WAAM: From Single Part to Serial Production – Focus on Industrial Applications.

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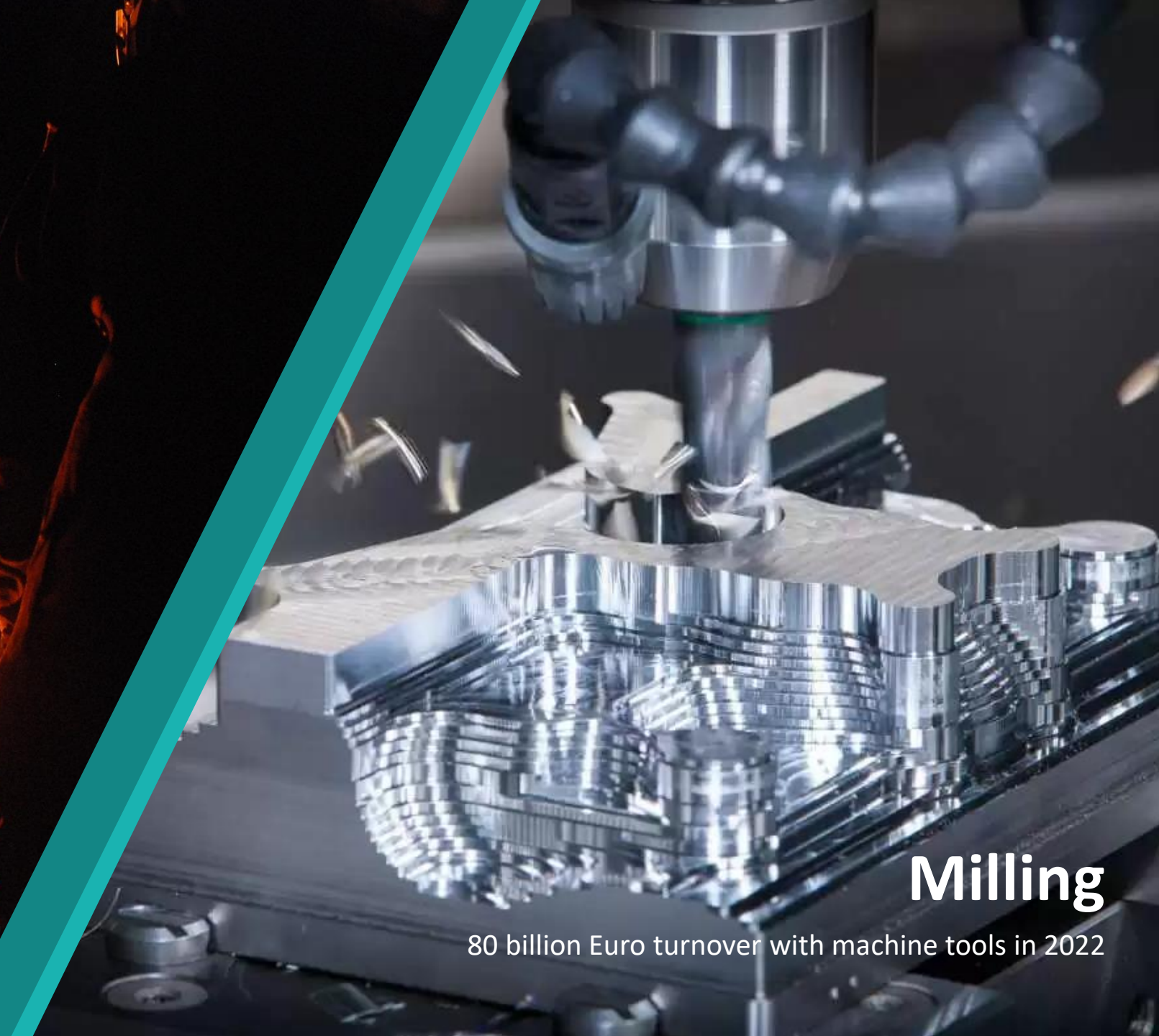
ONCE UPON TODAY

Conventional Technoligies

Casting

Since 5000 years

Today 120 mio t per year



Milling

80 billion Euro turnover with machine tools in 2022

Cash Burning with conventional Technologies


When your supplier doesn´t supply in time!


GEFERTEC

B.I.G.

100% owner of GEFERTEC

57 million € revenue in 2023

320 employees

Scansonic, Metrolux, Lumics, GEFERTEC

Market leaders in their niches

Your Guarantee of Success

As your partner in the world of WAAM technology, we work to ensure that you are always at the forefront of technological advancement together with us.

Experience: 42 Machines

We have established ourselves as a pioneer and market leader in the WAAM sector. 32 satisfied customers and 42 machines successfully installed in the market underscore this.

Expertise: 200 Projects

Over 200 successfully realized component projects not only demonstrate our technical expertise, but also our ability to find individual solutions for each of these orders.

Industries

Tool & die making, machinery & plant engineering, energy sector, maritime applications, aviation, as well as pressure vessel construction and the railway sector.

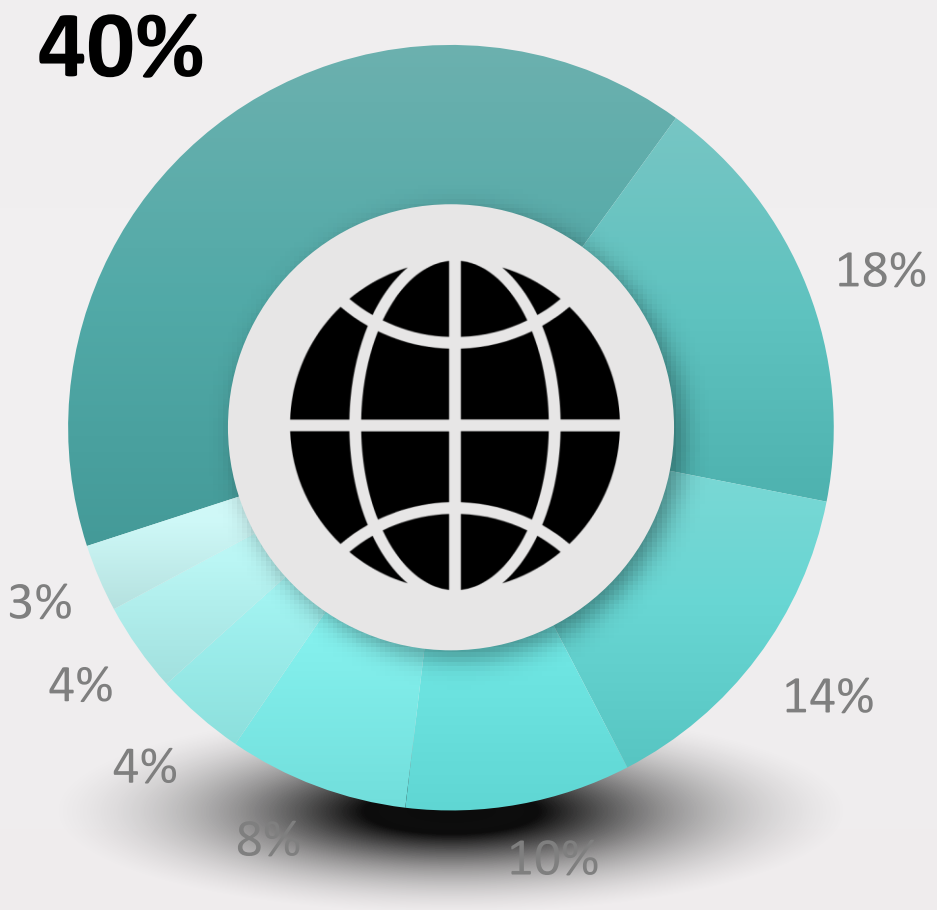
Market Share*1

Gefertec

Gefertec is by far the market leader in terms of quantity of sold systems. With 40% they have more than twice as much sold system as the second competitor. Gefertec is the only competitor offering systems that are used in 3-shift serial production.

Other Competitor

The other 5 competitor reach a total of only 28% which is combined 12% less than Gefertec.



Competitor 1

The second competitor follows with only 18% of market share. This results less industrial experience and therefore lower industrial readiness.

Competitor 2

The third competitor only has 14% of market share which is only one third compared to the leader Gefertec.

*1 – Numbers till end of 2023 are accounted for.

GEFERTEC

Research Projects

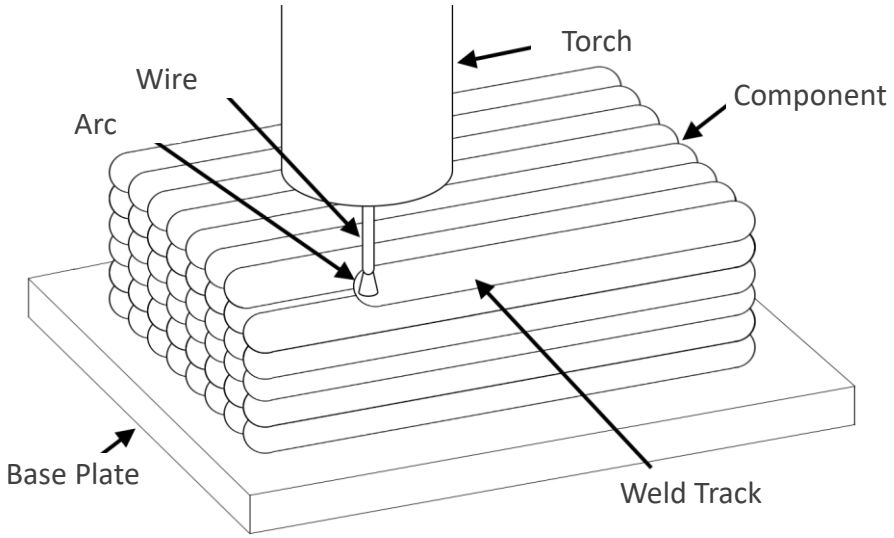
20 research projects
EU partners
Industry partners
Research partners

