Keys to success in Laser Metal Deposition (LMD)

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Why it can be difficult for a service provider to give meaningful presentations

- Non Disclosure Agreements
  - Customers security
  - Moral obligation
  - Legal consequences

- Intellectual Property
  - Competitive advantage
  - Invested time and money
This is our story only

Please keep in mind this presentation is based on our experiences and in no way do we claim to speak for other companies and their experiences. Some names have been changed to protect the innocent.
COMPANY PROFILE

Started in 1992
78 employees
2 facilities close to BDL (5 min. Hartford Airport)

CERTIFICATIONS

• ISO 9001: 2008
• AS9100
• ISO 13485
• NADCAP certified for welding
• ASME boiler & pressure vessel certifications S,R,U
• Registered with the DDTC for ITAR
• 55,000 ft$^2$ production space in two facilities
• Laser welding (19 lasers 50w – 8000w / 24 – stations)
• Laser cleaning
• Laser drilling
• Electron beam welding (3 – stations / 15kW max. – 2.5” pen.)
• GTAW, soldering, brazing (3 – stations)
• Supply chain and project management
• System design, build and integration
• (2) Metallurgical Labs
INDUSTRIES WE SERVE

- Power Generation
- Aerospace
- Petrochemical
- Military/Defense
- Medical Device
- Sensors/Instrumentation
- Semiconductor
Laser Metal Deposition (LMD) – Basic Technology
Laser Metal Deposition LMD with powder feeding

Source: TRUMPF
Laser Metal Deposition

- Laser beam creates molten pool on part
- Metal powder is fed into pool by precision powder feed system
- Powder is melted and incorporated into the pool to create a weld bead
Pros & Cons of LMD

**Advantages**
- Metallurgical bond (not mechanical – thermal spray)
- Wide variety of available powders
- Very low dilution is possible
- Relatively high deposition rates
- Process is highly repeatable
- Low impact on base material compared to similar processes (HAZ)
- Superior metallurgy compared to similar processes
- Virtually unlimited build height
- Very flexible tool path compared to wire applications

**Disadvantages**
- High capital equipment costs
- Powder cost is typically higher than wire
- Capture ratio of additive material < 100% (based on process parameters)
- Cannot control the process manually – CNC is required
- Experienced, specialized staff required (e.g. laser safety engineer, skilled operators)
- Less OEM competition than with traditional techniques
- Limited domestic application and equipment support
How did Joining Technologies get into the additive process?

• 2006 – Designed and built a LAW® workstation for “high value” component repair (P&W)
• Definition of “high value” was ≥ $65,000
Development trials of the LAW® workstation?
Why we initially chose wire vs. powder

- We understood and therefore - much more comfortable with the process
- The aerospace industry “engineers” were familiar with the wire processes
- It was currently being used in many applications
- At the time LMD was beginning to get traction in the service sectors, but most of our exposure came from papers written by academic institutions.
2008 - Joining Technologies decides to invest in LMD

Reasons to make the investment

- Encouragement from second parties
- Advantages over typical wire feeding
- P&W was beginning to show more interest in LMD
- Expanding number of OEM’s/Integrators offering LMD
- We felt the technology was still “new” - less competition

Reasons not to make the investment

- We didn’t have a single customer commitment
Is that a train?
Unexpected obstacles begin to arise

Joining Technologies
• Process development support is not easy to find – you're on your own
• Most tool path software was subtractive not additive – programming can be very difficult
• Immediate metallurgical results are a must – better Metlab required
• Powder suppliers weren't interested in our needs
• Sometimes diamonds can be created faster than an aerospace qualification

Overhaul & Repair
• Most engineers had little experience with the process – therefore too risky
• DER's (Designated Engineering Representatives) were uncomfortable with the process
• Most welding specifications aren’t all inclusive to LMD
• No AMS filler material specification – only chemistry composition
• JT is not an FAA Repair facility
Joining Technologies develops a new strategy for JTAD

Customer education became priority #1
- Applications Lab Day’s
- Seminars and conferences
- Samples and pictures

Diversify your customer base
- Power generation components
- IGT components
- Chemical refining/processing
- Valve components
- Machining mistakes

In aerospace – focus on the OEM’s
- Promoted R&D to establish relationships
- Initially JTAD was ≥ 90% R&D projects
- R&D improved our skill sets
- Previous aerospace R&D (≈ 2.5 years) will result in 20% growth in sales revenue for 2014

New facility to accommodate different customer components
- 6-tons / 40 ft length / 6 ft diameter
- 7.5 ton bridge crane

- 2013 resulted in >20 tons of powder metal being deposited
10 meter KUKA KL linear rail system

6.5 ton KUKA rotary gearbox

7.5 ton bridge crane

400 kilo KUKA tilt/turn rotary

Trumpf 4kw disk laser

10 meter KUKA KL linear rail system

KUKA 6 axis high accuracy robot
4000 watt
Disk Laser (2-output)

8000 watt
Disk Laser (3-output)
Laser cladding of HTSH tubing

- Base material: SA-213-T22 tubing
- Additive material: Ni-Cr-B-W
- Cladding thickness: 0.035” – 0.065”
- Typical coating hardness: 66 – 70 HRC

Raw powder chemistry
- Cr – 15%
- Fe – 3.5%
- W – 17.3%
- Ni – 56.4%

Laser clad chemistry
- Cr – 14.8%
- Fe – 4.3%
- W – 16.2%
- Ni – 54.4%

As read by Niton XRF analyser
IGT Knife Edge Seal Repair

- Relatively high component value
- Quality expectations are high
- Still requires higher skill sets
- Liability is lower than aerospace
Ti-6Al-4V Mis-machining repair

- Over 140 hours of machining time
- Relatively high component value
- Quality expectations are high
- Still requires higher skill sets
- Non–critical portion of component
- Significant distortion concerns
Sealing surface repair for injection mold industry
Valve Ball & Seat Weld Development
Valve Ball & Seat Hardness Profile

Additive Material

68.1 HRC
L5 (Length: 0.015 inch)

67.6 HRC
L4 (Length: 0.012 inch)

67.8 HRC
L3 (Length: 0.009 inch)

66.1 HRC
L2 (Length: 0.005 inch)

Base Material
INCONEL 718

38.1 HRC
L7 (Length: 0.004 inch)

36.9 HRC
L6 (Length: 0.009 inch)

100μm
Partial list of materials currently being deposited

- Inconel 622
- Inconel 625
- Inconel 718
- Jethete M152
- Stellite 6
- Stellite 21
- Stellite 75
- Waspaloy
- MAR-M-247
- PWA-694
- IN100
- 15-5 PH
- 17-4 PH
- 347 SS
- 316 SS
- 309L SS
- 304 SS
- 410 SS
- 420 SS
- H-13
- 4130 steel
- 4140 steel
- 4340 steel
- Ti 6Al-4V
- Aluminum
- Spherical & Crushed WC
- Nickel/Cobalt Chrome Carbide
- Various proprietary alloys

Spherical WC NiCr 60-40 (25X)
Thank you for your attention