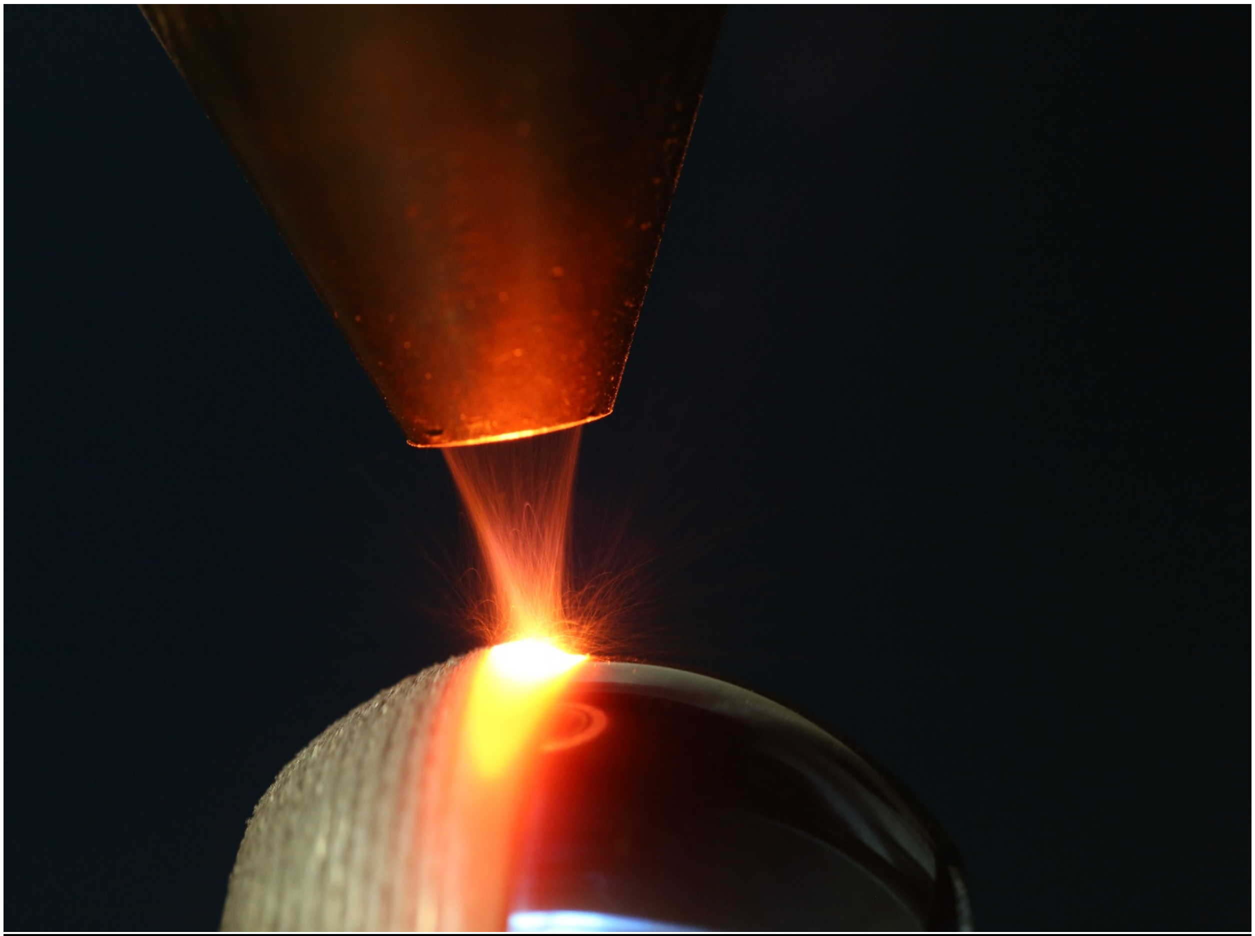
Laser Metal Deposition (LMD)
for
Metal Seated Valve Components



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NOTE

This document is meant to give an update on recent Laser Metal Deposition (LMD) advances as it pertains to “Metal Seated” Valve Components. The intent is to keep the information short and concise believing if interested, the reader will continue their investigation into the LMD technology as it pertains to their needs. Since American Cladding Technologies (ACT) is a “Service Provider”, we are therefore bound by our customer NDA’s and our own IP (Intellectual Property). Due to these restrictions, specific details may have been omitted to maintain confidentiality.