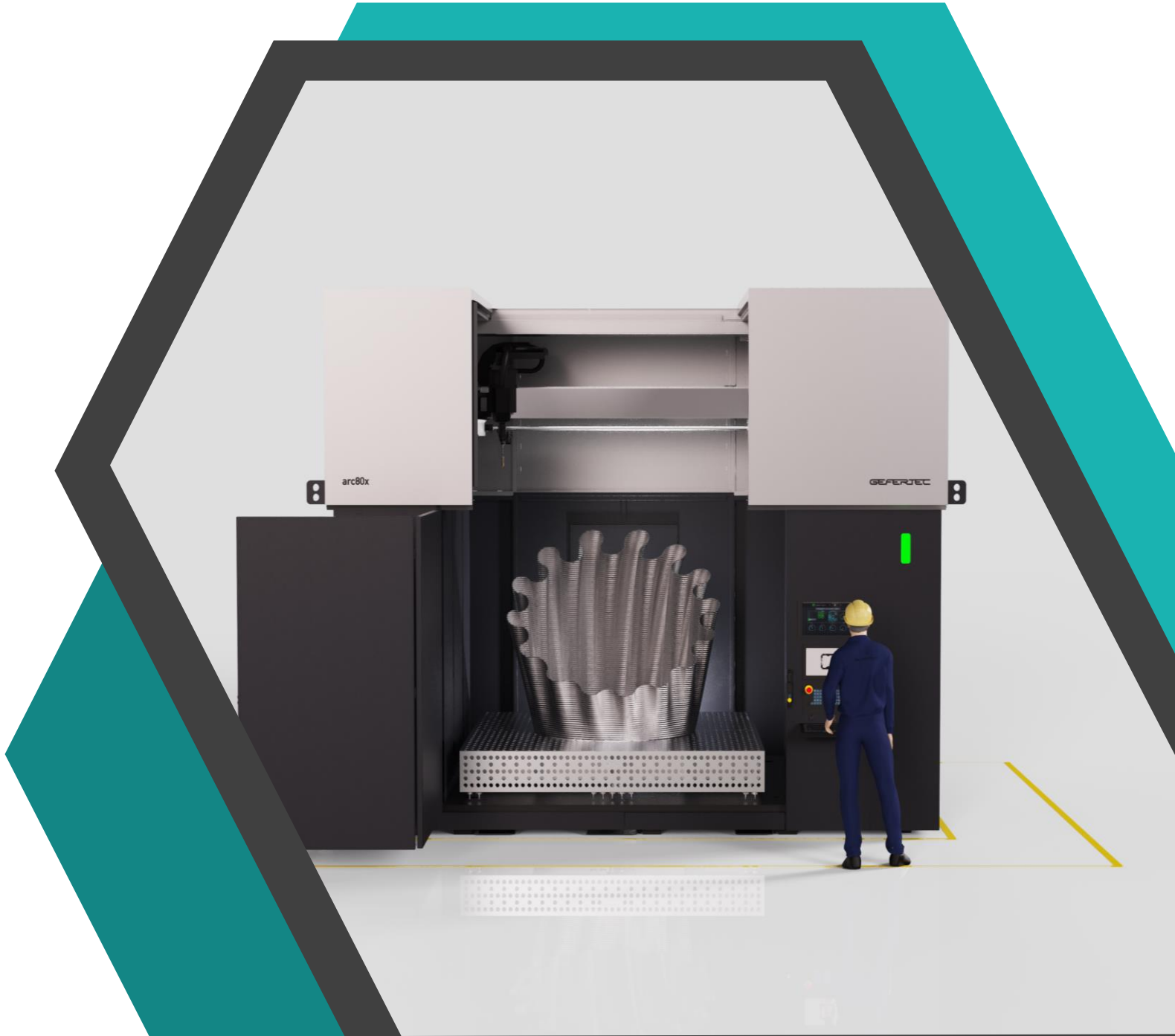
OUR SOLUTION

GEFERTEC

WAAM

Wire Arc Additive Manufacturing (WAAM) is a wire-based process that welds metal layer by layer using arc welding technology, thus additively constructing the component.





World Record

The manufacturing of steam turbines requires high quality, especially for the guide vanes from Siemens Energy. In 2018, a supplier delay triggered a crisis. This led to a rethink towards additive manufacturing - WAAM. The immediate availability of parts and the newfound independence from traditional supply chains marked a significant strategic shift. Siemens Energy was the first company worldwide to use the WAAM process in serial production. In 2023, the 1000th guide vane was printed - a world record!

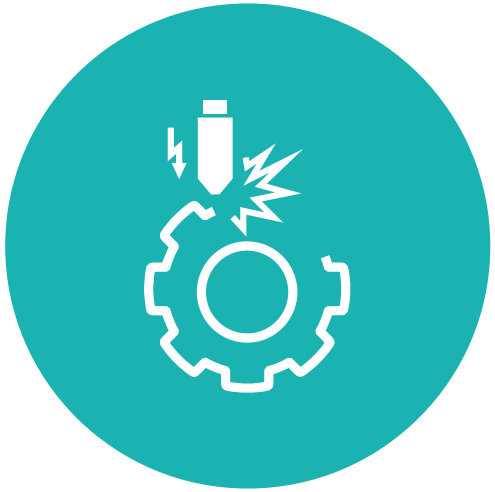
Independence

Supply chain independence
Materials in stock
Semi-finished product production
Digital warehouse

Cost Savings

Material savings
No special tools required
Economical
Batch size 1 to mass production

Functionality



Multi-material
Design freedom
Internal structures
Optimized properties

GEFERTEC

Conventional Manufacturing

Material: 1.4305

Raw Material
85 kg

Milling
Chips: 67 kg (80%)

Finished Part
18 kg

3DMP®

Material: 1.4316

Printed Blank (6.5 h)
25 kg (printed volume: 17 kg)

Milling
Chips: 7 kg (28%)

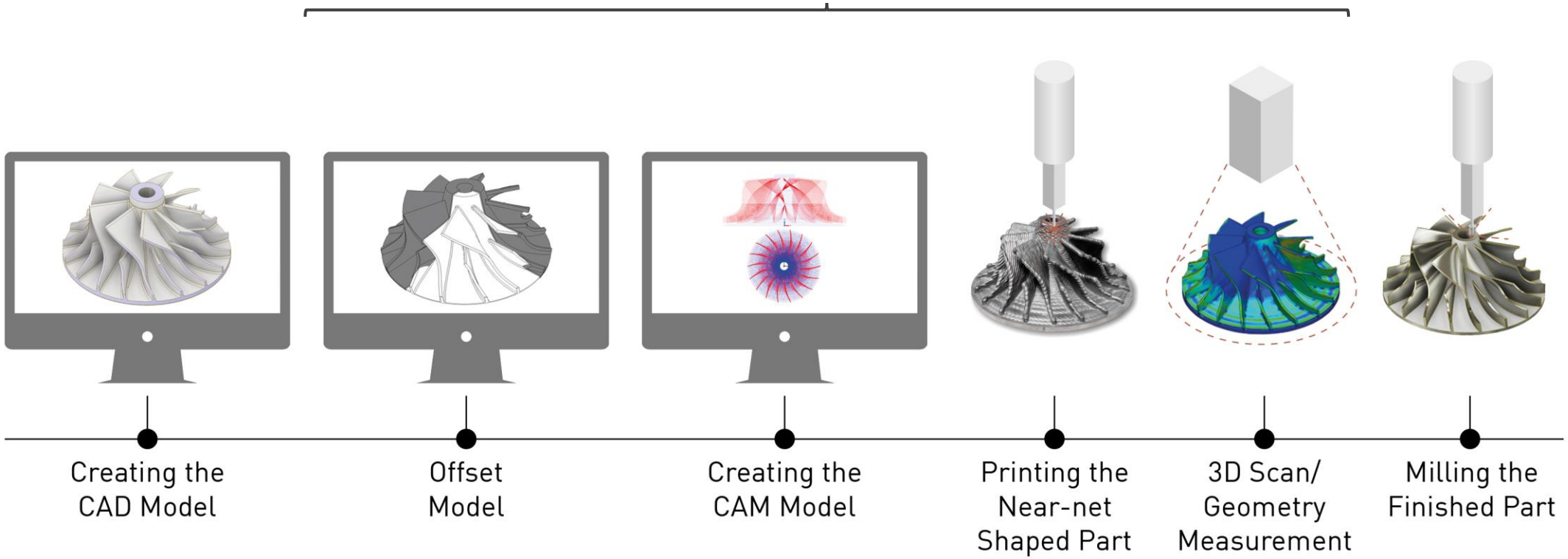
Finished Part
18 kg

WAAM vs Milling

PROCESS CHAIN

GEFERTEC

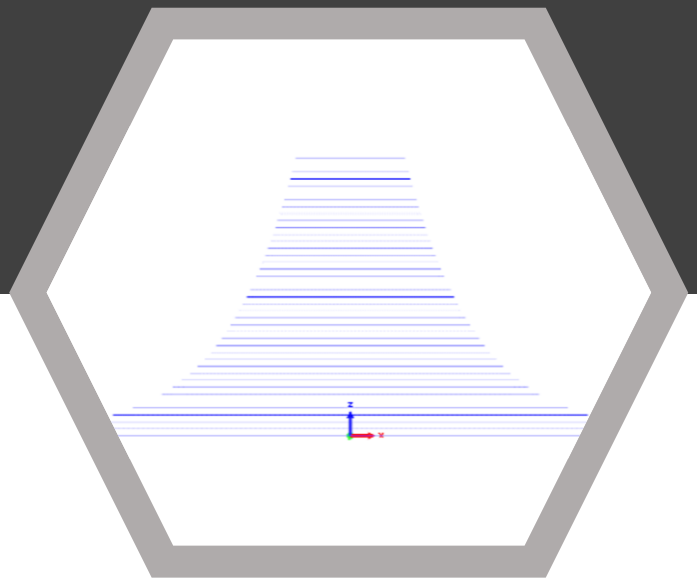
3DMP® Process Steps



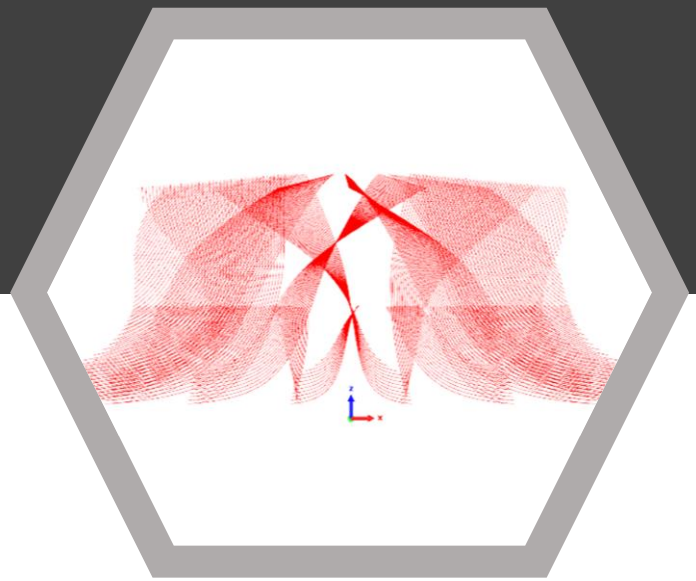
3DMP® combines the technically mature and highly reliable arc welding method with the CAD data of the metal parts that are to be produced. The CAD Data will be converted into individual digital printing layers - the so-called slicing.

This happens via a CAM software. Then, the blank part is printed fully automatically and in a controlled manner. This step is followed by a 3D scan for quality control and finally the milling of the finished part.

