Additive Manufacturing in Milling Quality
The unique combination of laser deposition welding with a powder nozzle and milling on the LASERTEC 65 3D is an innovative generative machining method. It allows a faster production of complex geometries and individual 3D-parts. Especially large components up to ø 19.7 in. can be produced cost-effectively with this hybrid solution. The flexible changeover between laser and milling operations enables direct machining of areas that can no longer be reached later on the finished part. The laser process uses a metal powder feed, which allows the additive manufacturing of parts without a processing chamber nor the need for supporting structures. The additive process is up to 10 times faster than the generation in a powder bed. DMG MORI is offering the complete process chain, starting with the NC-programming in the hybrid CAD / CAM system, via the usage of proven technology parameters coming from a material database, through to machining operations, process monitoring and documentation.
LASERTEC 65 3D

Applications.

PRODUCTION
- AEROSPACE
  - Turbine Casing

REPAIR
- AEROSPACE
  - Blisk

COATINGS
- OIL & GAS
  - Drill Bit

ENGINEERING
- Nozzle
- ENERGY
  - Pelton Wheel
- ENGINEERING
  - Bearing Block

VACUUM TECHNOLOGY
- Cooling Tube
- MOLD MAKING
  - Injection Mould

ENERGY
- Impeller
- PLANT EQUIPMENT
  - Drive Shaft

MOLD MAKING
- Cooling Element
- VACUUM TECHNOLOGY
  - Flange
LASERTEC 65 3D

Additive Manufacturing with Unique Technological Features.

**Highlights**

+ The flexibility of the generative process combined with the precision of milling technology
+ Laser generation of the workpiece with intermediate milling
+ High buildup rates due to coaxial powder nozzle
+ Large machining area for workpieces up to Ø 19.7 in. × 15.7 in. height
+ Reduced material usage
Basics
Laser Deposition Welding.

Working Principle
Using a coaxial nozzle, the metal powder is welded to the base material in layers (non-porous and crack free melting). Thereby the metal powder is joined with the surface in a high strength bonding. The coaxial nozzle shielding gas protects against oxidation during the buildup process. After cooling, the metal layers can be machined mechanically.

Materials
Tried and tested materials:
+ Stainless Steel
+ Nickel-Based Alloys (Inconel 625, 718)
+ Tungsten Carbide Matrix Materials
+ Bronze and Brass Alloys
+ Chrome-Cobalt-Molybdenum Alloys
+ Stellite
+ Tool Steel (weldable)

Metallurgy
Continuous process development in consideration of the following material characteristics:
+ Inspection of the powder material
+ Density measurement, structural analysis
+ Mechanical tests (tension, stress, bending)
+ Measurement: Surface quality, hardness, corrosion
+ 99.8% achievement of the casting density (e.g. Stainless Steel 316L / 1.4404)

<table>
<thead>
<tr>
<th>Characteristics 316L / 1.4404</th>
<th>Conventional Material Requirements</th>
<th>Laser Welding Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elastic Limit [R_{p0.2}] Mpa</td>
<td>≥ 200</td>
<td>229.5</td>
</tr>
<tr>
<td>Tensile Strength [R_{m}] Mpa</td>
<td>500 – 700</td>
<td>506</td>
</tr>
<tr>
<td>Elongation [A] %</td>
<td>≥ 40</td>
<td>53.05</td>
</tr>
<tr>
<td>Impact Test [KVJ] J</td>
<td>≥ 100</td>
<td>126 – 132</td>
</tr>
<tr>
<td>Hardness [H] HV5</td>
<td>≤ 230</td>
<td>160</td>
</tr>
</tbody>
</table>
Hybrid CAD / CAM for Additive and Subtractive Programming.

5: Finished workpiece ready for quality inspection

4: Laser Deposition Welding and Milling combined on the LASERTEC 65 3D (flexible changeover possible)

1: CAD / CAM customer data; separation in additive and subtractive areas; slicing of the single workpiece sections

2: Generation of the NC-paths for the laser process and milling in the post processor; definition of the program order

3: 3D-simulation for collision protection with consideration of the integrated laser head

Highlights

+ One software package for the complete process (design, programming, simulation)

+ Unique SAUER LASERTEC buildup strategies – fully integrated in the CAD / CAM software

+ The workpiece can be built up in several steps, while flexibly switching between laser deposition welding and milling operation in only one clamping setup
Complete Generation of 3D-Parts
Application Examples.

**Turbine Casing**
- **Material:** Stainless steel
- **Laser Deposition Welding:** 230 min.
- **Milling:** 76 min.
- **Dimensions:** \(\phi\) 7.1 in. \(\times\) 5.9 in.

**Fan Wheel**
- **Material:** Stainless steel
- **Laser Deposition Welding:** 312 min.
- **Milling:** 240 min.
- **Dimensions:** \(\phi\) 6.3 in. \(\times\) 6.3 in.

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1: Basic setup of the cylinder
2: 90° swivel: Generation of the flange
3: 90° swivel: Milling of the plane surface and the outer contour
4: Continuation of the cylinder generation with conical funnel
5: Manufacturing of the 12 connectors
6: Finishing of the inner and outer contour

1: Building a cylinder
2: Completion of the conical taper
3: Milling
4: Finish machining of the cylinder
5: Building of the cylinder vanes
6: Finish milling of the vanes
Additive Manufacturing
SAUER LASERTEC – Buildup Strategies.