The purpose of this document:

1. Give a comparative example of what is considered a “traditional” metal overlay process to the Laser Metal Deposition (LMD) process.
2. Introduce basic LMD “hardfacing” information to professionals in the valve industry.
3. Promote future valve design enhancements based on advantages realized through the LMD technology.

If needed, all subject matter within this overview can be discussed in more detail as it pertains to your specific applications.

For more information regarding this topic, please contact:

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AMERICAN CLADDING TECHNOLOGIES

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Overview

There is nothing new about the need to improve wear performance of valve components. Hardfacing overlays have been used for many decades. The more traditional methods of applying a hardfacing weld overlay, (SMAW, PTAW, GMAW, SAW etc..) have also been used for many decades. For this discussion, ACT chose to focus on Cobalt 6 (trade name Stellite 6) as the overlay alloy since it is probably the most common overlay for metal seated valves.

The information and photos that follow were created for ACT customers. None of the information and data was produced under any contract or purchase order. Instead, the data presented to the customer was through ACT's internal development, in an effort to better educate them on some of the benefits that can be realized with the laser application of Cobalt 6.

The Headache of Unrevised Blue Prints

Over the past 13 years of using lasers to apply metal coatings, ACT learned that sometimes the single largest hurdle to jump is the "old unrevised" blueprint that can date back to the 1980's or earlier. It can be very difficult to get blueprint revisions for "legacy" components. These blueprints usually specify that the Cobalt 6 coating must be applied to a significant thickness or the print will refer to an overlay specification that basically states the same. Some typical coating thickness values we see range from 3/16" – 1/2" (0.187" – 0.500").

The principal reason this thickness is required is due to the dilution of the overlay. Simply put, "Dilution" is the mixing of the base material with the applied overlay material. Since most traditional weld overlay application methods input significant amount of heat into the welding process, the amount of dilution is also significant and therefore requires a thicker coating in order to achieve the needed overlay chemistry. The issue of dilution is of concern in both hardfacing and corrosion resistant overlays.

Why Use Laser for Weld Overlay Applications

Probably the single largest advantage of using a laser to apply weld overlays is heat control. The focusing ability of the laser allows for very precise heat input which can translate into the following.

- Less component distortion
- Less welding stress
- Less dilution of the overlay material
- Smaller "Heat Affected Zone" (HAZ) at the weld interface
- Less overlay material needed since dilution is minimized

Example 1

One of ACT's customers was interested in determining if the LMD process could be superior when compared to their own in house overlay operation. Their focus was to compare the hardness values of the two processes. They currently applied Cobalt 6 on numerous components and were looking for performance improvements along with possible cost savings. Typical coating thickness was approximately 0.25". Their current overlay process included GMAW and PTAW.

Sample Preparation

- Removing a weld specimen from the customer supplied weld sample
- Mounting removed specimen into epoxy
- Wet polishing and acid etch preparation
- Microhardness through the clad and horizontally at final machining dimension (0.060")
- Microscope photo at 50x

Customer supplied sample of Cobalt 6 overlay by GMAW
(Indent spacing approx. 0.010")

