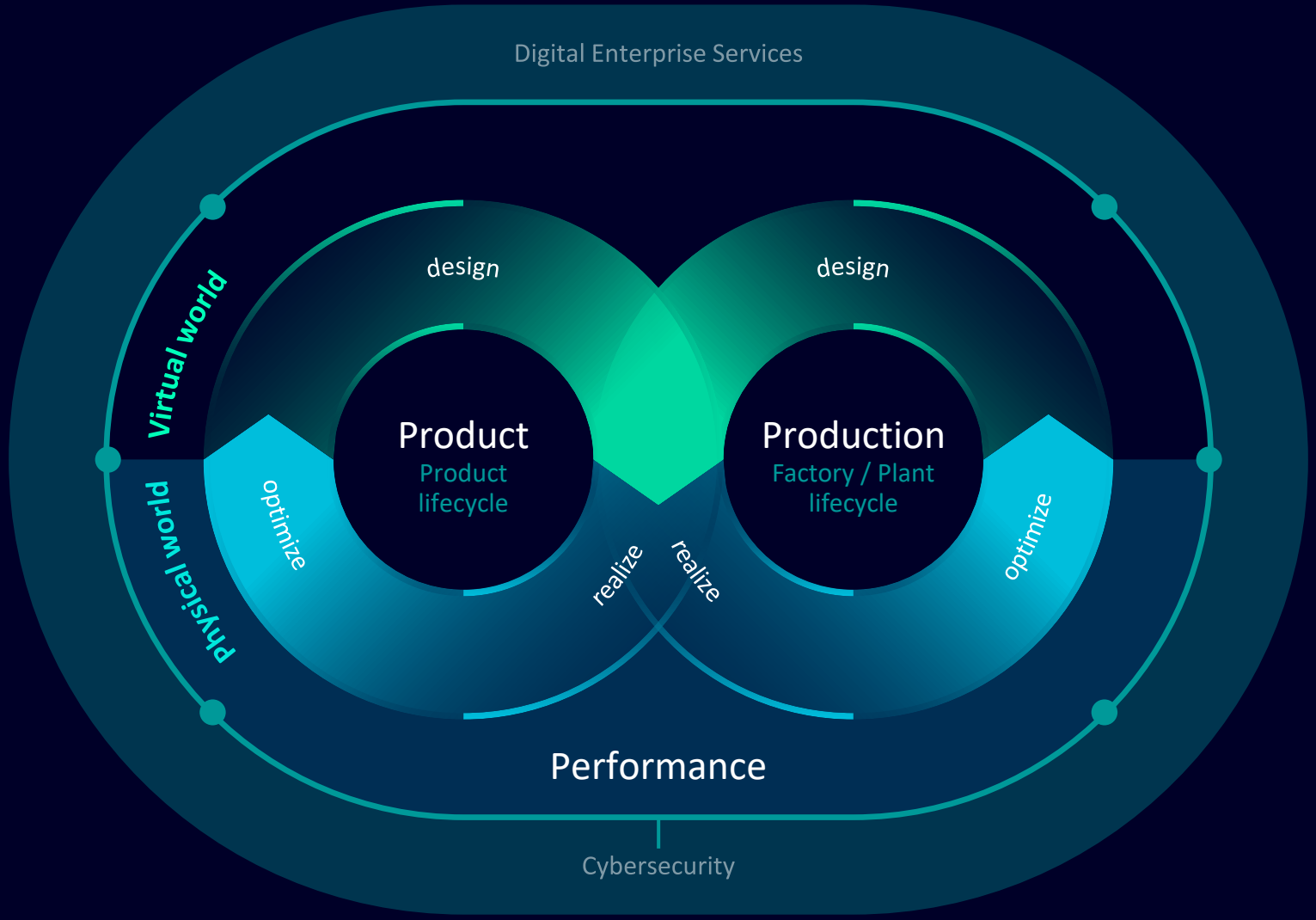
Let’s advance manufacturing – **How to connect the digital and real world in DED**

AM many years ago...

1 CAD drawing

3 differten real components

Industrial Additive Manufacturing needs a comprehensive fusion of the virtual process planning with production technology



SIEMENS

Challenge
Additive Manufacturing via WAAM

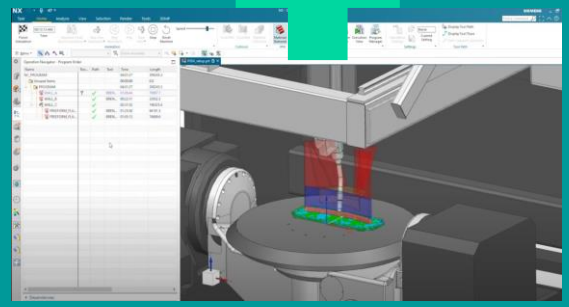
Problem

- Printing walls is easy, printing parts is hard
- Thermal conditions vary dependent on geometry and location
- Process parameters and welding characteristics to be chosen for stable thermal condition for each segment in a part

Wishlist

- Recommendations for path planning and suitable welding characteristics already during CAM
- Feedback in machine in case of deviations

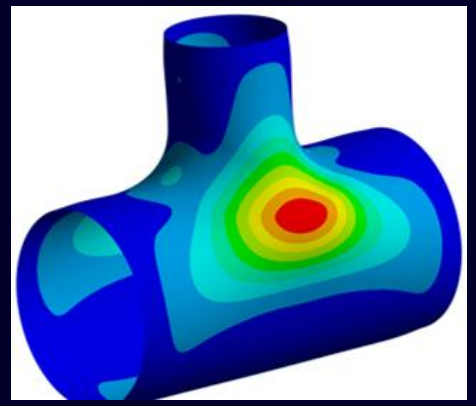
SOLUTION: Fronius Know-how & Siemens Software



SIEMENS

Industrial use case – Additive tube branch
The challenge

Local safety increase



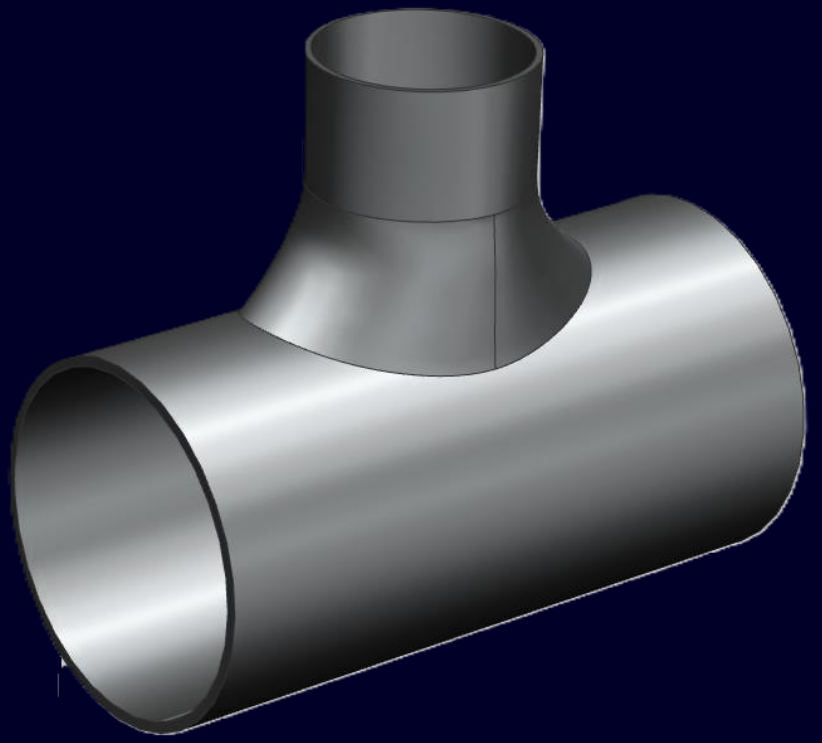
- Geometry leads to inhomogeneous stress in the part

