Advanced Robotic Laser Cladding
The Oerlikon MetcoClad™ System

July 2015
Laser Cladding is a welding technology

Laser Cladding (LC) means laser build-up welding, also known as Laser Metal Forming (LMF), Laser Metal Deposition (LMD), Direct Metal Deposition (DMD™), Direct Energy Deposition (DED) or Laser Engineered Net Shaping (LENS™)
Laser Cladding – how does it work?

- The laser beam is (de)focused on the work piece with a selected spot size.
- Metal powder as filler material is transferred with an inert carrier gas into the melt pool.
- Laser beam and powder nozzle are moved over the work piece surface producing single tracks, layers, build-ups.

Small beam focus and high power density mean highly localized part treatment.
# Laser Cladding – the growing niche between Thermal Spray and PTA

Source: Fraunhofer IWS, 2011

<table>
<thead>
<tr>
<th></th>
<th>PTA Welding</th>
<th>Laser Cladding</th>
<th>Thermal Spray</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density [%]</td>
<td>100%</td>
<td>100%</td>
<td>95+%</td>
</tr>
<tr>
<td>Build-up rate [kg/h]</td>
<td>≤12</td>
<td>≤6</td>
<td>≤20</td>
</tr>
<tr>
<td>Typical thickness [mm]</td>
<td>0.5 - 4</td>
<td>0.2 - 2+</td>
<td>0.05 - 0.5</td>
</tr>
<tr>
<td>Heat input</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Dilution [%]</td>
<td>8-18</td>
<td>&lt;5</td>
<td>0</td>
</tr>
</tbody>
</table>

- Perfect metallurgical bonding, fully dense coatings vs TS
- Small heat affected zone, low dilution between substrate and filler material vs PTA
- Extended weldability of sensitive materials like C-rich steels or Ni super alloys vs PTA
- Near net-shape weld build-up, less finishing effort vs PTA
- Surface coating as well as weld build-up on edges possible vs TS
- Fine, homogeneous microstructure due to the high solidification rate

- LC is a complementing technology to thermal spray
- LC becomes more and more competitive against PTA welding
- In advanced weld repair application LC outperforms conventional TIG welding
Laser Cladding and Oerlikon

- 1988 Sulzer: CO$_2$-laser system in operation for R&D purpose
- 2001 Laser Cladding as a coating service in Switzerland
- 2006 Fiber-laser system in operation
- 2012 Metco provides Laser Cladding services, materials and equipment
- 2014 Metco becomes part of Oerlikon

Metco has more than 25 years experience in Laser Cladding applications
Oerlikon Metco Laser Cladding services

- 3 large LC-systems in Winterthur (former Sulzer Innotec) and Wohlen
- LC service provider in several different business areas – from general industry to gas turbine components
- Experience with a broad range of materials – from Titanium to Steel to Co- and Ni-based super alloys, carbides, …

<table>
<thead>
<tr>
<th>Winterthur facility</th>
<th>Wohlen facility</th>
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<tbody>
<tr>
<td>2 kW CO₂-Laser</td>
<td>6 kW Diode-Laser</td>
</tr>
<tr>
<td>150 W Nd:YAG-Laser</td>
<td></td>
</tr>
<tr>
<td>1.7 kW Fiber-Laser</td>
<td></td>
</tr>
</tbody>
</table>

Our service business is the nucleus for our application know-how
Laser Cladding in the MRO business

Industrial Gas Turbines

- component repair and modification

Blade tip repair, 6mm weld build-up, MetcoClad™ 625 on In738

- Challenging materials
- Small heat-affected zone
- Near net-shape weld build-up, minimum finishing effort

Knife edge repair, up to 12mm high
Laser Cladding in the MRO business

Compressors and Pumps

- bearings, blades
- Turbocharger blade tip repair
- No post-weld heat treatment possible
- Qualified processes

Compressor shaft repair

(all Oerlikon Metco)
Laser Cladding hardfacing examples

Kneader teeth, fully covered with PlasmaDur™ 51xxx

- WC-coating with hardness 1500+ HV
- Homogeneous distribution of the WC particles
- Significantly improved wear resistance, several times increased service lifetime

(all Oerlikon Metco)
Laser Cladding hardfacing examples

- Low dilution with substrate material → thin but effective coatings possible!

Radial compressor blades
Wear and corrosion-resistant coating with MetcoClad™ 21

(all Oerlikon Metco)
How to deal with complex geometries?

Complete wear protection of kneader teeth

Complete coverage of screw conveyor

Laser Cladding on complex geometries requires

- application know-how regarding cladding strategies and process parameters
- flexible handling systems
- state-of-the-art CNC programming tools
Similar system design requirements ...