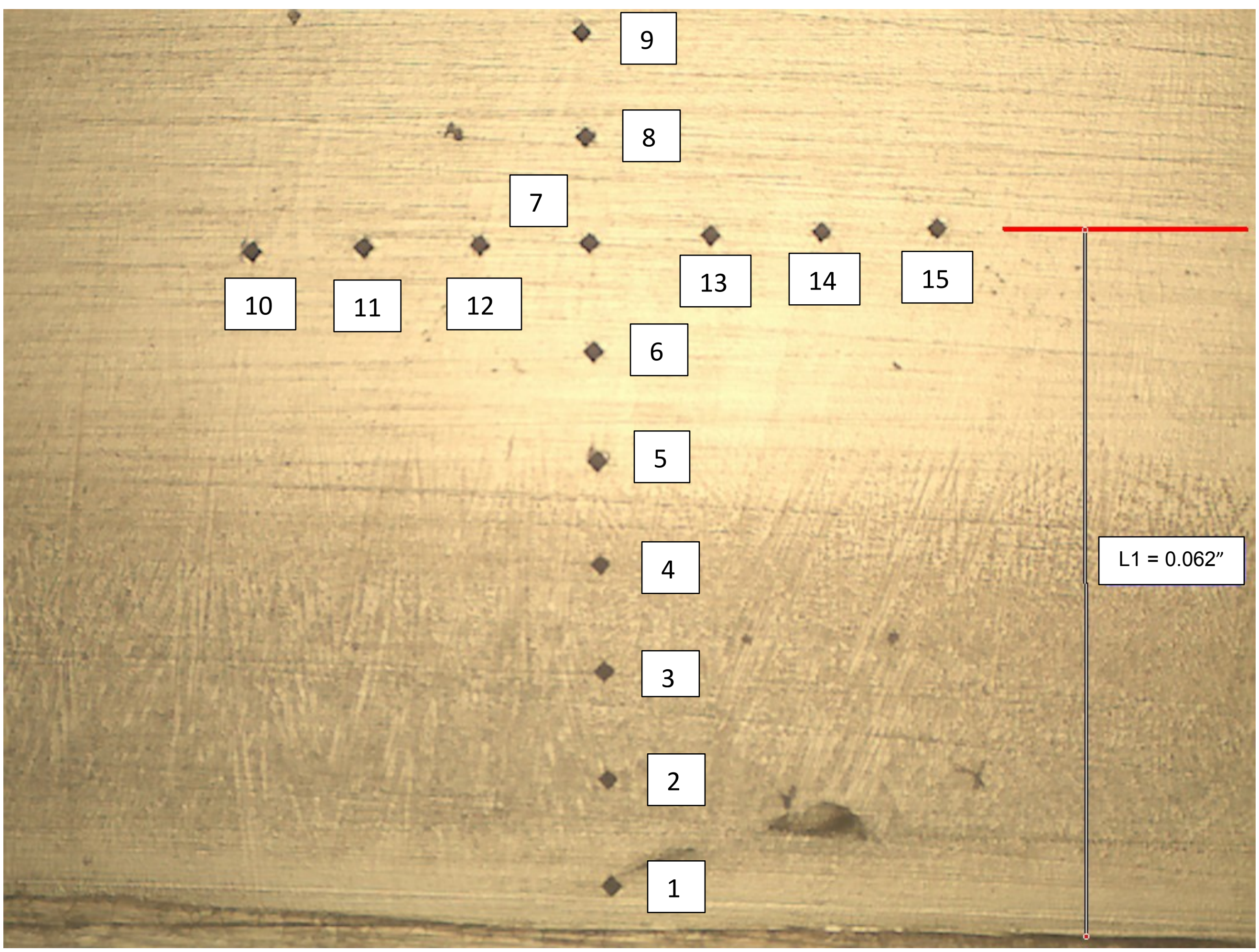

Figure 1

ACT laser clad sample of Cobalt 6 overlay
(Indent spacing approx. 0.010")