→ **Advanced design necessary**

Variation of wall thickness

- Flow & stress optimized design is enabled by additive manufacturing

→ **Difficult to produce conventionally**



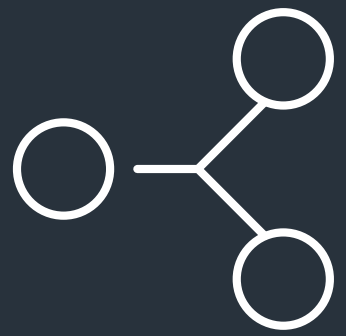
SIEMENS

Hot Topics

Fronius
Additive

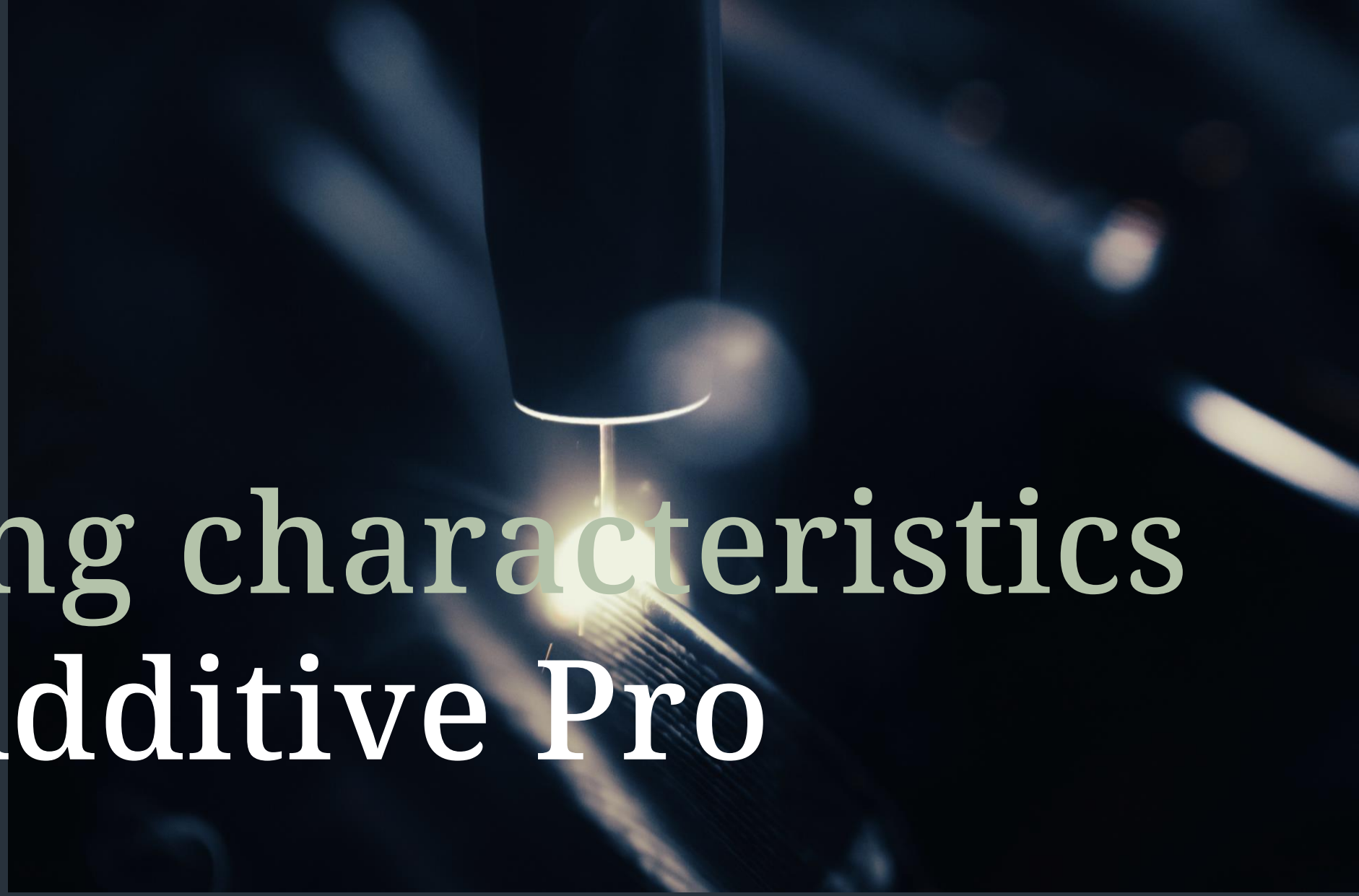
Recipe Generation (AMPS)

