CADMicro Technology Readiness Day – Toronto, ON

Metal Industrial Additive Technologies - Break Out Session

Adam Simons

Industry Manager Additive Manufacturing - North America

Jens Nothnagel

Head of Sales Additive Manufacturing - Americas

TRUMPF

Metal Laser Powder Bed Fusion – Break Out Session Agenda

1	**Introduction to TRUMPF**
2	TRUMPF Equipment Portfolio and Focus
3	Laser Powder Bed Fusion Process Overview
4	Materials, Benefits, and Relevant Industries
5	Highlighted Applications
6	Questions?

TRUMPF is …

Family business

Fiscal Year 2022/23

- Sales Revenue 5,400 mn. €
- EBIT Margin 11.5 %
- R&D Quota 8.9 %
- Employees 18,352

Technology Leader

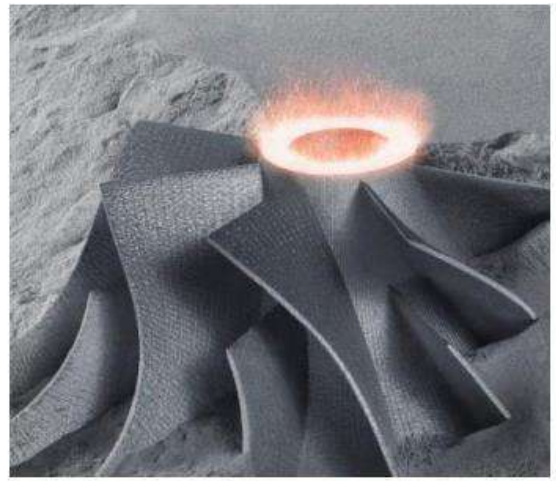
Business Units

- Machine tools for flexible sheet metal processing
- Laser technology with beam sources ranging from 20 W to 30 kW

Close to its customers

More than 70 subsidiaries

- 14 x Germany
- 30 x Europe without Germany
- 12 x Americas
- 17 x Asia / Pacific / Others



Innovation guarantor

Holistic and constant

- Machinery / Systems
- Markets
- People
- Methods

Additive Manufacturing History at TRUMPF

TRUMPF is a Pioneer of Industrial AM

1999
Start activities with Fraunhofer ILT

2003-2006
First LMF machine (TrumaForm)
Qualified for steel / titanium / Inconel

2007
LMD Technology Package

2012
LMD Systems Portfolio

2014
Re-entry Laser Metal Fusion

2015
TruPrint 1000

2017
TruPrint 3000

2019
TruPrint 5000

2020
TruPrint 2000

2021
TruPrint 3000 Series 2

2022
TruPrint 1000 Series 2

2023
TruPrint 2000 Series 2

Future

Additive Manufacturing by TRUMPF

Current Equipment Portfolio - Overview

Common Industrial Techniques

Relevance for metal manufacturing

Technology	Material	Relevance for metal
 **Powder Bed Fusion** (*e.g. LPBF, LMF*) Selective melting of powder bed areas through thermal energy flow	Metal, (plastic)	
 **Direct Energy Deposition** (*z.B. DED, LMD*) Focusing thermal energy to fuse components with targeted material input	Metal	
 **Sheet Lamination** Joining layers of material to form solid bodies	Metal, paper	
 **Binder Jetting** Selective introduction of binding liquids to bind loose material	Metal, plastic, moulding sand	

- Market currently still dominated by plastic 3D printing
- Metal 3D printing is currently generating strongly growing demand in industrial production

Sources: ASTM International Committee F42 on Additive Manufacturing Technologies; Roland Berger

The LPBF Process

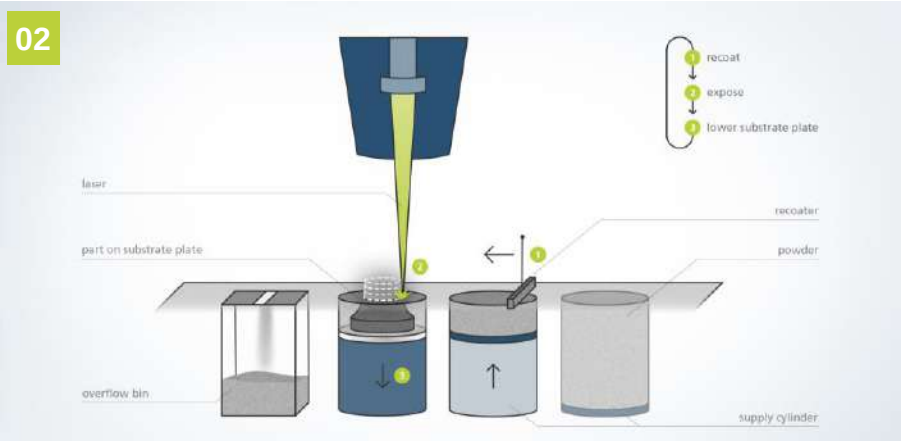
From the Idea to the Finished 3D Printed Component

