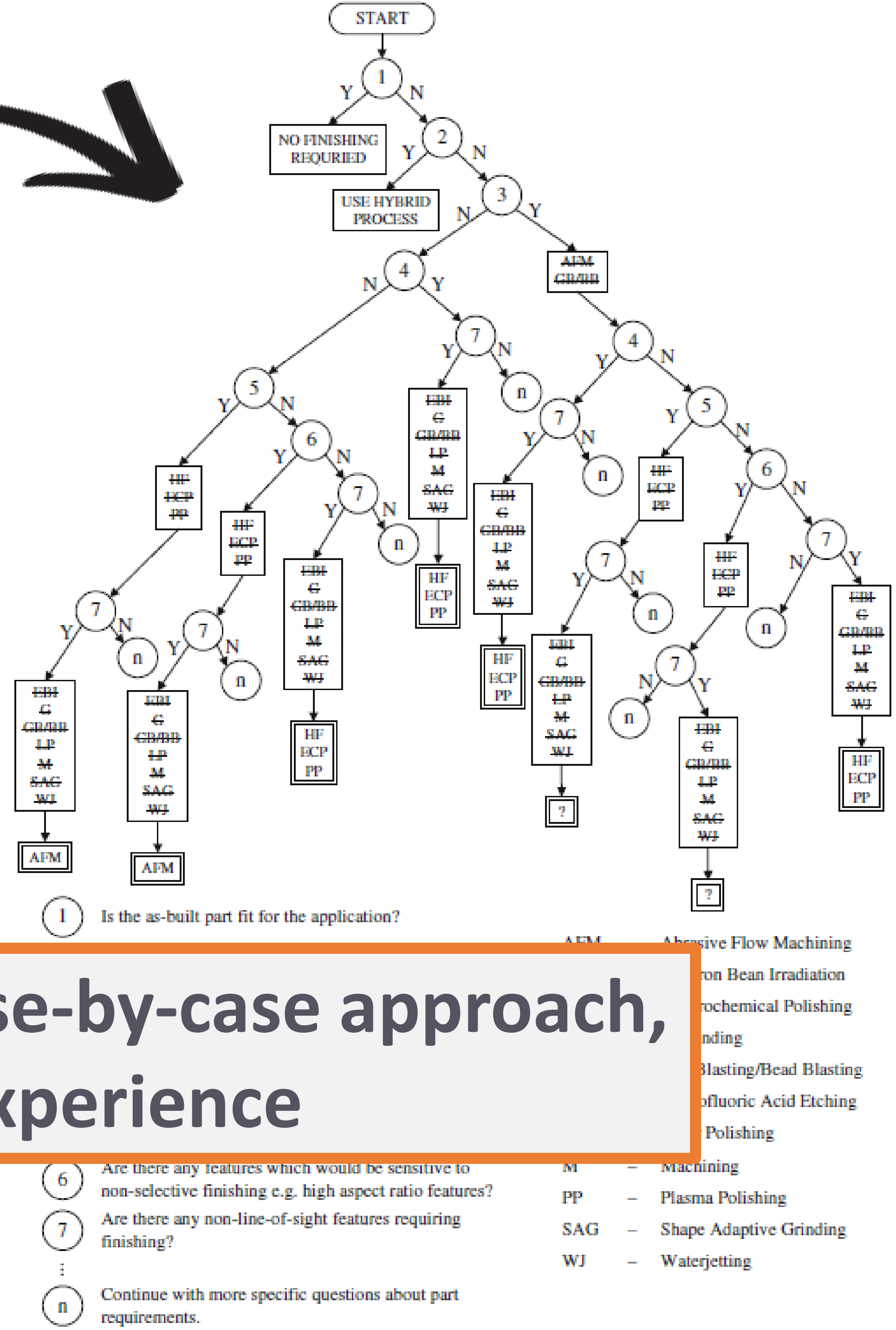
Do surfaces need to be post-treated?

How do I handle powders?

4 years ago:
“We need Flow Charts”

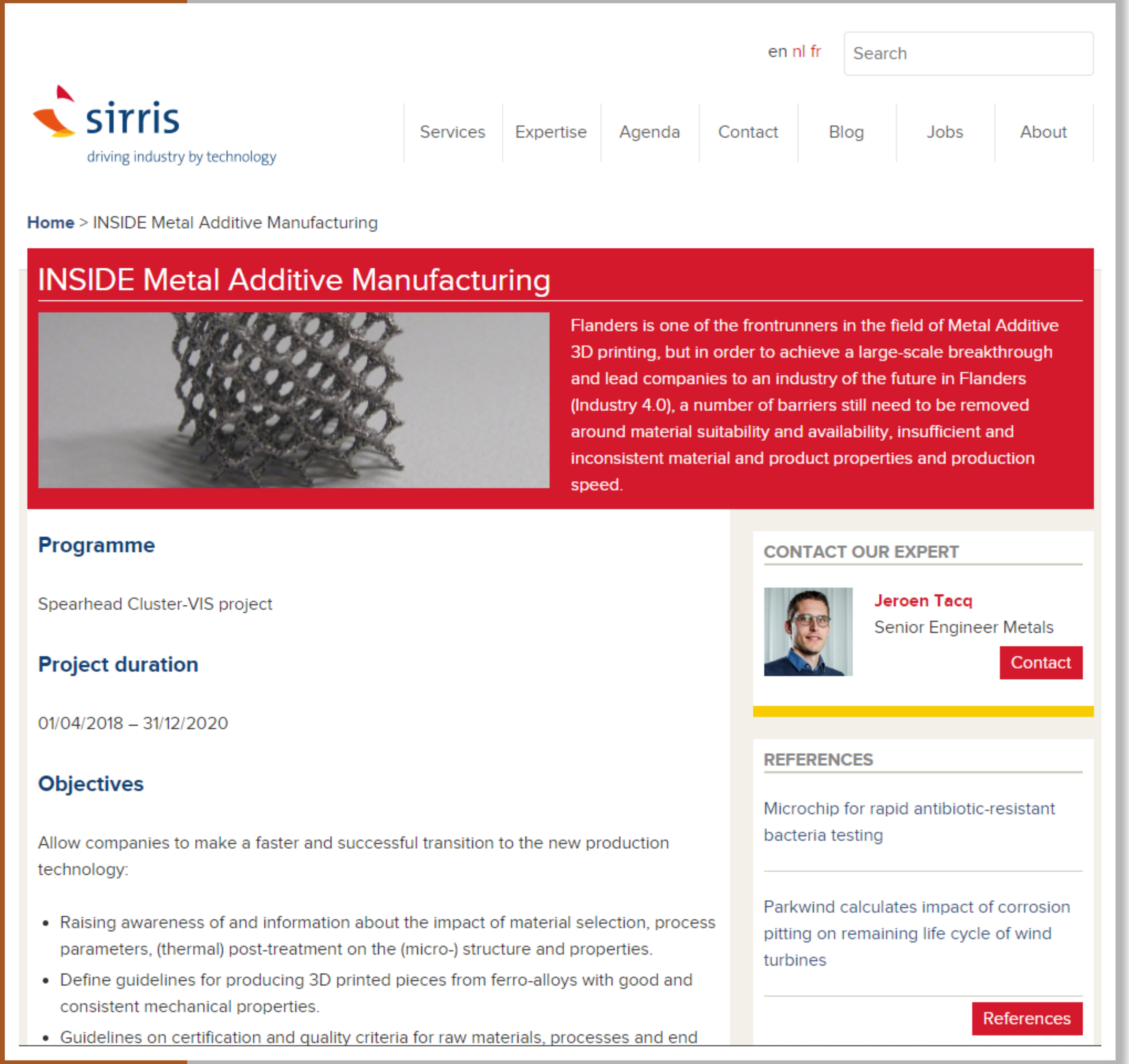


BUT
- Cannot capture all nuances
- Very application dependent
- New solutions regularly coming to market (e.g. dry electropolishing, plasma polishing, new materials)



Needs a case-by-case approach, based on experience

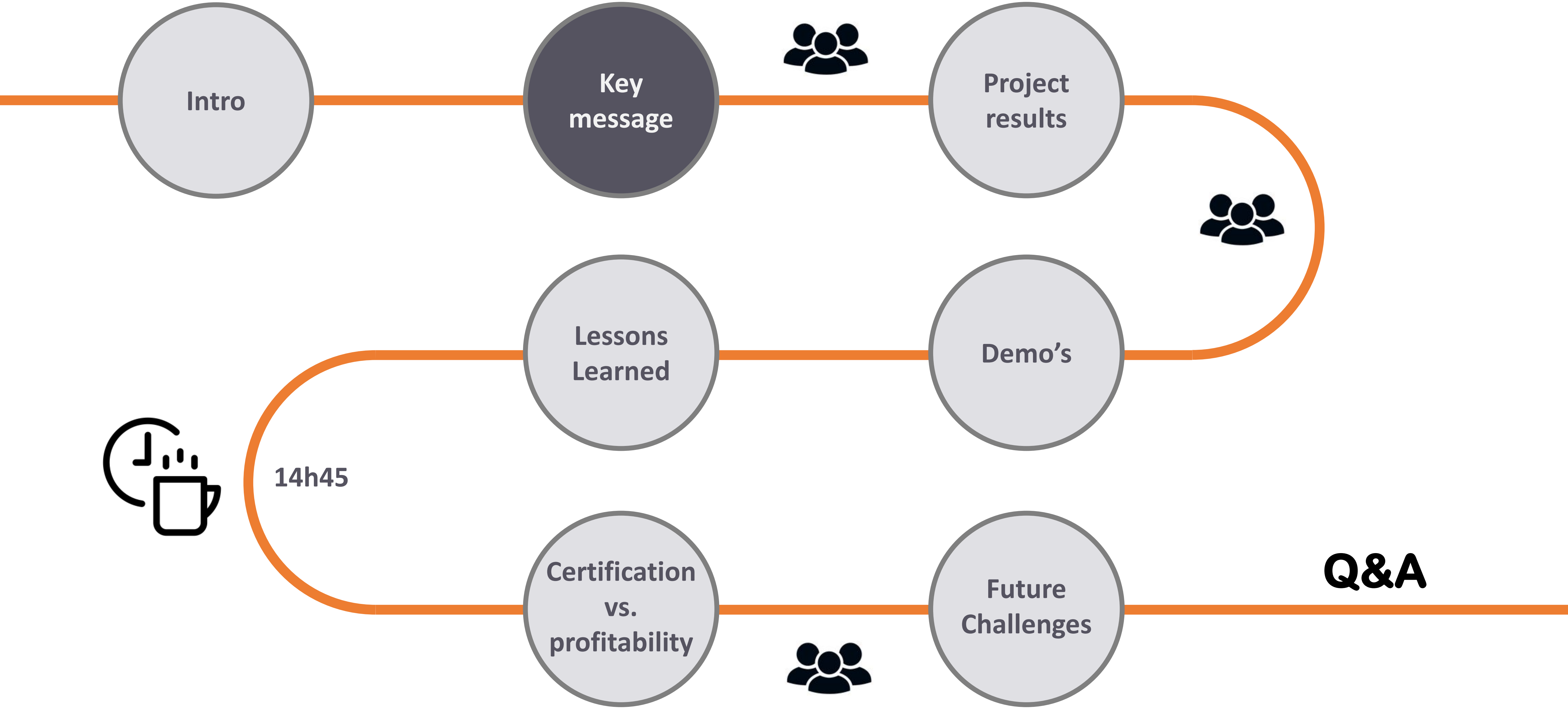
Gordon E.R. (2016) A Surface Modification Decision Tree to Influence Design in Additive Manufacturing. In: Sustainable Design and Manufacturing 2016. SDM 2016. Smart Innovation, Systems and Technologies, vol 52. Springer, Cham.



Our approach

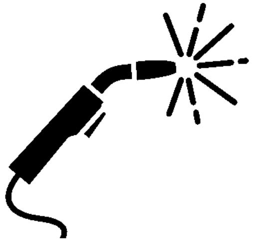
- Summary of test results, based on several questions.
- Will be made available as a **White Paper**.
- Reference to detailed reports for more info (or contact us directly).

https://www.sirris.be/nl/inside-metal-additive-manufacturing


Intro
Key message
Project results
Demo's
Lessons Learned
14h45
Certification vs. profitability
Future Challenges
Q&A

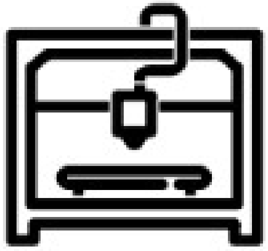
Key take-aways

Changing powder quality needs to be monitored

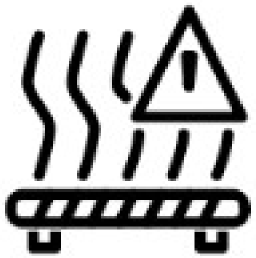


Respect the wire supplier recommendations

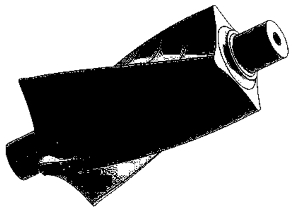
Focus on optimising density and build speed



Surface finishing choice depending on printing process

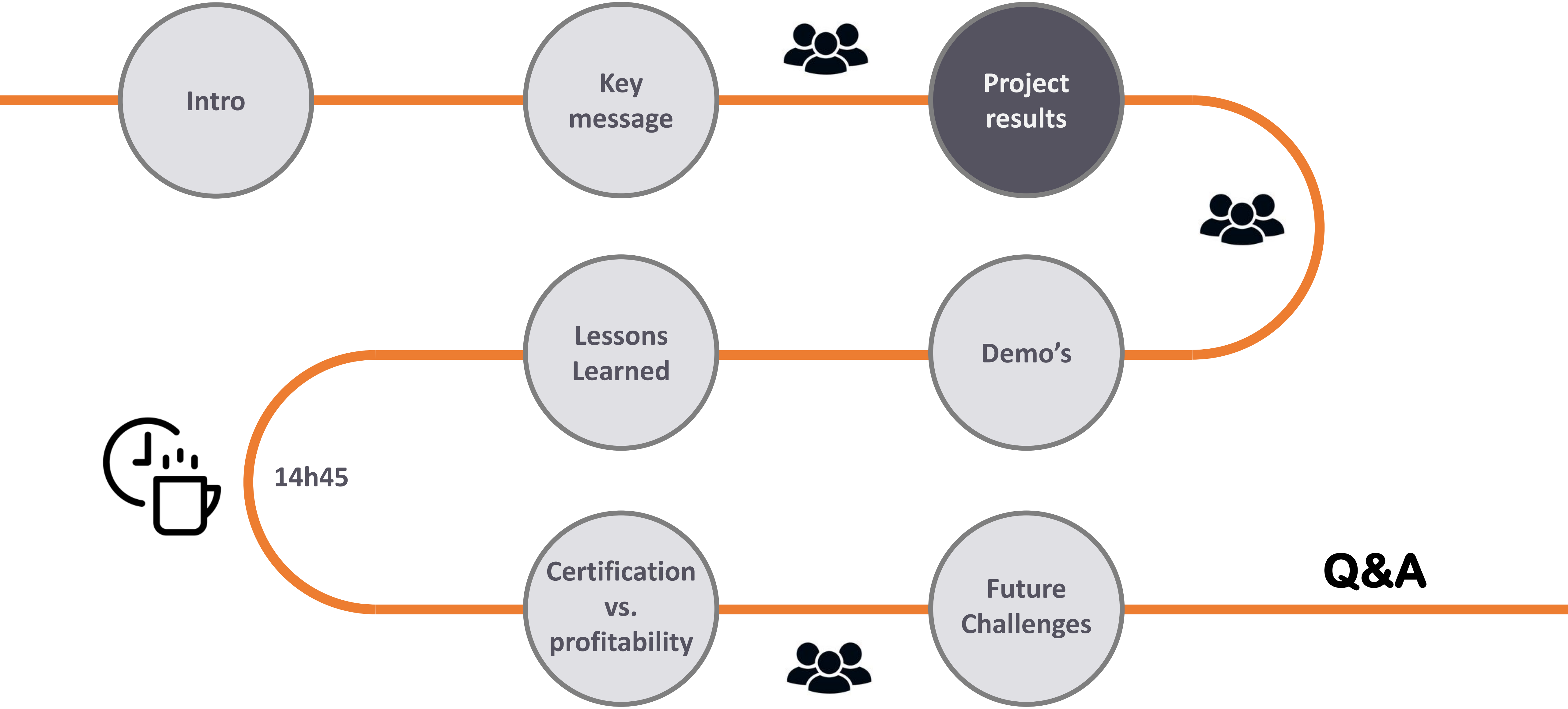


Heat treatment is critical



Making the right choices requires expertise.

Poll 1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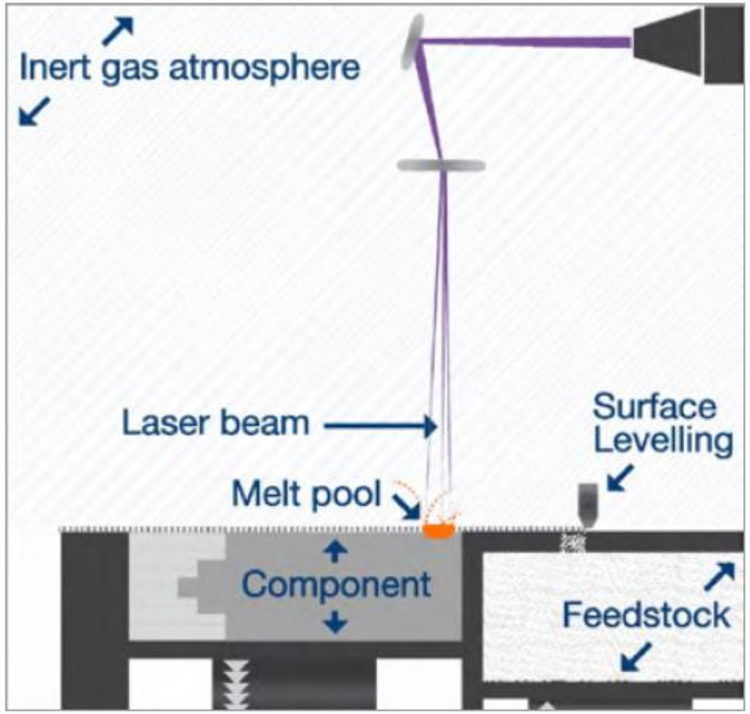
AM Technologies - INSIDE Metal AM project

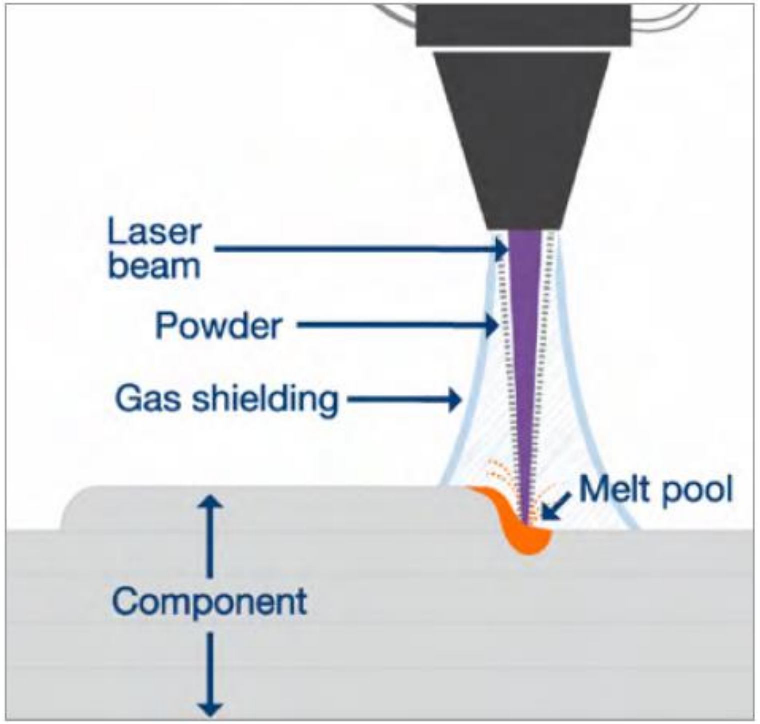
L-PBF

Powder Bed Fusion by Laser (PBF-LB)