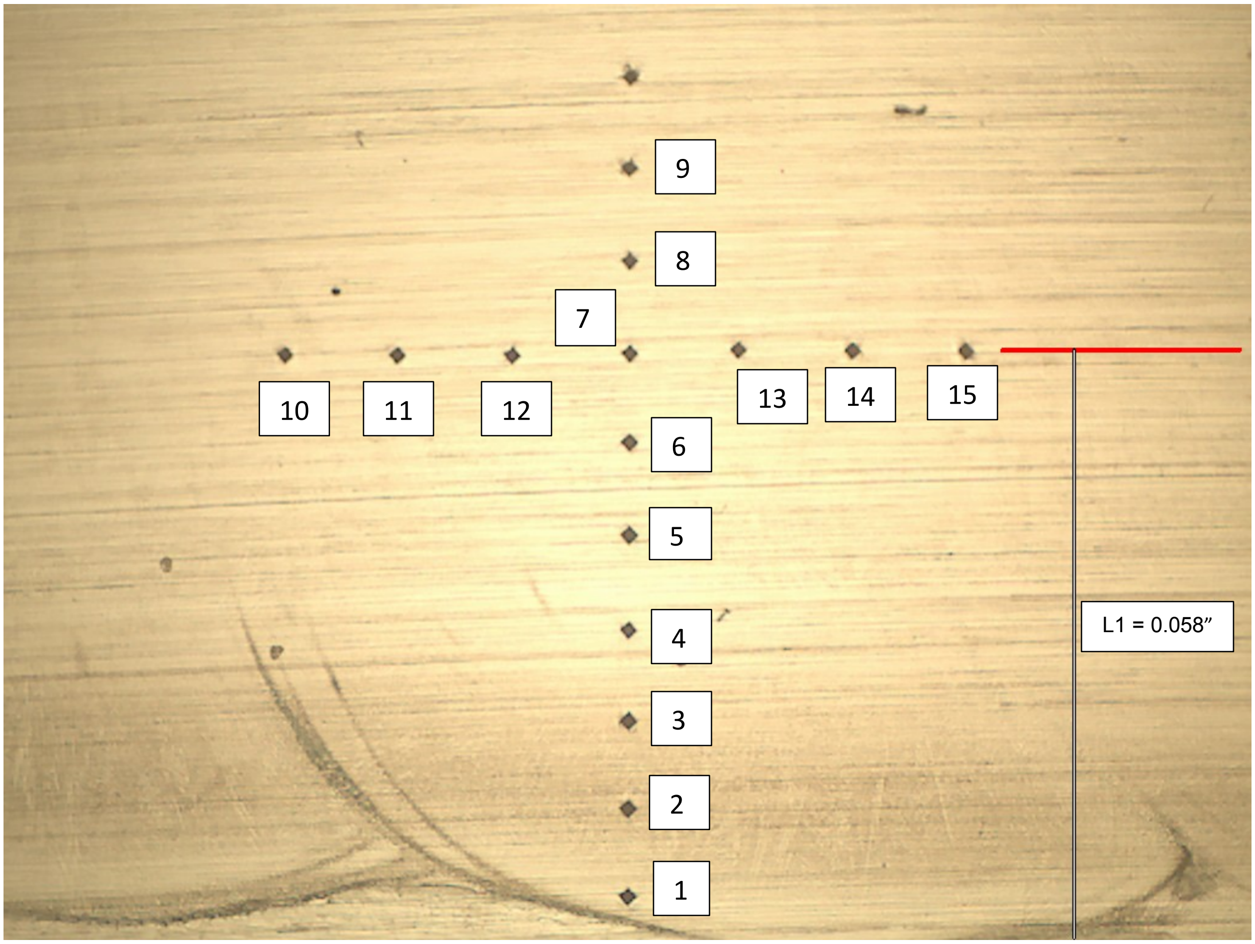

Figure 2

	Customer Supplied Sample		ACT Laser Clad Sample	
Indent	**HRc**	**HV**	**HRc**	**HV**
15	44.9	445.5	52.9	558.4
14	44.4	439.4	53.9	575.3
13	44.2	436.6	52.1	546.4
12	44.2	436.9	51.8	541.9
11	44.7	443.1	53.9	576.8
10	43.7	430.9	53.1	560.6
9	44.5	440.4	52.4	551.7
8	44.4	439.1	53.9	576.5
7	45.8	455.7	53.3	565.3
6	43.9	432.9	53.4	568.1
5	43.8	432.6	51.5	536.7
4	45.3	450.5	53.3	566.1
3	44.8	444.1	51.2	532.4
2	43.9	433.6	51.6	538.2
1	41.3	405.2	51.2	531.2
Average	**44.3**	**437.8**	**52.6**	**555.0**

Example 2

ACT submitted a laser applied Cobalt 6 hardfacing sample for an ASME Section IX qualification. The base material is ASTM-A516 Grade 70. The valve customer was interested in determining both hardness and dilution range through the coating. After the submission sample passed the metallurgical laboratories Liquid Penetrant Inspection, the sample was returned to ACT for cross sectioning. The customers required chemistry specification was per AWS A5.21 ERCoCr-A.

Sample Preparation

- Removing a weld specimen from the ASME Section IX qualification piece
- Mounting removed specimen into epoxy
- Wet polishing and acid etch preparation
- Microhardness (3 points) horizontally through the clad at 0.010” increments to final machining dimension (0.060”)
- Microscope photo at 50x
- Grind the sample down at 0.010” increments and measure chemistry with XRF analyzer. Monitor iron (Fe) as sample is tested at each layer. **NOTE:** Iron content for raw powder was 1.57% per suppliers certified MTR.