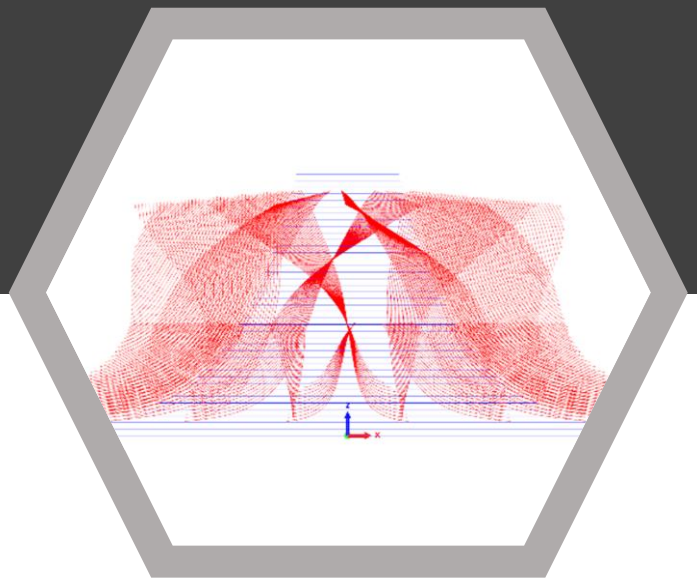
CAM-Programming



3-axis printing of the conical base body



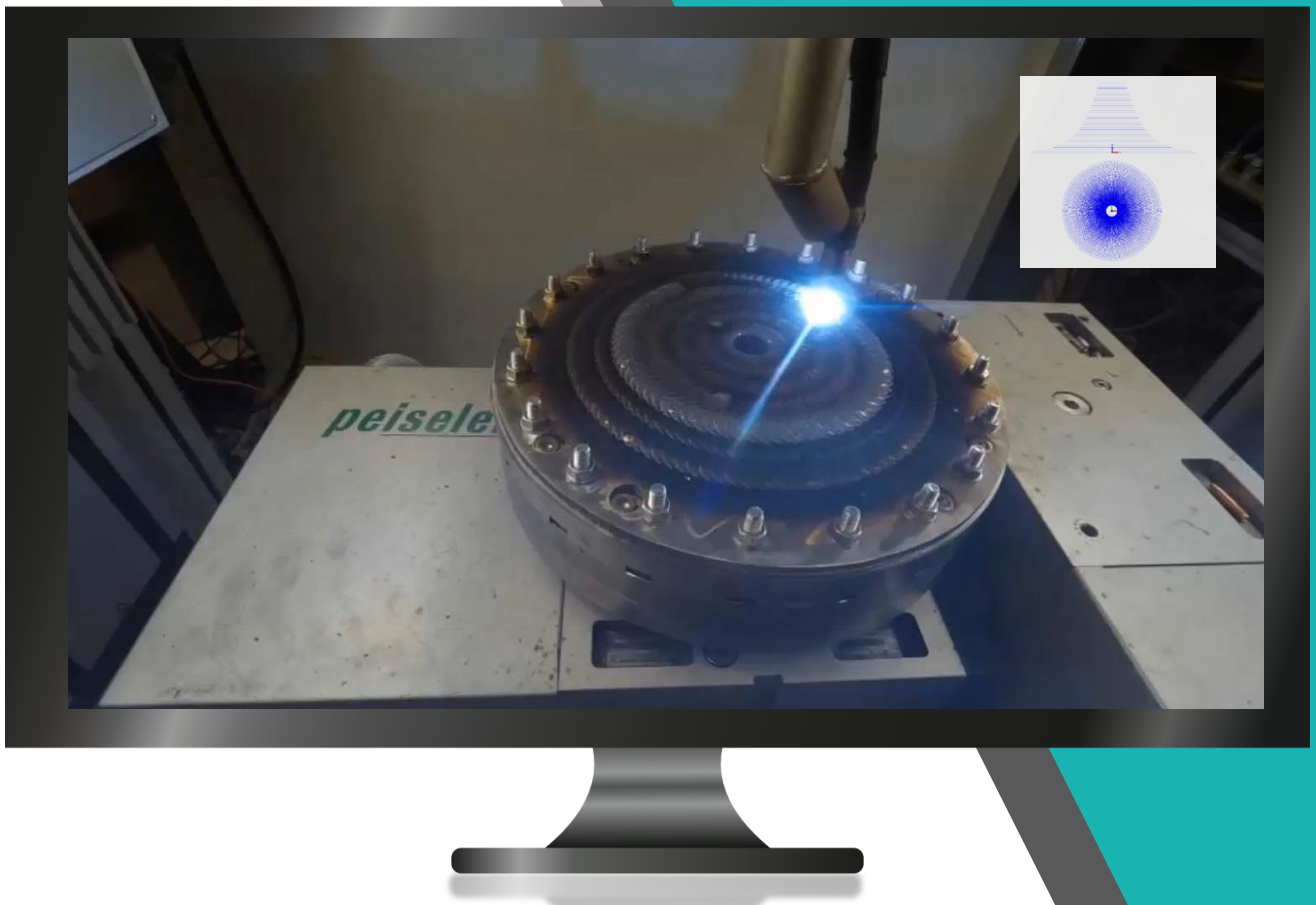
Path planning for simultaneous 5-axis machining to construct the impeller blades



Integrated path planning including cone and impeller blades

Print - Cone

In this case, the process was divided into two steps. First, the cone is printed in a 3-axis operation, with the CNC table remaining stationary and only the torch being moved by the Cartesian linear axis system in the X, Y, and Z directions.



Um eine gute Sichtbarkeit zu gewährleisten und das Video in einem bestimmten Zeitrahmen zu halten, wurde die Abspielgeschwindigkeit verdoppelt.

GEFERTEC

Print - Blades

In the next step, we additively apply the blades onto the already printed cone. This requires a comprehensive understanding of the processes, as the construction of this complex component demands high expertise. During this process, simultaneous control of the five available axes takes place. Not just the path planning, but also the selection of process parameters is of critical importance. With our expertise, printing such demanding parts becomes a straightforward task.

THE MACHINES

arc80X

Highest Part Quality
Use of high-precision CNC-controlled linear axes

Efficiency and Productivity
Highly automated and optimized with regard to, for example, production speed

Limitless Flexibility
Tailored precisely to you with more than 70 options

Reliable and Robust
Experience as market leader with 42 machines in the global market

GEFERTEC machines have been used for many years in industrial mass production, for example with three systems at Siemens Energy for the production of turbine parts. With the new arc80X, we offer you the next generation of machines.

For Industrial Production CNC

Batch Production

High process reliability needed
Same conditions in each position of the work space needed

Robot

Problems of Robot:
Velocity Reliability
Perfomance, Precision is dependend position
Different momentum in each position

CNC System

Advantages in serial production
Same condition in each position
Highly reliable in velocity
10x more precise in positioning
➔ High process reliability independ of position

Recommandation (Precision and velocity reliability) https://mediatum.ub.tum.de/doc/1595772/1595772.pdf

Part Quality

Due to CNC-controlled linear axes

The repeat accuracy of part quality and thus process stability depends largely on the achievable precision of the motion system used. For this reason, GEFERTEC exclusively uses CNC-controlled linear axes. In contrast to alternative motion systems, these are characterized by the following, lasting throughout the entire build volume:

- ✓ High Repeatability in Position
- ✓ High Positioning Accuracy
- ✓ High Repeatability in Path Accuracy
- ✓ High Path Accuracy

Source : https://www.rollon.com/

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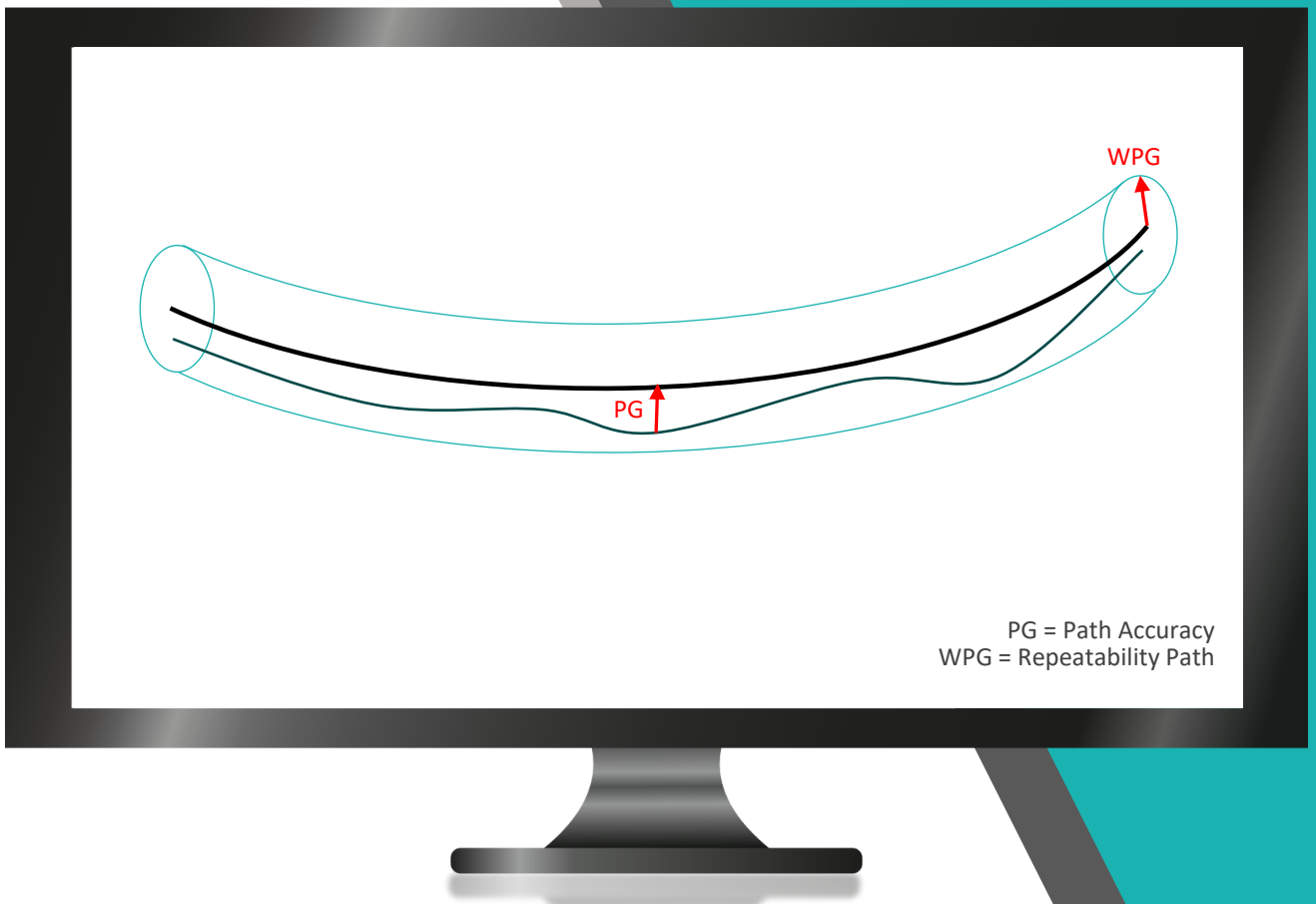
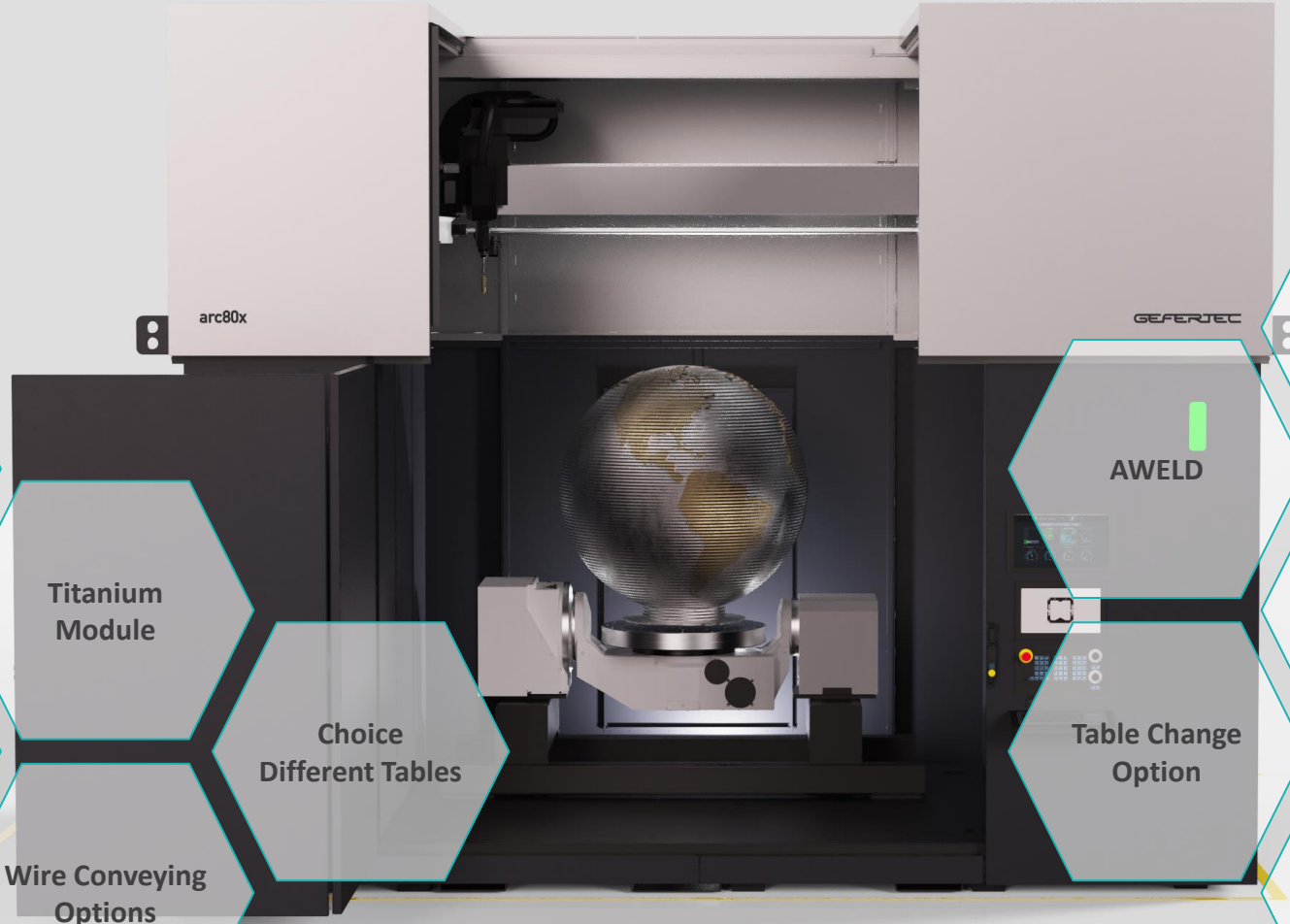