Process Stability



Repeatability and Transferability

Predictability

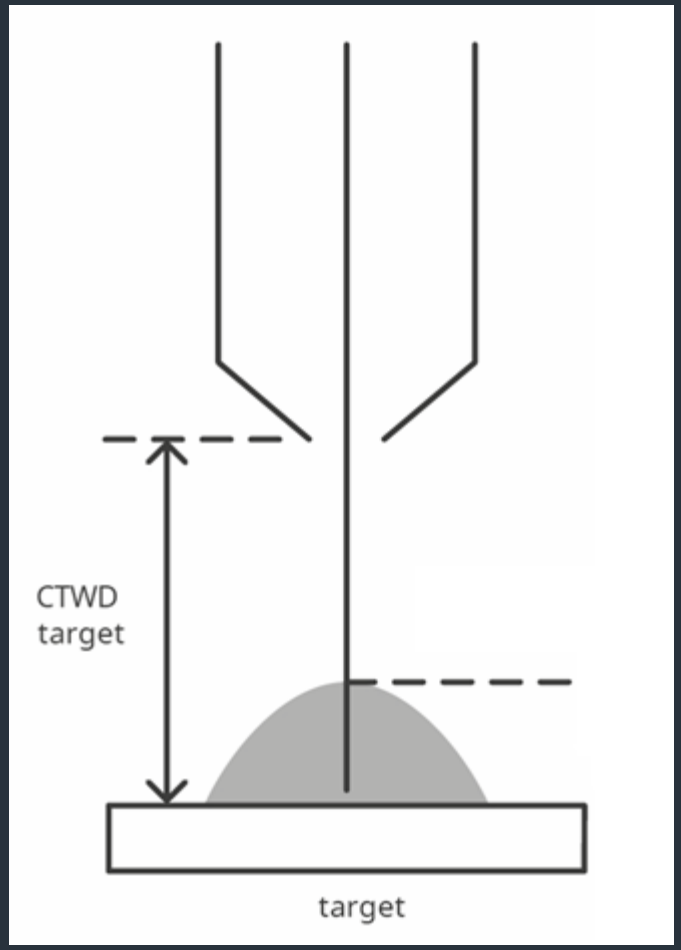


New Welding characteristics CMT Additive Pro

Fronius

Fronius Additive

Repeatability & even layer buildup



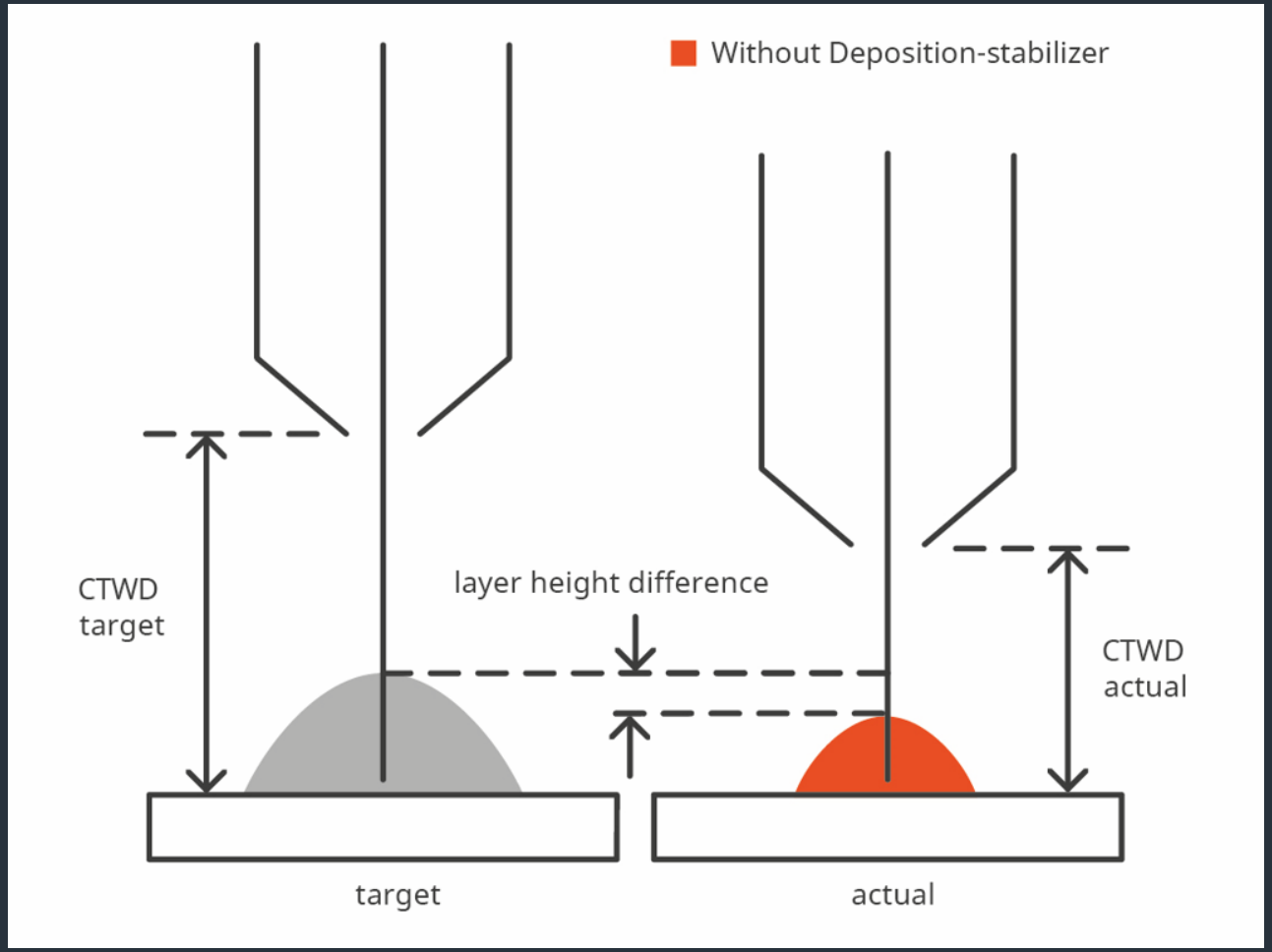
Repeatability & even layer buildup

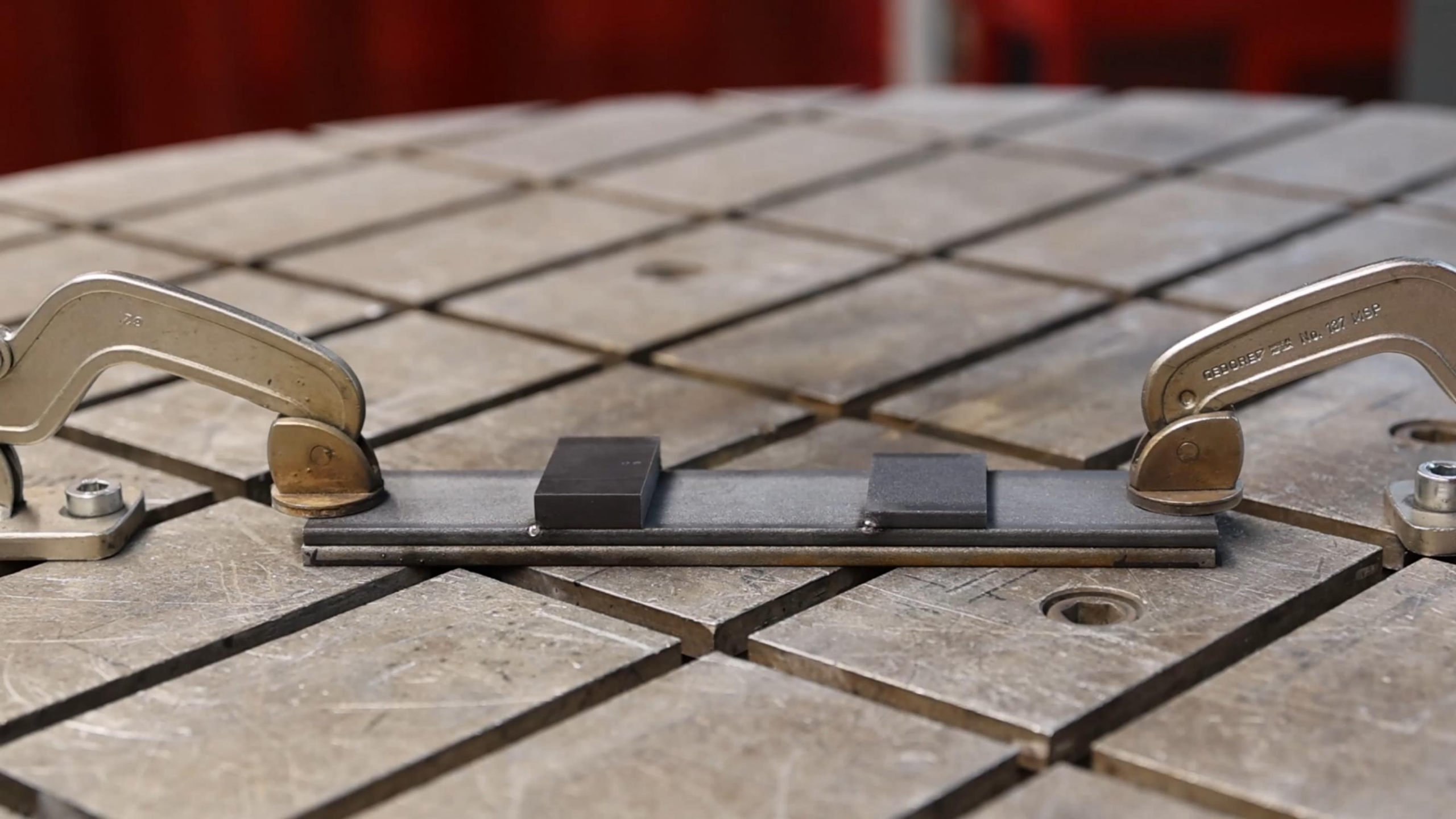
CMT universal is controlled to an average **constant current.**

This has the effect that different CTWD values result in different wire feeds.