01

Preparation

- AM-specific part design
- Support design & part positioning
- Data preparation & transfer to machine
- Setting up the machine
- Documentation / QS

02



Building process

- Transfer of powder form stock into the building cylinder
- Removal and collection of excess powder for later reprocessing
- 1-3 laser welding powder layers
- Partial construction of supporting structures for stabilization
- Industrial component made of solid and dense metal
- Documentation / QS

03

Post-processing

- Unpacking from powder bed
- Cutting substrate plate
- Remove support structures
- Heat treatment
- Mechanic processing
- Measuring
- Cleaning (e.g. ultrasound)
- Documentation / QS

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Current Qualified Materials

In General: Anything you can Weld…

Aluminum Alloys
- AlSi10Mg
- AlSi12
- AlSi9Cu3
- CustAlloy
- M174+
- Scalmalloy

Amorphous Metals
- ZR01
- ZR02
- ZR03

Precious Metals
- White Gold
- Yellow Gold
- Silver
- Platinum

Stainless Steel
- 316L (1.4404)
- 630 (1.4542)
- Printdur HAS
- Medidur

Cobalt Alloys
- CoCrWMo
- CoCr ASTM F75

Copper Alloys
- Pure Copper
- CuCr1Zr
- CuNi2SiCr
- CuSn10

Nickel-base Alloys
- Pure Nickel
- IN718
- IN625
- Hastelloy X

Refractory Metals
- Tungsten
- Tantalum
- Niobium/C103

Titanium Alloys
- Ti6Al4V G23
- Ti6Al4V G5
- Ti6242

Tool Steels
- 1.2709/M300
- 1.2343/H11
- 1.2344/H13
- Dievar
- M789
- W360

Central Benefits

The Use of LPBF can Achieve many Different Goals

Geometric complexity

Maximum geometric design freedom offers 3 major advantages:

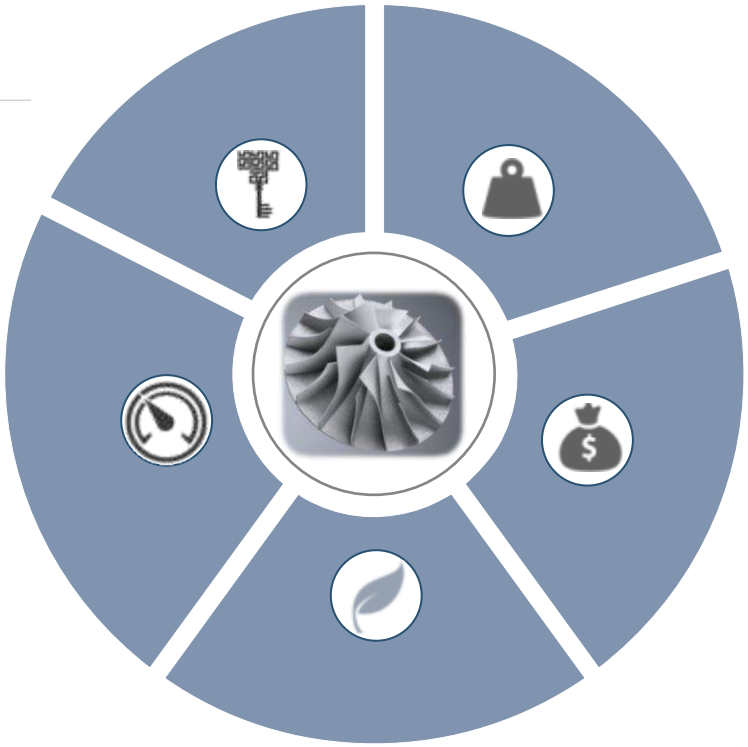
- New geometries that cannot be produced with other methods
- Integration of functionalities
- Monolithic design

Speed

Reduction of production steps (e.g. tool-free production)

Performance

More design freedom enables part geometries that are not achieved by other methods. This allows optimization opportunities that improve performance.