Limitless Flexibility



Automation

Titanium Module

Table Cooling

Choice Different Tables

Wire Conveying Options

AWELD

Table Change Option

Temp-Control

Active Part Cooling

Consumables Monitoring

Cockpit

Process Monitor

Welding Source Options

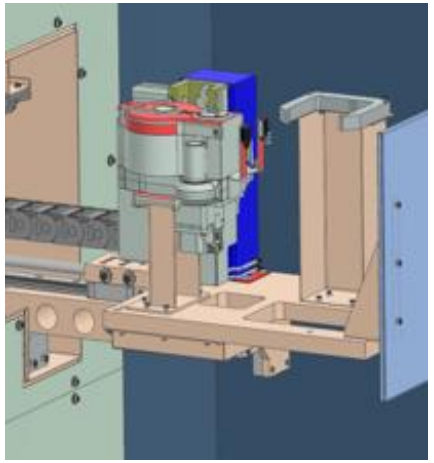
Wire Feed Options

CAM Software Options

Options Extraction

Economical and Productive

With a total of 42 systems sold worldwide, we are the undisputed market leader for WAAM systems. We receive ongoing feedback from over 30 customers. All of this experience and the associated know-how benefit you directly – including in the form of highly automated machines that operate economically and efficiently.



Automation Tool

The automation tool enables unmanned production with the arc machines. It consists of an automatic contact tube changer, nozzle cleaning, tool measurement, and wire cutter.

AWeld

Adjustable automatic routines in response to ignition errors during the production process. The need for manual intervention due to ignition errors is significantly minimized.

Cockpit

The cockpit consolidates all information about the machine's status in one overview. It can be accessed both at the machine itself and on a computer in the network.

Configuration

3-axis configuration
Maximum component size: 2 x 2 x 2 m
Maximum component weight: 8000 kg
Outer dimensions: 5.0 x 3.5 x 3.8 m

5-axis configuration
Maximum component size: 0.9 x 1.4 m (Ø x Z)
Maximum component weight: 500 kg
Outer dimensions: 5.0 x 3.5 x 3.8 m

JT2Go 2312 - [ASM_Arc80X_240318_01.jt]

SIEMENS

File Home View Render Analysis Manufacturing Tools Help JT2Go

Window | Orientation | Clipping | Navigation | Style | Visibility | Performance

Window | Previous View | Next View | Automatic Motion | Navigation Preferences | View Preferences | Stop Streaming | Performance Settings

Menu

Project Workspace

Item Name

Models

ASM_Arc80X_240318_0

Z

X

For Help, press F1

Mem: 2040,2M/16234,0M AA: 4

THE MATERIAL

Overview Properties 3DMP®

Wire Designation		Union K56	Thermanit 18 17 E Mn	AM Print 2209	3Dprint AM 304L	Union X96	AM Print 316L	AM Print 625	Union AlMg4,5Mn	TiAl6V4	UTP A34
Material Classification		ER70S-6 G 46 4 M21 - 4Si1	ER 317 L 1.4453 G Z 18 16 5 N L	ER 2209 ~1.4462 X2CrNiMoN 22-9-3	AISI 304 L 1.4306 X2CrNi19-11	ER 120S-G G 89 5 M21 - Mn4Ni2,5CrMo	ER 316 Lsi 1.4430 G 19 12 3 L Si	Alloy 625 2.4831 NiCr22Mo9Nb	ER 5183 3.3548 AlMg4,5Mn0,7	Titan Grade 5 3.7165 TiAl6V4	ER CuAl-A 1 2.0921 S Cu 6100
Typical Base Material		S 355 1.0045	AISI 317L 1.4438	AISI 318 LN 1.4462	AISI 304 1.4301	S 960 1.8933	AISI 316L 1.4404	Alloy 625 2.4856	Al 5183 2.4856	TiAl6V4 3.7165	Cu AL 7 2.0921
Yield Strength [MPa]	ST	≥ 410	≥ 330	≥ 440	≥ 270	≥ 680	≥ 300	≥ 385	≥ 130	≥ 840	≥ 140
	MT	≥ 390	≥ 340	≥ 450	≥ 300	≥ 580	≥ 310	≥ 380	≥ 140	≥ 820	≥ 190
Tensile Strength [MPa]	ST	520 - 530	560 - 630	700 - 780	480 - 510	930 - 960	530 - 550	660 - 710	270 - 290	950 - 990	420 - 440
	MT	520 - 530	600 - 620	750 - 800	540 - 560	980 - 1060	530 - 590	670 - 730	300 - 310	890 - 940	475 - 500
Elongation [%]	ST	≥ 31	≥ 30	≥ 30	≥ 25	≥ 17	≥ 32	≥ 49	≥ 15	-	≥ 40
	MT	≥ 29	≥ 39	≥ 31	≥ 39	≥ 19	≥ 34	≥ 42	≥ 20	≥ 7	≥ 43
Impact Work [J]		≥ 210	≥ 160	≥ 140	≥ 110	≥ 70	≥ 110	-	≥ 20	≥ 27	≥ 105
Wire Diameter [mm]		1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2
Process Gas		M12-ArC-2.5	M12-ArC-2.5	M12-ArC-2.5	M12-ArC-2.5	M21-ArC-18	M12-ArC-2.5	Z-Ar-HeHC-30/2/0.05	I1-Ar	I3-HeAr30	I3-HeAr30
Deposition Rate(1) [kg/h]		4,2	4,4	4,4	4,4	4,7	4,4	4,8	1,0	4,0	3,8

Overview Properties 3DMP®

Applied Testing Methods:

- Makro- & Micrographic Analysis
- X-Ray
- Charpy Impact Test
- Tensile Test

➔ **Quality Evaluation Based on ISO 5817, ISO 6520, ISO 10042**

Validity:

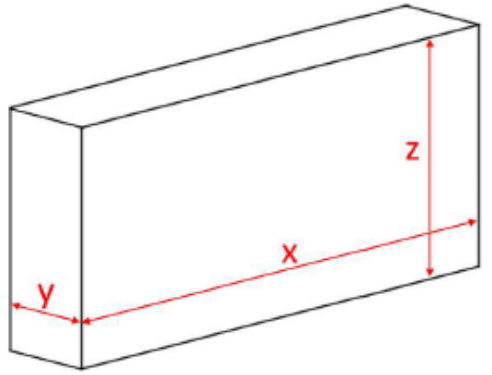
Parameters are validated for the displayed base geometries. Deviations from base geometries may require adjustments for optimal processibility.

Thick-walled Base Geometry

Multi Track

meander motion

Base Geometry Dimensions [mm]	X	230
	Y	25
	Z	100

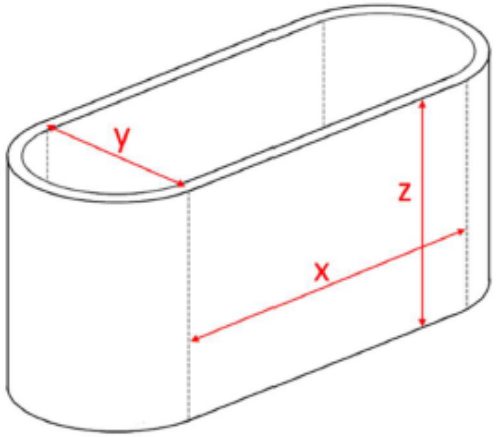


Thin-walled Base Geometry

Single Track

Track width 7 to 10 mm

Base Geometry Dimensions [mm]	X	150
	Y	80
	Z	150

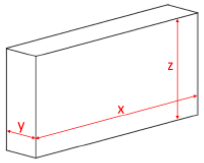


Overview Properties 3DMP®

GEFERTEC

Base Geometry

Base Geometry Dimensions [mm]	X	240
	Y	24
	Z	115



Base Parameters

Mechanical Technological Specifications	Condition	As printed	
	Orientation	X	Z
	Yield strength [MPa]	307.3 ±1.7	303.3 ±2.5
	Tensile Strength [MPa]	557.5 ±3.7	548.0 ±2.4
	Elongation at break [%]	51.0 ±5.9	40.7 ±1.1
	Impact energy @ RT [J]	124.7 ±5.5	164.7 ±3.2
Economical Specifications	Net build rate (excl. cooling time)	4.44	kg/h
		568.77	cm³/h
	Gross build rate* (incl. cooling time)	1.34	kg/h
		171.36	cm³/h

*depending on part geometry

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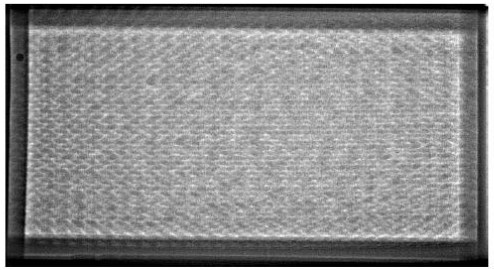
Radiographic Testing