Example of Typical Samples Extracted
for Chemistry and Microhardness Evaluation

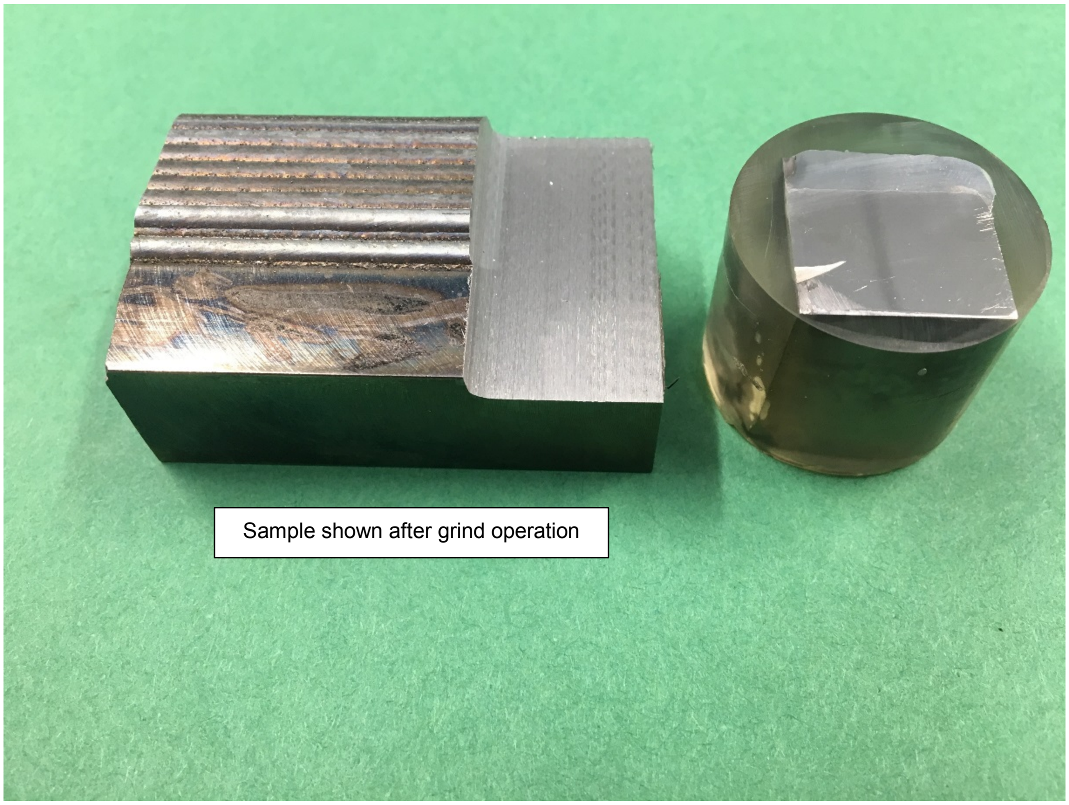

Figure 3

ASME Section IX Qualification Sample

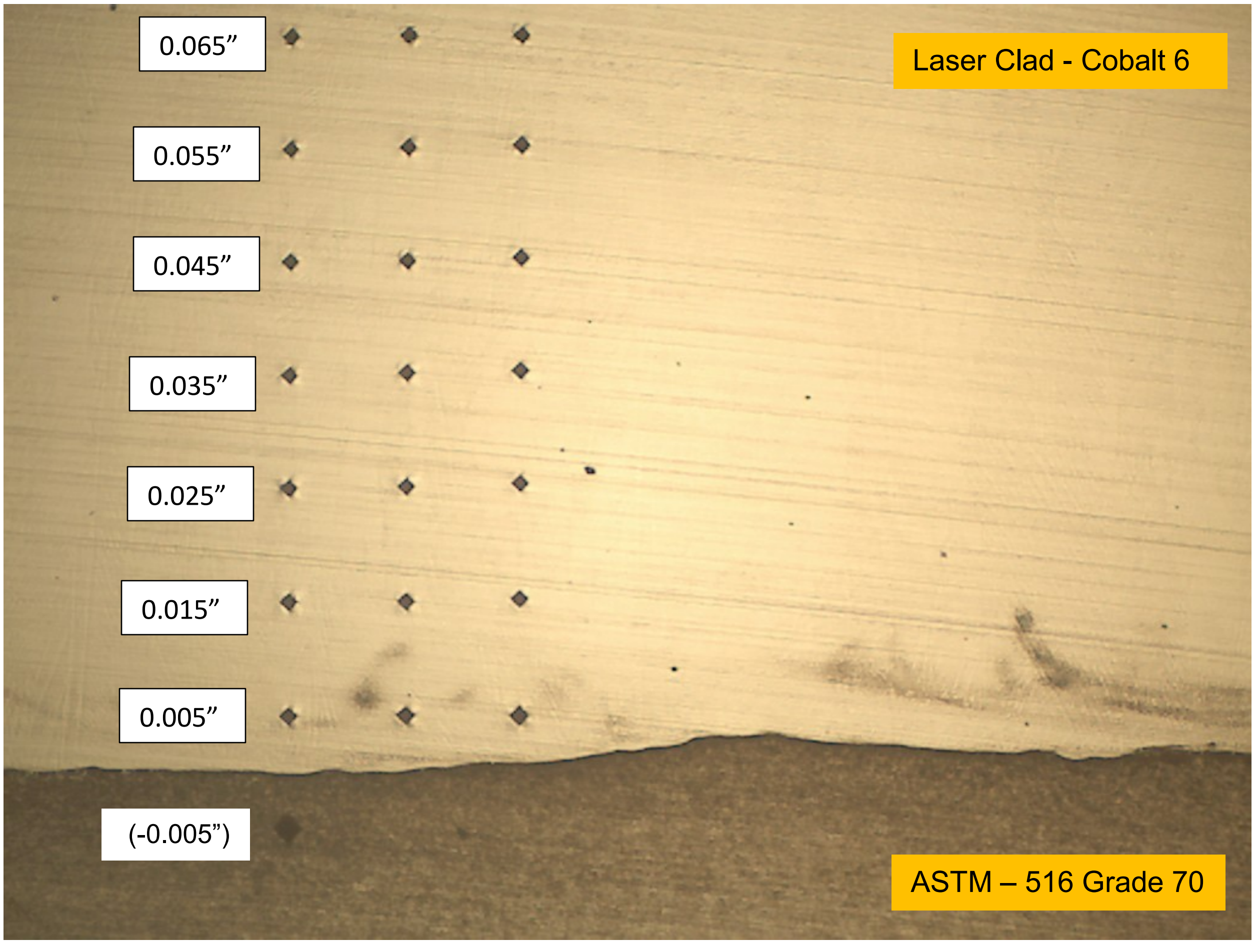

Figure 4

Hardness and Chemistry Results from ASME Section IX Qualification Sample

Indent	#1 (Rc)	#2 (Rc)	#3 (Rc)	Ave. (Rc)	Ave. (HV)	% Fe
0.065”	52.5	50.9	52.4	51.9	543.8	1.68
0.055”	52.5	53.4	55.2	53.7	572.9	1.59
0.045”	53.8	53.7	51.7	53.1	562.6	1.82
0.035”	51.8	53.7	54.2	53.2	565.8	2.21
0.025”	54.4	53.9	53.8	54.0	578.6	3.26 *
0.015”	52.7	52.6	52.0	52.4	548.9	5.79 *
0.005”	52.2	49.5	47.6	49.8	512.6	12.72 *
Base	11.0	N/A	N/A	11.0	200.2	97.12

* Denotes iron content above limit for AWS A5.21 ERCoCr-A. (3% MAX)
Iron content of raw powder was 1.57% per suppliers certified MTR

Example 3

For a marine application, ACT performed both microhardness and chemistry evaluation for a Cobalt 6 hardfacing. The base material is Monel K500. Chemistry specification per AWS A5.21 ERCoCr-A.

Sample Preparation

- Removed a weld specimen from a development component
- Mounting removed specimen into epoxy
- Wet polishing and acid etch preparation
- Microhardness (single point) through the clad at 0.010" increments to final machining dimension (0.100")
- Microscope photo at 50x
- Grind the sample down at 0.010" increments and measure chemistry with XRF analyzer. Monitor copper (Cu) as sample is tested at each layer. **NOTE:** The measured copper content for Monel K500 was 30.6%.