Weight reduction

Robust lightweight construction through hollow spaces, grid structures or bionic design

Cost reduction

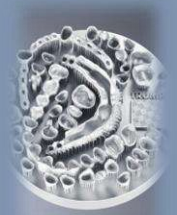
Cost-effective production of small and mid-sized components, starting with lot size 1. Especially for complex structures (“complexity for free”) e.g. small series and prototyping

Sustainability

Protection of resources through low material and energy consumption – in both the production and in operation of the finished parts

Industry Overview

LPBF Meets the Requirements of a Wide Range of Industries

	Aerospace	Energy & turbines	Automotive	General Industries	Tool & die making	Medical	Dental	Development & Institutes	Fashion & Lifestyle	Jewelry	Job Shops
Materials	Titanium, aluminum, nickel-based alloys	Nickel-based alloys	Aluminum, steels	Aluminum, steels	Tool steel	Titanium, cobalt-chrome	Cobalt-chrome	Various	Bronze, steel, titanium	Precious metals, bronze	Various
Applications	Structural parts, brackets	Turbines, nozzles	Prototypes, tools, small series	Various	Dies, tools, tooling inserts	Implants, medical instruments	Dental crowns, bridges	Material developm., R&D for parts	Accessories, design objects	Rings, brooches, necklace pendants	Suppliers for multiple industries
Sample parts											

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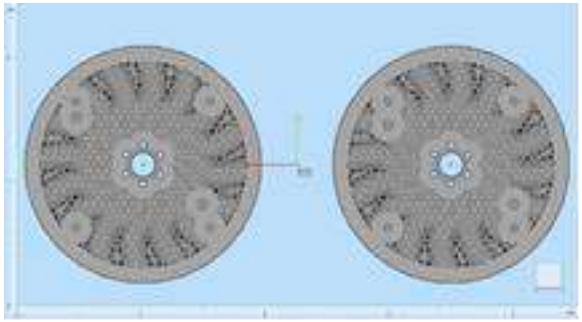
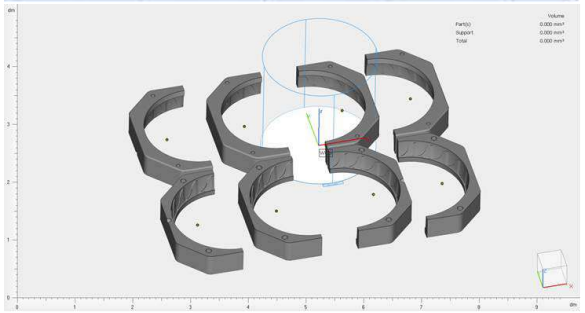
Injection Mold Tooling Success Story





Application:

- Injection Mold Tooling for Cooler Wheel:
- Wheel rated for 250 lb load.
- Made of 3 lbs. of Injection Molded Plastic

Traditional Tooling:

- 20 Day Lead Time to Produce
- 2.4 minute cycle time
- Cost ~ $20K USD

Additive Manufactured Tooling:

- All components printed in 6 days
- Minimal Post Processing Required – Completely ready in Mold Cavity in 1 day
- Cycle Time Reduction by 50% to 1.2 minutes without any Coolant.
- Cost ~ $6K USD

Injection Molding - Insert

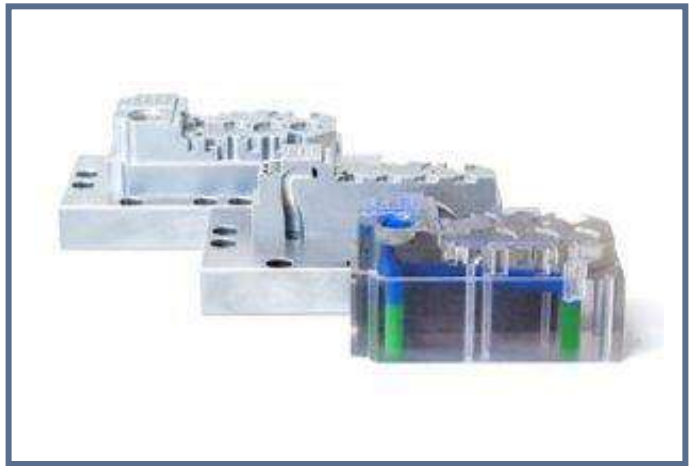
Tooling

Preform

500°C

TruPrint 5000

supported by TRUMPF Consulting



Material: H11

Features: Conformal Cooling
Preform Basic

Why TruPrint 5000?