↑ CTWD → ↑ wire feed speed

↓ CTWD → ↓ wire feed speed



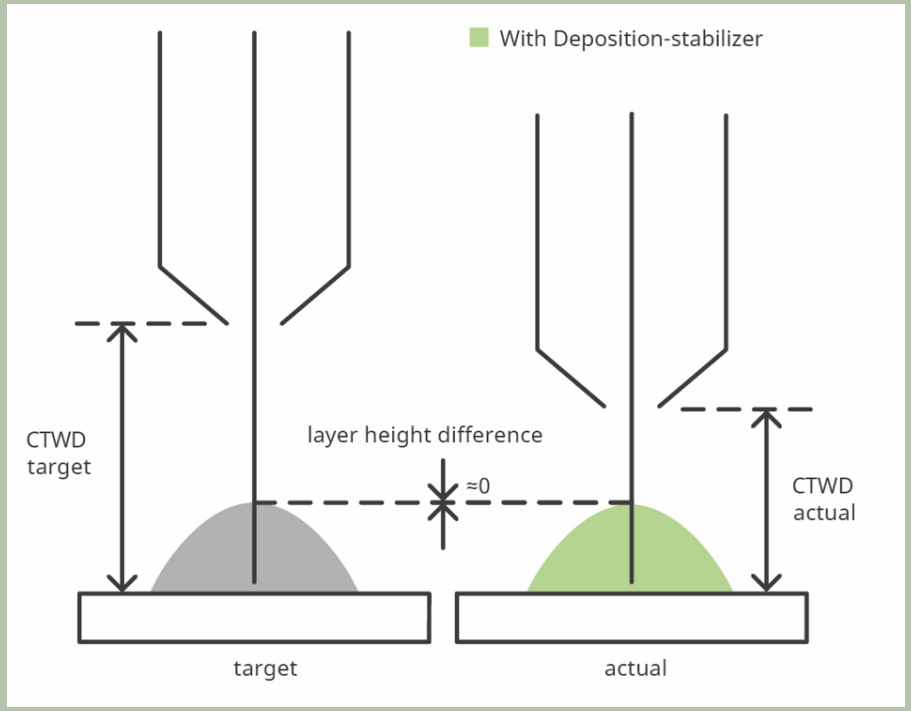

GEDORE Nr. 187 MBP

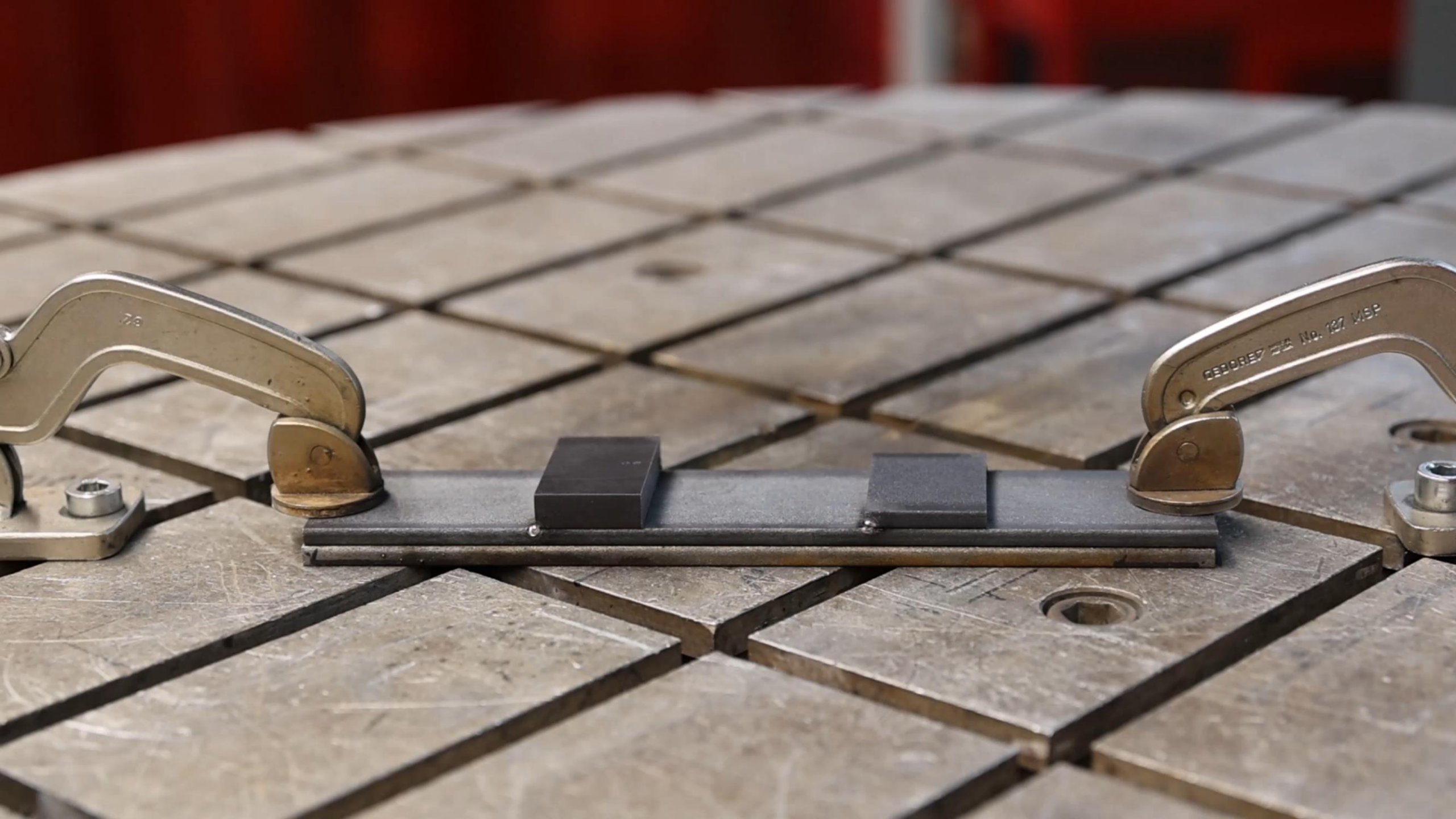
Deposition-Stabilizer

Our solution

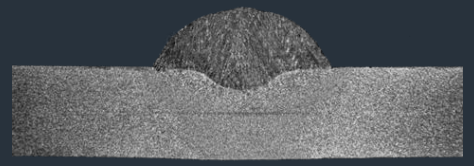
Improved constant wire feed speed → Improved constant deposition rate → Improved constant layer built up

- Simplified welding path planning
- Optimized transferability of welding parameters
- Increased reproducibility

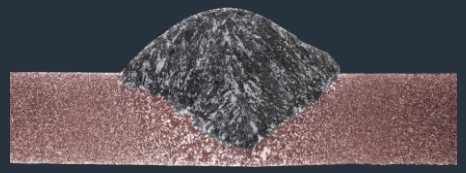



GEDORE Nr. 187 MBP

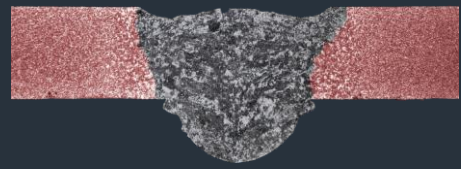
Controllable heat input



25°C



250°C



800°C

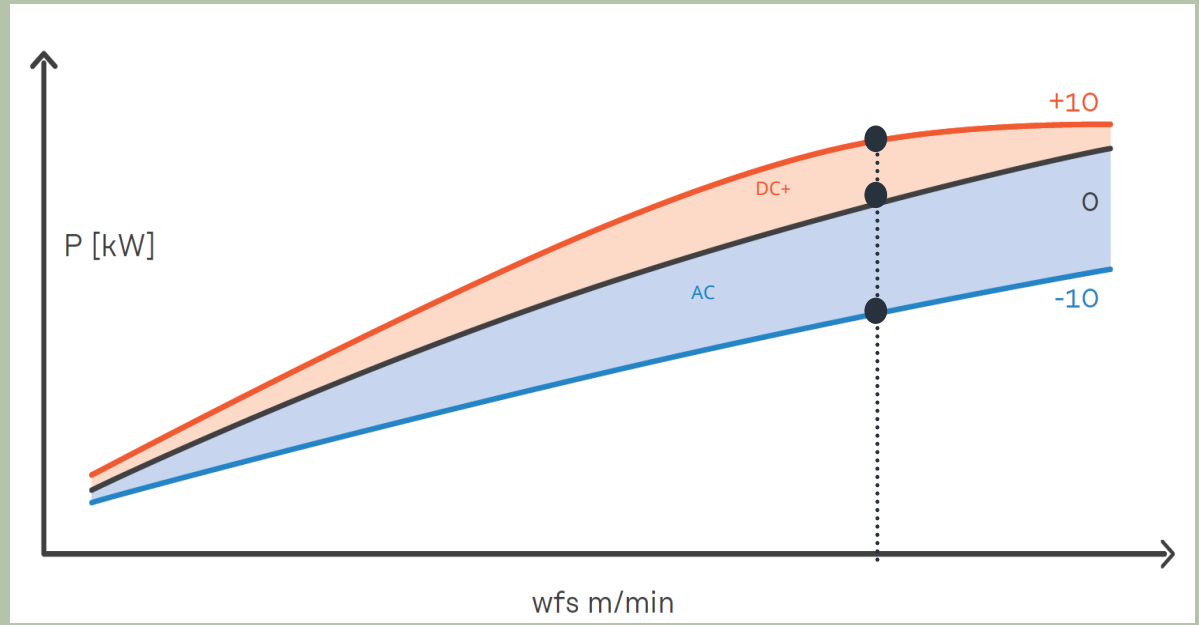
CMT-universal (DC+): 3 mm steel / vD= 6 m/min / vs= 80 cm/min / Ø1,2mm G3Si1 / Ar+ 18% CO2 / CTWD= 18 mm