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Macro/Micro Sections

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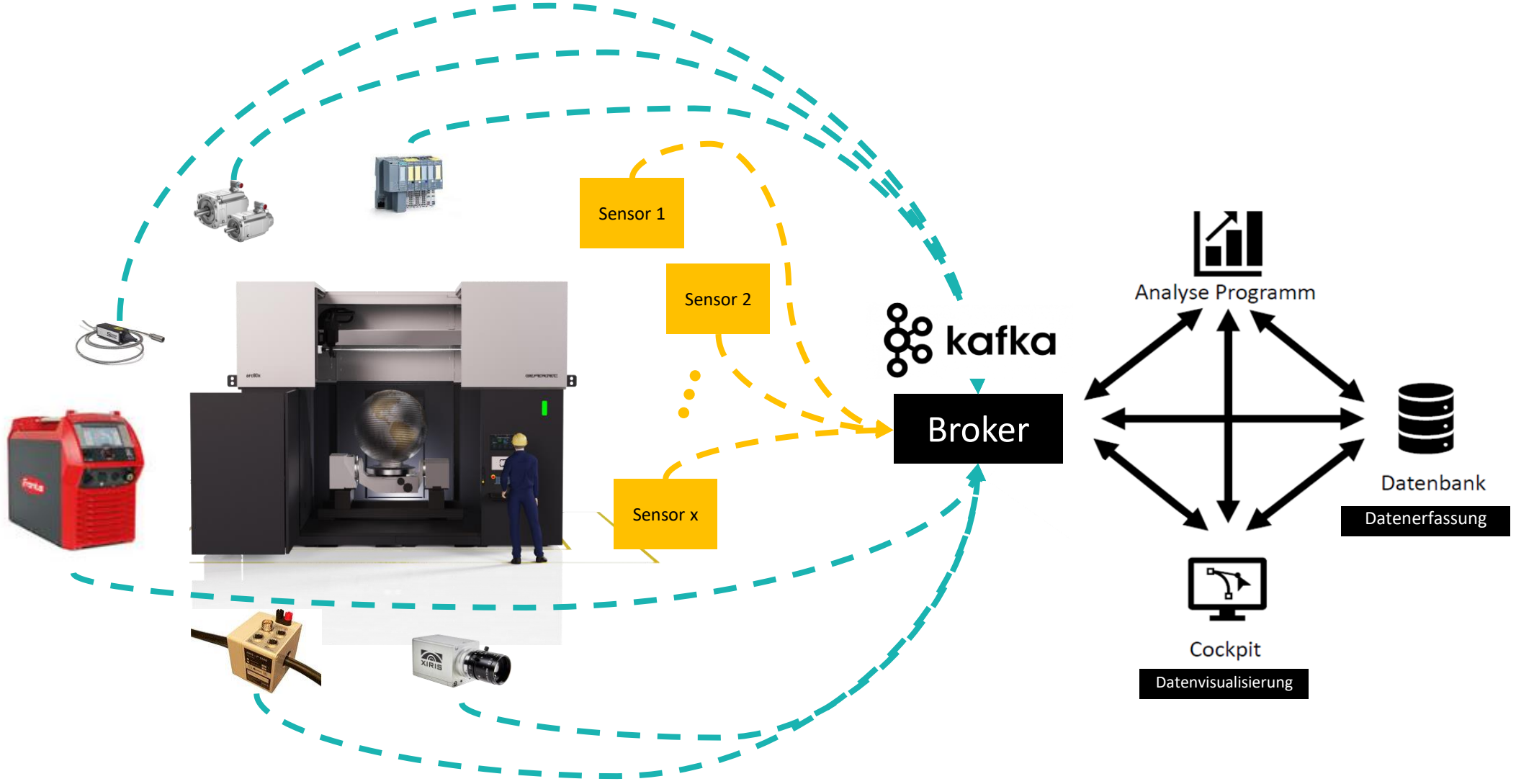
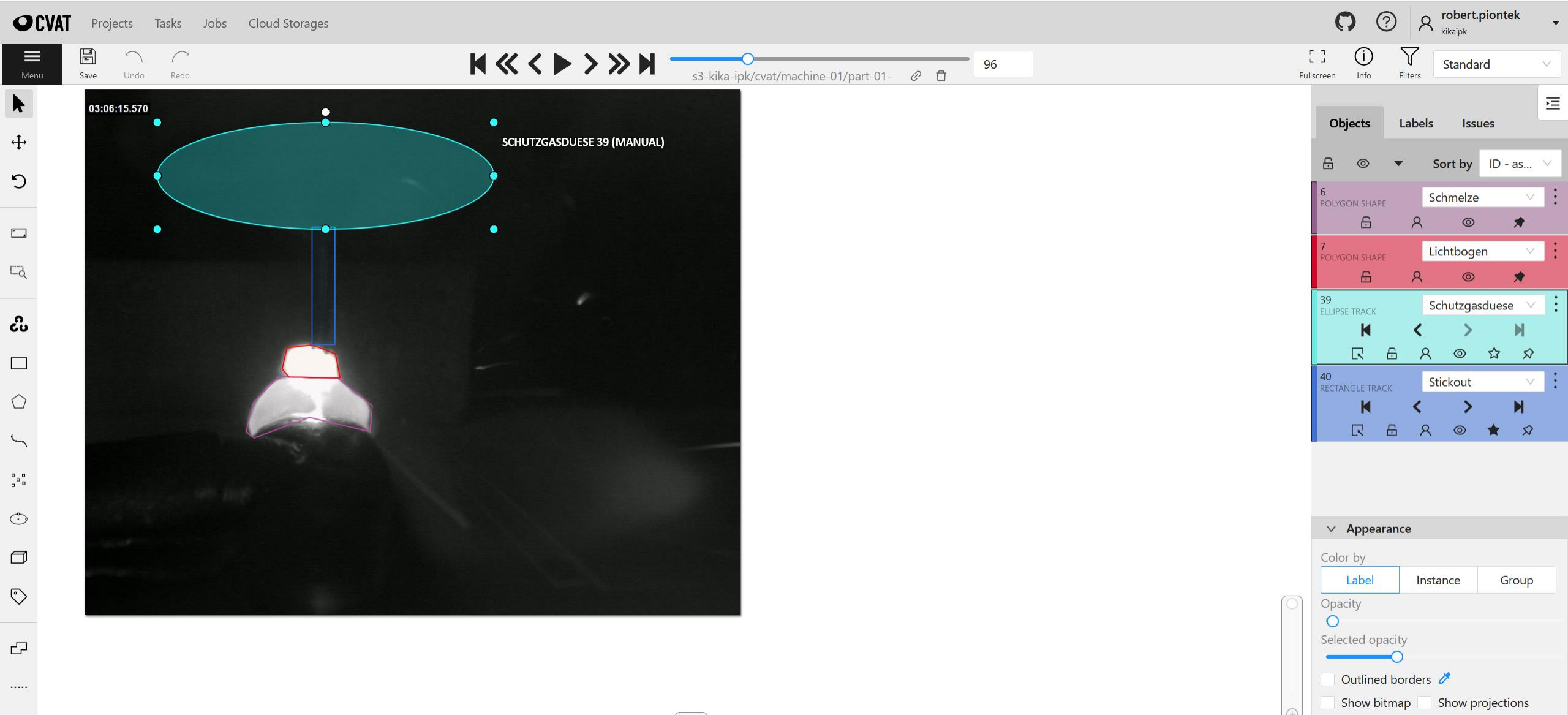
Macro/Micro Sections

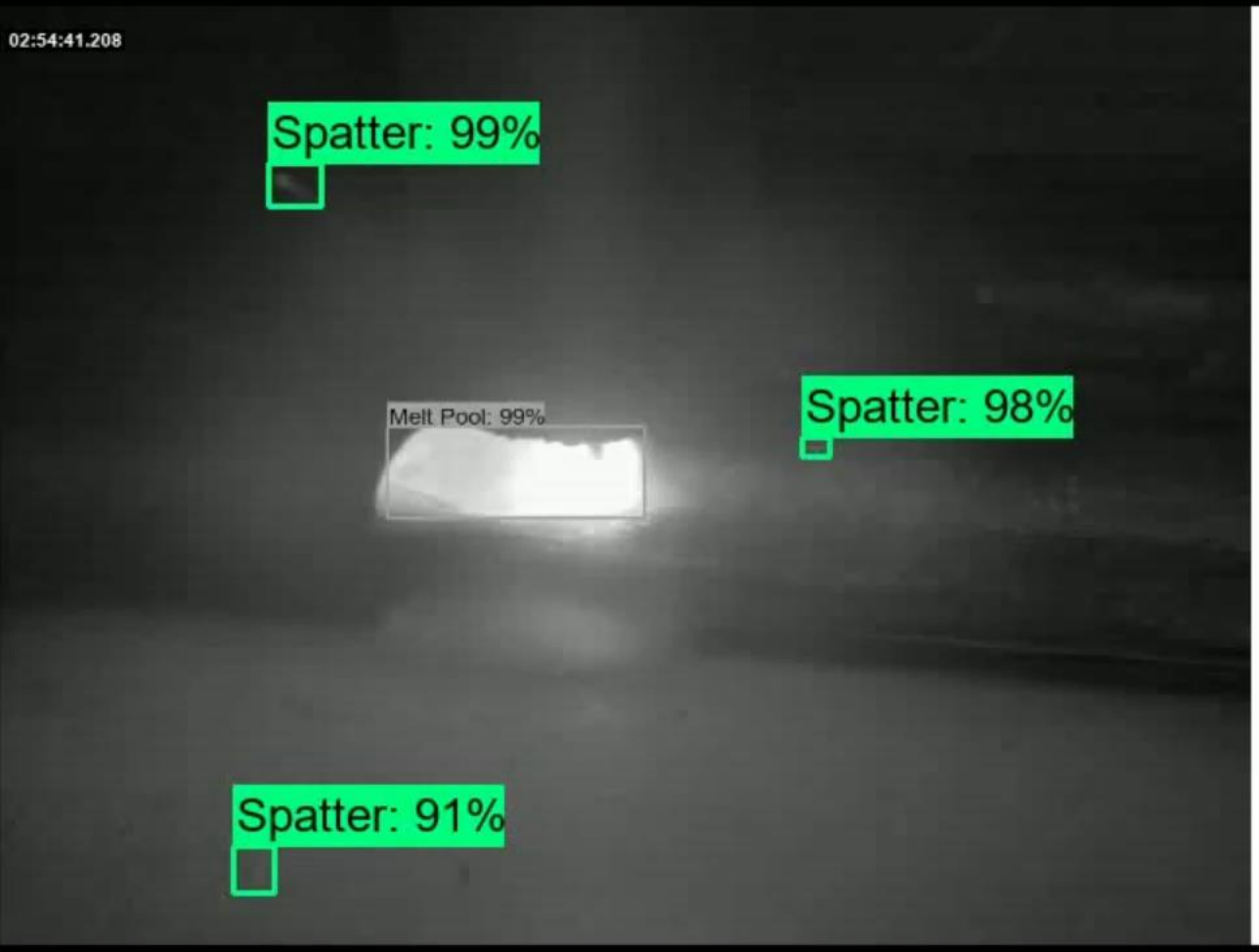
PROCESS MONITORING

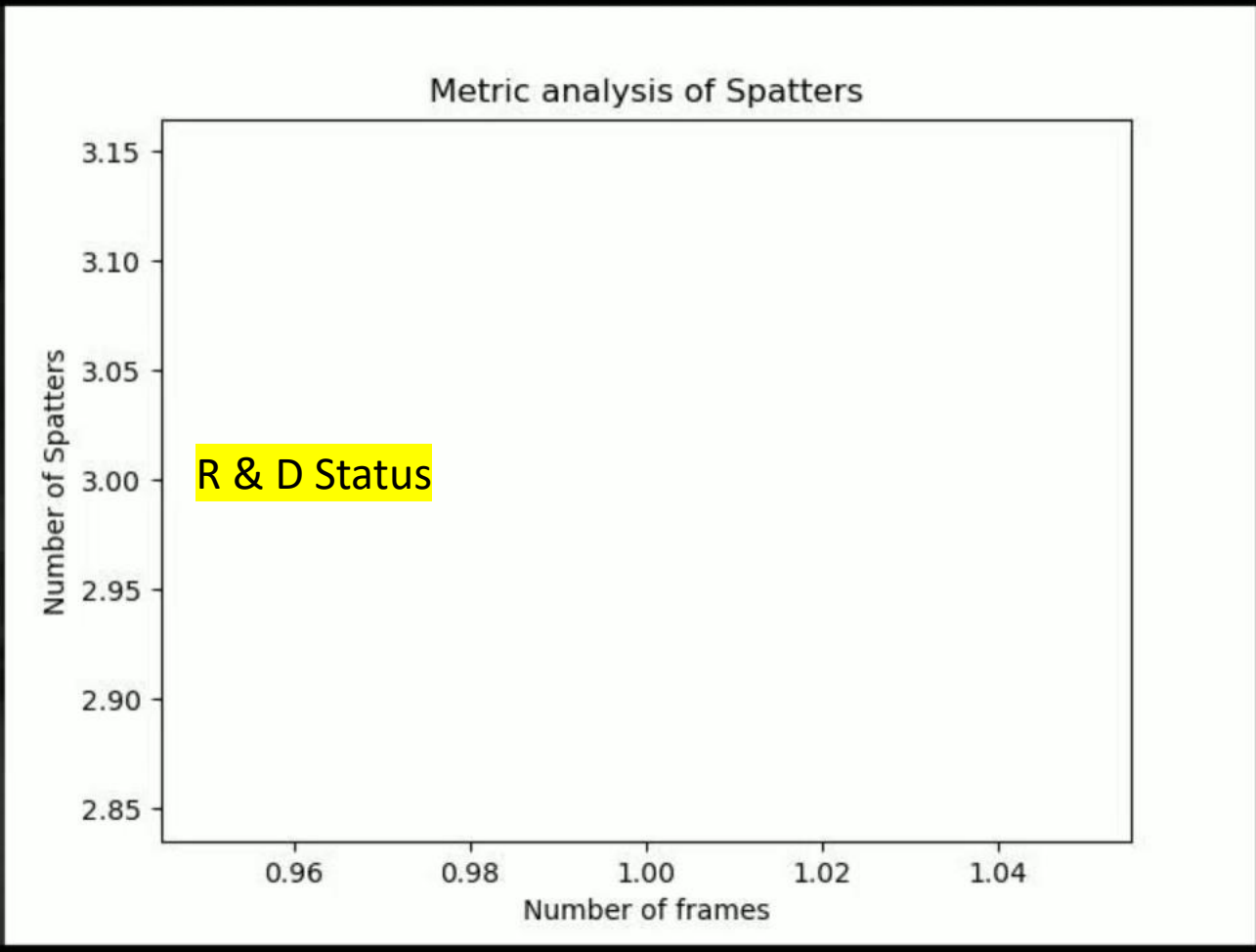
Open Source – Process Monitoring



AI-Training & Labeling




02:54:41.208
Spatter: 99%
Melt Pool: 99%
Spatter: 98%
Spatter: 91%


Metric analysis of Spatters
Number of Spatters
3.15
3.10
3.05
3.00
2.95
2.90
2.85
0.96
0.98
1.00
1.02
1.04
Number of frames