- H11 (500°C necessary)
- Preform Basic

50% COST REDUCTION

PREFORM BASIC

CARBON STEEL

Highlight: Cost reduction by 50%

Part	Without Preform	With Preform	Savings
Print volume	267 cm³	132cm³	50%
Production time	8,2h	4,5h	48%
Postprocess	Sawing/wire cutting	Screwing	100%
Printing costs	2805€	1424€	49%
Preform costs	-	207€	-
Total costs	2805€	1631€	42%

Created by
H&B Electronic

"With H11 we can finally print long lasting tools for highly abrasive plastic materials. With the new Preform feature we can additionally save a lot of costs compared to a full additive part."

Thomas Weinmann
/H&B/ Electronic GmbH & Co.KG

More information

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Aluminum backbone for downhill bike – Intense Cycles

General Industry

TruPrint 3000

supported by TRUMPF Consulting

Material	6061 RAM2
Features:	Complex geometry, high productivity and good CPP on 2x700W

Why TruPrint 3000?	Possibility to build very tall components thanks to the dual supply cylinder | 2x700W combines high build speed and low CPP.

- PART CONSOLIDATION
- GEOMETRICAL FREEDOM
- OUTSTANDING SURFACE QUALITY AND CPP

Highlight

Intense Cycles validated 6061 RAM2 3D printed parts for prototype manufacturing. The material proved to be easily weldable and also anodizable.

Truprint 3000 is able to produce parts with outstanding surface quality and high productivity.

More information

Courtesy of INTENSE

"I love new tech especially advanced materials and process that speeds up the prototyping.Finally 6061 Weldable, heat treatable printing powder. These 3D printed backbones combining printed and tubular alloy parts welded in a conventional process here in our FAB LAB"

Jeff Steber, CEO and owner of Intense Cycles

Improving Performance and Production Cost

General Industry

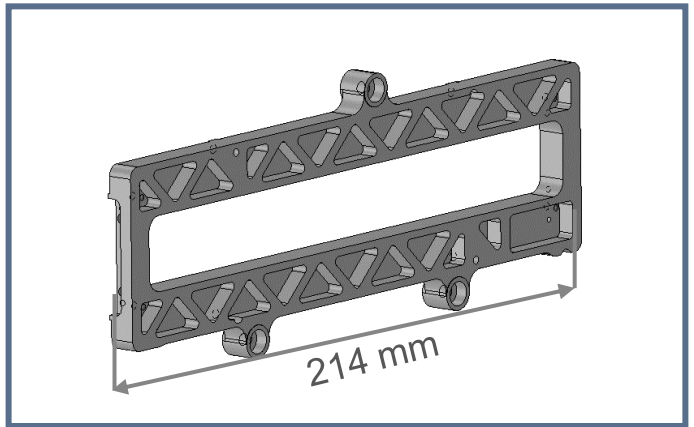
supported by TRUMPF Consulting

Optics Support Plate

Serial production

TruPrint 3000

CONVENTIONAL DESIGN



Weight	144 g
Deflection	8,1 µm
1. natural frequency	657 Hz
Manufacturing costs	100 %

AM DESIGN

Weight	93 g (-35%)
Deflection	5,9 µm (- 27%)
1. natural frequency	1145 Hz (+74%)
Manufacturing costs	60 %

- COSTS REDUCED
- MATERIAL SAVED
- WEIGHT REDUCED
- PERFORMANCE INCREASED

Highlight

Additive manufacturing enables the use of complex structures optimized for the respective application. This was utilized in the optics support plate in order to obtain a stiffer and cost-effective component despite a reduction in weight.

Created by TRUMPF for TRUMPF

"Additive manufacturing made it possible to realize lightweight components, with reduced weight, increased rigidity and even reduced costs."