Power correction

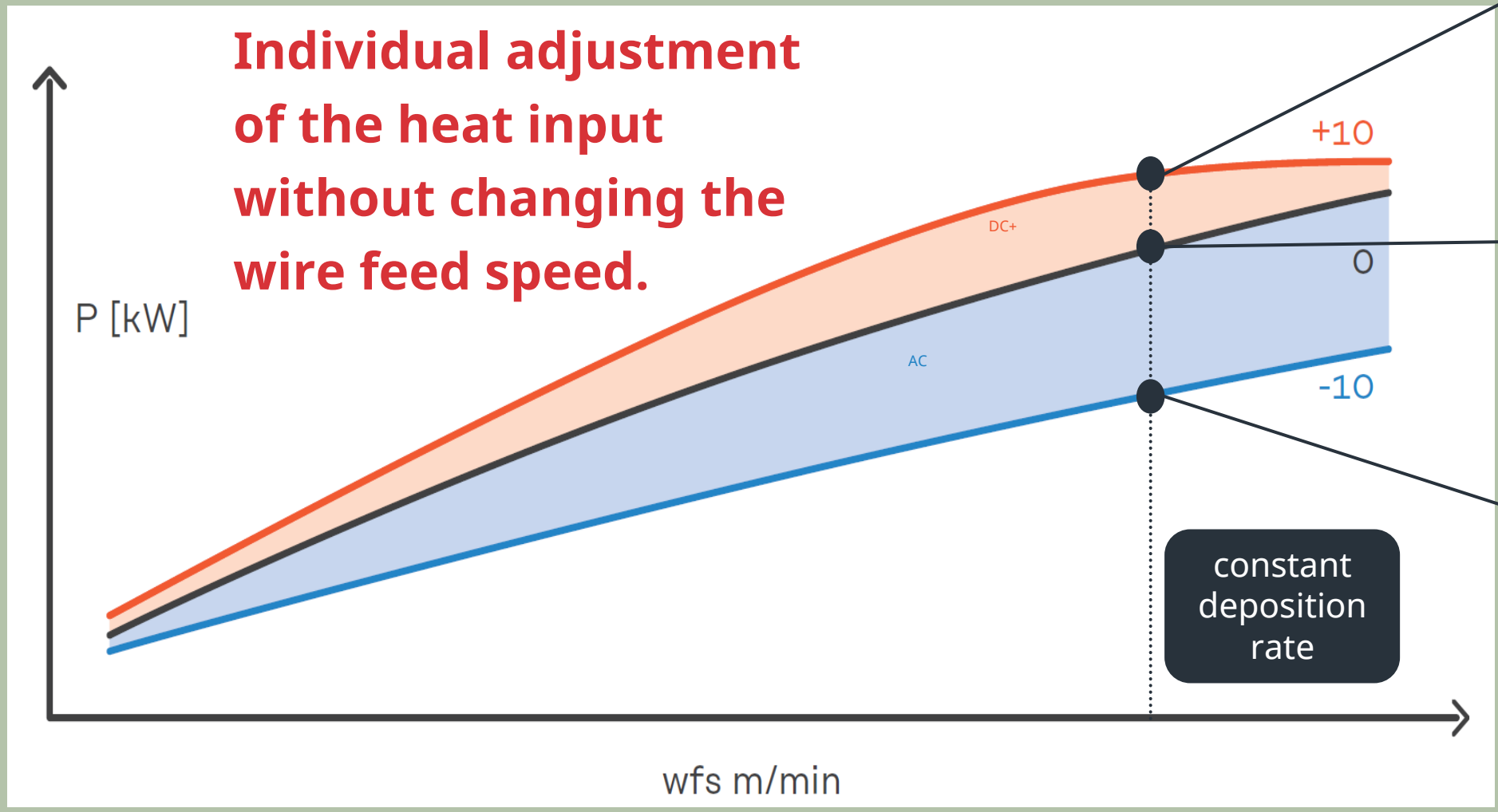
Fronius Additive

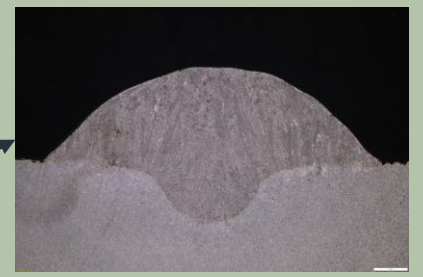
Our solution

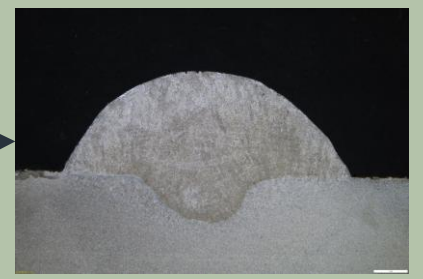
Individual adjustment of the heat input without changing the wire feed speed.

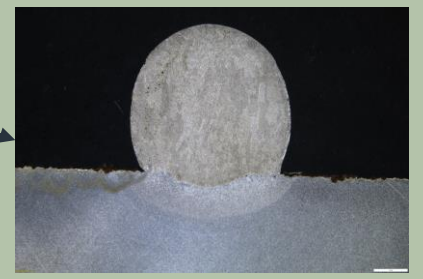


Control of the flow behaviour of the seam



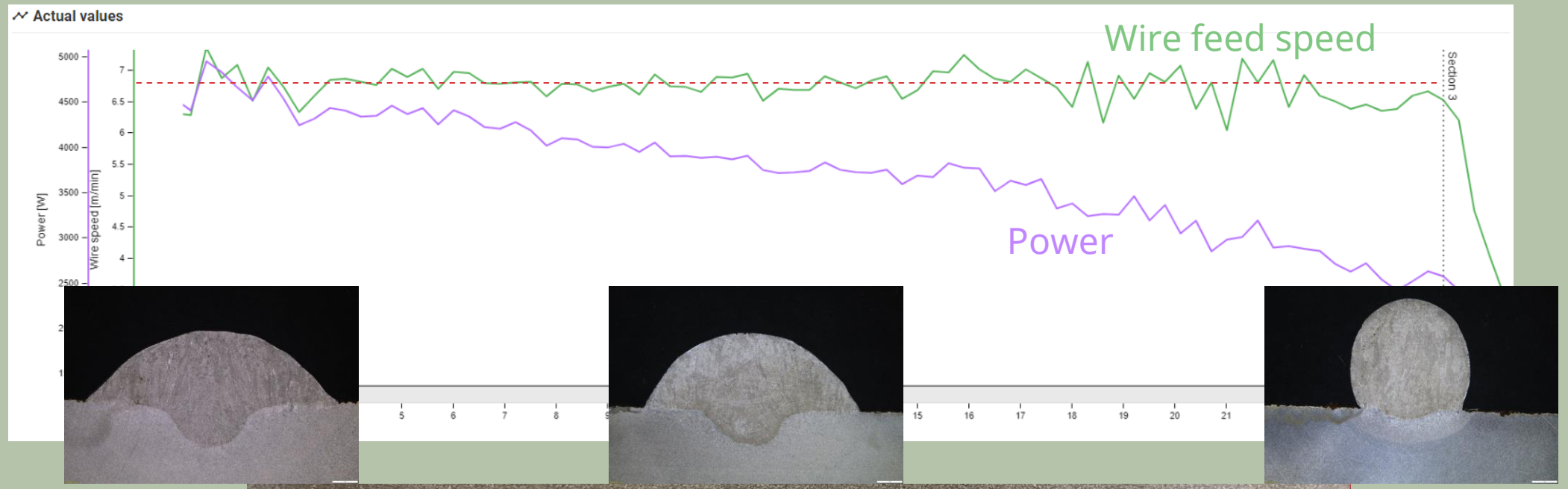


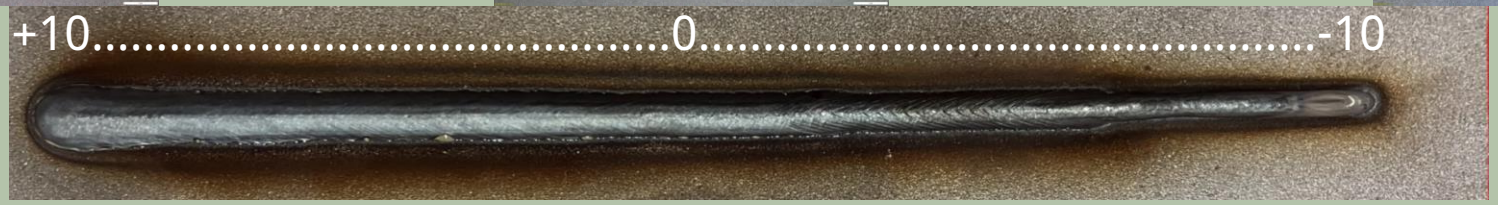


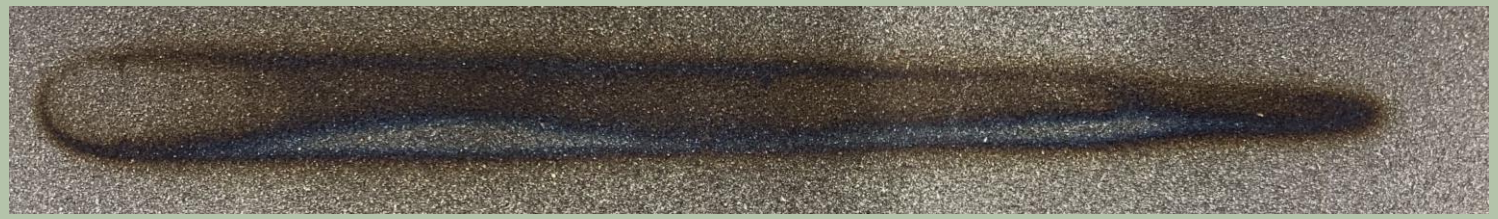



INTELLIGENT REVOLUTION
S2-Takt
Steel
M20 ArCO2
Additive Pro
Ø 1.2mm
Mean
211 A
15.3 V
10.0
Mean
6.7 m/min
3.58 kW
SFI
HOT
aus
Leistungskorrektur
P
ein
Fronius

Power Correction



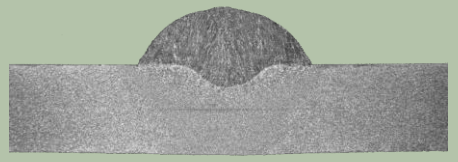




Comparison Power Correction

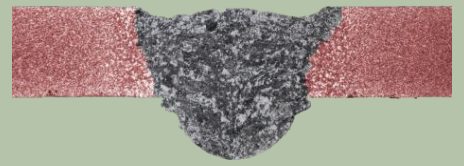
CMT universal (DC+)

3 mm steel / vD= 6 m/min / vs= 80 cm/min / Ø1,2mm G3Si1 / Ar+ 18% CO2 / CTWD= 18 mm