R & D Status

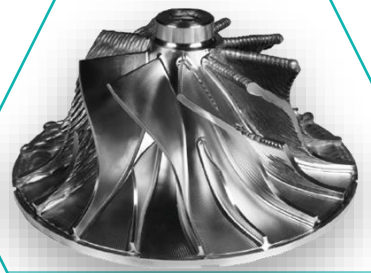
CASE STUDIES

Application Examples

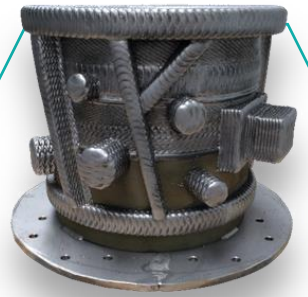
Our expertise extends across various key industries, such as tool and die making, machinery and plant engineering, the energy sector, maritime applications, aviation, as well as pressure vessel construction and the railway sector.

ALSTOM
Schlingerdämpfer

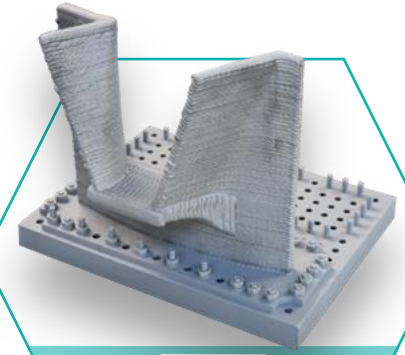
Propeller



Impeller

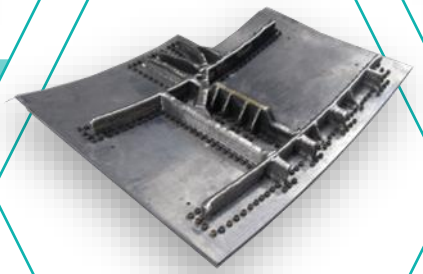


EMAG
Getriebegehäuse



SIEMENS energy
Load Collar

DB
Radsatzlagerdeckel



AIRBUS
Notausstieg

SCHULER
Umformwergzeug

IKR
Einlauftrompete

Schneidwerkzeug

DB
Kastenkulisse

Wilhelmsen | thyssenkrupp

GEFERTEC

Propeller

Technical Data

Machine: arc405
Dimensions [mm]: Ø = 640 x 250
Wire: 316L | CuAl7
Printing Material: 58.6 kg
Printing Time: 31.0 hours (including cooling times)

WAAM vs. Casting

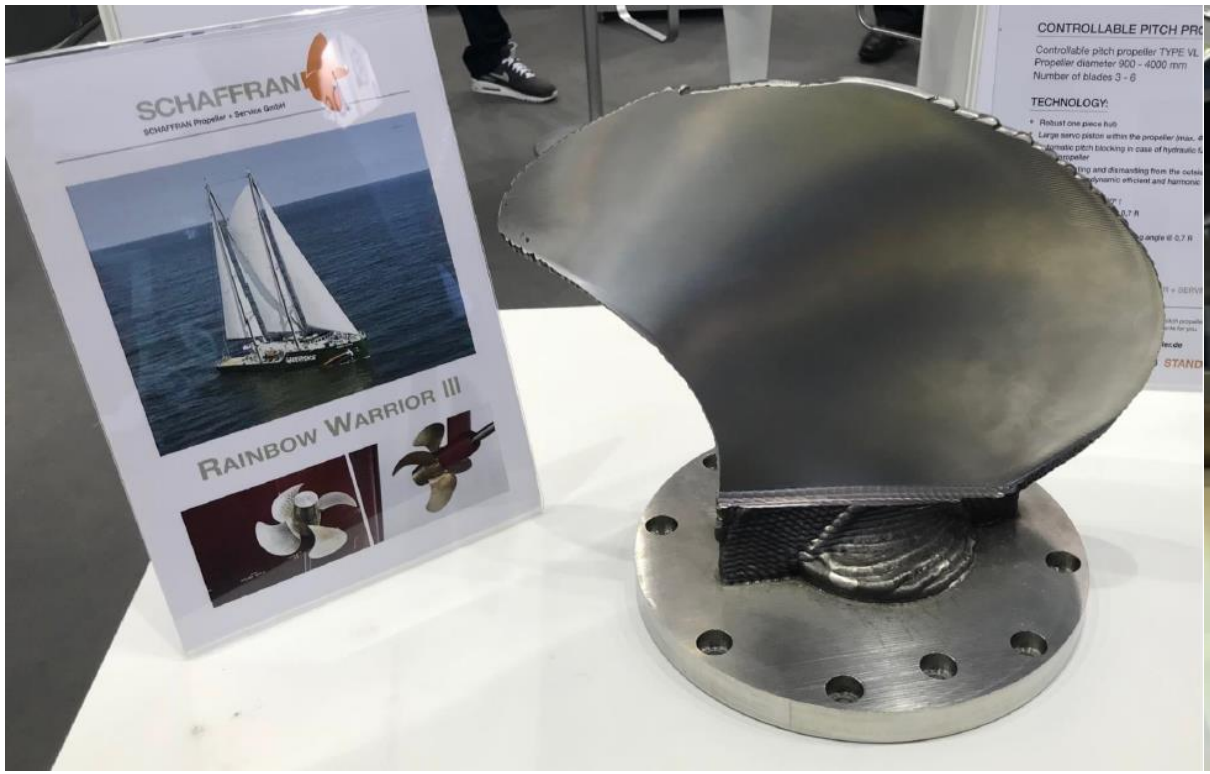
- ✓ Fast and flexible procurement of near-net-shaped blanks
- ✓ Subsequent adjustments can be easily made
- ✓ Wider range of corrosion-resistant materials available
- ✓ Lower inventory costs of forged parts
- ✓ Shorter lead times for forged parts