Marine Application

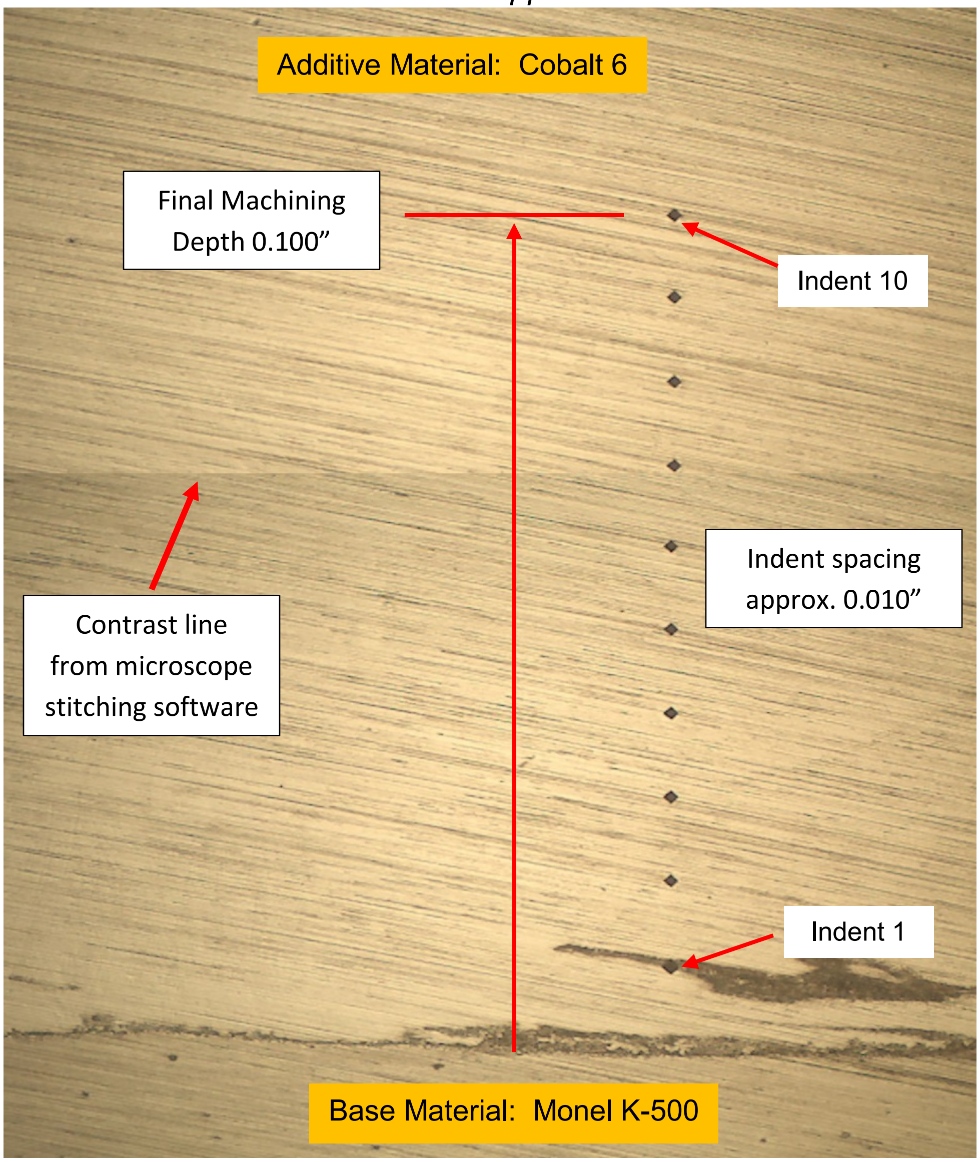

Figure 5
Hardness and Copper Dilution of Marine Sample

	Hardness		Dilution
Indent	**HRc**	**HV**	**% Cu**
10	53.7	571.9	ND
9	54.6	589.0	ND
8	54.8	591.7	ND
7	54.8	592.6	ND
6	55.0	595.5	ND
5	55.3	600.3	ND
4	54.3	583.7	ND
3	51.8	542.0	0.61
2	55.0	596.7	1.03
1	45.0	447.1	2.40
Weld Interface			30.52
Ave. Hardness	53.4	571.05	
ND – “None Detected”			

Summary:

- Regarding the coating dilution, the three examples shown above represent actual process welding parameters. The average deposition volumes range around 7-10 lbs/hr. ACT felt it important to show actual production floor processes, not the absolute maximum nor minimum that can be achieved. Coating dilution and hardness can be further improved, but this is not always economical for all customers and therefore was not the point of focus in this testing.
- The customer in Example 1 determined that for their application, the increased Rockwell hardness from the mid 40’s to low/mid 50’s will translate into a 3X increase in their product life.
- In most cases, after development and qualification are completed, the LMD application of Cobalt 6 can be as cost competitive as traditional methods of application.
- Due to the low heat input and subsequent rapid solidification of the weld pool, microstructure of the overlay is typically superior to traditional overlay methods.
- Minimal heat input from the laser can result in very low coating dilution. It is possible to achieve full material chemistry in as little as 0.005” – 0.010” coating thickness, though this may not always be economical for the end user.
- Corresponding with the low heat input, the “Heat Affected Zone” (HAZ) associated with the welding is also minimized.