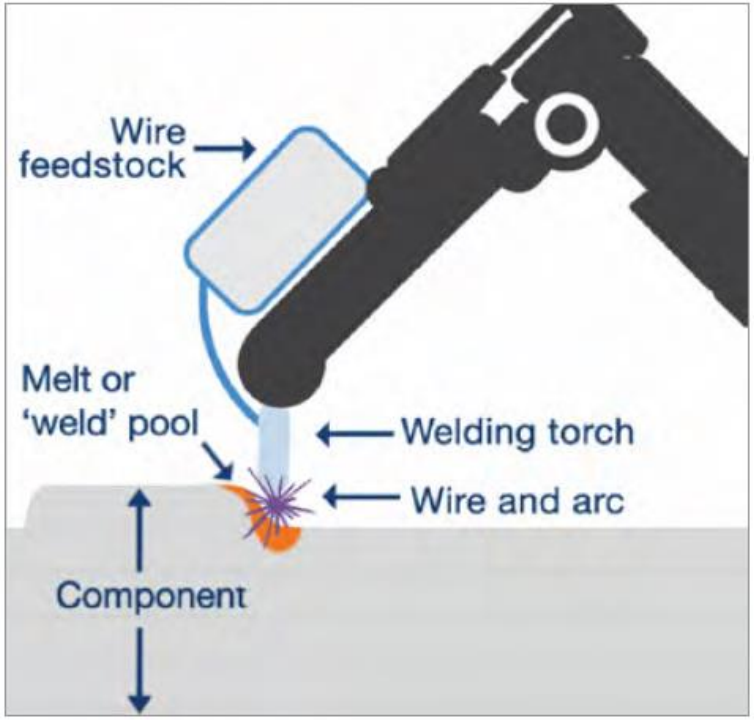
LMD

Directed Energy Deposition by Laser (DED LB)



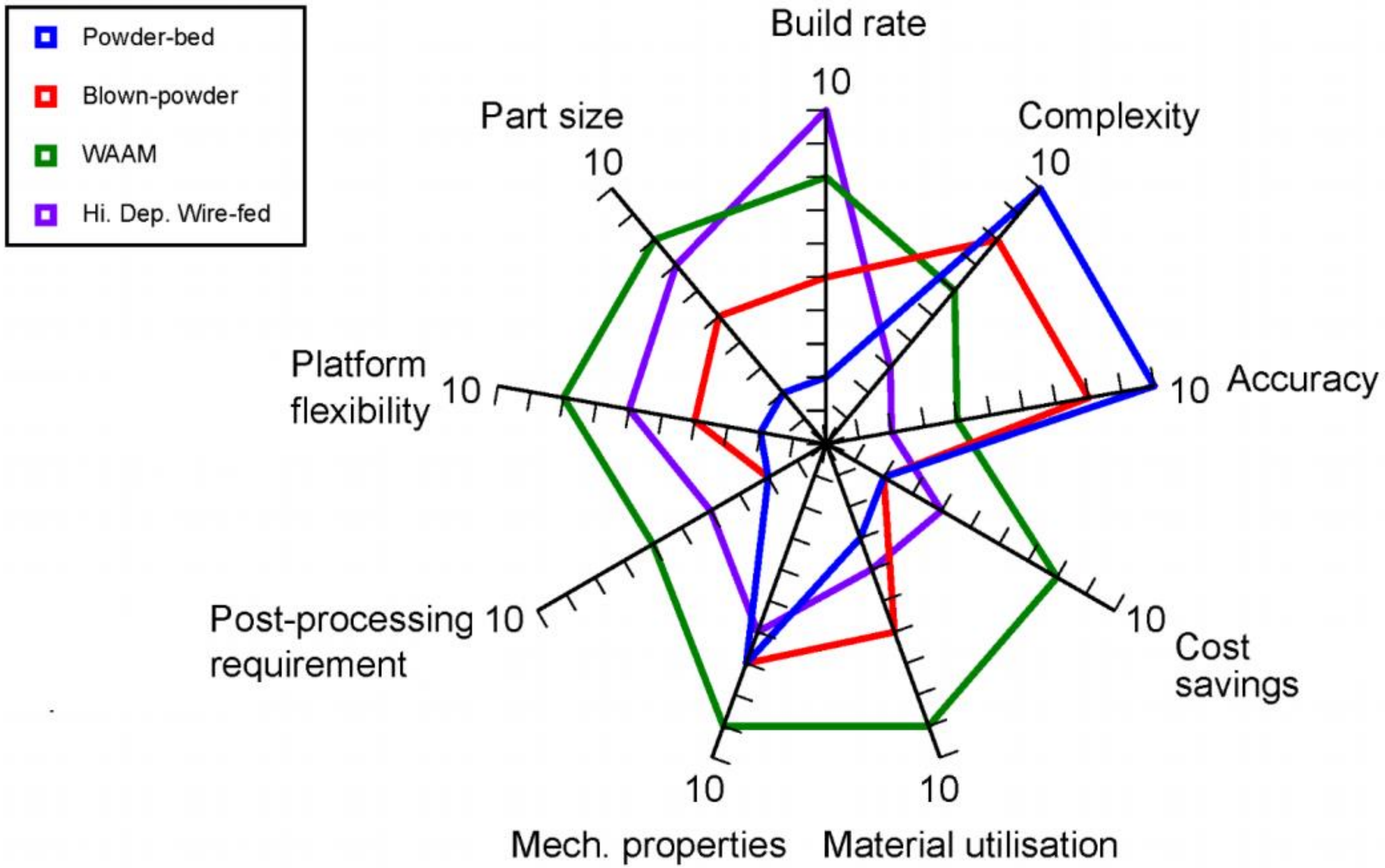
WAAM

Directed Energy Deposition by Arc (DED Arc)



Source: Lloyd's Register & The Welding Institute (TWI) – *"Guidance notes for Additive Manufacturing"*

Technology Selection

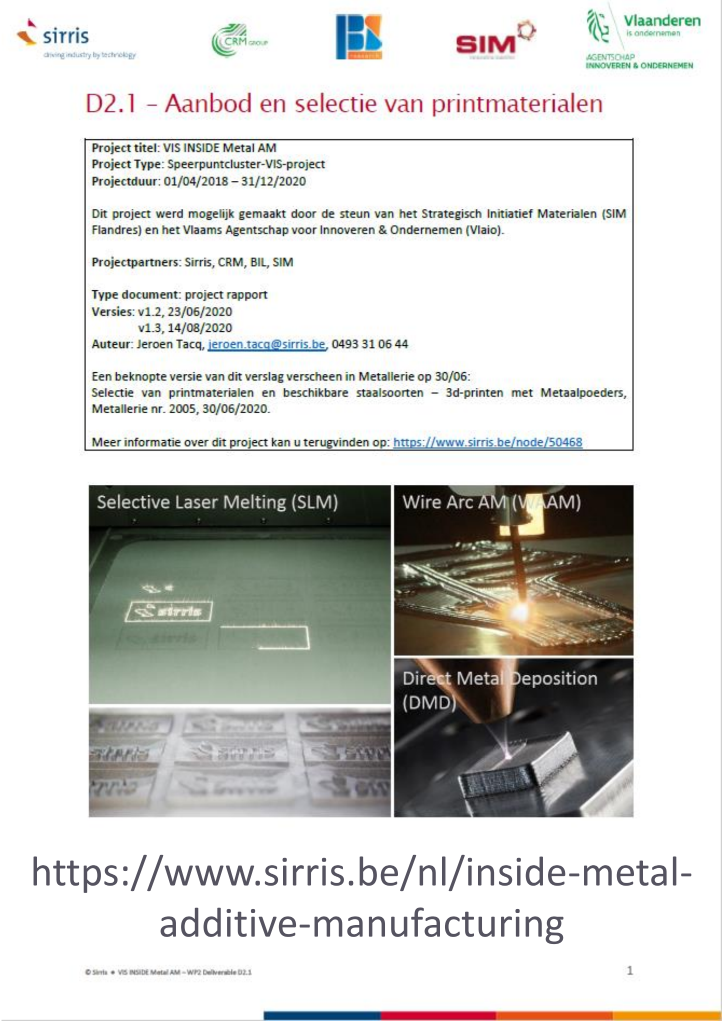


Source: Cranfield University

Technology Selection

Topic	L-PBF	EBM	Binder Jetting	FDM	DED-LB	DED-WAAM	Sheet lamination
Feedstock	Metal powder < 60 µm	Metal powder < 80 µm	Metal powder up to 100 µm	MIM feedstock, wire or pellet	Metal powder < 150 µm or wire	Metal wire ø 0.8-1.6 mm (multi-wire)	Metal sheets
Bonding means	Laser	Electron beam	Polymer binder	Extruded in heated nozzle	Laser	Electric arc	Friction, mechanical
Part size	Std : 250 mm Max : 1000 mm	Std : 200 mm Max : 380 mm	Std : 100 mm Max : 800 mm	Std : 100 mm Max : 300 mm	Up to several m (robot vs CNC)	Up to > 10 m (robot on rail config.)	Up to 4m
Min wall thickness	0.3 mm	0.8 mm	1 mm	1.2 mm	1 - 2 mm (focal spot, material)	2 - 3 mm (ø wire, material)	Depends
Strengths	- Accuracy - Surface finish - Fine details	- Limited stress - Handle bulky parts - Low contamination - Manufacturing speed	- Limited stress - Atm. Conditions - High speed	- Limited stress - Clean - Affordable	- Medium size … - AM on existing part - Multi-material and FGM	- High deposition rate - Lower investment/m² - Integrate substrate - Good density	- Sheet mech. properties - As-built accuracy - Sensor embedded - Multimaterials
Weakness	- Supports removal - Internal stresses - Post process	- Powder cake removal - Limited material range - As-built roughness	- Needs sintering (Shrinkage 20%) - OR Infiltration (weakness infiltrant)	- Shrinkage 20% - Needs sintering - Slow technology	- No supports - Limited overhang and precision - Surface finish (waviness)	- Low part complexity and surface finish - High HI, residual stresses and distortions - Under development	- Slow process
Applications	- Large range of thin, accurate parts - Parts with cavities, channels	- Small to medium bulky organic structural components without cavities	- Small parts, with quite thin walls in huge quantities	- Small parts, with quite thin walls in small quantities	- Parts of medium … - Cladding, repair - Customization of existing parts	- Large structural parts (aerospace, marine) - Large machine parts, tooling (machining)	- Quite uncommon
Suppliers	SLM Solutions Concept Laser 3D Systems EOS Trumpf AddUp	Arcam (GE) EBAM (Sciaky)	Digital metal ExOne Desktop Metal HP	Markforged Desktop Metal 3DVigo AIM3D Pollen	Optomec Trumpf DMG Mori Seiki BeAM Hornet (modular)	Gefertec Prodways Hornet (modular)	Stratoconception

Material Selection


sirris
driving industry by technology
CRM group
SIM
Vlaanderen is ondernemen
AGENTSCHAP INNOVEREN & ONDERNEMEN

D2.1 – Aanbod en selectie van printmaterialen

Project titel: VIS INSIDE Metal AM
Project Type: Speerpuntcluster-VIS-project
Projectduur: 01/04/2018 – 31/12/2020

Dit project werd mogelijk gemaakt door de steun van het Strategisch Initiatief Materialen (SIM Flandres) en het Vlaams Agentschap voor Innoveren & Ondernemen (Vlaio).

Projectpartners: Sirris, CRM, BIL, SIM

Type document: project rapport
Versies: v1.2, 23/06/2020
v1.3, 14/08/2020
Auteur: Jeroen Tacq, jeroen.tacq@sirris.be, 0493 31 06 44

Een beknopte versie van dit verslag verscheen in Metallerie op 30/06:
Selectie van printmaterialen en beschikbare staalsoorten – 3d-printen met Metaalpoeders, Metallerie nr. 2005, 30/06/2020.

Meer informatie over dit project kan u terugvinden op: https://www.sirris.be/node/50468

https://www.sirris.be/nl/inside-metal-additive-manufacturing

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- Material selection (steel) linked to implemented technology
- Doesn't need to be the same as conventional part

LMD/L-PBF

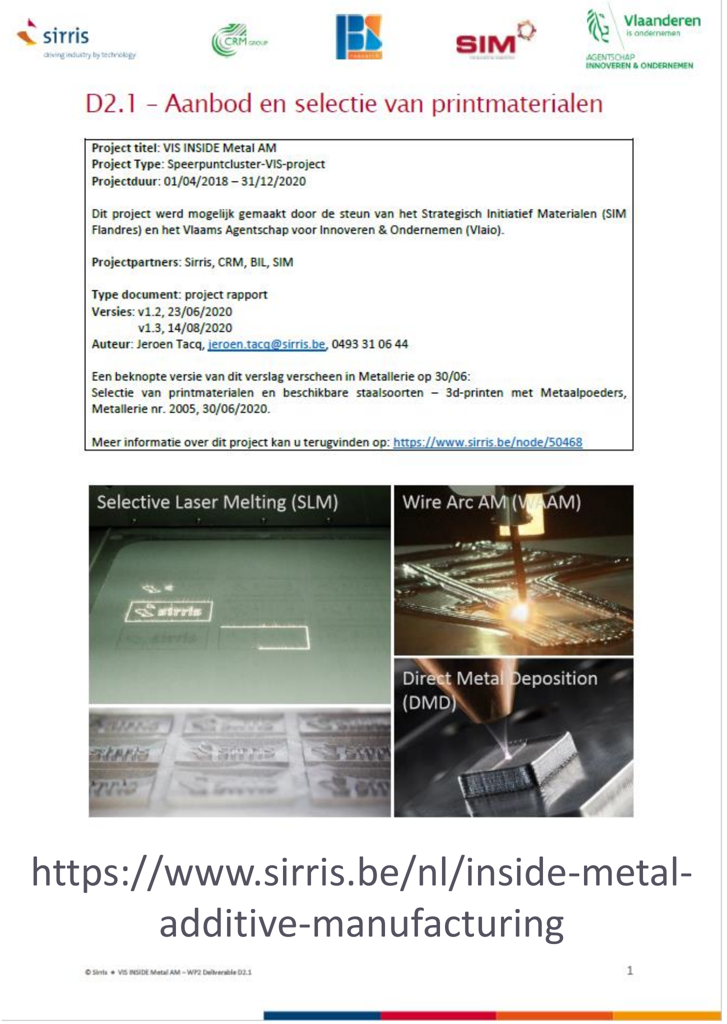
- Limited material choice
- New materials frequently added

INSIDE Metal AM project

- 316L, 17-4PH, H11

316L
304
H11/H13
M300
15-5PH
17-4PH
CL 91RW
CX
BLDRmetal L-40
M789
Corrax
M3
Invar36

Material Selection



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https://www.sirris.be/nl/inside-metal-additive-manufacturing

- ➢ Material selection (steel) linked to implemented technology
- ➢ Doesn't need to be the same as conventional part

WAAM

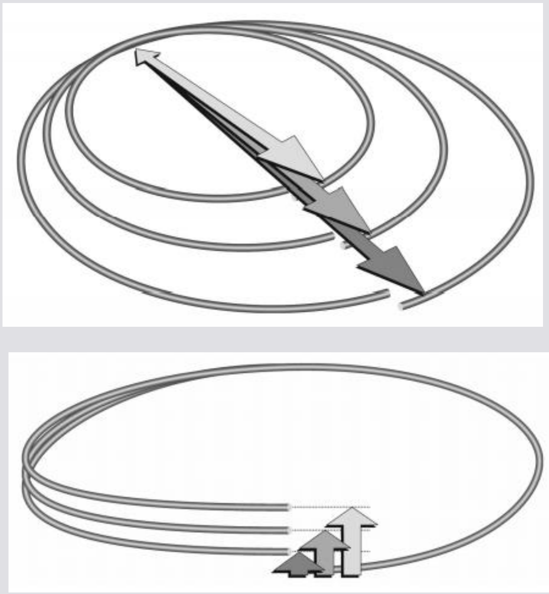
- ➢ Mostly welding consumables
- ➢ Specially developed WAAM wires

INSIDE Metal AM project

- ➢ 2209, 316L, S355

Raw material quality

Wire quality and gas choice



Source: National Standard

Wire

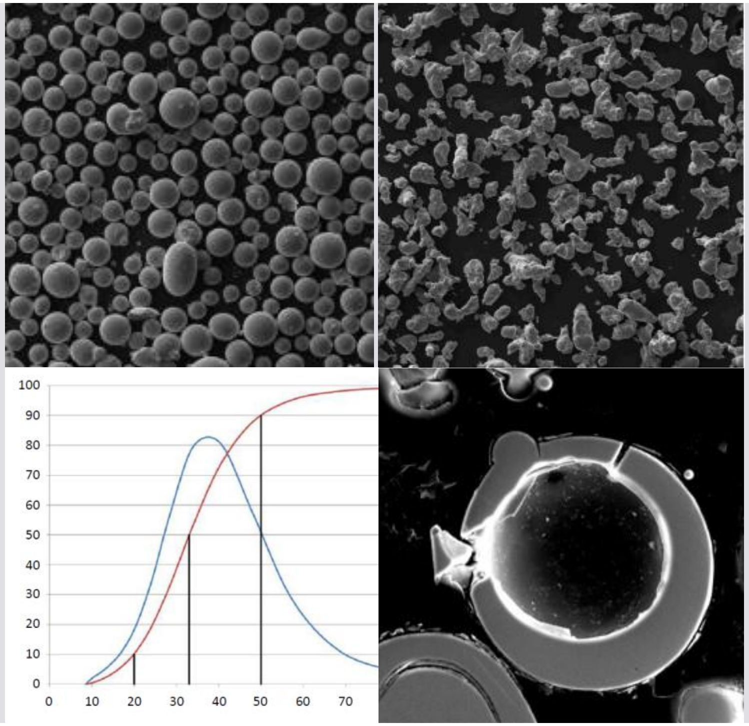
- Cast and helix (feedability, arc stability)
- Chemical composition
- Surface condition