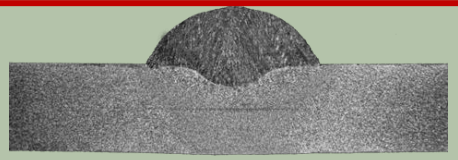
25°C

250°C



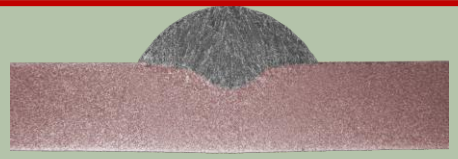
800°C

+5



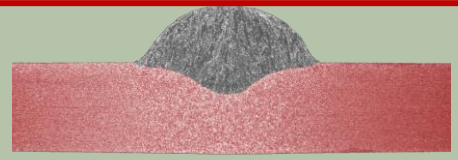
25°C

0



250°C

-5



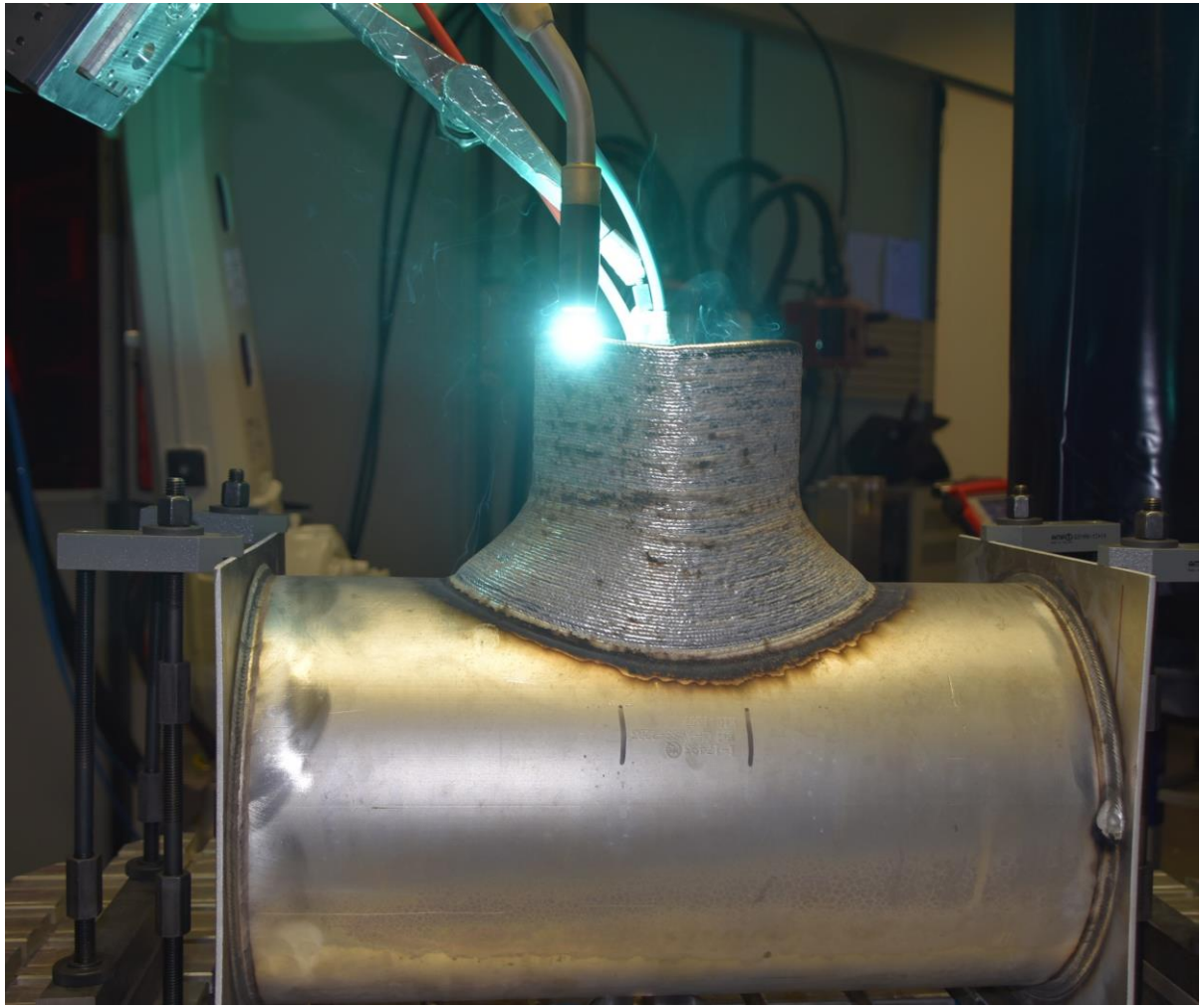
800°C

CMT Additive Pro with Power correction

3 mm steel / vD= 6 m/min / vs= 80 cm/min / Ø1,2mm G3Si1 / Ar+ 5% CO2 / CTWD= 18 mm

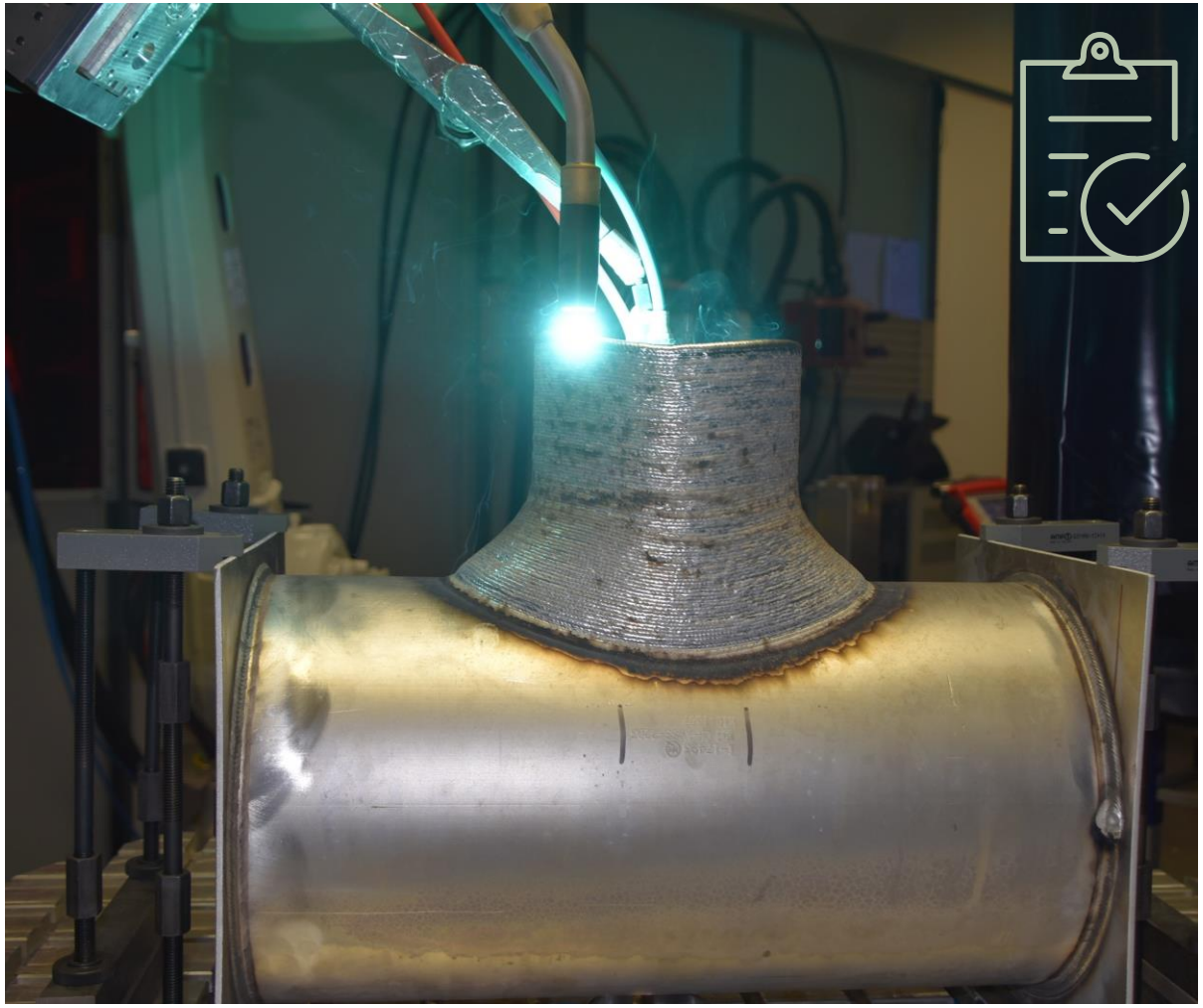
The seam geometry can be kept almost constant thanks to the power correction!

The results



Power source	iWave AC/DC 500i
Welding process	CMT additive pro (Aufbau) CMT mix (Verstärkung)
Filler material	Ø1,2 mm AlMg4,5Mn
Shielding gas	Ar 4.6
t_Arc	3h 26 min
t_Cooling	0 s
m_additive	4,1 kg
$\dot{m}$_additive	1,2 kg/h
T_interlayer	80 – 100 °C

The results



Certificated according to prEN 13445-14

NDT and DT testing

	Additive		Base material	
	actual	target	actual	target
Ultimate strength R_m [MPa]	298	≥ 275	319	≥ 270
Yield strength $R_{p0,2}$ [MPa]	141	≥ 130	157	≥ 125
Fracture strain A [%]	23	≥ 10	16	≥ 14

WeldCube

Full documentation of process parameters

ArcView2

Full visual documentation

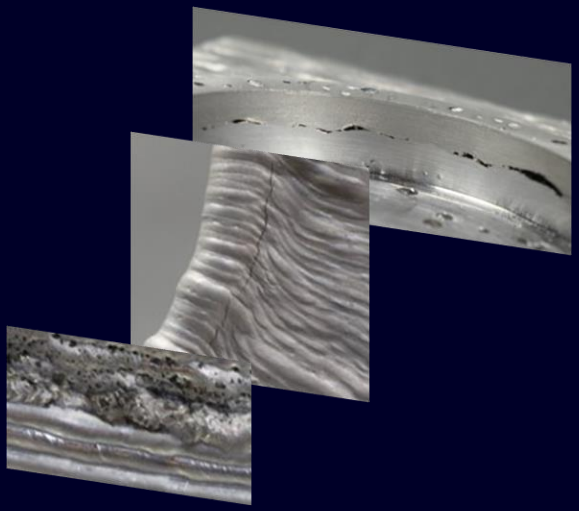
Pressure test - Burst pressure = 150 bar