<table>
<thead>
<tr>
<th>You need</th>
<th>for Laser Cladding</th>
<th>for Thermal Spray</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ an energy source and process device</td>
<td>laser, optic,</td>
<td>power supply,</td>
</tr>
<tr>
<td></td>
<td>powder nozzle</td>
<td>spray gun</td>
</tr>
<tr>
<td>▪ a material supply</td>
<td>powder feeder</td>
<td>powder feeder</td>
</tr>
<tr>
<td>▪ a 'gun' manipulator</td>
<td>cartesian system, robot</td>
<td>robot</td>
</tr>
<tr>
<td>▪ a part manipulator</td>
<td>lathe, turntable, …</td>
<td>lathe, turntable, …</td>
</tr>
<tr>
<td>▪ a safety cabin against</td>
<td>laser radiation</td>
<td>noise, dust</td>
</tr>
<tr>
<td>▪ an exhaust for</td>
<td>welding fumes</td>
<td>heat, fumes and powder</td>
</tr>
<tr>
<td>▪ material</td>
<td>metal powder</td>
<td>powder</td>
</tr>
</tbody>
</table>

Oerlikon Metco has long-standing experience in Thermal Spray system design and manufacturing
... but also some significant differences!

Handling system accuracy
- at least for complicated geometries (off-line programming with CAD-data)
- should be more in the range of ~0.1 mm than ~1 mm

Close link between process parameters and geometry i.e robot movements
- Laser power, focal diameter, powder mass flow and feed rate can vary within one application
- Switching the laser on/off must work right in-time on your part

Laser Cladding requires a higher level of system integration for process and handling control
The Oerlikon MetcoClad™ System in Wohlen

First system in Switzerland

- Application support and development
- Customer demonstration
- Laser Cladding services

Design features

- Oerlikon Metco LC Controller
- Oerlikon Metco Powder Feeder
- Oerlikon Metco Powder Nozzles
- 60W - 6 kW Laser Power (Diode Laser)
- 10 axes handling system: track-mounted robot, tilting turn-table, lathe

Customer solutions will be tailored according to customer needs and may require less laser power, less robot-controlled axes, a smaller or larger or probably no lathe, ...

The MetcoClad™ system is the consistent enhancement of Metco’s available thermal spray coating equipment.
The Oerlikon MetcoClad™ System in Wohlen

Operator desk with LC-Controller, offline programming system, camera surveillance and device monitoring tools
The Oerlikon MetcoClad™ System in Wohlen

Handling system with track-mounted robot, tilting turn-table, lathe and powder feeder
The Oerlikon MetcoClad™ System in operation

Water-cooled roll

1 layer with MetcoClad™ C-276, ~1.2mm

(all Oerlikon Metco)
**MetcoClad™ system**

«Standard system setup»

**System specification**

- 2.5 kW diode laser
- Twin powder feeder, process head with 3-beam powder nozzle, operating desk, MetcoClad control center with GMC, PLC, …
- Handling with
  - ABB IRC5 robot controller
  - Robot ABB IRB 2600-20 / 1.65
  - Tilting turntable ABB IRB A, 500 kg payload
- Options
  - Metco scope-of-work with or without safety cabin and welding exhaust system
  - Inner Diameter (ID) cladding optic
  - CAM-System for Laser Cladding, inductive preheating device, …

**Selected applications**

- Turbine blades/vanes/casings, pump parts, impellers, valve parts, mining tools, drill bits, dies, molds, blades and knife edges, …
- Additive manufacturing
**MetcoClad™ system**

«Oil & Gas setup»

**System specification**

- 3-4 kW diode laser
- Twin powder feeder, process head with 3-beam powder nozzle, operating desk, MetcoClad control center with GMC, PLC, …
- Handling with
  - ABB IRC5 robot controller
  - Robot ABB IRB 4600-40 / 2.55
  - Tilting turntable ABB IRB A, 500 kg payload
  - Metco lathe for work pieces up to 2 tons weight, 3m length, 1m diameter

**Options**

- Metco scope-of-work with or without safety cabin and welding exhaust system
- Inner Diameter (ID) cladding optic
- CAM-System for Laser Cladding, inductive preheating device, …

**Selected applications**

- Drill collars, stabilizers, MWD/MWD-tools, coupling parts, drill bits, gate/ball valves, pump/compressor shafts, impellers, …
Tailored MetcoClad™ system concepts

Customer solutions will be designed according our customer needs
Summary

- Metco has more than 20 years experience with laser cladding
- Metco Laser Cladding services is active in several industries, from gas turbine component repair to hardfacing in new part manufacturing
- Metco offers a complete portfolio of laser cladding powders for wear resistance, corrosion resistance and general surface build-up and restoration
- Metco offers dedicated laser cladding systems, based on the long-standing experience with thermal spray equipment and laser cladding applications

Oerlikon Metco can combine material, equipment and application know-how like nobody else in the market