Gas choice

- Stability of the process
- Surface finish

Raw material quality

Powder quality features

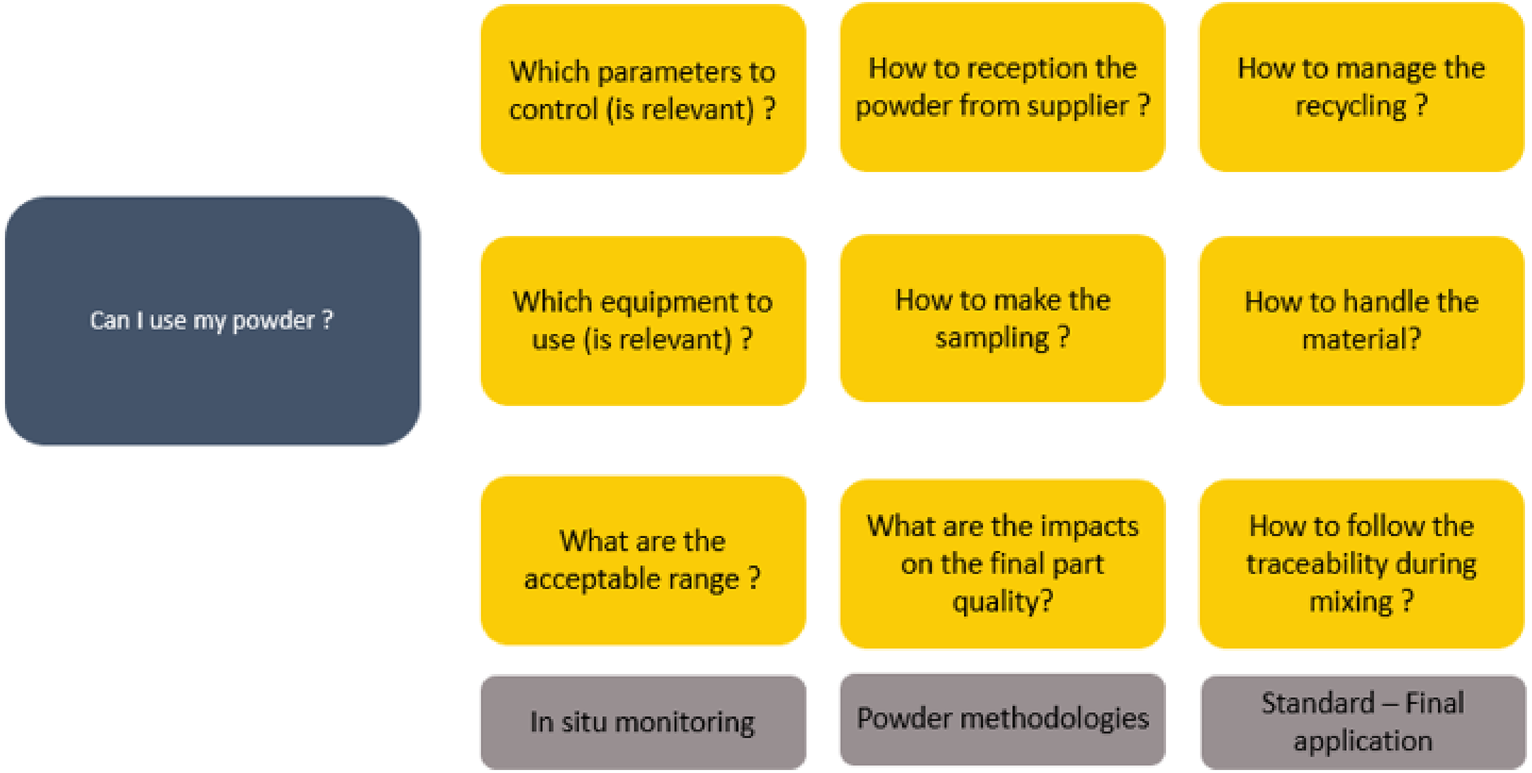


- ✓ Particle size and distribution
- ✓ Shape
- ✓ Flowability
- ✓ Entrapped gas

SLM vs. LMD

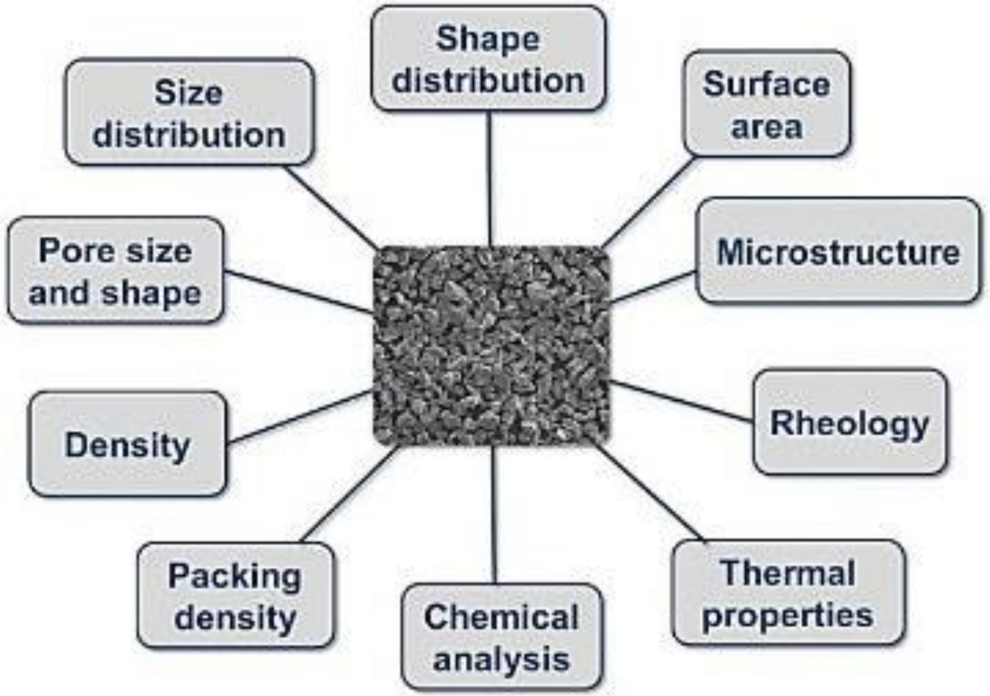
Powder Quality

The main questions coming from the industry



Powder Quality

Fact 1 : Use the right equipment to characterize

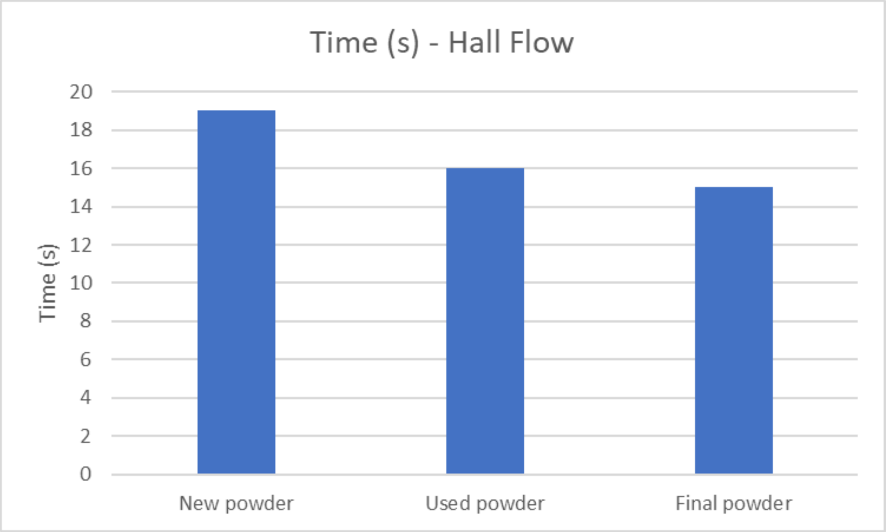


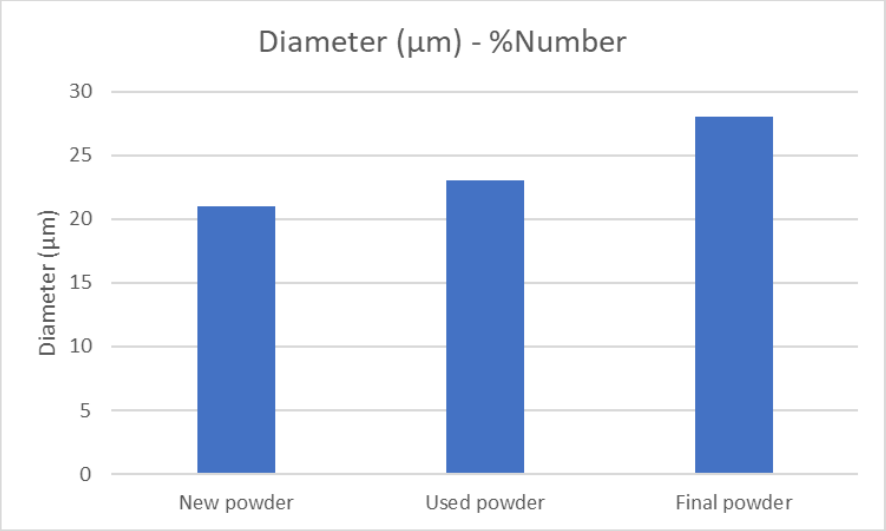
- Lot of equipment on the market in order to characterize the powder :
  - ✓ Each of them have pro and negative points
  - ✓ Depend on the nature of the material
  - ✓ Depend on the printing technology

The main goal is to detect the right characterization equipment to perform a relevant, quick and robust test.

Powder Quality

Fact 2 : Process impacts the powder properties



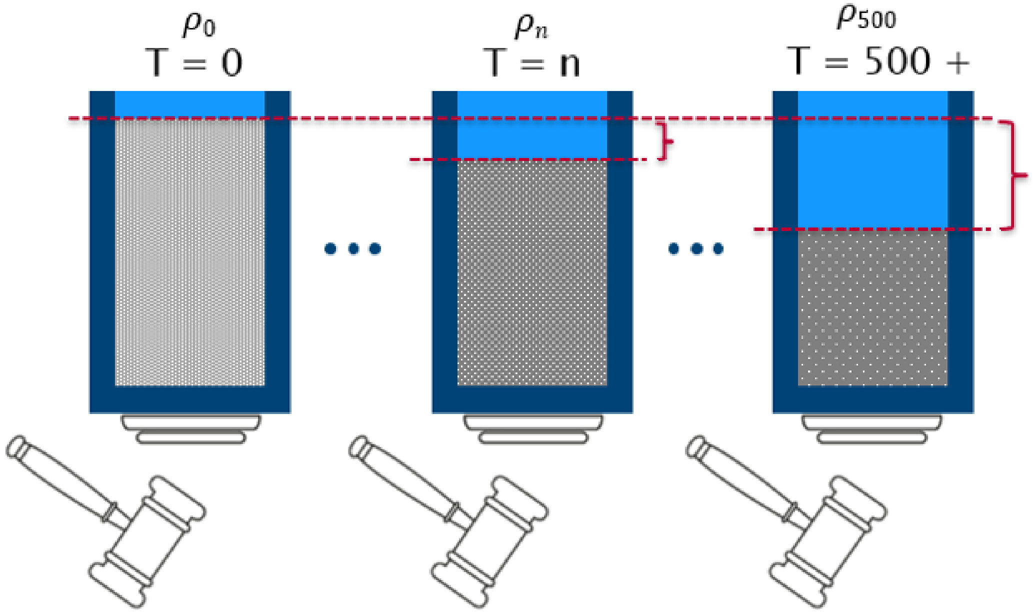


- ✓ Printing
- ✓ Sieving
- ✓ Mixing
- ✓ Handling
- ✓ Storage

Mastery of the full chain of material handling is mandatory to reach good quality on final part and powder properties.

Powder Quality

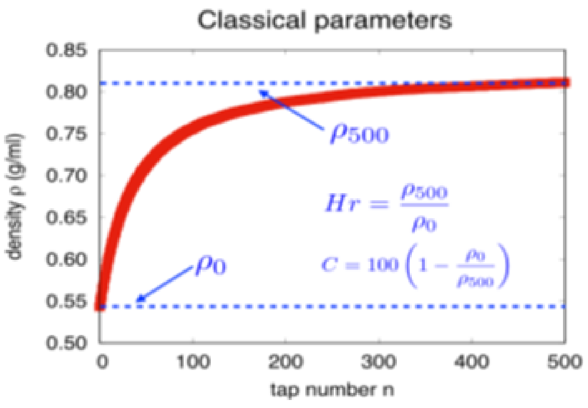
Fact 3 : Compaction curves give relevant information



$\rho_0 = intial\ density$

$\rho_n = density\ after\ "n"\ taps$

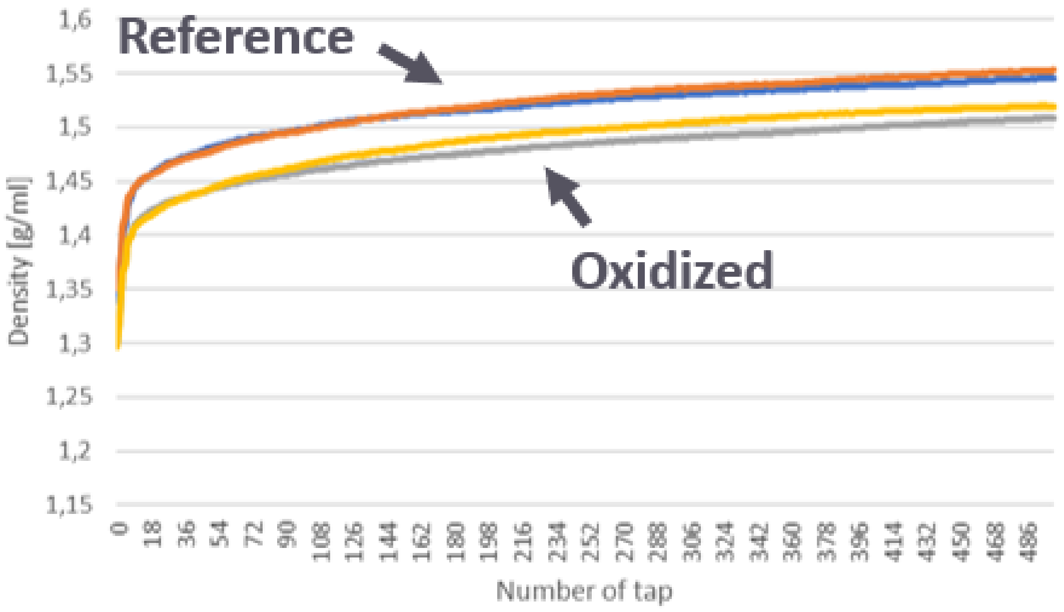
$$H[n] = \frac{\rho_n}{\rho_0} = Hausner\ ratio$$



- ✓ Oxidation
- ✓ Humidity
- ✓ Size distribution
- ✓ Spreadability
- ✓ Segregation

Powder Quality

Fact 3 : Compaction curves give relevant information

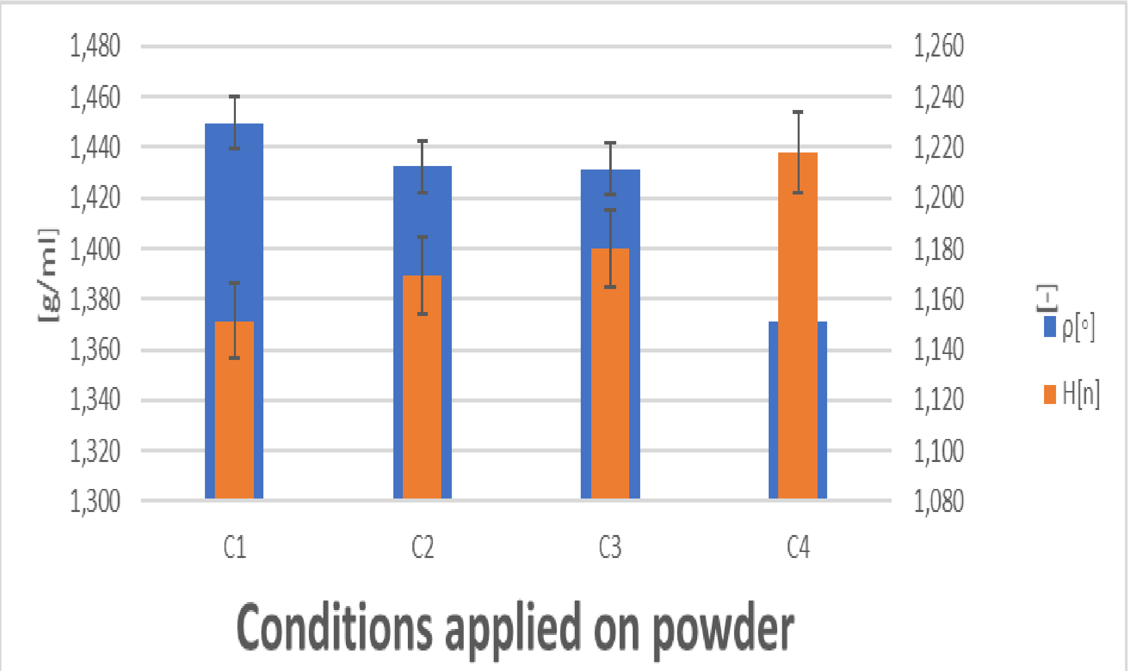


- Issue during sieving of powder : batch of oxidized powder injected

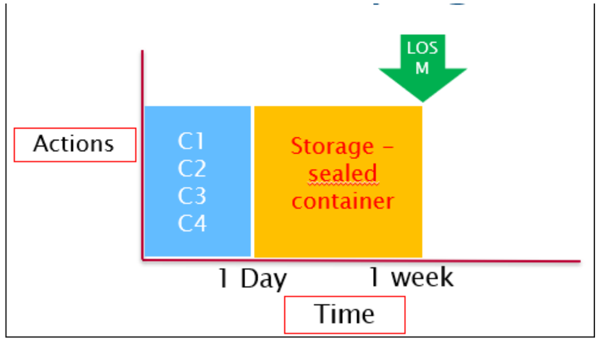
Compaction curves are sensitive to the level of oxidation of the powder

Powder Quality

Fact 3 : Compaction curves give relevant information



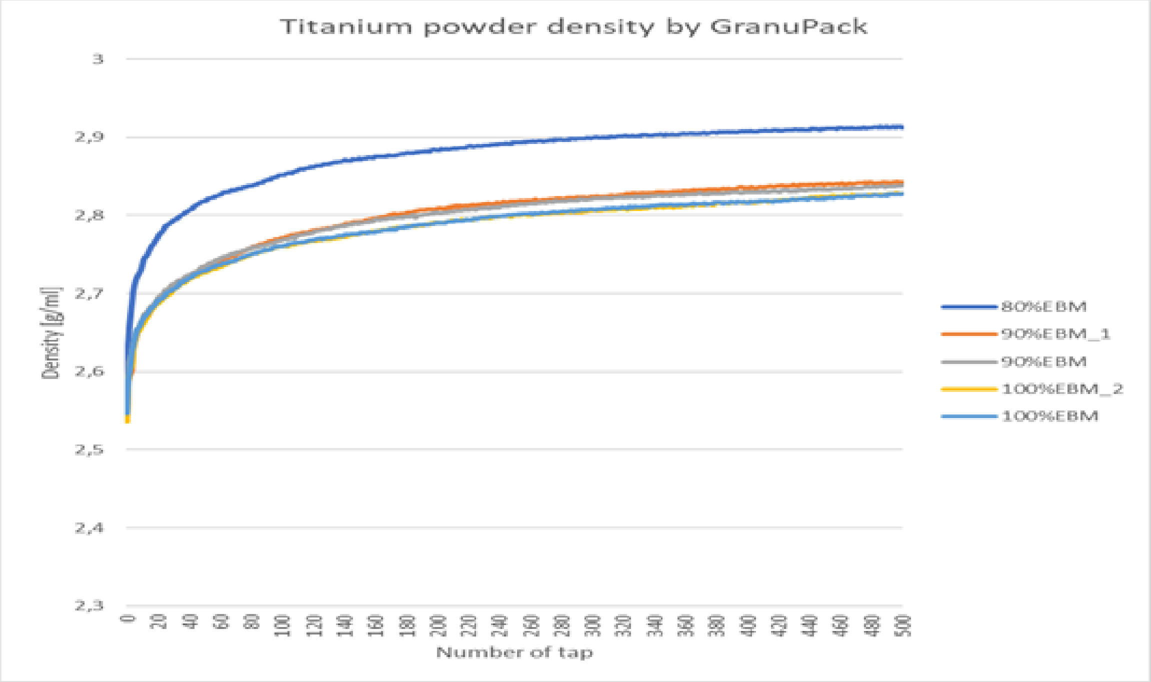
conditions	Fresh powder	AR/22°C/24h	44%/22°C/24h	95%/22°C/24h	stabilisation (168h)	rH% after stabilisation
C1	x				x	0,038
C2	x	x			x	0,039
C3	x		x		x	0,037
C4	x			x	x	0,043



Compaction curves are sensitive to the level of humidity of the powder

Powder Quality

Fact 3 : Compaction curves give relevant information

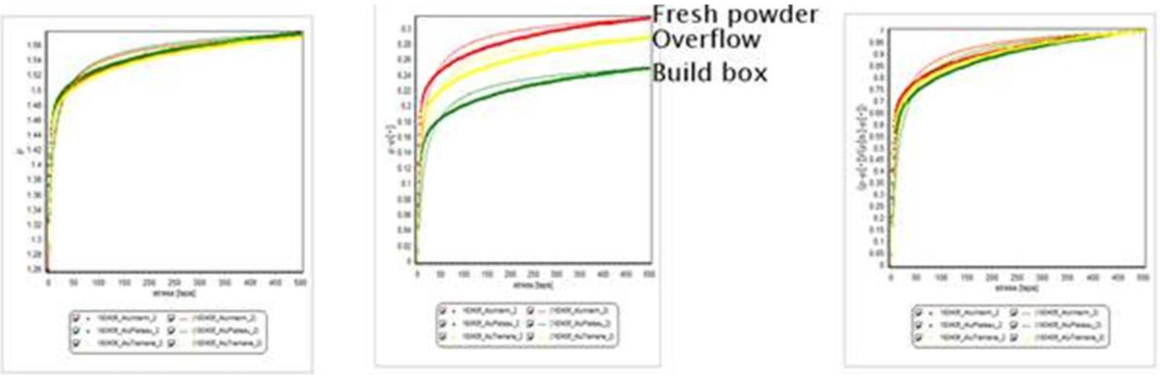


- Mix of two same material with 2 PSD range :
  - EBM : 45-100µm
  - SLM : 20-63µm

Compaction curves are sensitive to the particle size distribution of the powder

Powder Quality

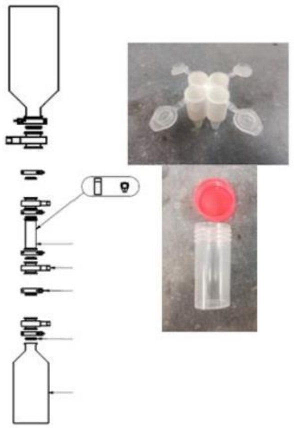
Fact 3 : Compaction curves give relevant information

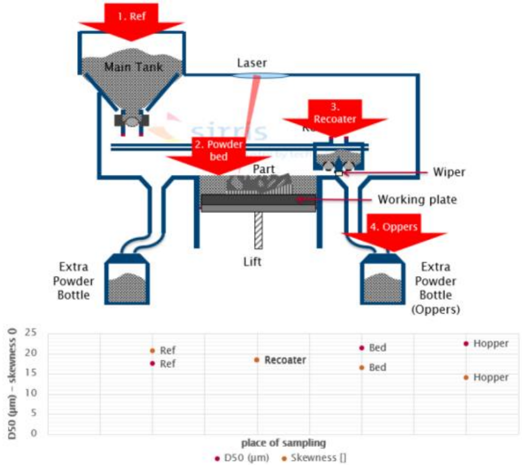


Initial density

Hausner ratio

Compaction speed





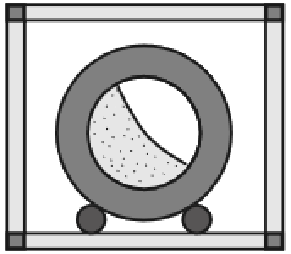
	ρ[0]		ρ[n]		n½		H[n]	
	average		average		average		average	
new	1,258333	0,28%	1,567333	0,27%	3,466667	4,64%	1,245	0,30%
Over Flow	1,278667	0,33%	1,570333	0,26%	4,433333	1,06%	1,228667	0,21%
Build box	1,323	0,43%	1,580333	0,27%	5,6	11,57%	1,194667	0,67%

Lower Flowability

Better Flowability

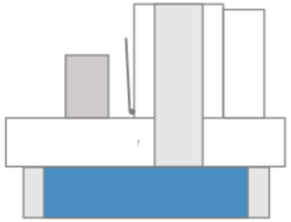
Compaction curves are sensitive to the global effect of the process itself