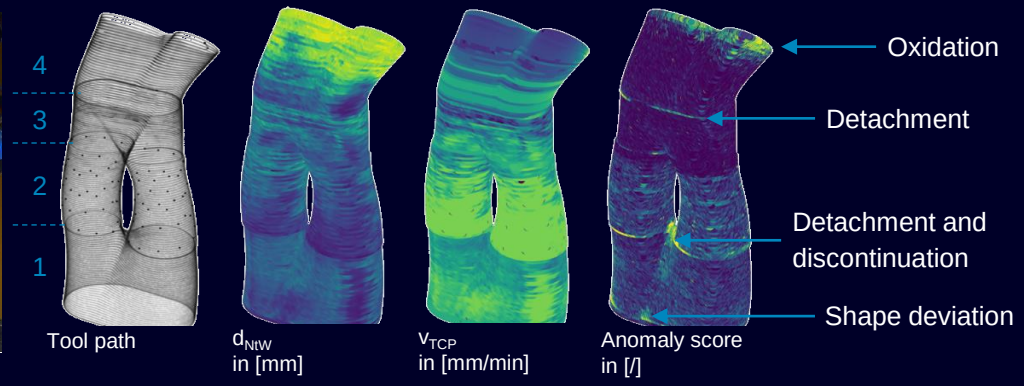
- Operating pressure = 45 bar

DED-Arc: challenges in WAAM process
Solution lies in smart process monitoring

Process defects in WAAM of Aluminum:

- *Oxidation and slag*
- *Detachment*
- *Porosity*
- *Discontinuation*
- *Distortion*
- *Crack*
- *Heat accumulation*



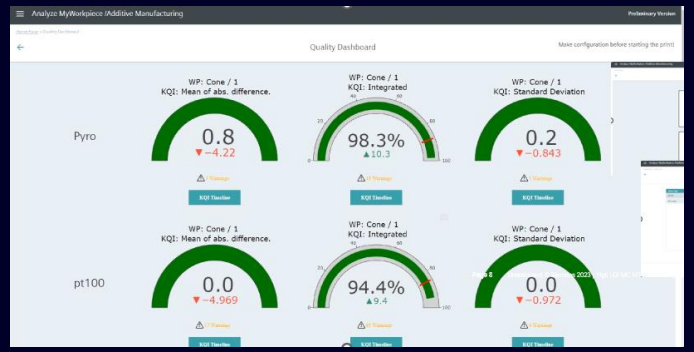


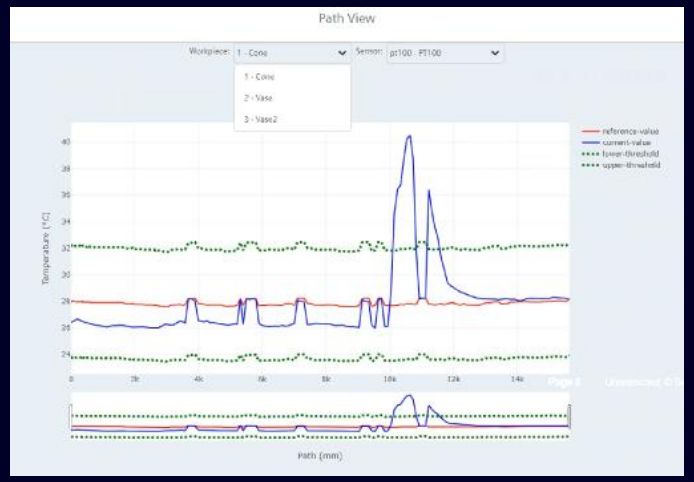
Example of process monitoring at Siemens Technology