“Internal Feature”
Feasibility of channels within a solid part structure e.g. cooling channels as well as similar complex, internal structures as cooling elements and other similar cooling components for injection molds.

“Multi-Material”
Combination of two different materials in one part. Two individually selectable powder feeders allow the combination of various materials, even the building of “Sandwich” workpieces.

“Build on Curve”
The basis for this operation is an existing part (buildup by Additive Manufacturing or with an alternative production process) “Flanging” of an additional 3D contour onto the existing part.

“3D-Coating”
Metal deposition of partial or complete coatings for corrosion protection and wear resistance. “3D-Coating” on 3D-parts as a material coating or a repair.
**Unique Technology Integration**

+ Intelligent combination of Laser Deposition Welding and Milling for highest surface quality and part precision

**Laser Deposition Welding with a Powder Nozzle**

+ 10 x faster compared to powder bed; 3D-parts up to ø 19.7 in. also with undercuts and without supporting structure

**Hybrid CAD / CAM Module for Laser and Milling Process**

+ One universal programming solution for the laser and milling process incl. design, additive and subtractive programming, post processing and simulation in one software package

**“Closed Loop” - In-Process Regulation, Analysis and Control**

+ Continuous measuring and monitoring of the laser buildup process
+ Automatic regulation of the laser power guarantees a high quality “Closed Loop” build in real-time
+ Ensuring of a uniform laser welding process
+ Process monitoring for highest process safety and homogeneous part quality

**Flexible Integration of the Laser Head via the HSK Milling Taper**

+ The laser head is handled by a fully automatic shuttle – without manual intervention
+ Coaxial nozzle for the uniform distribution of the metal powder
+ Independent of the laser buildup direction
+ Integrated safety glass monitoring
+ Optimal powder volume supply
+ During milling operations, the laser head is protected against dust, coolant and chips outside the work area

**Additive Manufacturing Material Database for Users**

+ Basic parameter suggestions for users of the hybrid CAD / CAM in various materials
+ Customer development of process parameters for surfaces, ridges as well as 3D-parts in various materials
+ Influencing factors: Surface quality, process speed and powder efficiency
+ Customer specific material development in one of our 4 Additive Manufacturing Technology Centers Worldwide
LASERTEC 65 3D

Layout Plans

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Front View

LASERTEC 65 3D
Top view
# LASERTEC 65 3D Technical Data

## Working area / drives
- **Traverse X / Y / Z** in. 28.9 / 25.6 / 22.0

## Work table / workpieces
- **Dimensions (NC swivel rotary table)** in. ø 25.6
- **Maximum workpiece dimensions (Additive Manufacturing)** in. ø 19.7 x 15.7
- **Maximum workpiece weight (NC swivel rotary table)** lbs. 1,322.8
- **Rotary axis (C axis)** Degrees 360
- **Swivel range (A axis)** Degrees –120 to +120
- **P\text{\textsubscript{max}} under VDI / DGQ 3441 (C axis / A axis)** Ws. 7 / 9

## Milling spindle
- **Maximum speed (standard / optional)** rpm. 10,000 / 18,000
- **Output 40 % DC / 100 % DC (standard spindle)** hp. 17.4 / 12.1
- **Torque 40 % DC / 100 % DC (standard spindle)** ft. / lbs. 61.2 / 42.0
- **Tool holder Type** HSK-A63

## Laser source
- **Fibre laser diode (standard)** Watt 2,500
- **Focal length (fixed)** in. 7.9
- **Laser spot diameter 1 (standard)** in. 0.1
- **Laser spot diameter 2 (optional)** in. 0.06

## Linear axes (X / Y / Z)
- **Rapid traverse speed** in. 1.6 / 1.6 / 1.6
- **Maximum acceleration on X / Y / Z** ft. / sec.\textsuperscript{2} 19.7 / 19.7 / 19.7
- **P\text{\textsubscript{max}} under VDI / DGQ 3441** in. 0.0003

## Tool change system
- **Standard / optional tools** Number 30 / 60 / 90

## Machine data
- **Width x depth x height (basic machine)** in. 164.6 x 137.3 x 113.5
- **Machine weight** lbs. 24,912.2

## Control system
- C\text{\textsuperscript{\textregistered}} OS\textsuperscript{\textsubscript{\textregistered}} from DMG MORI with 21.5” ERGO\textsuperscript{\textregistered} line
- **Control** with Operate 4.5 on SIEMENS 840D solutionline

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**SAUER LASERTEC Excellence Center in Pfronten**

- > 25 years of experience in laser precision machining
- > 600 LASERTEC machines installed (worldwide)
- Application expertise: Training, customer support and complete turnkey solutions
- Regular LASERTEC Technology Seminars
Expertise Spanning the World – Additive Manufacturing Technology Centers.

With our four Additive Manufacturing Technology Centers in Pfronten, Chicago, Tokyo and Singapore, we are able to serve our customers locally in primary markets in the areas of technology and material development, processing of test parts as well as training inquiries.

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