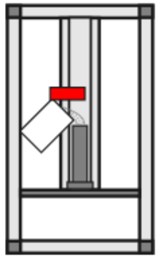
Key take-aways on powders



Use the right equipment to characterize

Process impacts the powder properties





Compaction curves give relevant information

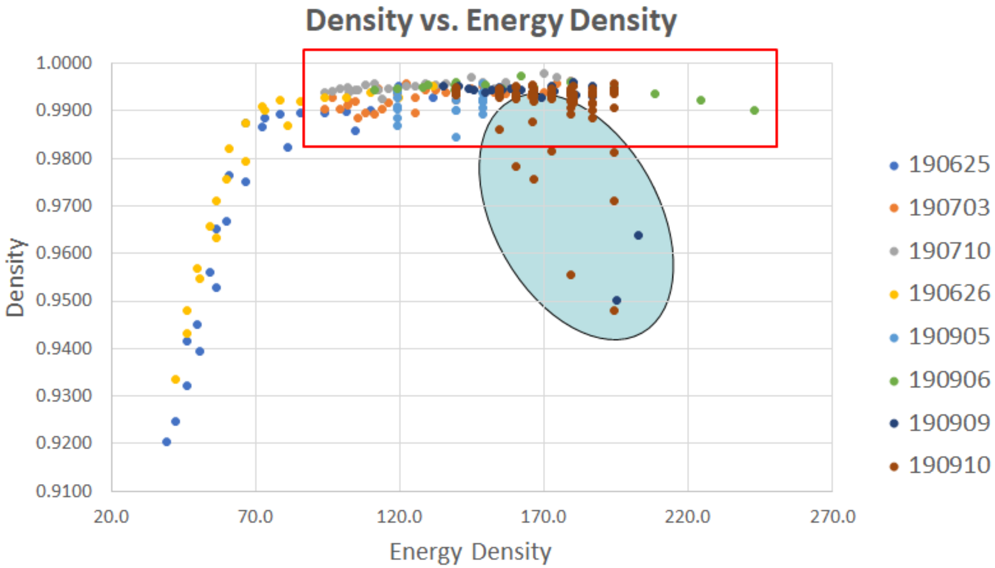
Build up a history for your printing equipment in your environment and define a threshold for powder acceptance

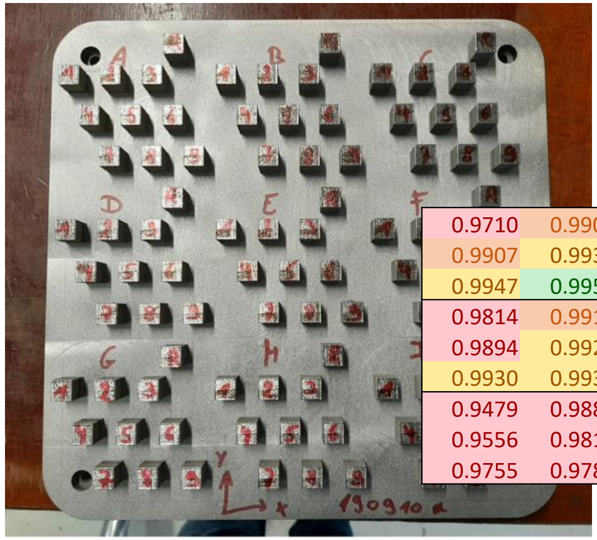
Properties of your printed parts

What are good settings ***for your machine***?
What ***material properties*** do you get?
What is the influence of ***heat treatment***?

Process optimisation for heat treatable materials

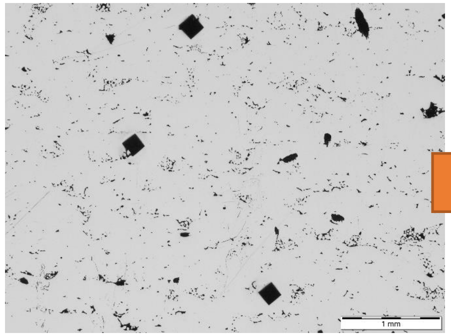
- ✓ Appearance
- ✓ Density
- ✓ Process stability
- ✓ Hardness
- ✓ (Surface)

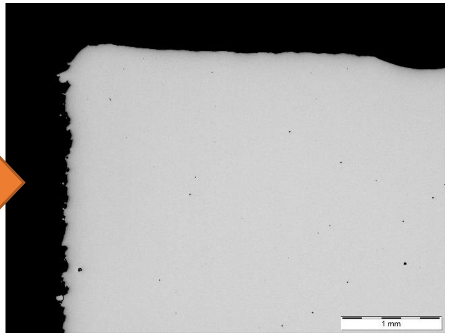




L-PBF vs. WAAM/LMD

0.9710	0.9902	0.9918	0.9940	0.9938	0.9937	0.9957	0.9916	0.9933
0.9907	0.9934	0.9930	0.9945	0.9939	0.9940	0.9941	0.9933	0.9932
0.9947	0.9953	0.9936	0.9934	0.9926	0.9948	0.9943	0.9948	0.9945
0.9814	0.9914	0.9927	0.9936	0.9936	0.9934	0.9946	0.9948	0.9951
0.9894	0.9928	0.9955	0.9933	0.9933	0.9938	0.9934	0.9948	0.9952
0.9930	0.9932	0.9938	0.9930	0.9933	0.9934	0.9943	0.9932	0.9942
0.9479	0.9884	0.9918	0.9907	0.9934	0.9923	0.9944	0.9938	0.9934
0.9556	0.9814	0.9876	0.9919	0.9924	0.9935	0.9923	0.9935	0.9939
0.9755	0.9784	0.9861	0.9919	0.9932	0.9927	0.9934	0.9936	0.9946

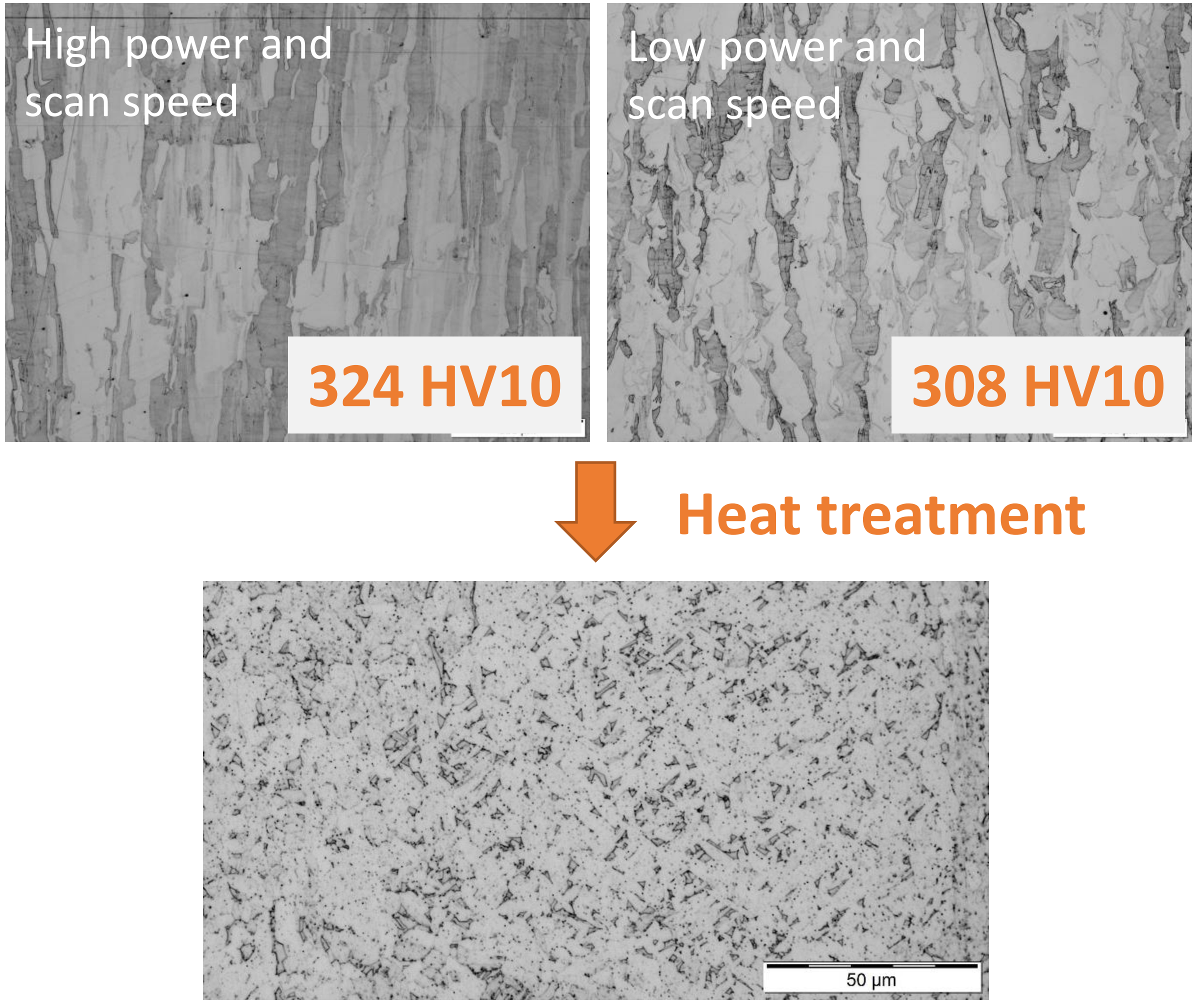




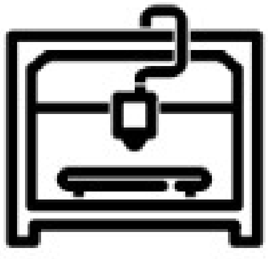
Process optimisation for heat treatable materials

- ✓ Appearance
- ✓ Density
- ✓ Process stability
- ✓ **Hardness**
- ✓ (Surface)

17-4PH / L-PBF



Process optimisation for heat treatable materials



Process optimisation **for heat treatable materials** should focus on optimising density and build speed

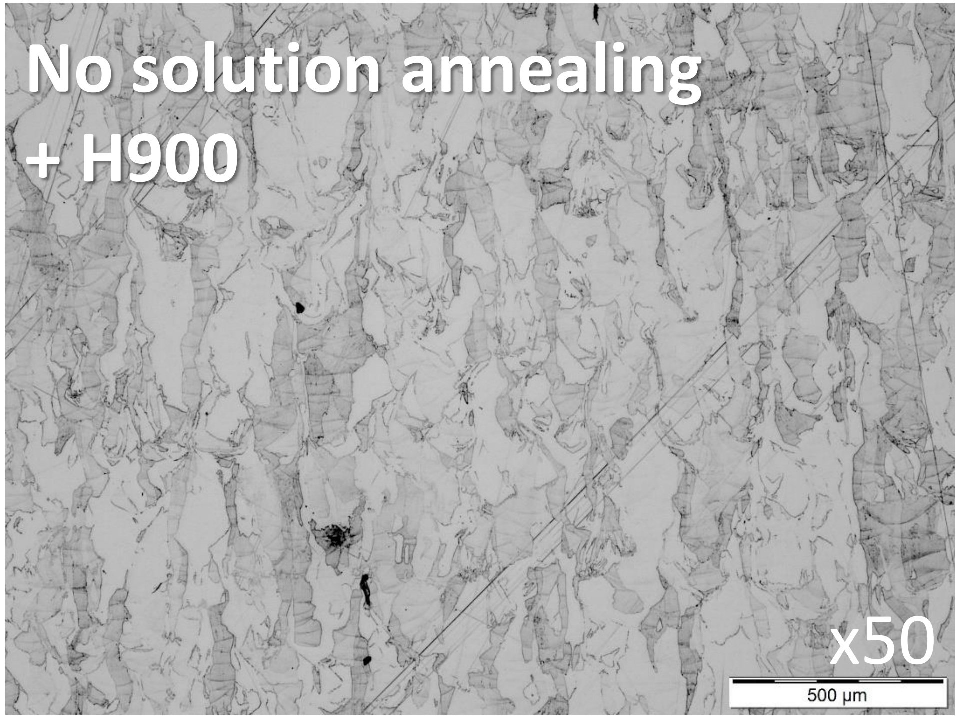
Step 1: optimize for density (> 99.8%)
Step 2: optimize stability/HI control
Step 3: optimize for productivity

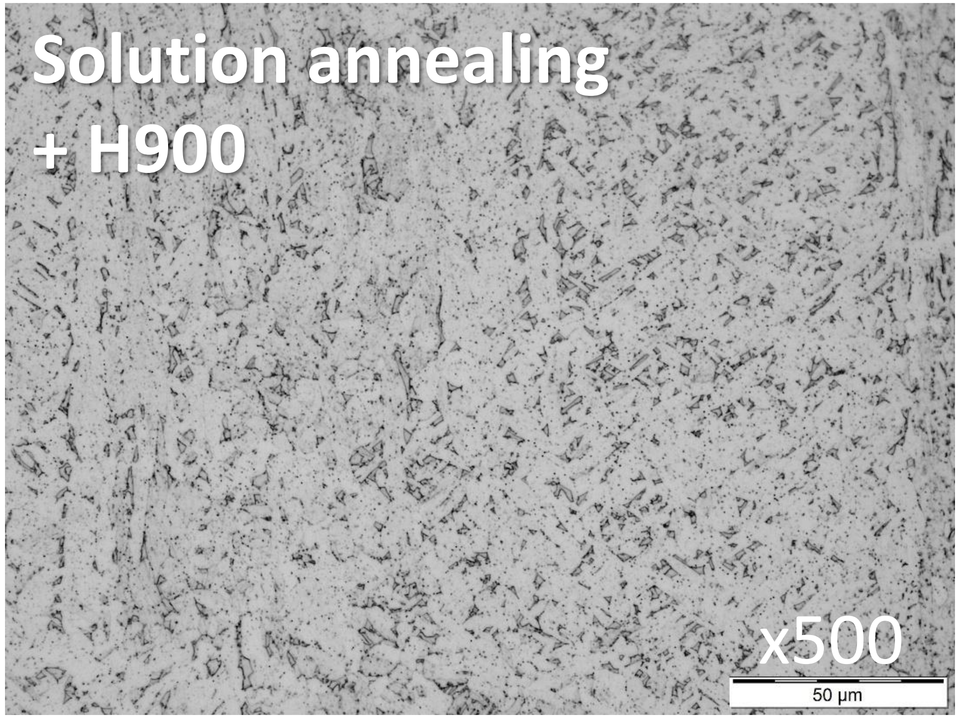
L-PBF vs. LMD/WAAM

Heat Treatment

- ✓ Reduce residual stresses
- ✓ Large impact on properties

17-4PH / L-PBF

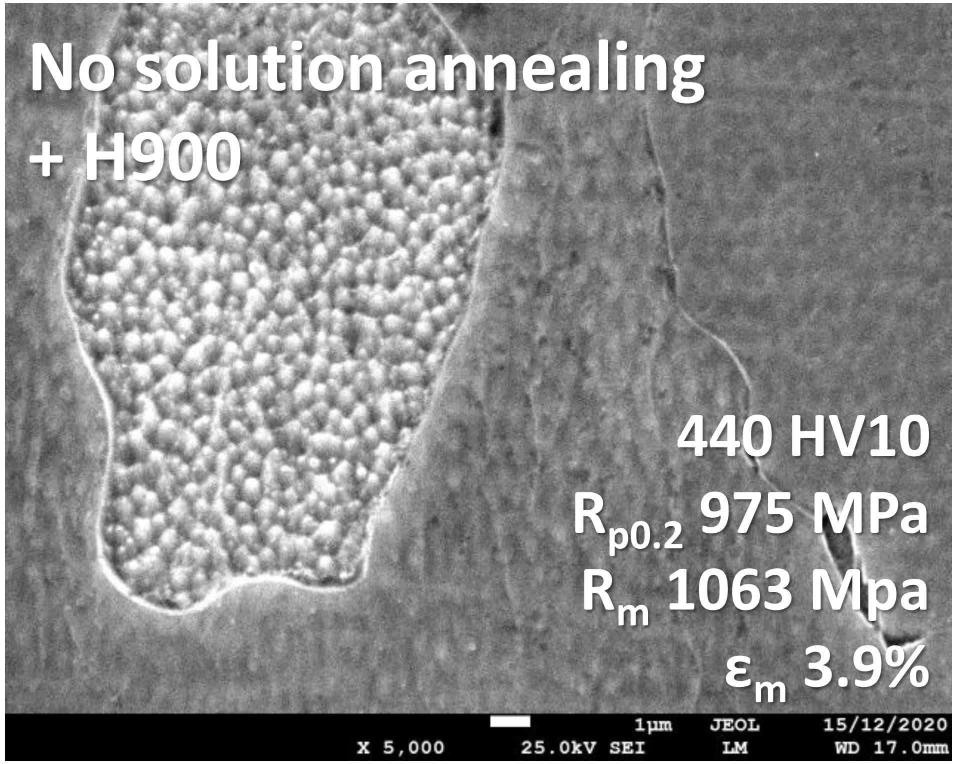


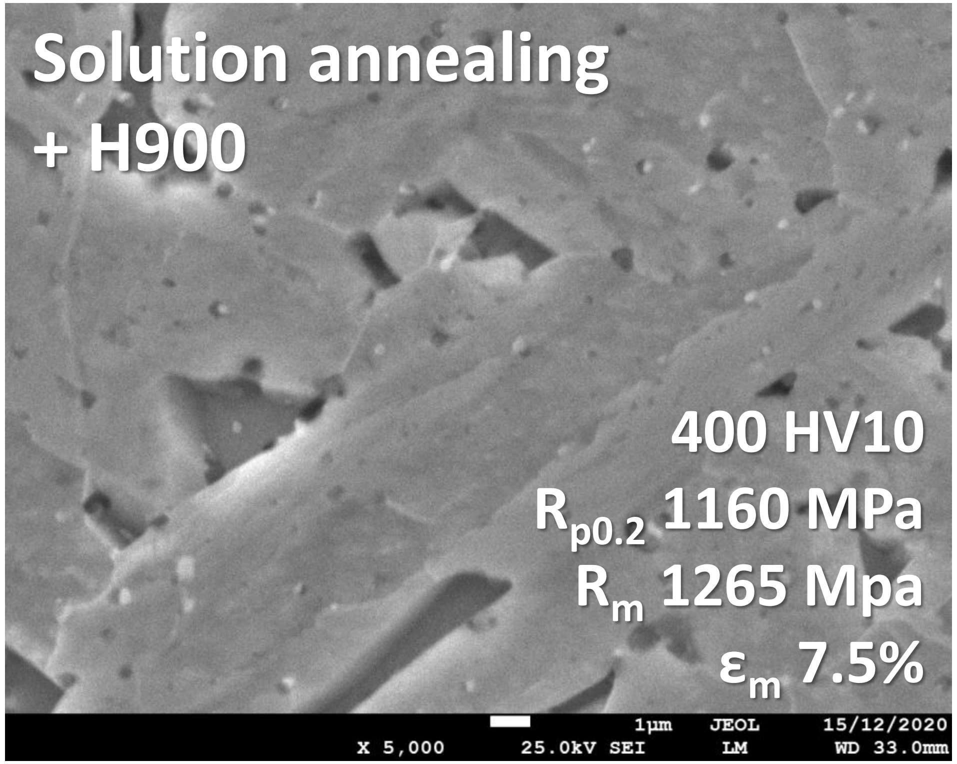


Heat Treatment

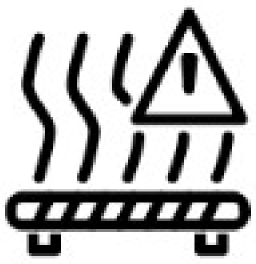
- ✓ Reduce residual stresses
- ✓ Large impact on properties

17-4PH / L-PBF





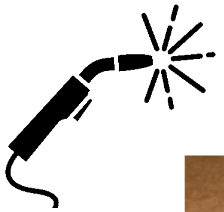
Heat Treatment

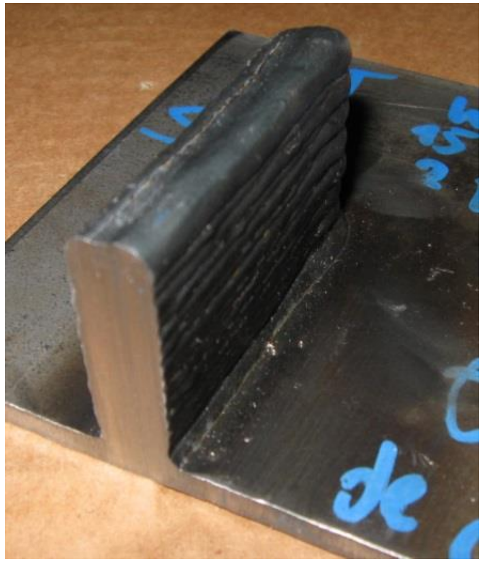


Heat treatment needs to be carefully considered as a **critical step in the process chain**.