Jakob Spiecker, TRUMPF

More information

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TRUMPF Serial Parts

supported by TRUMPF Consulting

Motor Cooler

Serial production

TruPrint 3000

CONVENTIONAL DESIGN

Weight	76,5 g
Volume	19 cm³
Parts	10 pieces
Costs	100% + Assembly

AM DESIGN

Weight	40 g = - 48%
Volume	5 cm³ = - 73%
Parts	1 = - 90%
Costs	60% + Assembly

- SIMPLIFIED ASSEMBLY
- PROFITABILITY
- WEIGHT REDUCTION

Highlight

The serial product is only made out of one component instead of a complete assembly. That way, the economic efficiency could be increased by 30%.

More information

Created by TRUMPF Consulting for TRUMPF

„The successful establishment of our own series applications demonstrates the time-demanding but sustainable use of this technology in our company.“

Klaus Parey, TRUMPF

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TRUMPF Serial Parts

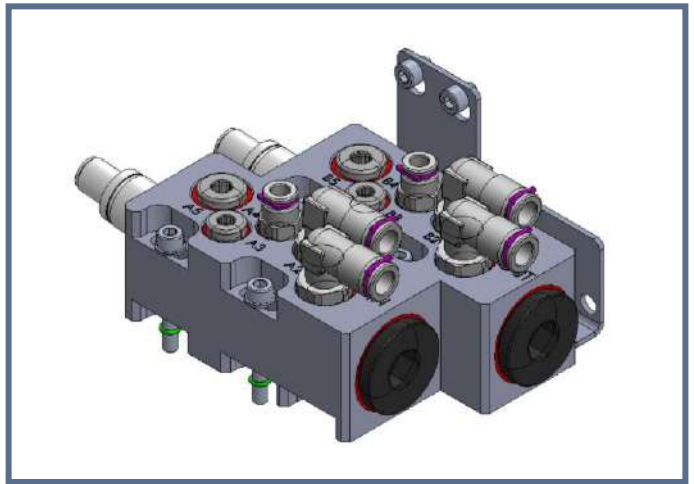
supported by TRUMPF Consulting

Hydraulic Manifold Design

Serial production

TruPrint 3000

CONVENTIONAL DESIGN



Material	316L
Manufacturing costs	100%
Vibrations	100%
Mounting bracket	Assembled

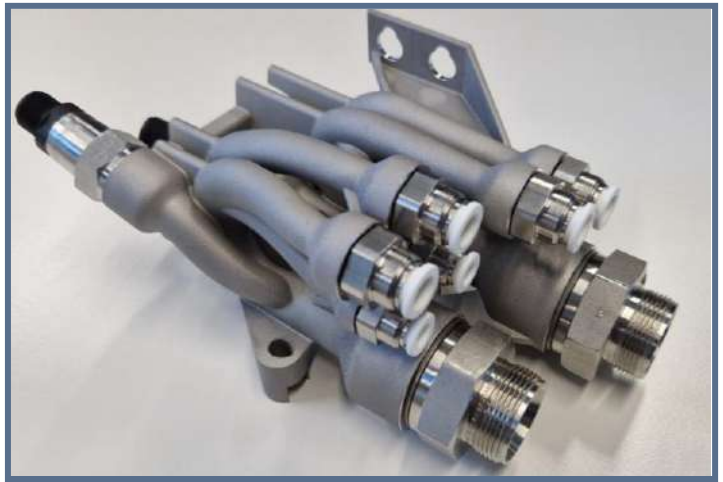
Highlight

The hydraulic block was designed with help of internal Trumpf consulting.

The result is a monolythic part with integrated mounting brackets, less leakage points and higher performance.

More information

AM DESIGN



Material	316L
Manufacturing costs	162% (but much better performance)
Vibrations	12%
Mounting bracket	Integrated

Created by TRUMPF for TRUMPF

“The AM manufacturing process is slightly more expensive than the traditional milled hydraulic block. The advantages in terms of vibration reduction, pressure loss reduction, part consolidation and therefore reduction of leakage points are more important to us.
Thanks to this benefits we deliver higher performance machines true to Trumpf quality standards.”

Markus Fichter, TRUMPF 4/16/2024

- VIBRATION INDUCED FLOW REDUCTION
- PRESSURE LOSS REDUCTION
- DESIGNED FOR AM: NO SUPPORTS NEEDED

TRUMPF

Want to Learn More?

Contact Us to Discuss your Application and Schedule a Visit to our Laser Application Center:

TRUMPF Laser Technology
47711 Clipper St.
Plymouth, MI 48170