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EFFECTS OF THE CLADDING SPEED ON THE CLADDED LAYER GEOMETRY

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Abstract: *In this paper a short description of laser cladding parameters influence is made. Several tests were made to hightlight the scanning speed influence over the geometrical appareance of the cladded layer. For the investigation a 3, 3 Kw Nd: YAG laser together with an ABB 6-axes robot and a coaxial cladding head made by Rofin were used.*

Key words: *laser cladding, scanning speed, flow rate*

1. INTRODUCTION

The Laser (Light Amplification by Stimulated Emission of Radiation) has a short history. This history begins in 1917 when Einstein study for the first time the stimulated emission. In only 60 years from fundamental research to industrial applications laser technology has became an important tool for material processing. Although the laser started to be used during ’70s, it had been used at the real value only during the last decade thanks to the progress of technology, which facilitated the use of laser beam like heating source for highly precise welding and cladding. At this moment there are a various type of lasers suitable for laser cladding. Commonly in industrial applications the most used are solid state lasers and gas lasers.

2. LASER CLADDING

Laser cladding is a process in which a laser beam is used like thermal source and a filler material, wire or alloy powder is deposed on a substrate to improve the surfaces. For a quality layer a low dilution is required (Bruck, 1988). Basically high laser density powers produce a hight dilution, but for a good bonding between the clad layer and the substrate require a hardly dilution (Kim & Peng, 2000).

Many actual technologies are available to realize coatings (ex: electroplating, thermal spraying), but this methods limit the thickness of the layer to around 0.5mm in one scan. In laser cladding a thin layer from base material is melted and therefore a good metallurgical bond is created, versus thermal spraying where powder is sprayed onto the surface without a solid bond between the two layers. In laser cladding, the layer thickness could vary between 0, 05 and 2 mm in one scan, with a good bonding between the substrates and the cladding.

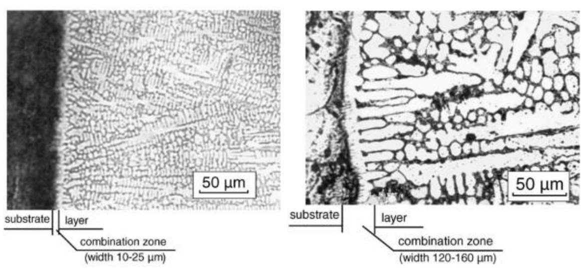

Fig. 1. Laser cladding (left) and plasma spray (right) on 1Cr18Ni9Ti base material coated with 0,8C, 28Cr, 6W and Co.

Comparing the technology of laser cladding with the conventional technology of plasma spraying, the dilution and diffusion rate of laser cladding components are lower, more chemical compounds are formed, the hardness, strength and toughness is improved remarclaby in case of laser cladding. In figure 1 may be observed the difference between plasma spray and laser cladding in case of austenite stainless steel cladded with a Co base alloy (Shi et al., 2004).

Parameters like scanning speed or powder flow rate have a direct influence over the dimensional and physical proprieties of the cladded layer. The velocity of the cladding unit must be rated with the laser density power and flow rate. Currently scanning speeds used in laser cladding are in range of 5 to 25 mm/s (Hoffman, 2009).

3. EXPERIMENTAL

For the achievement of the experimental tests, a 3,3 kW Nd:Yag continous wave laser was used as a thermal source together with an ABB 6-axes robot and a coaxial cladding unit made by Rofin. All the experiments were made using a 2mm laser spot diameter and for carrier gas was used Argon at 25 l/ min. The tilt angle of the cladding unit was 3, 2 ^{o} in the cladding direction.

Two sets of experiments were made in order to determine the scanning speed influence on the geometry appeareance of the cladded layer. To assure the substrate melting for all the experiments a power of 1000W was used.

Single clad experiments were performed with contionous increase of scanning speed from 3 to 9 mm/s and maintaining the power and the feed rate at 7g/min and 10g/min. For this investigation a nikel base alloy powder Sulzer Metco® 15E and a 6mm of AISI 5140 steel plate as a substrate were used. The chemical composition is presented in Table 1(*** 2010).

Chemical composition								
Material	Form	Element (wt. %)						
		Ni	Cr	Mn	Fe	Si	B	C
Metco® 15E	Powder	Bal.	17	-	4	4	3.5	1
AISI 5140	Plate	0,0096	0,98	0,65	97,5	0,22	-	0,29

Tab. 1. Chemical composition of base material and powder

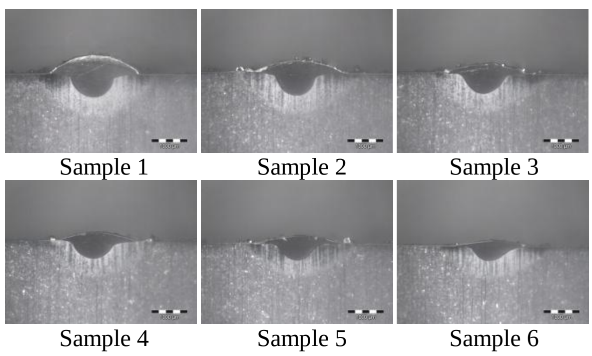

Fig. 2. Cross section of laser tracks for fixed power at 1000W and feed rate of 7g/min