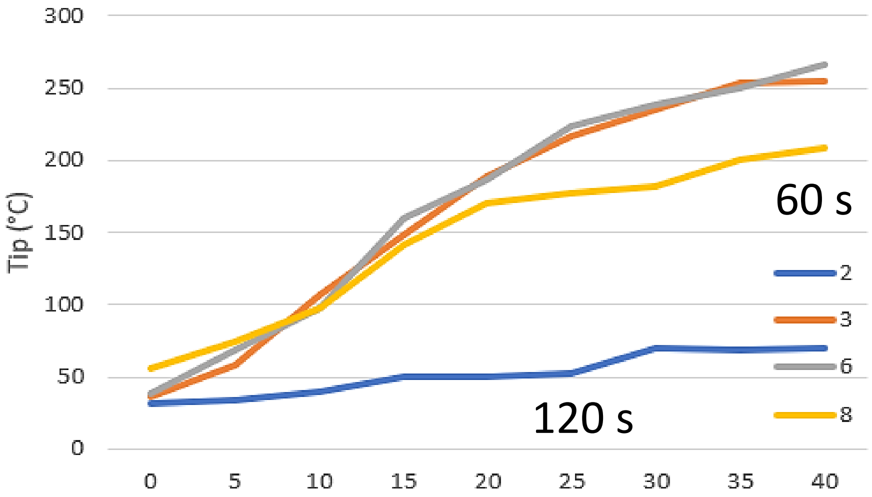
- Significant influence on both properties and structure
- Good control of HT is required! (≠ conventional)
- Can be used to tailor material properties.
- Has a larger influence than print parameters.

Respect the supplier recommendations for WAAM

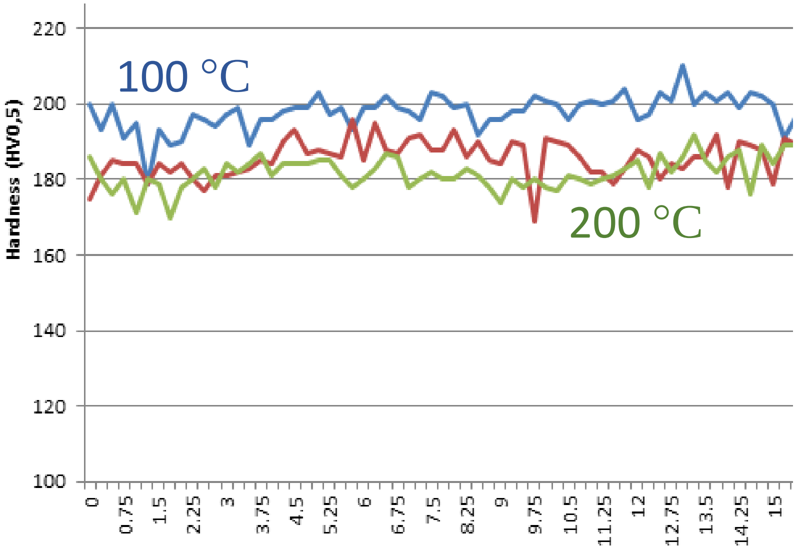




- ✓ Interpass temperature for non-heat treatable alloys:
  - ✓ Controls the microstructure (cooling rate)
  - ✓ Increases homogeneity

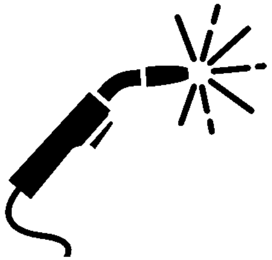


Temperature at constant waiting time



Hardness profile

Respect the supplier recommendations for WAAM



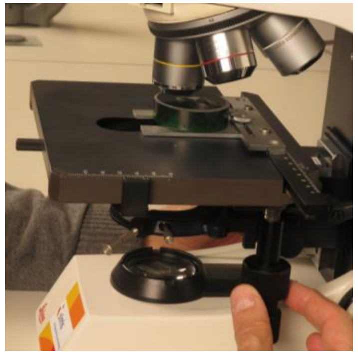
The properties of **non-heat treatable** wires depend greatly on **the cooling rate**.

- Respect the recommended interpass temperature
- Control by temperature and not time
- Properties only stabilizes after few passes
- Parameters such as arc-correction play a big role on stability and porosity

Finish the part

- Locally vs globally?
- Machining or surface treatment?
  - Holes, cavities?
- Inspection and certification have to be chosen soon enough
- Account for everything in the cost

Post-processing



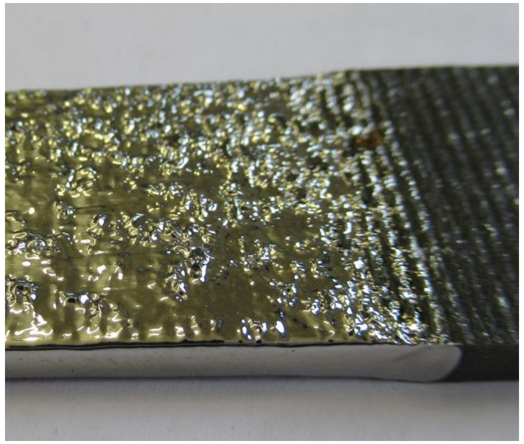
Inspection & Testing

Surface Finish

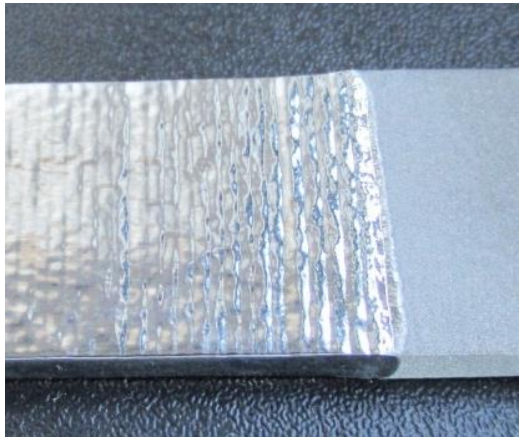
Choice of post-process:

- What is the goal?
- Which is the initial state?

Effect of sandblasting on LMD electropolishing

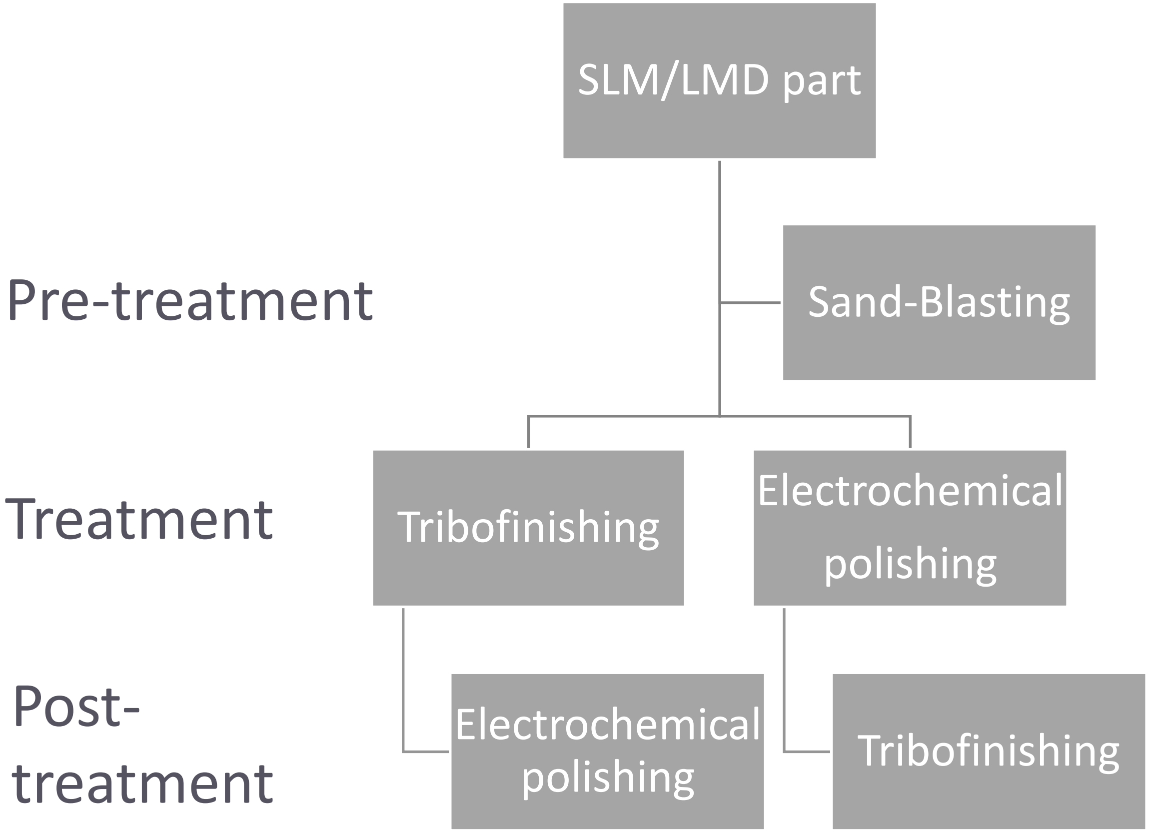


As-built



sandblasted

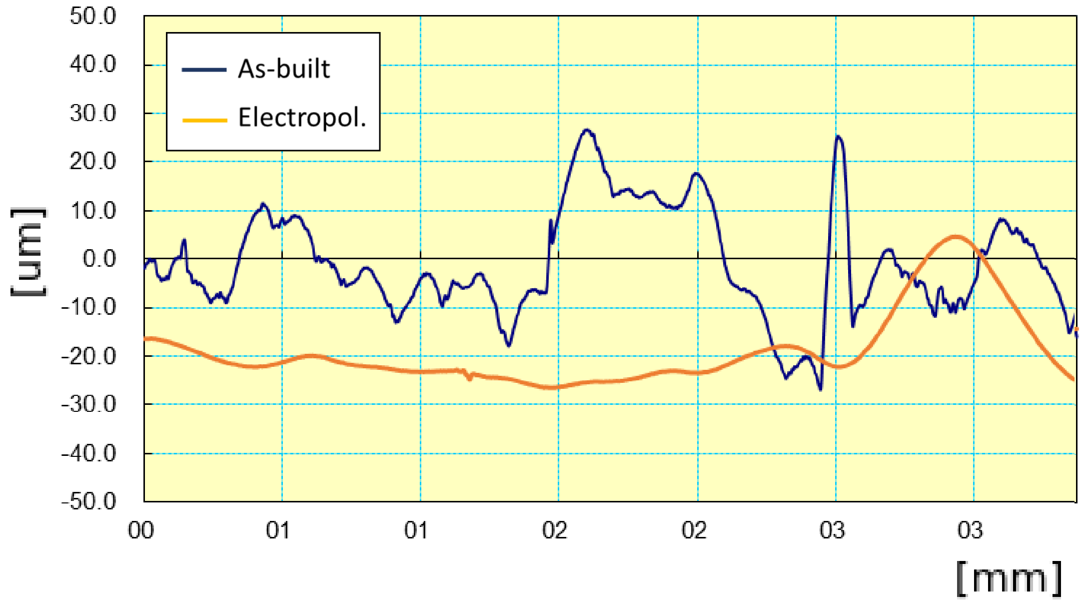
- Combination of processes might be needed

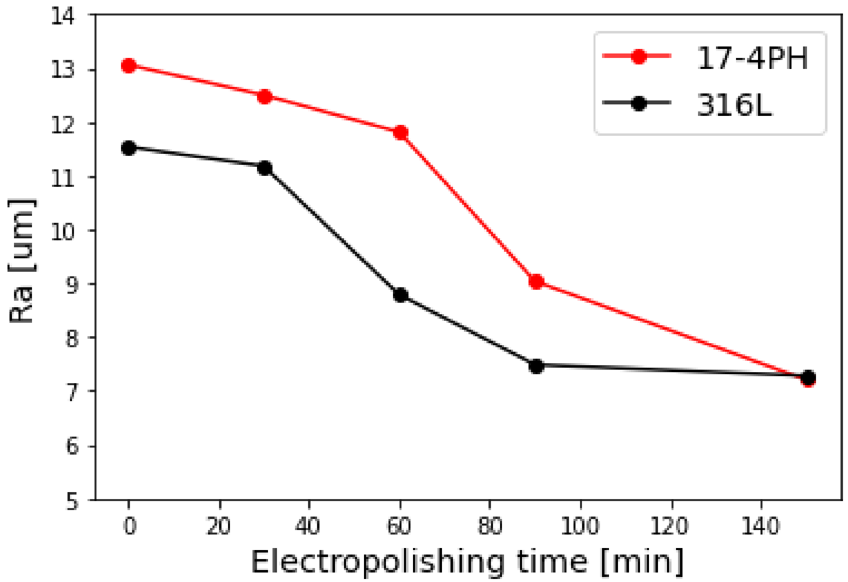


Surface Finish - SLM

On SLM 17-4PH & 316L, Electro-Polishing shows enough smoothening

- Achievable roughness: 4-6 µm Ra
- Important to account for section reduction





Surface Finish - LMD

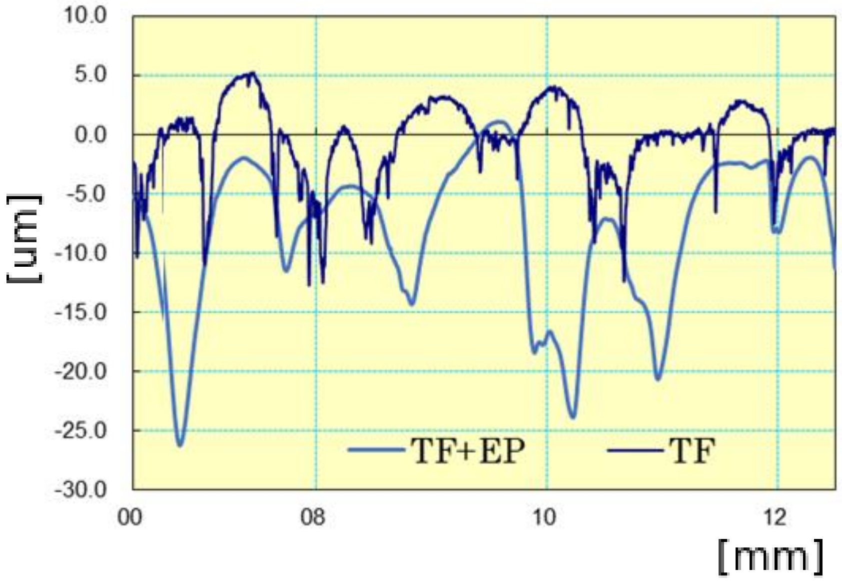
Sandblast + Tribofinishing
+ Electropolishing

LMD requires combining techniques

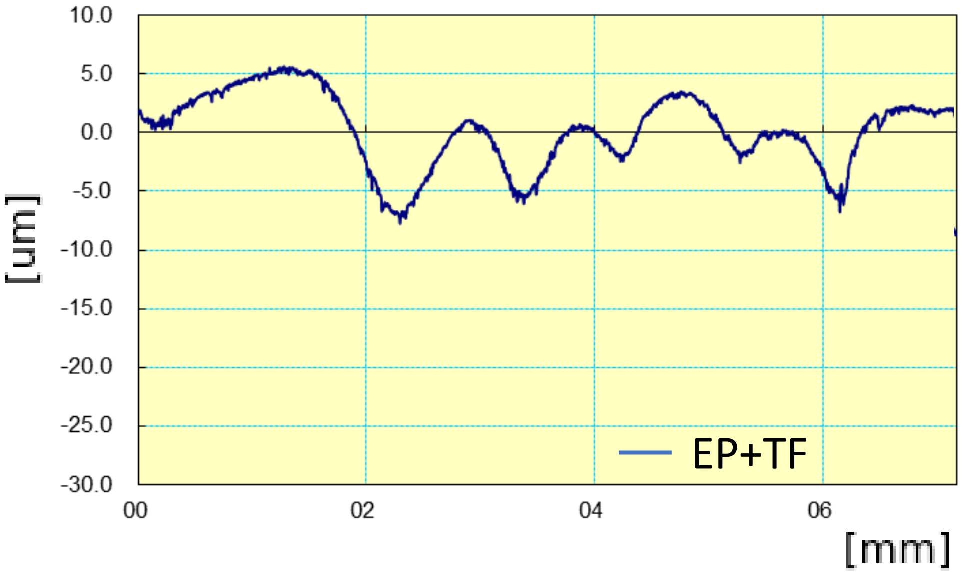
- Important to choose the right order

- Similar Ra (4-5 µm), different profiles !!

Total time 8.5 h



Total time 5 h



Surface finishing

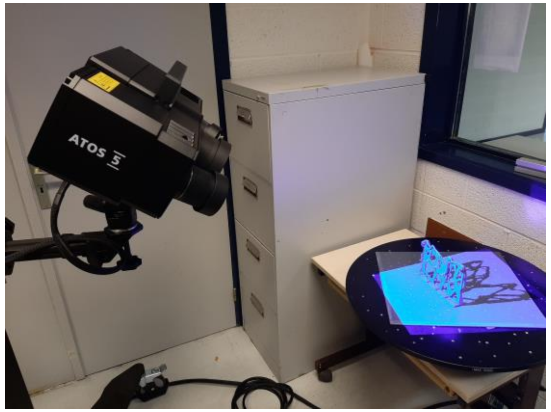
Surface finishing is the right combination of several techniques for a given material and process.

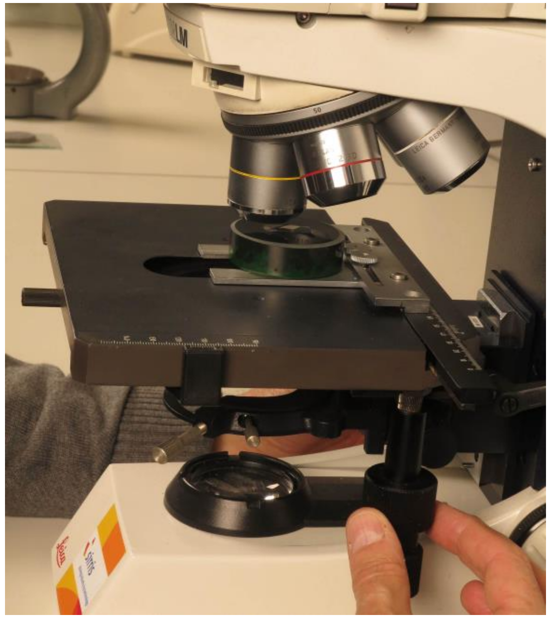
- Not a single solution for all processes and materials
- Chose the right roughness descriptor
- Trade-off between cost/time and surface quality
- They rely on material removal, sections can be modified

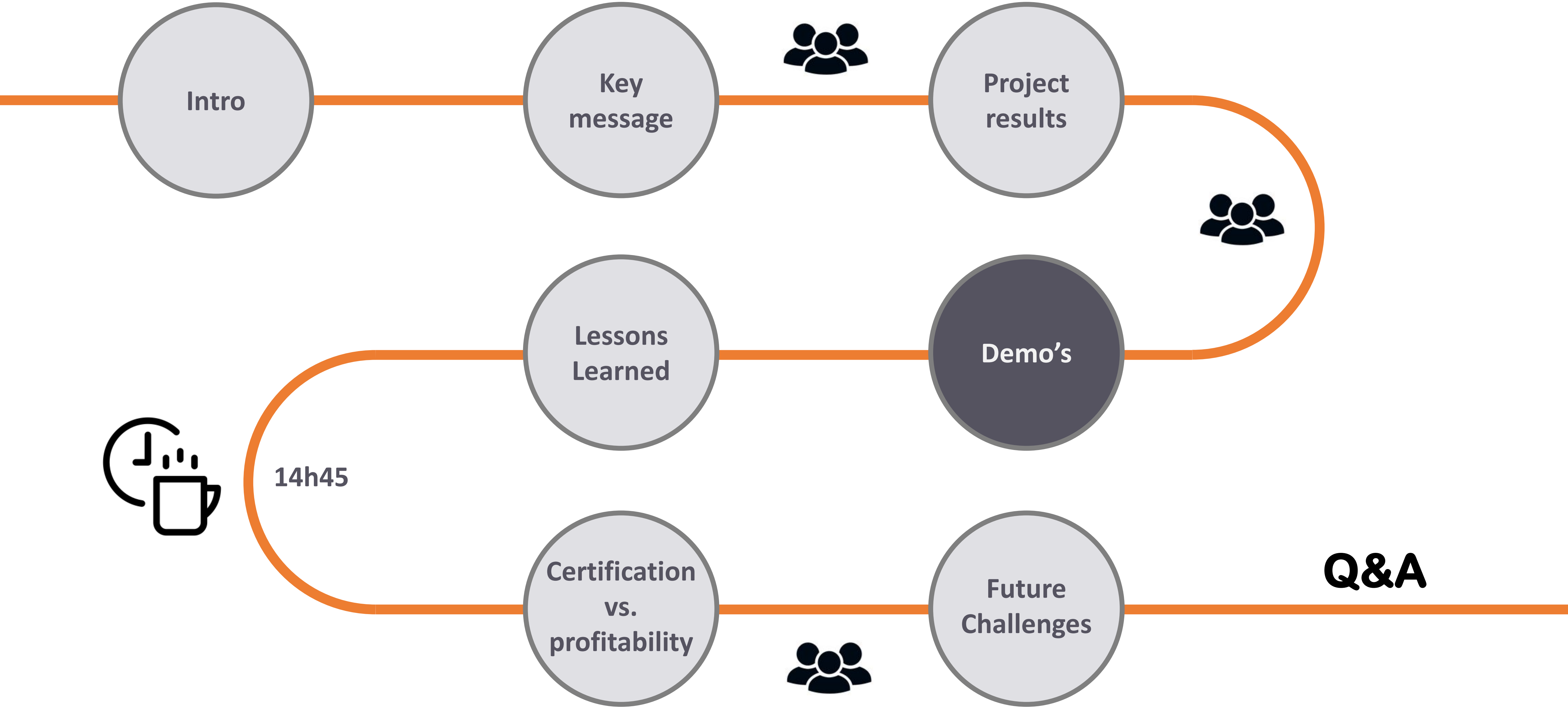
Quality Check

- ✓ Dimensional tolerances
- ✓ Material properties
- ✓ Tomography
- ✓ Surface Quality
- ✓ Residual stresses

