Laser Additive Manufacturing by using a Novel Martensitic Steel Powder; Characteristics and Performance

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***Abstract*—A recently developed martensitic stainless steel powder designed for laser additive manufacturing was characterized. Mechanical as well as microstructural investigations were performed. It was concluded that the investigated powder is very robust and have a wide process window. The microstructural examination indicates that the powder has a martensitic structure possibly containing small amounts of ferrite in the grain boundaries, which is also supported by thermodynamic calculations.**

Keywords - laser; martensitic; stainless; steel; cladding

I. Introduction

Laser additive manufacturing is a collective name for technologies where surfaces and structures are created by adding one or more layers of material, and where a laser acts as the heat source. A wide variety of materials can be used, among them metal powder.

This paper focus on blown powder processes as Laser Engineering Net Shape (LENS) and Laser Cladding (LC). These technologies are used for build up and repair but also to improve and tailor surface properties.

II. Theoretical Investigation

Martensitic stainless steels are the smallest group of stainless steels compared to ferritic, austenitic and duplex stainless steels. Compared with austenitic stainless steels, martensitic stainless steels have modest corrosion properties but the hardness provided by the martensitic structure provides these materials with a competitive edge.

Table 1 shows hardness and corrosion resistance of laser cladded coatings of one austenitic (316 HSi) and one martensitic (431 L) stainless steel.

Table 1 Hardness and PRE-number of austenitic (316 HSi) and martensitic (431L) stainless steels

Properties	Material	
	316 HSi	***431 L***
Hardness (HV_1)	215	265
PRE-number*	25	17

*Higher PRE-number indicates better corrosion resistance

III. Experimental

Laser cladding is a surface coating process where the coating material is added as powder or wire. The coating material is continuously fed into a melt pool created by the laser beam and is rapidly solidified onto the workpiece with a minimum of dilution with the substrate material, see figure 1.

Welded martensitic steels are normally very brittle and prone to cracking, which can be avoided with pre- and/or post heating. This novel martensitic stainless steel however, shows much less susceptibility for weld cracking than other martensitic stainless steel powders.

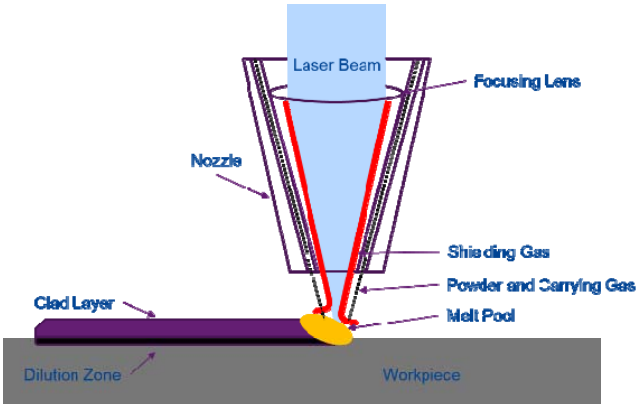


Fig. 1. Schematic of blown powder process; Laser Cladding.

IV. Discussion

In laser cladding large amounts of heat are induced locally leading to high solidification rates. This affects the microstructure of the cladded

layer since it may not solidify at equilibrium. If the solidification rate is high enough, formation of stable phases can be suppressed because diffusion is not fast enough, resulting in metastable phases in the weld bead. The high cooling rate achieved in laser cladding results in a refined microstructure and smaller austenitic grains. For martensitic stainless steel, the smaller austenite grains formed during solidification suppress the solid state martensite formation. Since the amount of soft retained austenite will increase the hardness will subsequently decrease. A small addition of Co in stainless steel however, has been found to increase the tempering resistance by stabilizing austenite, i.e. the hardness of the steel is reduced slower and the hardenability is increased.

V. CONCLUSION

As can be seen in table 2, laser cladded coatings of the novel powder (powder X) are significantly harder and have a relatively high PRE-number compared to 316 HSi and 431 L (table 1). This, together with excellent cladding properties shows that this novel material effectively bridges the gap between austenitic and martensitic stainless steel powders used today.

Table 2 Hardness and PRE-number of the novel powder (powder X) compared to austenitic (316 HSi) and martensitic (431L) stainless steels

Properties	**Material**		
	316 HSi	***431 L***	***Powder X***
Hardness (HV_1)	215	265	375
PRE-number*	25	17	22

*Higher PRE-number indicates better corrosion resistance