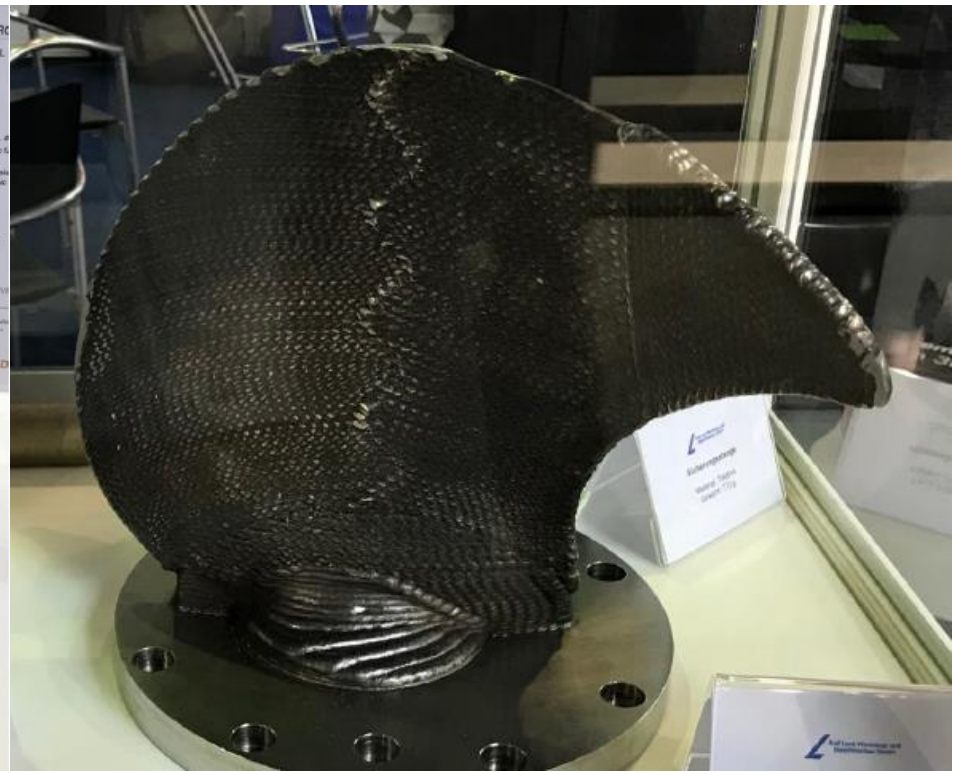
Material Savings

Small Batches

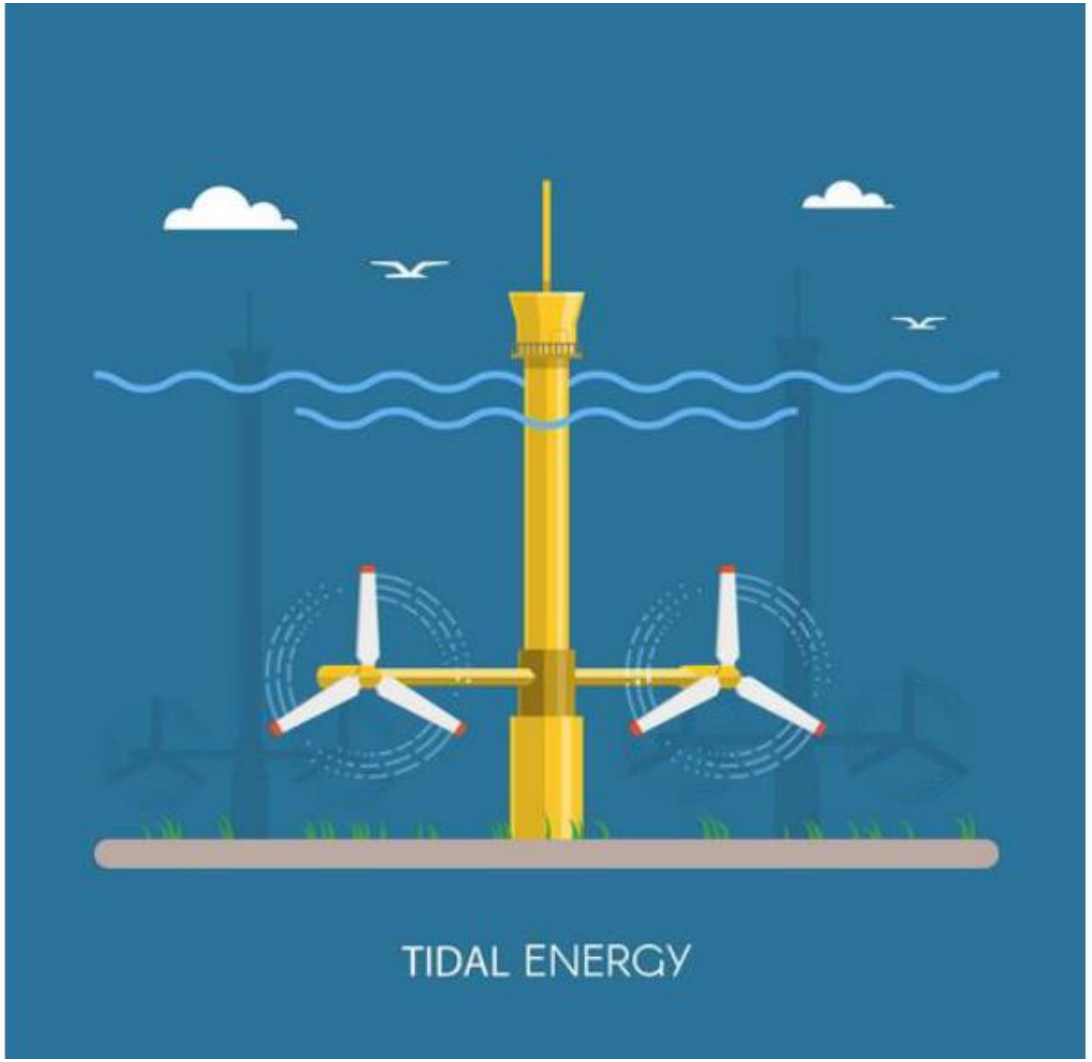
Time Savings

Propeller Blade





Blade for Tidal Power Plant



GEFERTEC

SIEMENS energy

Load Collar

Technical Data

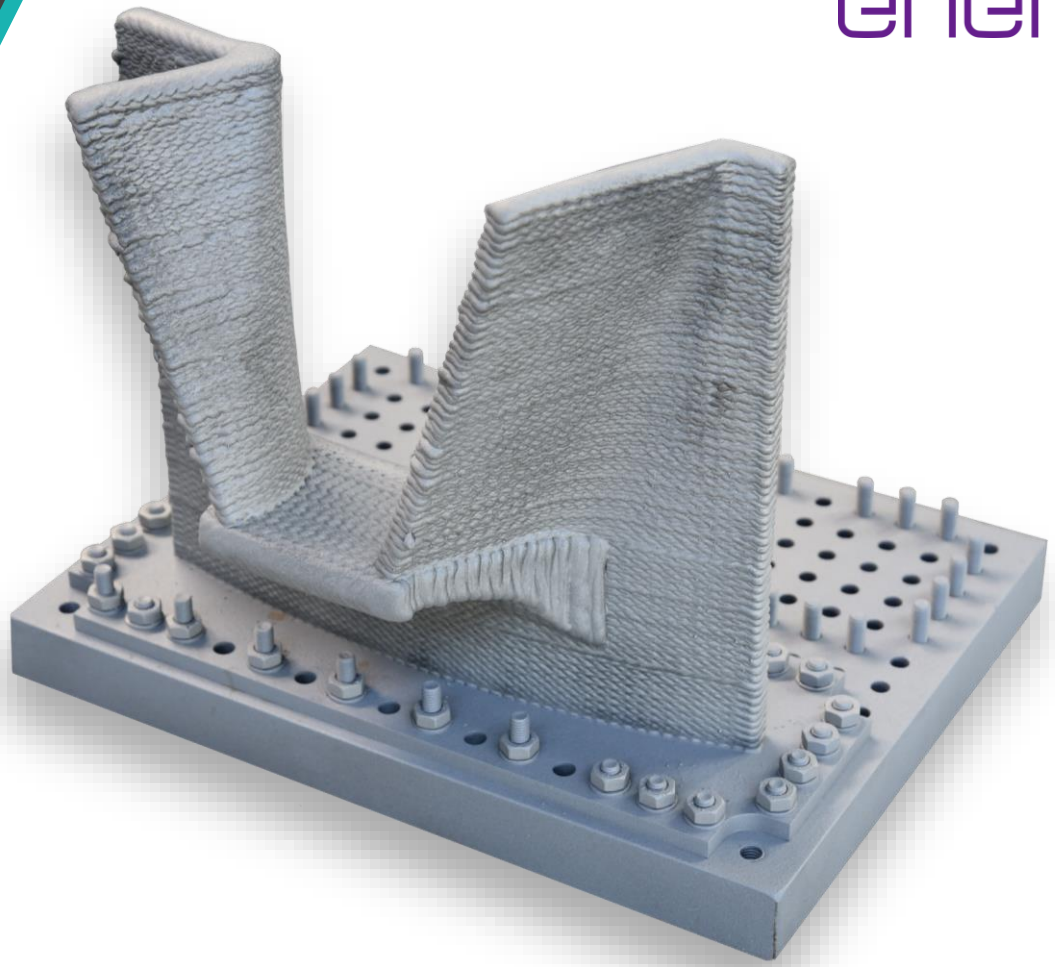
Machine: arc405
Dimensions [mm]: L = 100 | H = 300 | W = 350
Wire: 1.4948 | Ø 1.2 mm
Printing Material: 16 kg
Printing Time: 4.5 hours

Conventional Manufacturing

Milling from an 83 kg block to a 7 kg component

Challenges

- ✓ Manufacturing according to internal Siemens standards
- ✓ Fatigue/vibration tests
- ✓ Qualification process according to existing fusion welding standards, e.g., DIN EN ISO 15614



Material Savings
Cost Savings
Small Batches
Time Savings

Turbine Blades

Materials | Deposition Rates*

*Batch-Production

2.4856 (IN625)	| 3kg/h
1.4545 (15-5 PH)	| 3,5kg/h
3.7164 (Ti6AL-4V	| 4kg/h

Required Properties

Corrosion resistant
Heat resistant
High hardness

Reduction of manufacturing costs

For near-net-shaped parts, the amount of material to be removed during milling is reduced.

No forging or casting tools required.

Reduce inventory and lead times.

Universal-Draht, bedruckt in der gewünschten Form, reduziert die Lagerhaltung im Vergleich zu geschmiedeten Rohlingen oder Stangenmaterial

Advanced design

The multi-material construction can extend the lifespan of parts by reinforcing areas with high stress.

- ✓ Hollow structures can reduce weight and improve dynamics.

Author:Cblades | Source: https://upload.wikimedia.org/wikipedia/commons/3/36/TurbineBlades.jpg

GEFERTEC

AIRBUS

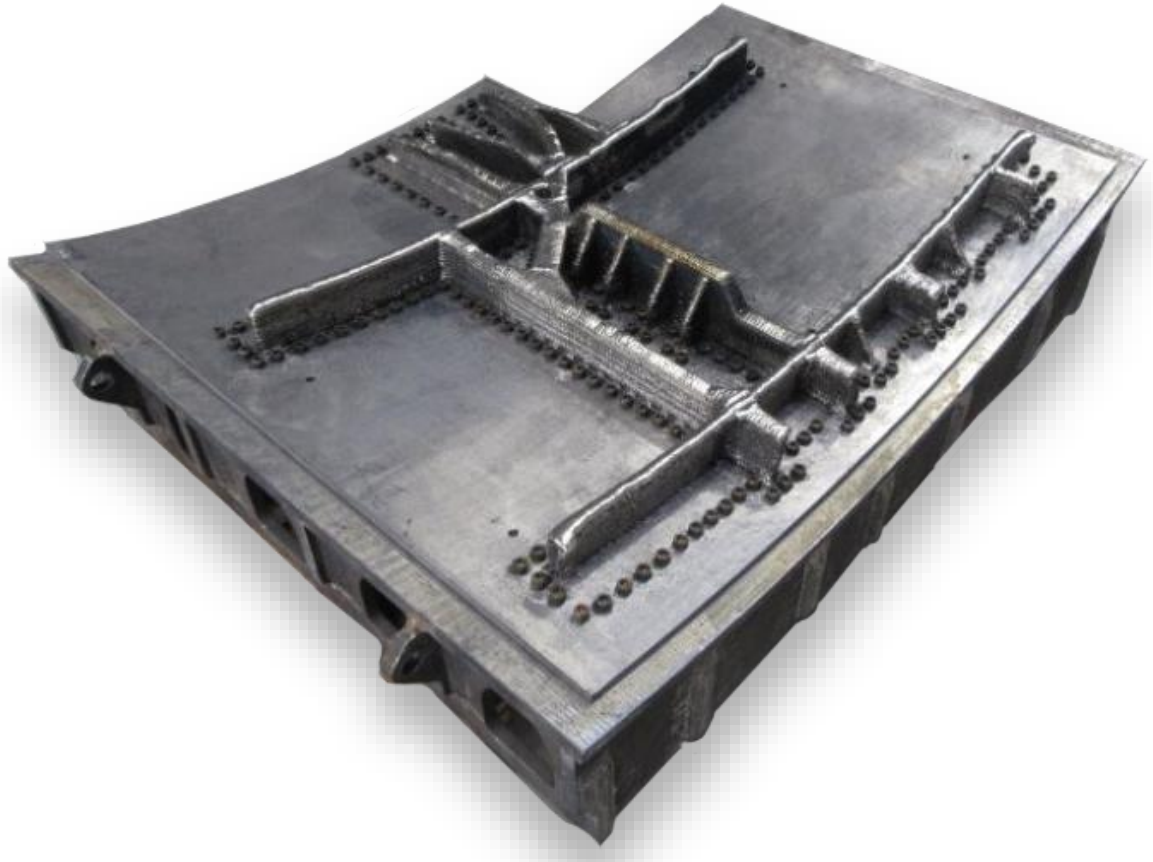
Emergency Exit

Technical Data

Machine: arc603
Wire: Titanium Grade 5
Dimensions [mm]: 1260 x 1160 x 190
Printing Material: 45 kg
Printing Time: 48 hours (including cooling)

Conventional Manufacturing

- ✓ Block 1.3 t → 45 kg Printing Material
- ✓ Door on the aircraft = Breaking point, as a break in the aircraft structure
- ✓ If not made of Titanium, then from Composite Materials (Aluminum & Carbon Fiber)
- ✓ Manufacturing from Titanium, as it is lighter and easier to assemble
- ✓ Prototype for feasibility study



Functionality | Weight Reduction | Cost Savings | Small Batches | Time Savings

GEFERTEC

SCHULER

Hot Forming Die

Technical Data

Machine: arc405
Dimensions [mm]: L = 400 | H = 187 | W = 214
Wire: 1.4316 | Ø 1.0 mm & 1.2343 | Ø 1.0 mm
Printing Material: 1.4370 | 11.3 kg & 1.2343 | 3.1 kg
Printing Time: 7.0 hours

Current Challenges

- Inefficient cooling, as cooling channels are drilled and thus do not precisely follow the freeform of the surface.
- The complete tool consists of multiple segments, as cooling channels can only be drilled.