d_{NtW}: nozzle-to-work distance; v_{TCP}: velocity of tool-center-point

SIEMENS

Analyze MyWorkpiece /Additive Manufacturing
Tracks the process



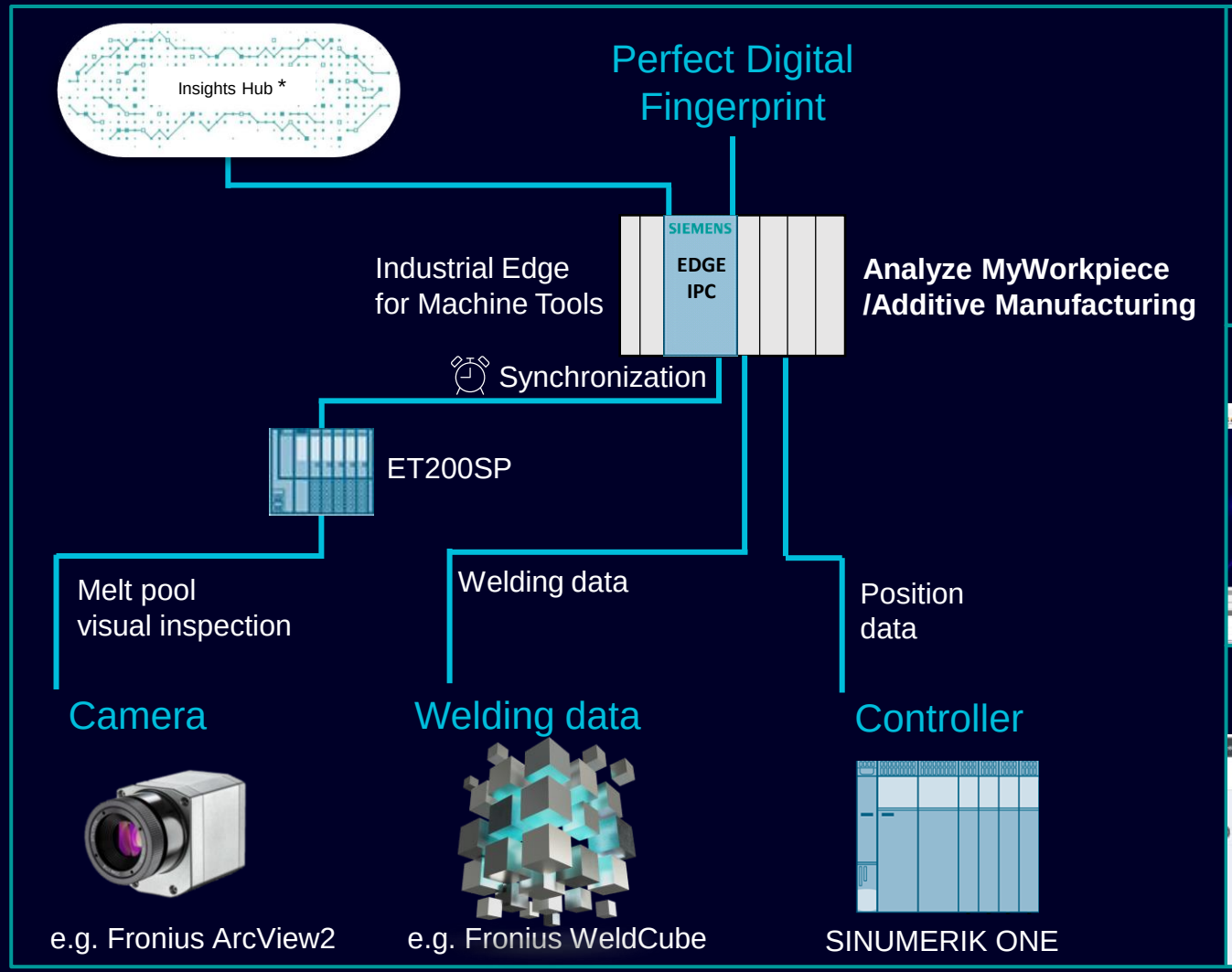


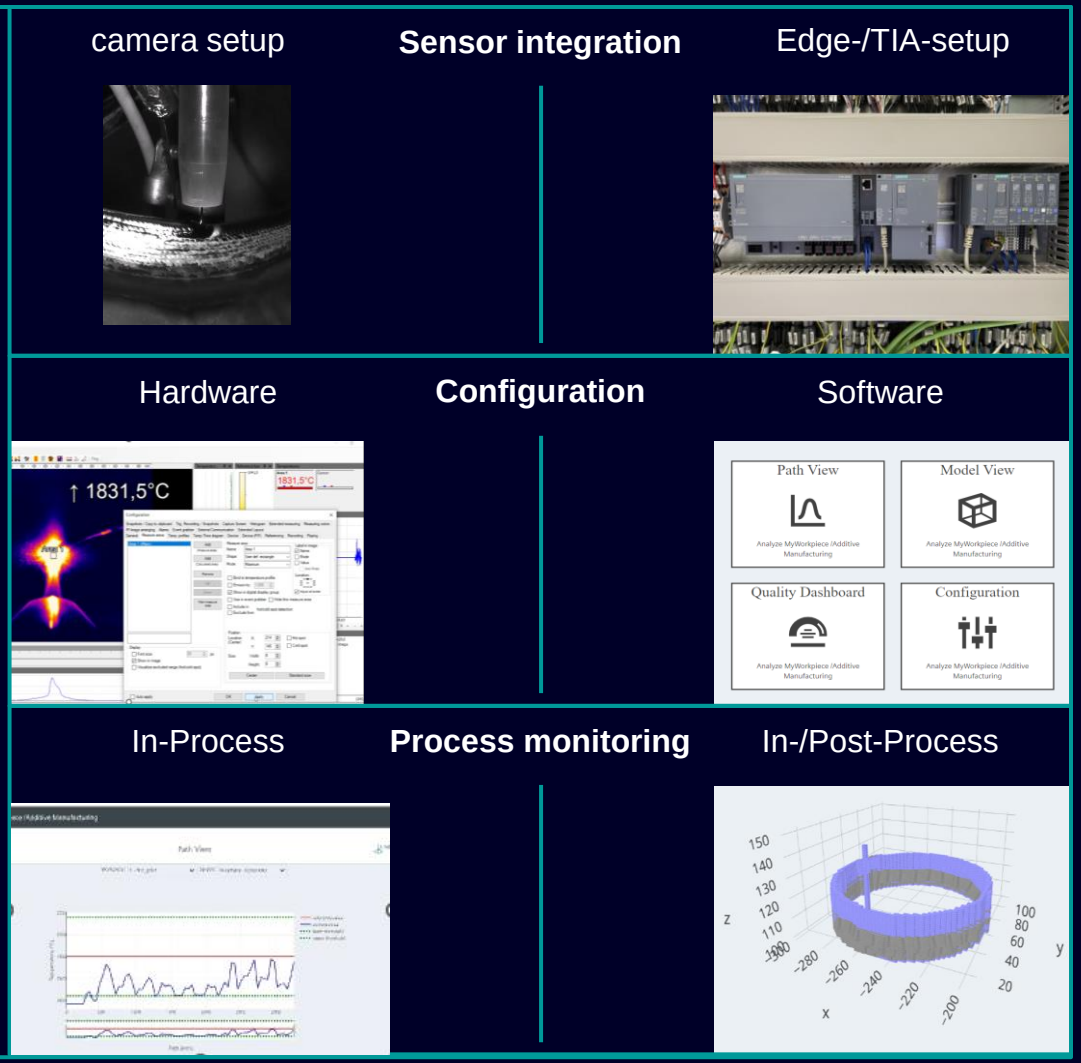
Generate and visualize **the digital fingerprint** based on synchronized high frequency data from process sensors on an edge device

Currently for SINUMERIK driven machines

SIEMENS

Analyze MyWorkpiece /Additive Manufacturing
Available for Sinumerik-based machines (pilot phase)





Outlook
What does the future hold?

Fronius & Siemens

SIEMENS

DED-Arc in Re-Manufacturing

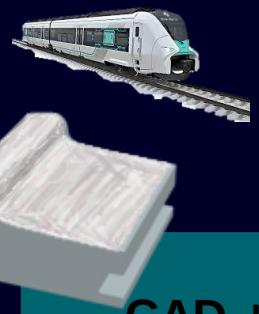
„Erfolgreiches Remanufacturing durch datenbasierte Entscheidungsfindung und intelligente Prozessplanung (eRep)“

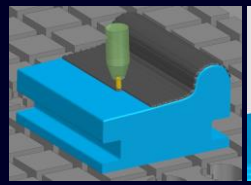
Gefördert vom
Bundesministerium für Bildung und Forschung
aufgrund eines Beschlusses des Deutschen Bundestages

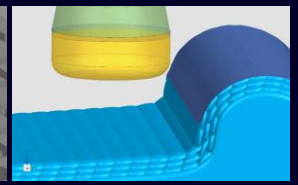
Industry-proven SINUMERIK CNC control for WAAM

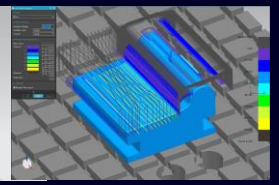
- Sinumerik RunMyRobot | DirectControl
- Integration of Fronius CMT welding source and COMAU NJ 130 industrial robot + WEISS spindle
- Edge for process monitoring (product “AMW /AMF”)
- Sustainability assessment in NX for deciding on manufacturing strategy
- Re-manufacturing toolchain using Fronius WireSense & NX CAM In-machine Probing

Sinumerik-based Re-Manufacturing WAAM Line









CAD + Scan → CAM WAAM + Milling → Simulation → Re-manufacturing & Monitoring → Final Scan

SIEMENS

Hot Topics

Fronius Additive

Outlook

Determining and react to the difference between the real and virtual part

Recipe Generation (AMPS)

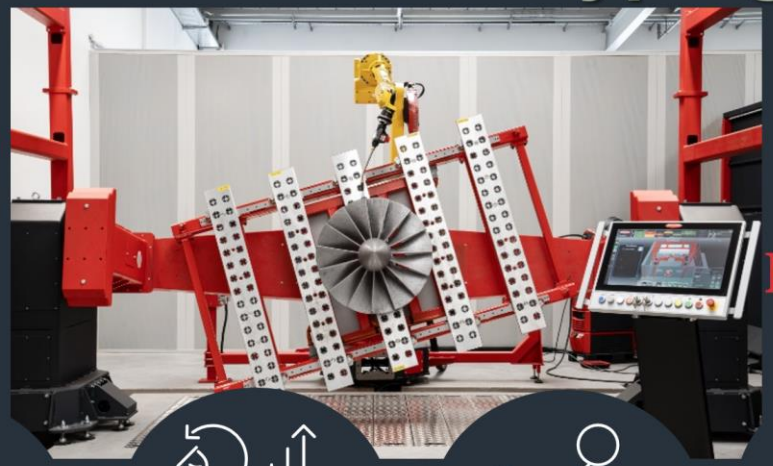
Process Stability

Repeatability and Transferability

Predictability

Additive Prototyping

PoC Proof of concept



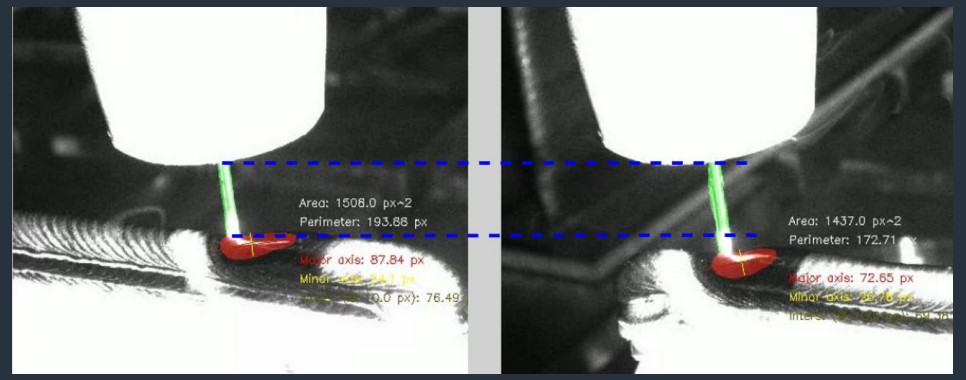
SoP Start of production

Feasibilty study

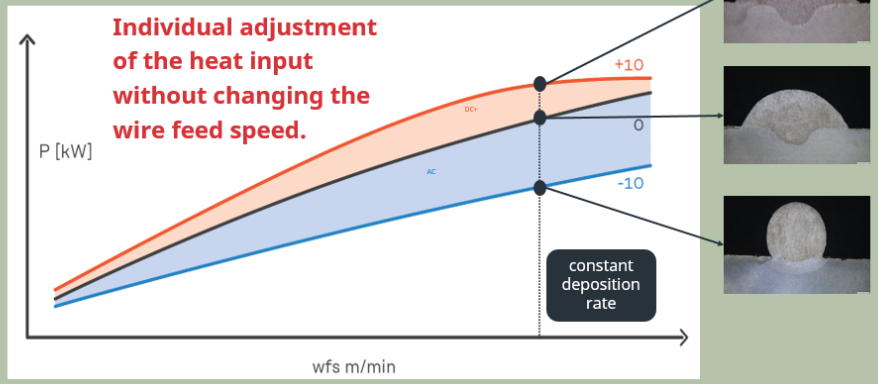
Prototyping

Pre-series production

Onsite



Control of the flow behaviour of the seam



Thank you

Tobias Kamps

Siemens Technology

Tobias.kamps@siemens.com

Philipp Roithinger

Fronius Int. GmbH

Roithinger.philipp@fronius.com