✓ *Potentially also to be done before post-processing*



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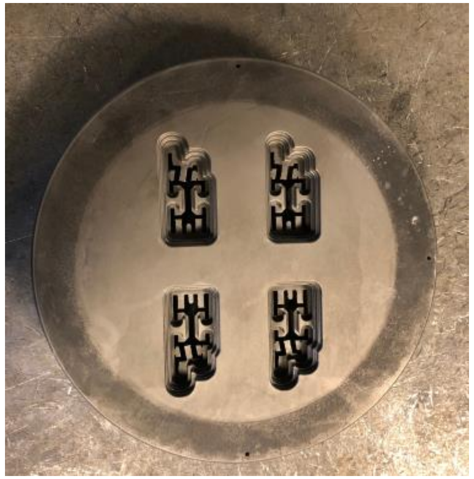
Poll 2

Industrial demonstrators

- Aluminium extrusion moulds
- ‘Generalised’ rotor
- Pump body



Aluminium Extrusion Mould

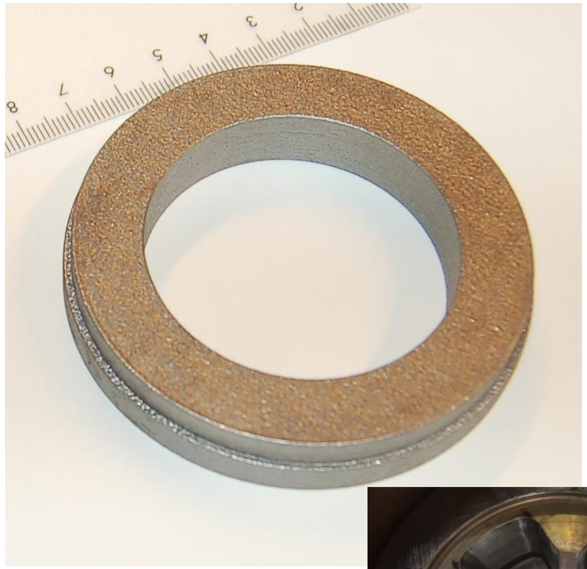
L-PBF of H11 steel

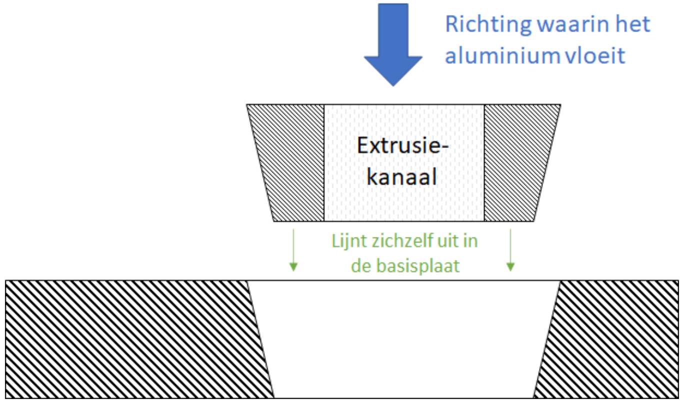
TRUMPF

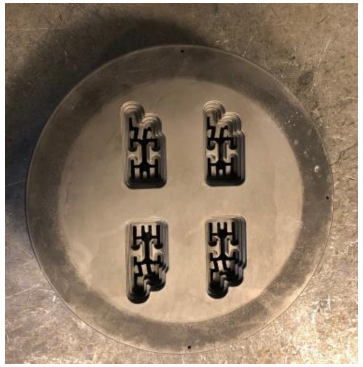
V.A.C MACHINES

EMAX SUSTAINABLE ALUMINIUM

Starting small can lead to new insights







Internal cooling for improved extrusion of recycled aluminium.

Generalised rotor

L-PBF and LMD of 17-4PH steel

An example on technology selection: L-PBF vs. LMD

L-PBF

LMD

Total Height: 225mm
Ø 80-100mm

The following is a comparison based solely on our own experiences and best estimates!

Technology comparison

L-PBF

- Printed in a single step
- Printing is relatively slow (2 days > 14h)
- Approx. 20% dead time (recoating)
- Deposition: 50-150 g/h
- Overhangs up to 45°

LMD

- Multi step process
- Printing is fairly fast (11h > 8h)
- 50% dead time, large reduction for parallel printing
- Deposition: 700 g/h
- Overhangs require skill and complex machine movement (here: 20°)

Technology comparison

L-PBF

- Walls: 3mm
- Internal structure can be very complex
- Fine, complex shaped cooling channels possible
- Layer thickness: 30-60µm
- Post processing to reduce roughness, tolerances <0.1mm possible

LMD

- Walls: 9mm
- Internal structure is kept more simple
- Holes for cooling
- Layer thickness: 500µm
- Finishing in most cases by machining (tolerances 0.5-1mm)

Economic (cost) comparison

L-PBF

Main Cost elements

- Preparation time mainly in design phase
- Machine time (# of layers, material volume)
- Material cost (powder cost and efficiency)
- Cleaning time
- Post processing and Finishing

LMD

Main Cost elements

- Preparation time strongly scales with complexity
- Machine time (cooling, start/stop, volume)
- Material cost (powder cost and efficiency)
- Cleaning time
- Post processing and Finishing

Economic (cost) comparison

L-PBF

Estimated build cost:
1000-2000 euro

Total material cost:
±120 euro (2 kg)

Only limited influence of complexity on total cost.

LMD

Estimated build cost:
800-1000 euro

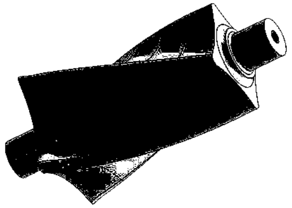
Total material cost:
550 euro (5.5 kg)

Larger influence of complexity on total cost (preparation time).

Comparison to conventional manufacturing
(NNS casting + machining)

- Obsolete spare parts
- Single parts (vs. high cost for moulds), impact of number of parts
- Cooling/weight reduction
- Complexity

Making the choice…



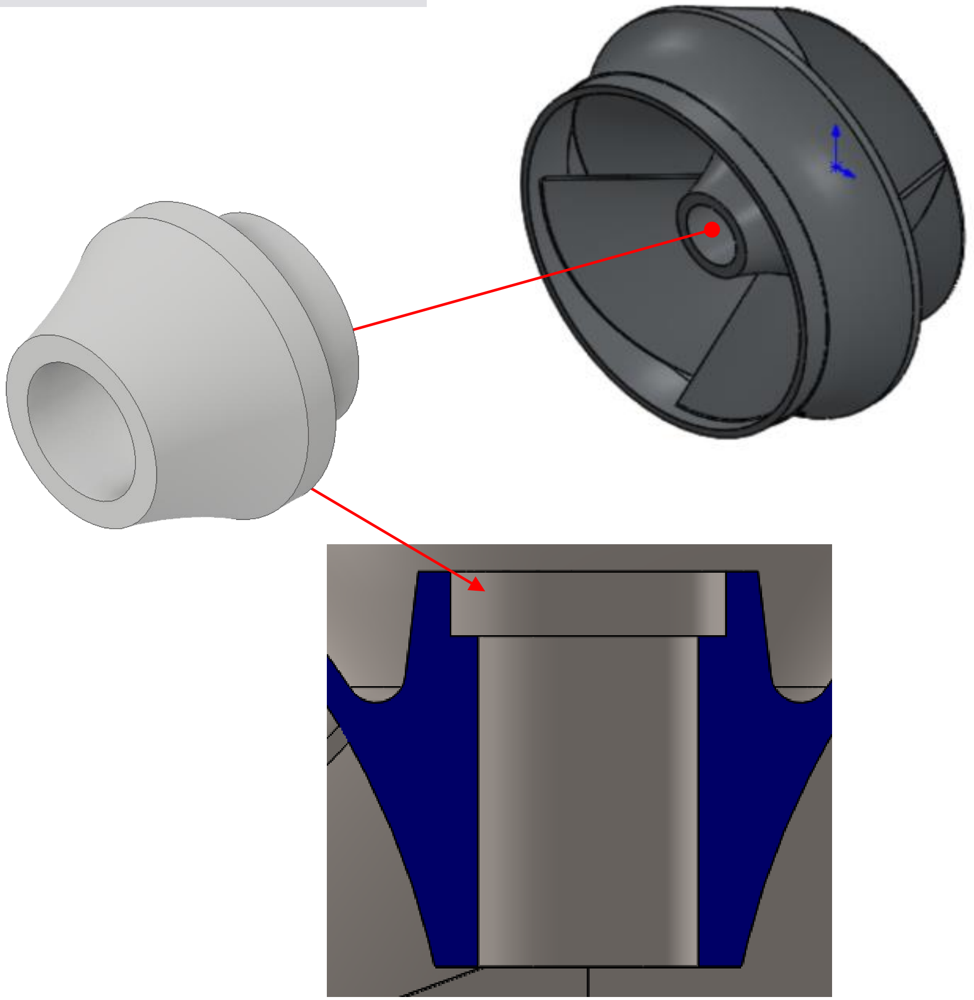
Even for a specific case, **the choice** between these two technologies **is not self evident**. A good knowledge of the application is required, as well as a good understanding of the possibilities of each technology.

WAAM pump body

- A large duplex stainless-steel part
  - 1.6 m diameter! About 1500 Kg
- WAAM is chosen for productivity

Challenges

- Not constant section
- Overhanging surfaces



Cross section

WAAM pump body

Building time

- ~16h

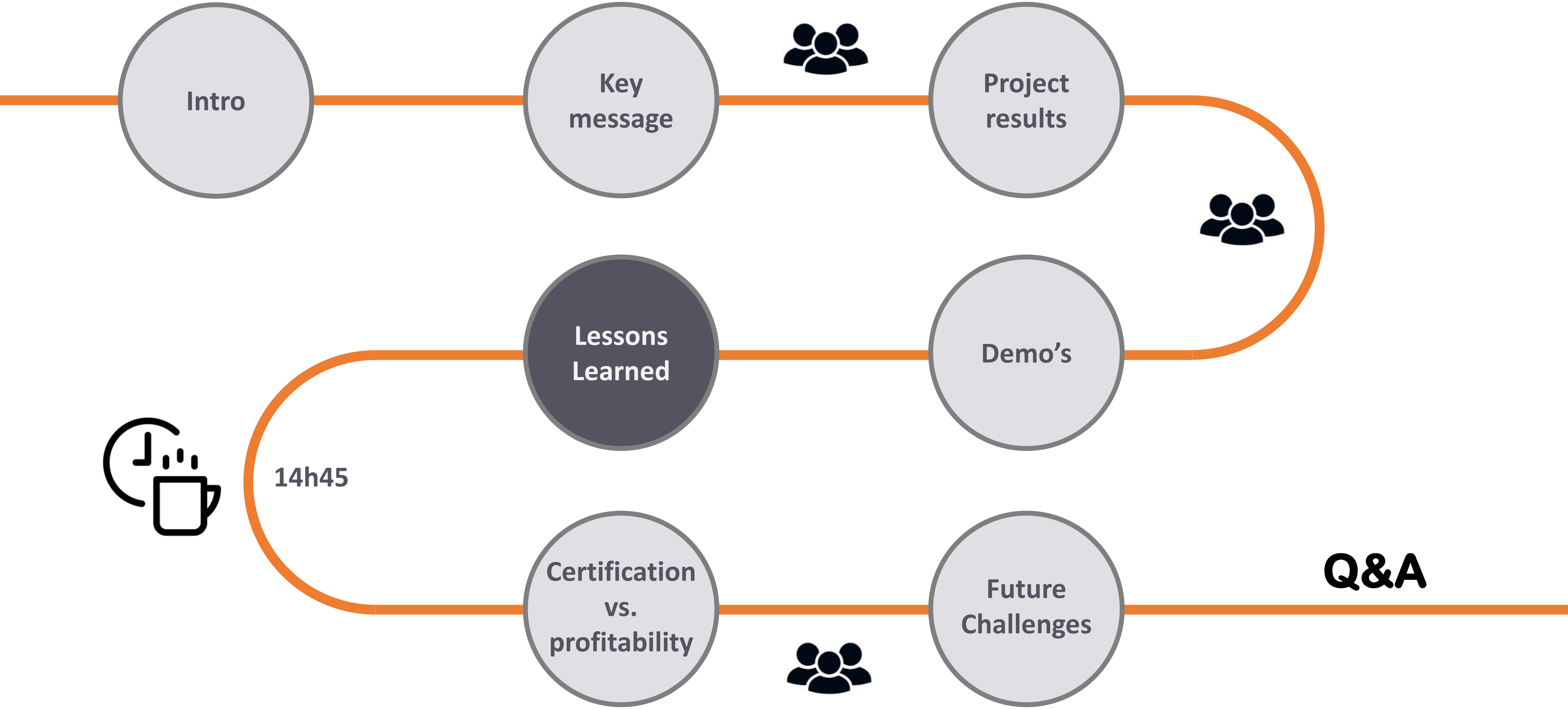
Deposition rate

- ~2kg/h

Cooling time

- ~50% of total time

Selection of right parameters to allow for overhanging printing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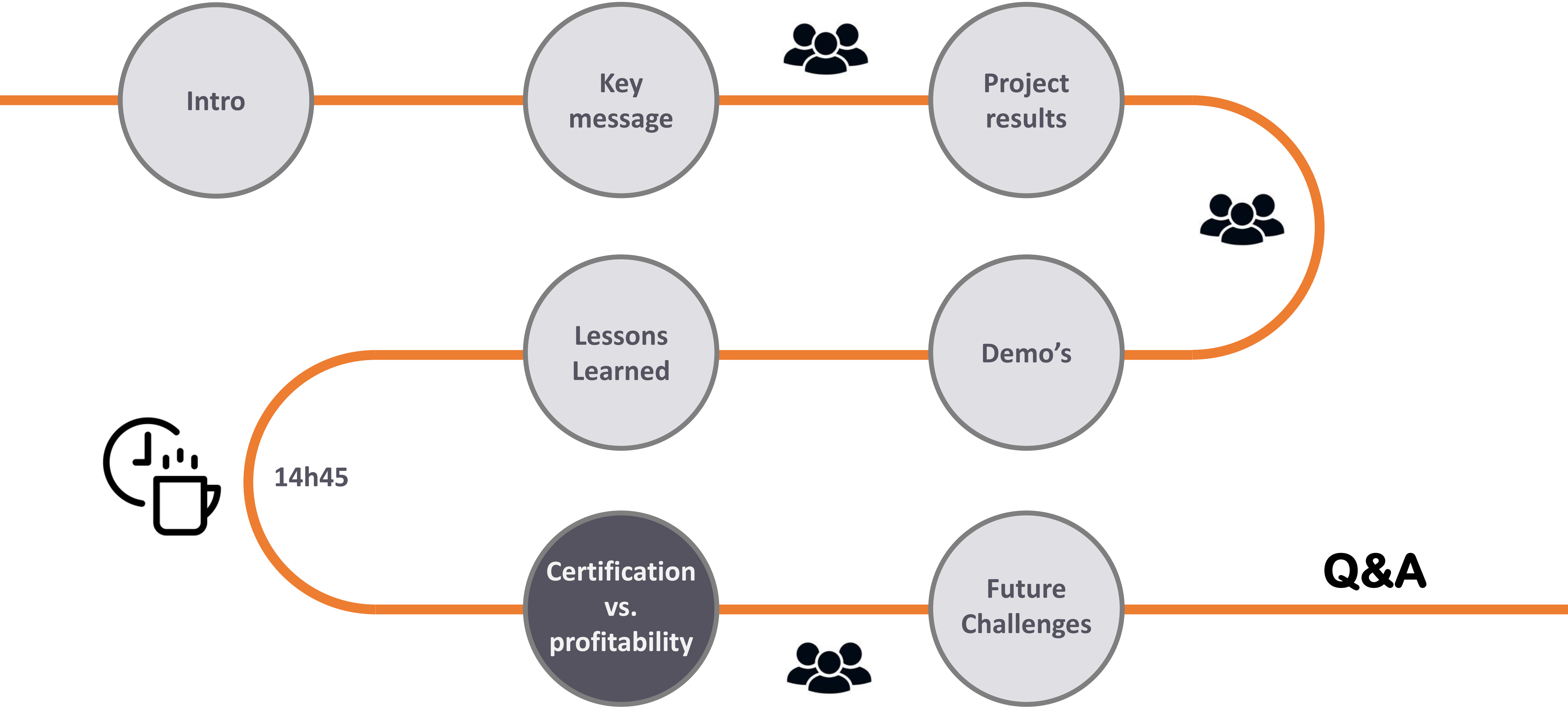
Lessons Learned

- ✓ The Printing process itself has an impact on **powder properties**, which impact the part quality.
- ✓ **Compaction curves** give relevant information on most important powder properties.
- ✓ **Process optimisation** for heat treatable materials should focus on optimising density and build speed
- ✓ **Process stability** is machine dependent and critical to know and control, in order to deliver a consistently high quality
- ✓ The **heat treatment** step can have a tremendous impact on material properties and needs to be carefully considered as a critical step in the process chain (even for non-heat treatable materials).
- ✓ The **properties of non-heat treatable wires** depend greatly on the cooling rate.
- ✓ **Surface finishing** is the right combination of several techniques for a given material and process.
- ✓ **Making the right choices** with respect to technology, material, post treatment, etc. requires both application knowledge, as well as a good understanding of the possibilities of each technology.
- ✓ **Starting** small can lead to new insights.