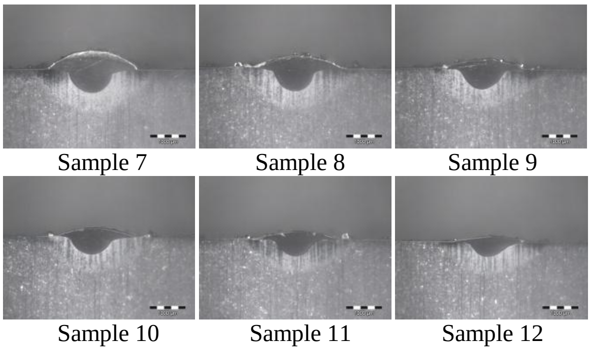

Fig. 3. Cross section of laser tracks for fixed power at 1000W and feed rate of 10g/min

Visual measurement of high, width, melt depth and heat affected zone was performed by using the substrate as a base for all measurements. All the samples was prepared with grit paper, alumina powder and etched in 2% Nital.

Figure 2 and 3 shows the main geometric features of the laser cladded tracks. Those figures highlight the speed influence for the appareance of the clad track. The high, width, melt depth, heat affected zone and dilution are clearly influenced by the scanning speed.

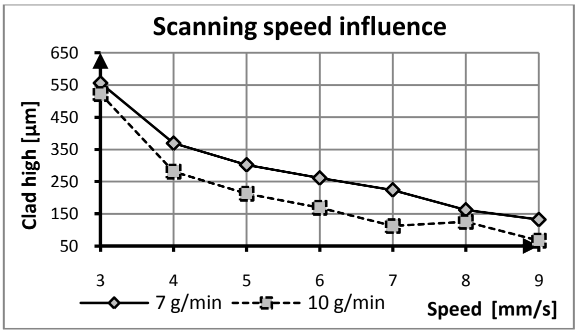

Fig. 4. Laser clad high as a function of scanning speed and fixed power and feed rate (7 g/min and 10 g/min)

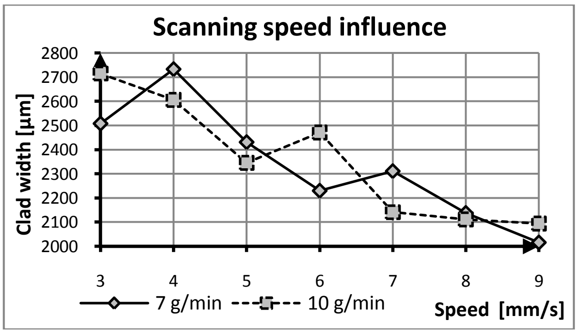

Fig. 5. Laser clad width as a function of scanning speed and fixed power and feed rate (7 g/min and 10 g/min)

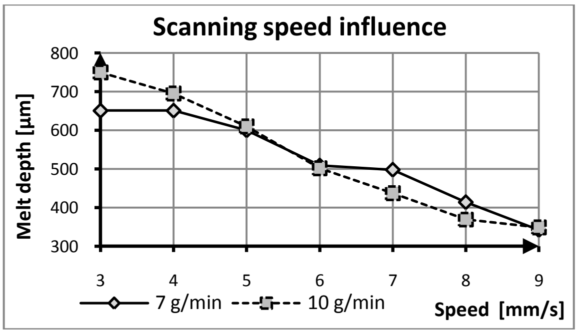

Fig. 6. Laser clad melt depth as a function of scanning speed and fixed power and feed rate (7 g/min and 10 g/min)

4. RESULTS AND DISCUTIONS

Generaly for a quality layer a small high and dilution of the clad is required. The thickness of the substrate melt pool is influenced by the density power and it must be as small as possible in order to obtain a pure surface coated layer. Only a correlation between the power and the speed will provide a quality, poor free clad layer.

The data collected form these experiments are presented in figures 4, 5 and 6. In figure 4 the clad hight as function of scanning speed is presented. There is no significant difference between the two courves. Bouth feed rate value 7 and 10 g/min ashore a clear visible tendency of clad hight. The clad hight is decreasing with the increasing of trevell speed. It can be observed that at 3 and 8 mm/s the value of the clad hight it is almost the same. The powder feed rate has a small influence over the cald dimension. All the measurements reveal that a lower hight is achived with a higher value of feed rate. Higher quantities of powder will absorbe more laser energy and for this reason a saller quantity of powder will be melted and deposited. For the same reason the melt depth of the substrate have appropriate value for different powder feed rate (figure 6).

The clad width is also decreasing with the increasing of the speed. The chart shows the same descending trendline like in the case of hight and the melt depth. As expected, the clad hight, width, melt depth depends on speed process.

5. CONCLUSIONS

Scanning speed is an important parameter wich influence the principal geometric features of the cladded layer. The hight and the melt depth are directly influenced by the process speed. A hight speed is necessary for a small clad and for a low dilution. Even so, the speed has a major influence over the cladded track, only a correlation between the speed, power density and powder feed rate will provide a quality cladded surface. In further research hight speed laser cladding for obtaining very thin deposited layer it will be investigated.

6. ACKNOWLEDGEMENTS

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