Cost Savings | Multimaterial | Time Savings | Easy Adaptation | Material Savings

Fraunhofer IPK | ifw Jena | SWM Werkzeugfabrik | FLIESS SINCE 1915

GEFERTEC

ToolPrint

- ✓ Cutting tool developed through the combination of multiple materials
- ✓ Base plate: Structural steel
- ✓ Base body: 1.7373
- ✓ Cutting edge: Powder-filled wire
- ✓ Reduction of chip volume from 60% to 17%
- ✓ Production run showed a 16-fold increase in tool life
- ✓ Reduction of setup time and manual rework

Functionality | Cost Savings | Small Batches | Time Savings

Secondary Roll Stop – Deutsche Bahn

Benefits of 3DMP®

+ Reduction of manufacturing time
+ Cost savings
+ Small units
+ Material savings
+ Fast customization

Technical Data

Machine: arc405

Dimensions [mm]: L = 250 | H = 312 | W = 216

Wire: SW 100S NiMoCr | Ø 1.2 mm

Printing mass: 36.3 kg

Printing time: 26.0 h

Conventional Manufacturing – Casting & Milling

- Application: high speed ICE trains
- Mobility relevant component in the bogie area of ICE trains
- Ensures safe passage of trains in tight curves (the box gate limits the lateral play of the car body)
- Problems with spare parts requirement:
  - Delivery time of the spare part: min. 10 months

GEFERTEC

ALSTOM

Yaw damper

Technical Data

Machine: arc603
Dimensions [mm]: L = 690 | H = 290 | W = 160
Wire: Steel K56 | Ø 1.2 mm
Printing Material: 36.3 kg
Printing Time: 14 hours - Batch production (2 pieces)

WAAM vs. Casting

+ Fast and flexible procurement
+ Design adaptation for WAAM process
+ Printing of the component with proven and qualified parameters
+ Component qualification through X-ray, hardness, and fatigue tests
+ Monitoring of the printing process using 3DMP® Process Monitor

Cost Savings

Small Batches

Time Savings

IKR

GEFERTEC

Bellmouth Intake

Technical Data

Machine: arc605
Dimensions [mm]: Ø = 850-650 x 315
Wire: 316L | Ø 1.2 mm
Printing Material: 170 kg
Printing Time: 45.0 hours (including cooling times)

Challenges

- ✓ Inspection according to the AD 2000 code
- ✓ Introduction of 3DMP® WAAM as an alternative manufacturing process including process qualification according to DIN EN ISO 15614-1:2017-12 (Level 2)
- ✓ Monitoring with 3DMP® Process Monitor

3DMP® WAAM

- \+ Reduction of delivery time by 60%
- \+ Reduction of material costs by 70% (240 kg instead of 1.6 tons)
- \+ Shortening of the supply chain
- \+ Increased flexibility in product development and meeting customer demands

Cost Savings

Time Savings

Quick Adaption

Material Savings

Bucket tooth

Advantages of 3DMP® WAAM

+ Reduced manufacturing time
+ Cost savings
+ Material savings
+ Fast delivery time

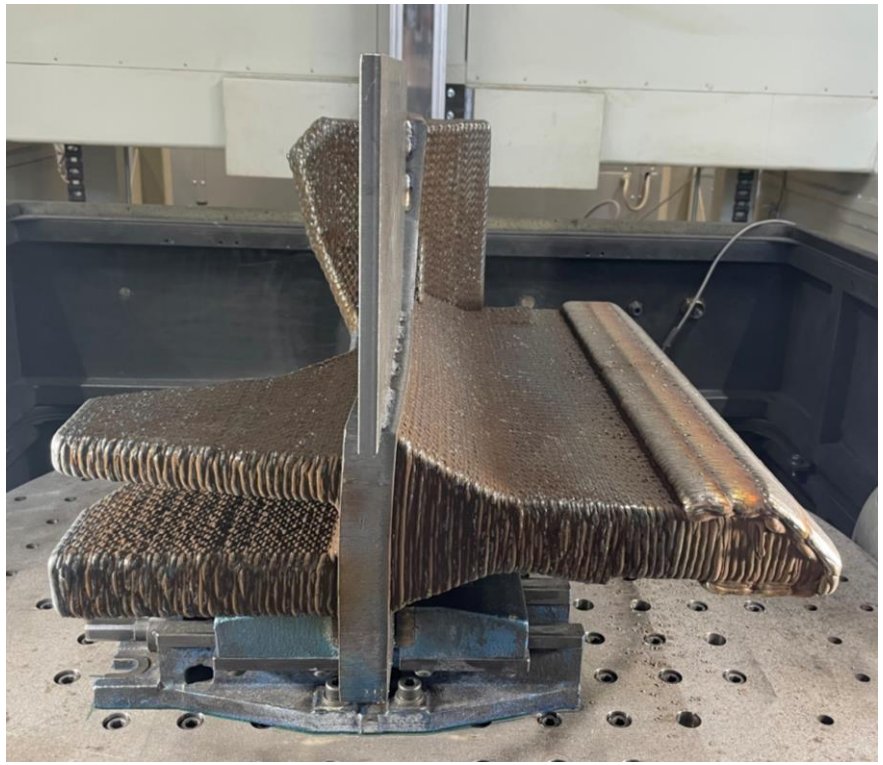
Technical Data

Machine: arc605

Wire: K56 + Flow ED-A 60 hard coating

Dimensions [mm]: 530 x 465 x 335

Printing mass: 96 kg



Component Information

- Bucket tooth of a brown coal bucket wheel excavator
- Multi-material application
- Hard deposit on the wear layer

Profile segments – Dahmen

Advantages of 3DMP® WAAM

+ Reduced manufacturing time
+ Cost savings
+ Material savings
+ Quick adaptation

Technical Data

Machine: arc603

Dimensions [mm]: L = 1150 x W = 730 x H = 200

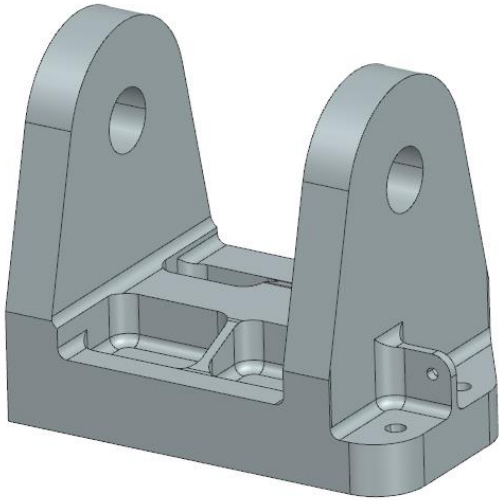
Wire: S355 (K56)

Printing mass: 63.0 kg

Conventional Production

- Component size varies from 600 to 1200 mm in length
- Maximum profile depth of 110 mm
- Approximately 50% of the ingot is machined away
- Roughing times between 16 and 36 hours depending on component size
- Long delivery times for the ingot
- Frequent occurrence of voids in the ingot, leading to significant rework

Bearing Block – GKN



Vorteile von 3DMP® WAAM

+ Reduced manufacturing time
+ Small batch sizes
+ Material savings
+ Cost savings

Technical Data

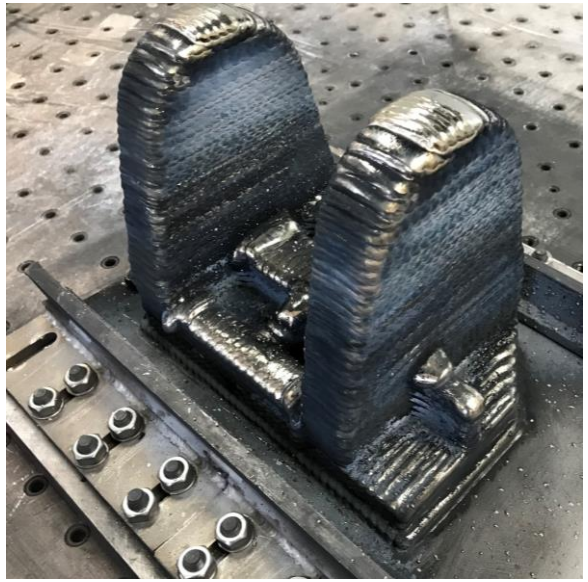
Machine: arc403

Dimensions [mm]: 230 x 180 x 160

Wire: Titanium Grade 5

Printing mass: 6.1 kg

Finished part mass: 7.8 kg



Conventional Production

- Milling from solid block
- From a 50 kg block, 7.8 kg finished part is milled
- Optimization through AM, as it leads to significant material savings

OUTLOOK

Casting

Total volume 120 million tons/year
In principle, like 5000 years ago
Limited supplier
Long leadtimes
Significant quality issues
Inflexible

WAAM – the biggest revolution in casting since 5000 years

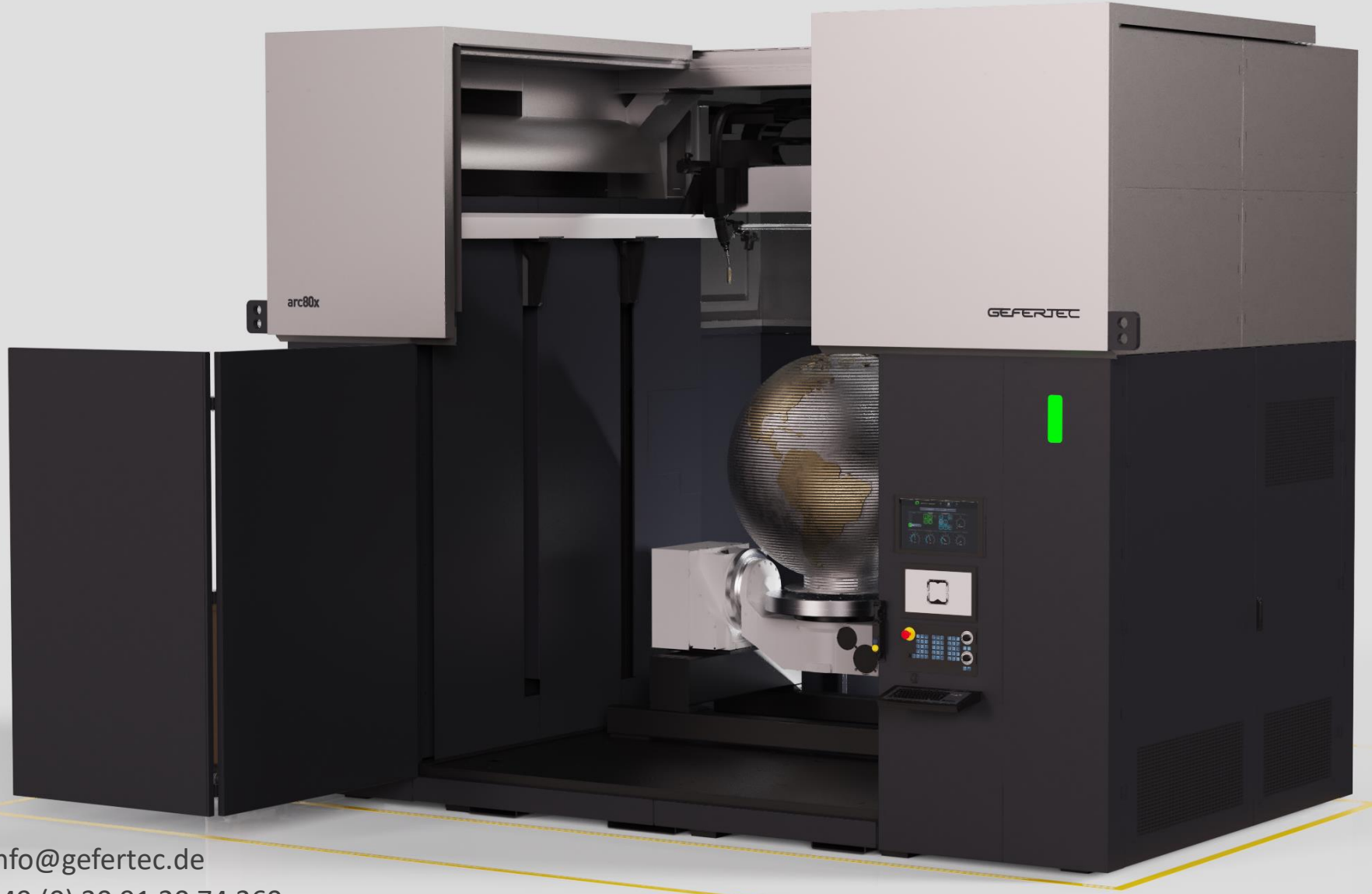
Independence from the supplier market
Just print your part quickly
No tools, no defect parts in production
Low investment costs

The Future is Now

WAAM instead of Conventional Casting


WAAMATHON
#2 BERLIN
Stay tuned – May 21, 2025!
Register for our newsletter!

Thank you!



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