More Information → Website and reports, or contact us directly.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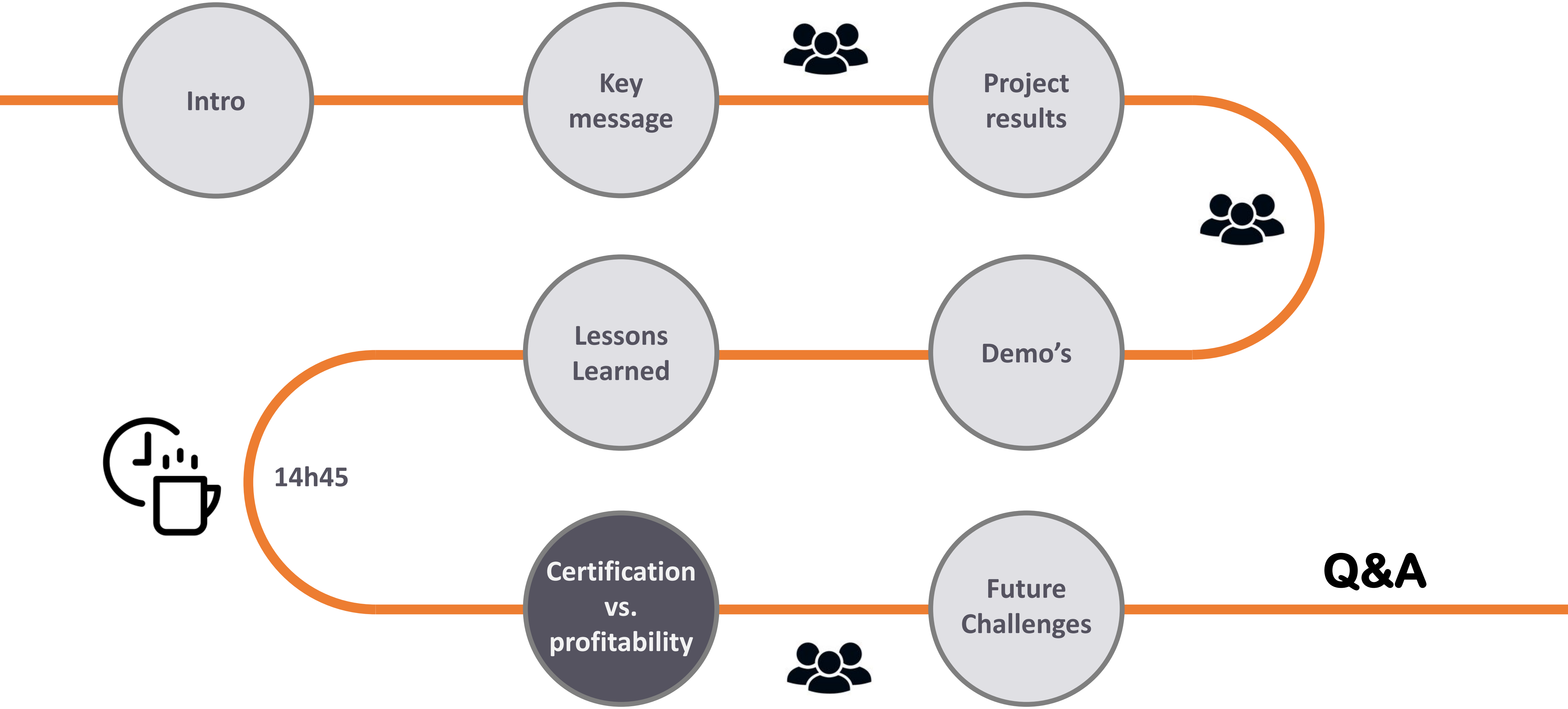
15 min. break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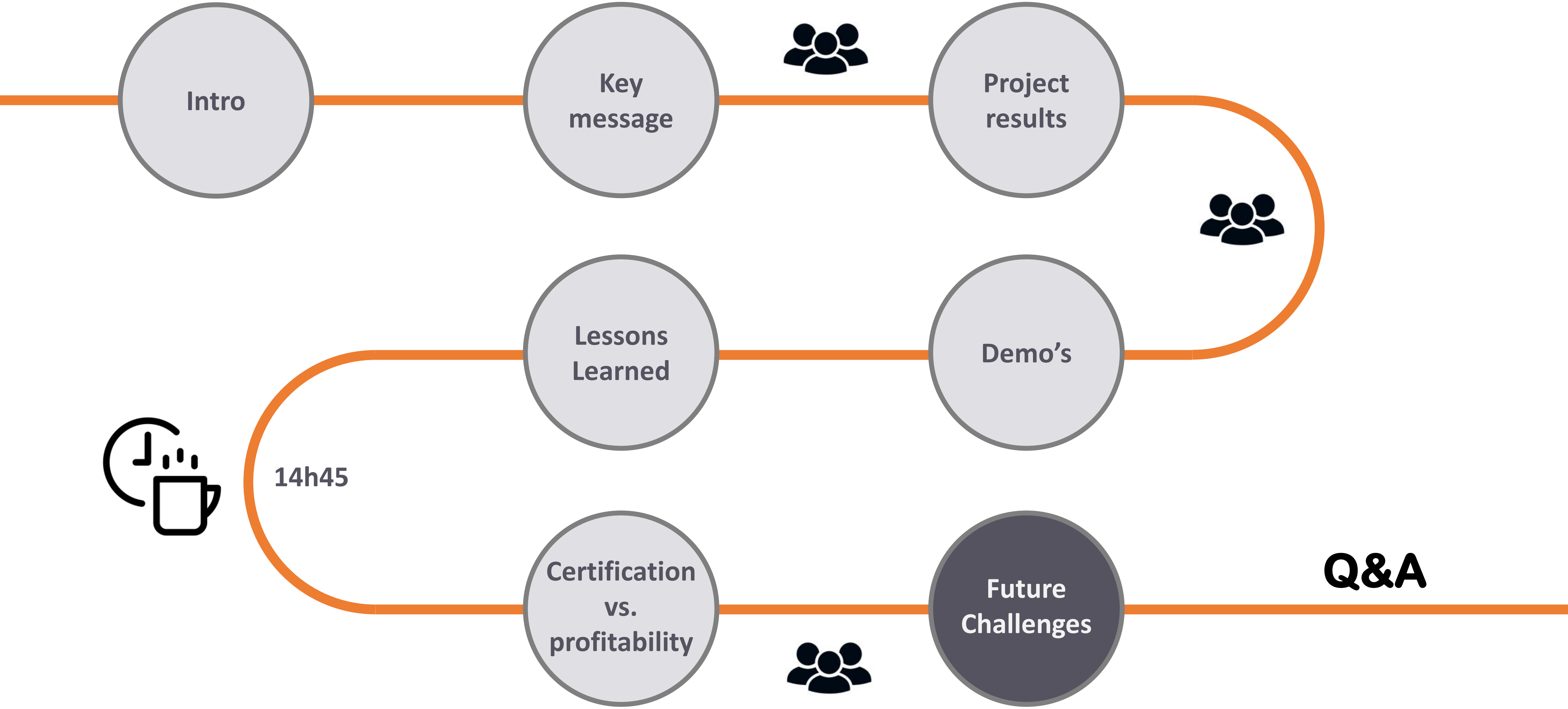
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Poll 3

Future Challenges

Obstacles 1 – 3:	%
Lack of internal expertise and knowhow on AM	**45%**
Investment (cost)	**40%**
Lack of business case or unclear business case	**34%**

Technological limitation

- Product quality
- Production speed
- (multi-)materials

Certification and standardisation

https://www.flam3d.be/hoe-ziet-de-groei-van-3d-printing-eruit/

Lack of internal expertise and know-how on AM – 45% (Flam3D)

Seminars, Trainings, Master Classes, etc.

Master Class - Integrate 3D printing in your business

What you'll learn:

- Get an overview of the state of the art in additive technologies
- Learn how to identify potential applications within your company
- Explore the AM process chain from design to finished part
- Design thinking for AM
- How to interact with a service provider when subcontracting

Day 1 - 27 April 2021, 13h30-17h
Day 2 - 30 April 2021, 13h30-17h

Participation fee: € 1220
Companies based in Flanders will pay only € 366 within the framework of the #industry partnership project.

Fab+ project

- Materials and process in AM
- Parts conception in AM
- Manufacturing of parts by AM
- Reverse Engineering
- Topological optimization
- Intellectual property
- AM part finishing

www.enmieux.be
FEDER UNION EUROPEENNE Wallonie
LE FONDS EUROPÉEN DE DÉVELOPPEMENT RÉGIONAL ET LA WALLONIE INVESTISSENT DANS VOTRE AVENIR

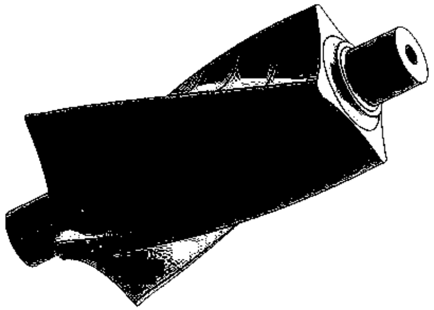
Contact:
Frederik.Cambier@technifutur.be

https://www.sirris.be/agenda/masterclass-integrate-3d-printing-your-business

Lack of business case or unclear business case – 34% (Flam3D)

Requires:

- ➢ Application knowledge (company) & an open mind
- ➢ Expertise on Additive Manufacturing



In Flanders: **“Industrie Partnerschap”**

- ➢ Help you in taking steps to becoming a Factury of the Future
  - ✓ Orienting advice, 2 days in a short period, € 981
  - ✓ Individual coaching, 3 days spread over time, € 1612

Product Quality – Residual Stresses

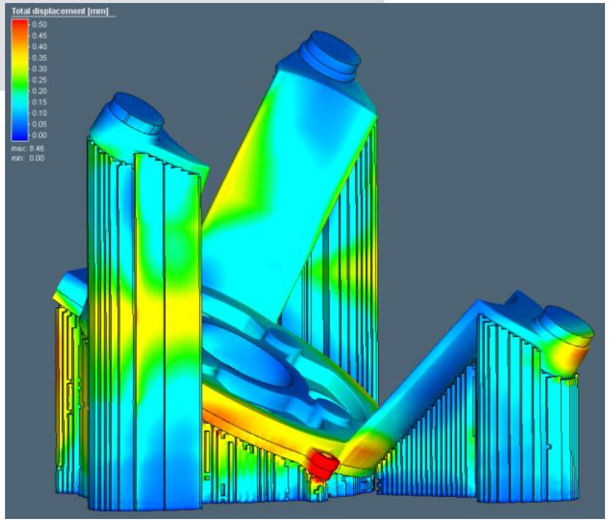
Possible build failure, but also influences part performance and lifetime.

- ➢ Fatigue
- ➢ Stress Corrosion Cracking

Modelling

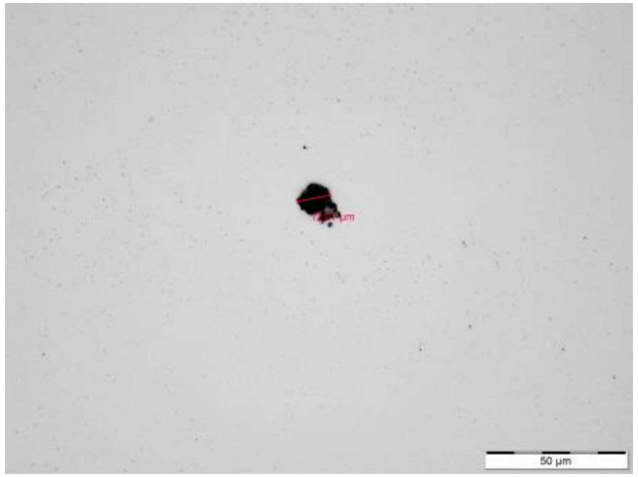
Measurement
Quality control (NDT)

Heat treatment



Product Quality – Structural Integrity

- Behaviour in terms of fatigue and fracture?
- What is an acceptable defect sizes? Bulk vs. (sub)surface?
- NDT methods (economical, practical)?



Testing and modelling efforts (research)
Macro Mechanical properties

Fatigue: A large variation in results is possible in AM products

In some guidelines quite extensive testing is proposed
- High costs
- Conservative designs

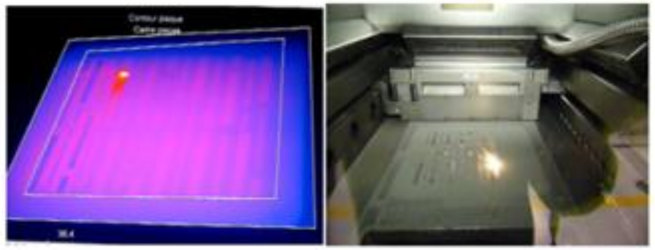
WAAMMEC (prenormative project), generate fatigue data for fabrication and product application standards.

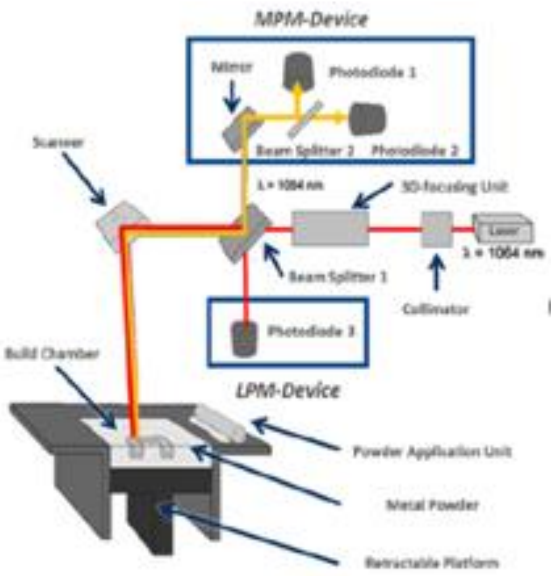
research
sirris
driving industry by technology
CRM GROUP

Product Quality – In-Situ Monitoring

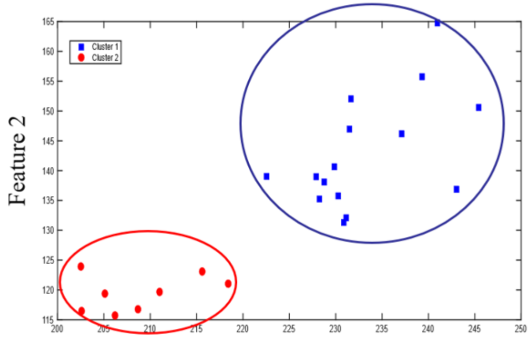
Decrease NDT control effort by using Monitoring and Modeling

- ➢ Detection of defectives parts
- ➢ Localization of the defect in the part





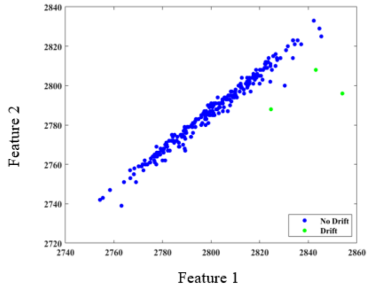
- Vertical tensile samples



- 35 AlSi7Mg0.6 tensile samples were fabricated on same build plate.
- Features were extracted based on the variation in each layer as shown above.
- K-means clustering algorithm trained for 23 samples.
- Cluster 1: YS > 280 MPa
- Cluster 2: YS <270 MPa

Enable Project results

- Lack of fusion samples



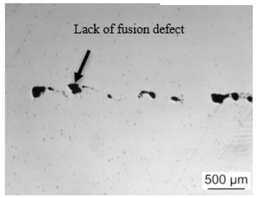


Fig. 10. (a) Pr ... ls for the lack of fusion defect, (b) optical micro... defect.

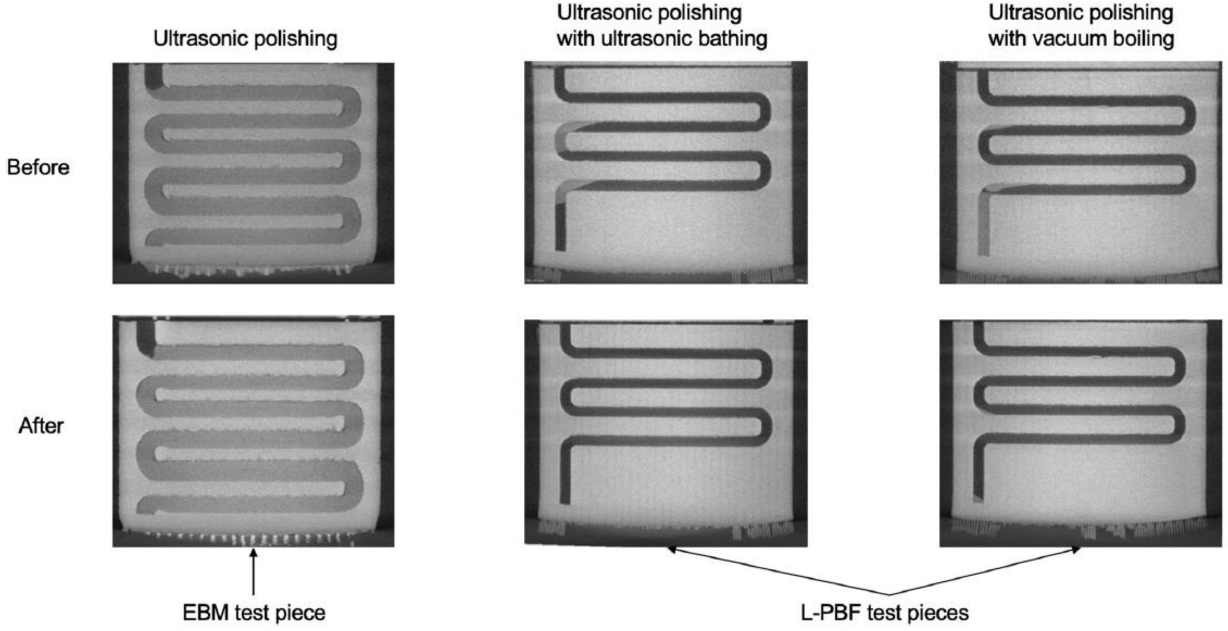
Product Quality – Powder removing

Complex geometry and internal channel need to be clean and free of powder

- ➢ Anticipate the problem of cleanliness
- ➢ Methodologies to remove the powder (chemical, mechanical,…)

Assessment of trapped powder removal and inspection strategies for powder bed fusion techniques

Luke W. Hunter[1] • David Brackett[2] • Nick Brierley[2] • Jian Yang[2] • Moataz M. Attallah[1]



Product Quality – Thin walls

Lightweight parts and heat exchanger application need to decrease wall thickness for efficiency :

- ➢ Trade-off between roughness quality and material health
- ➢ Maintaining quality and robustness of process

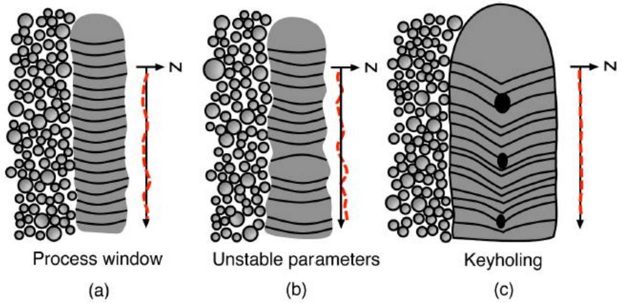
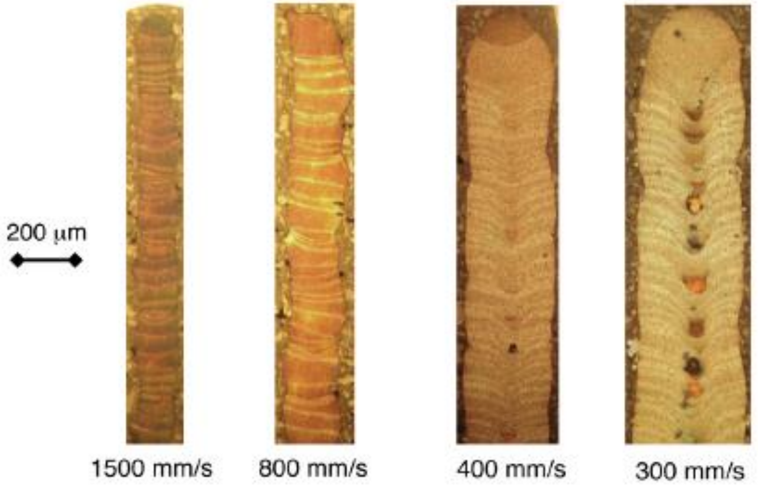


Fig. 13. Schematic representation of cross-sections and profiles of SWT samples for (a) process parameters in the process window, (b) outside the process window (e. g. balling conditions) and (c) in keyhole conditions. The dashed red curves is a schematic representation of the expected roughness. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

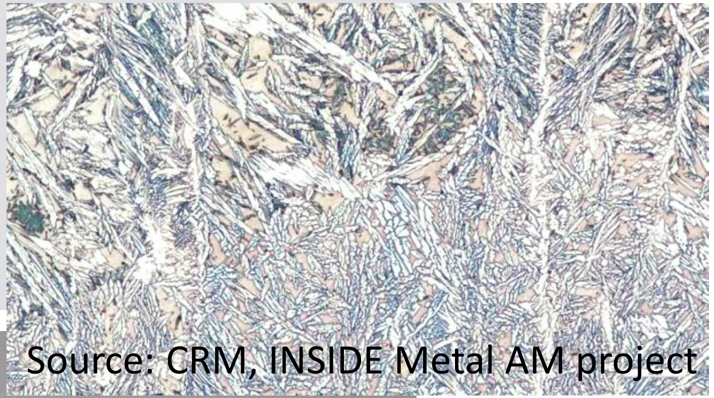


Product Quality – Structural Integrity

WAAMMEC (prenormative project): Mechanical properties for steel structural components produced by WAAM

- Focus on fatigue properties
- Aims to generate data for fabrication and product application standards

Product Quality – Corrosion



Source: CRM, INSIDE Metal AM project

Source: Sirris, INSIDE Metal AM project

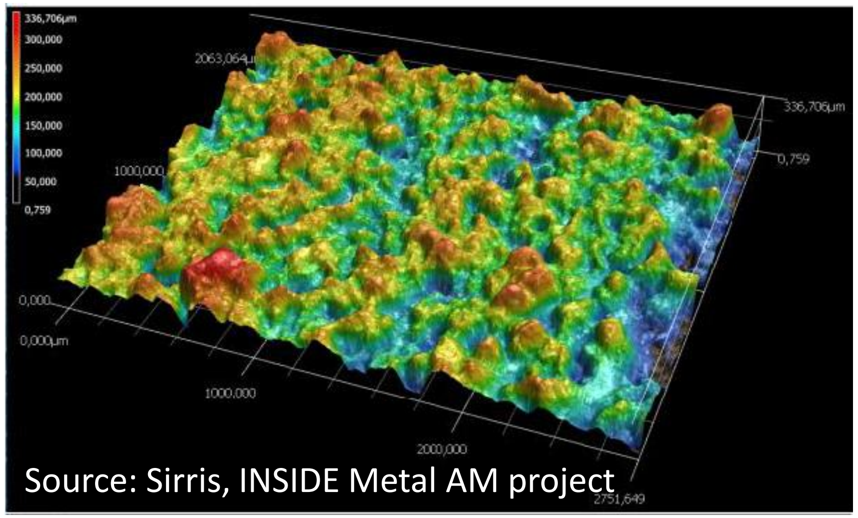
Corrosion of AM materials can deviate from conventional materials.

- Different microstructures
- Meltpool boundaries
- Stresses
- Porosity
- Surface condition

Also differences in corrosion protection methods (anodization, passivation, coatings,…)

Avoid problems due to corrosion

https://bil-ibs.be/project/corrosie-van-3d-geprinte-onderdelen

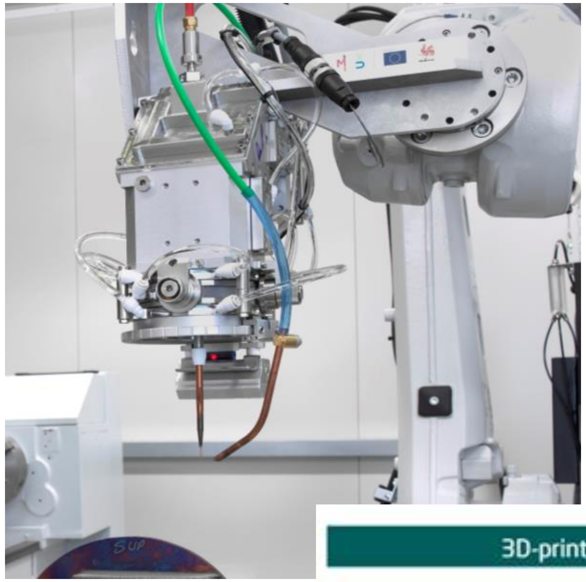


Source: Sirris, INSIDE Metal AM project

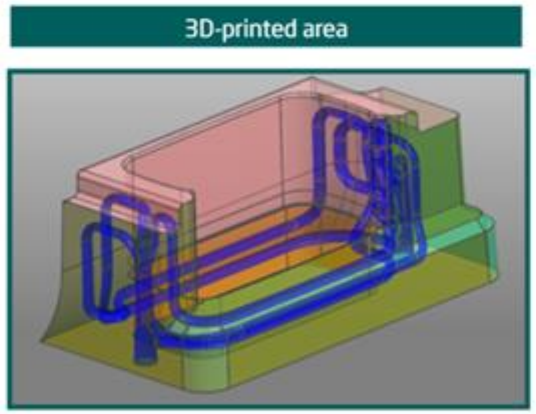
Production Speed – Hybrid-manufacturing

Combining forming, additive and subtractive techniques

- Integration of new manufacturing knowledge into designing
  - Being aware of different techniques (SLM, WAAM, LMD, WLAM…)
- Welding AM to cast/forged, 3D coating, adding features…



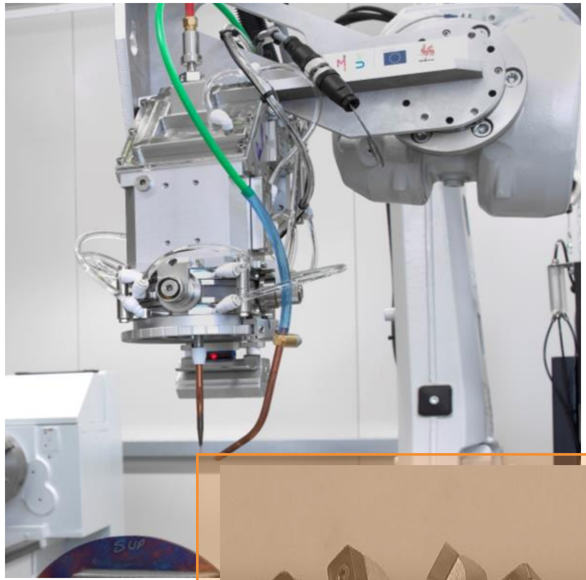
Multideposition equipment



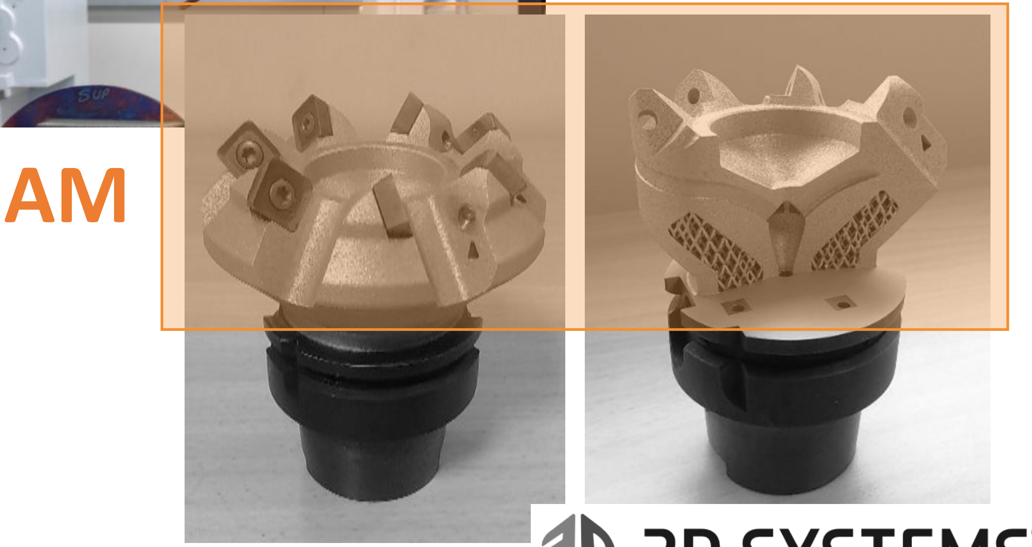
Production Speed – Hybrid-manufacturing

Combining forming, additive and subtractive techniques

- ➢ Integration of new manufacturing knowledge into designing
  - ➢ Being aware of different techniques (SLM, WAAM, LMD, WLAM…)
- ➢ Welding AM to cast/forged, 3D coating, adding features…



Multideposition equipment



3D SYSTEMS

Production Speed – Hybrid-manufacturing

Combining forming, additive and subtractive techniques

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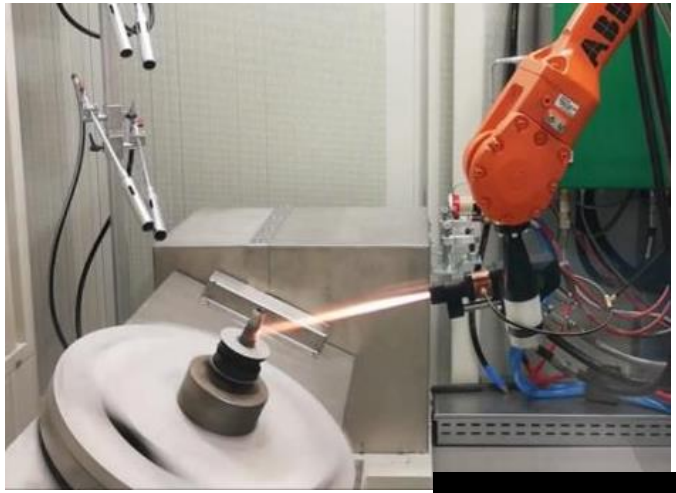
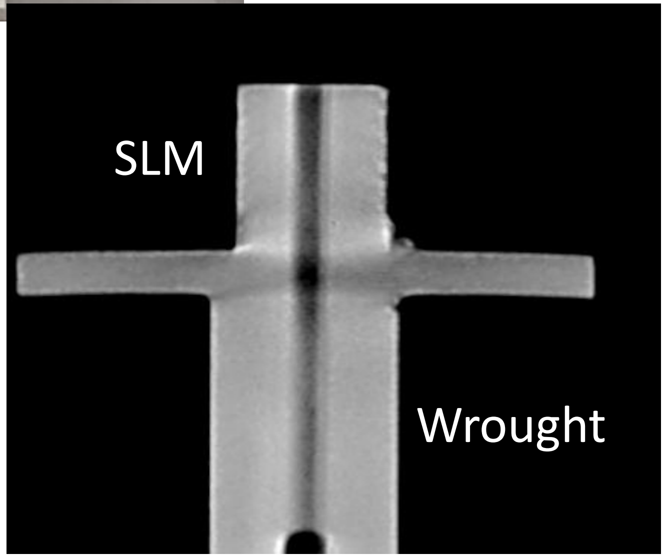


3D coater

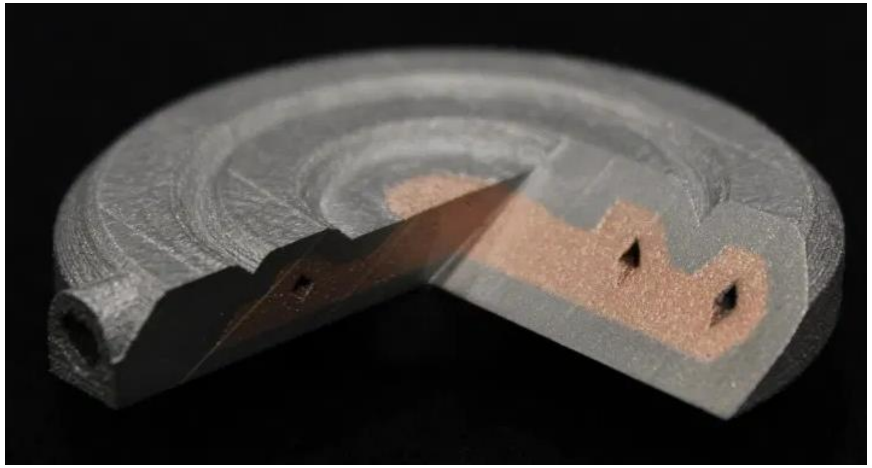


CT scan of a weld between SLM and forged tubes

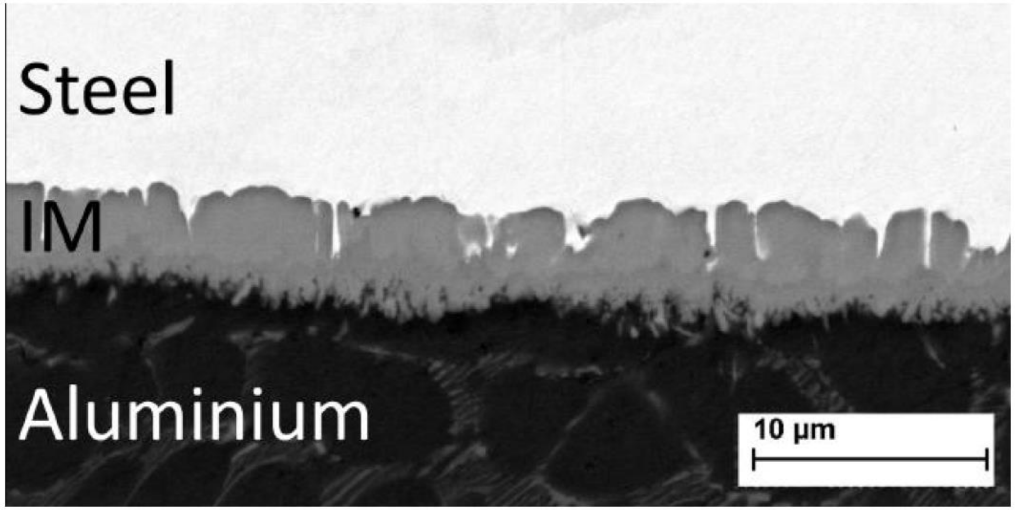
Multi-material structures

MultiMat3D (Win2Wal: Aerosint, UCLouvain)

- Can we create parts **topologically** and **functionally** optimized?
- Set the conditions to SLM together 2 dissimilar materials



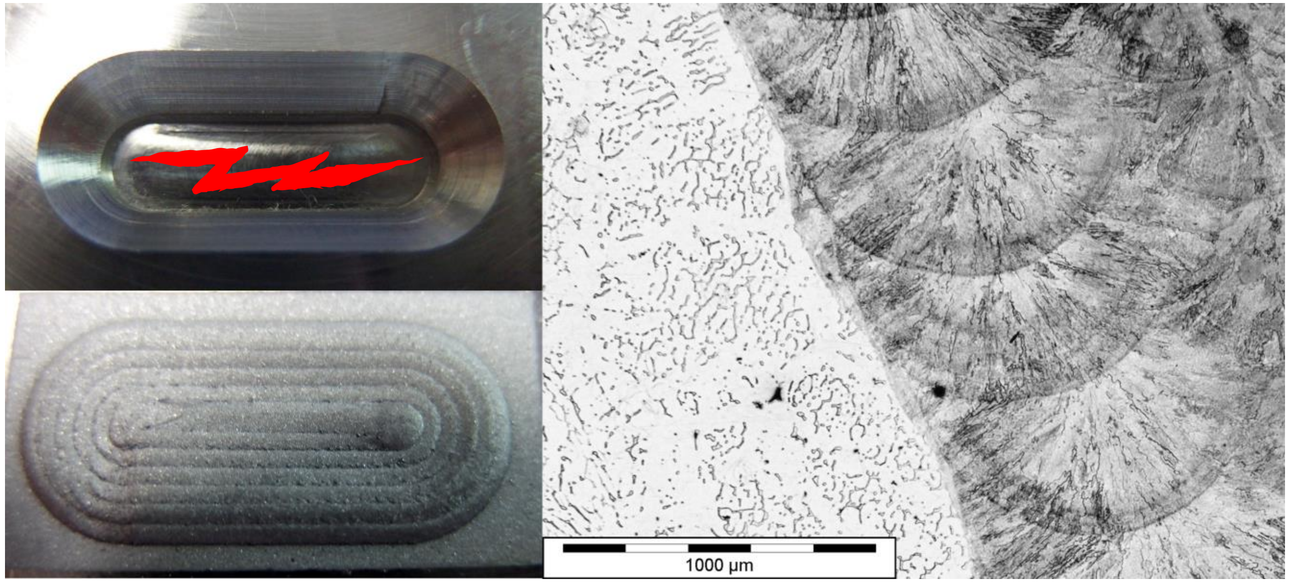
Courtesy of Aerosint



Integration of AM in a circular economy – Reuse

Make the reparation of damaged parts a well-stablished process

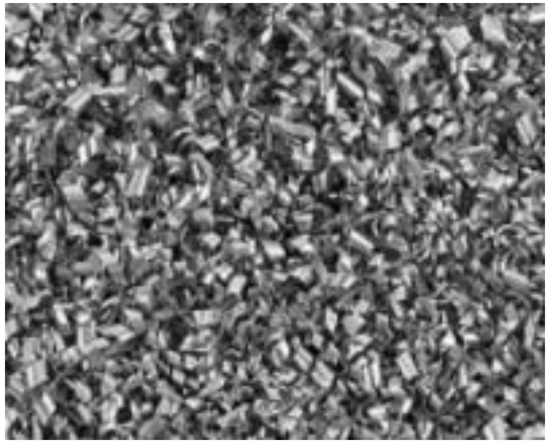
- Flexible equipments
- Meaningful control & certification



Integration of AM in a circular economy – Reduce & Recycle

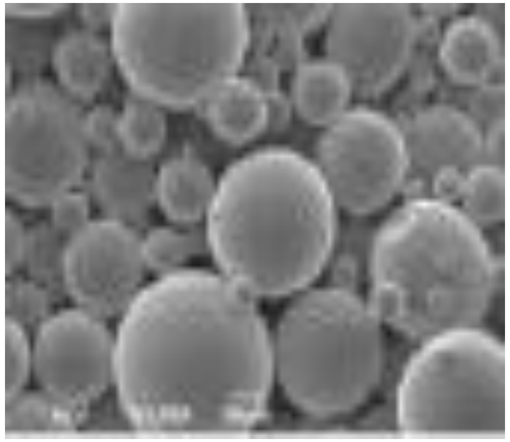
Varetit (Cornet): Create high added value powders from scrap metal

- Recycling Ti6Al4V chips and transform directly to SLM/LMD powder
- Reduce the energy consumption of the powder manufacturing



Ti6Al4V chips

Meltless process →

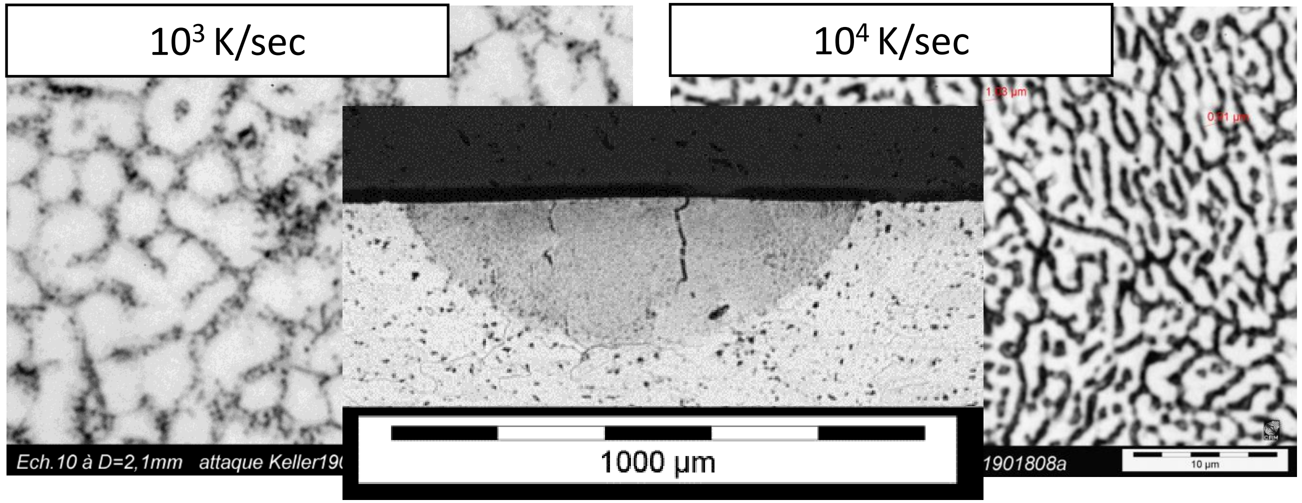


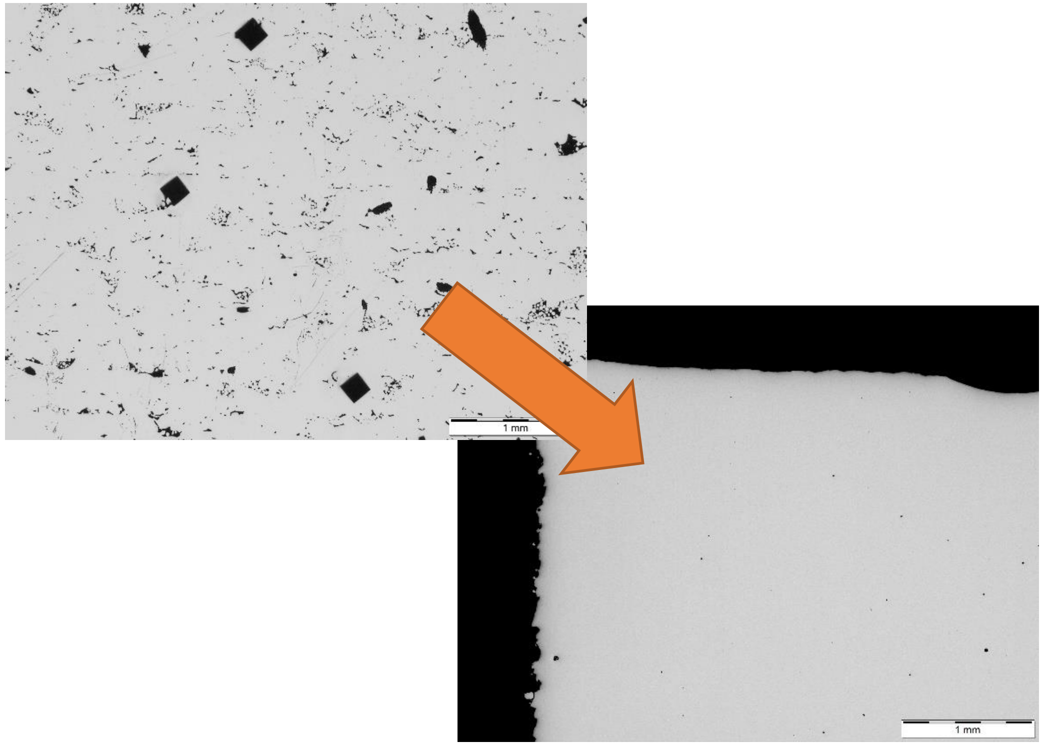
Ti6Al4V powder for AM

Development and implementation of novel alloys

Accelerate the experimental stage of new alloys developments for AM

- Preparation of alloys, simulation of the ultra-fast thermal cycles
- Tuning of the heat treatments
- Parametrization for SLM, LMD, WAAM…





And don't forget about challenges in:

- Standardization
- Digitalization and Quality Assurance
- Surface finishing of the parts
- Simulation and digital twin

You don’t have to make this journey on your own.

Knowledge and experience is available within Belgium to support you in your journey.

More information

You'd like to discuss a specific topic with us ?

Send us a message: jeroen.tacq@sirris.be

Recording, slides and white paper will be sent by mail.

Reports: Project webpage

https://www.sirris.be/inside-metal-additive-manufacturing

<u>How to contact us:</u>

fleur.maas@bil-ibs.be Norberto.jimenez@crmgroup.be jeroen.tacq@sirris.be

Questions?