

LASER BASED REFURBISHMENT OF STEEL MILL COMPONENTS

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ABSTRACT

The steel manufacturing industry is often faced with challenges pertaining to the wear and damage of various components used in the steel production process. The replacement of these components can be a time consuming and costly exercise.

Laser cladding is establishing itself as a surfacing technology for the refurbishment, hard facing and build-up of various components in the manufacturing industry, and can definitely offer a solution to the above problem and extend the life of the components.

The process involves the deposition of the weldable material on the surface to be repaired using a laser beam. Laser cladding offers advantages over other conventional welding processes such as low dilution, excellent control and repeatability as well as metallurgical bonded layers are obtained.

A selection of worn and damaged components which included rolls, distance sleeves and a shaft were obtained from a steel manufacturer to be evaluated for refurbishment by means of laser cladding. This paper describes the application of laser cladding for the refurbishment of the various components with special reference to the processing parameters, various consumables considered and typical set-ups that were used.

KEYWORDS

Laser cladding, Refurbishment, Steel mill components

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1 INTRODUCTION

Laser based refurbishment was performed on various components from the steel mill environment. The inherent properties of laser based processes and in particular laser cladding offer potential advantages for this type of application. The laser refurbishment process involves the deposition of the weldable material on the surface of a metal substrate using a laser beam.

The fundamental procedure is schematically illustrated below:

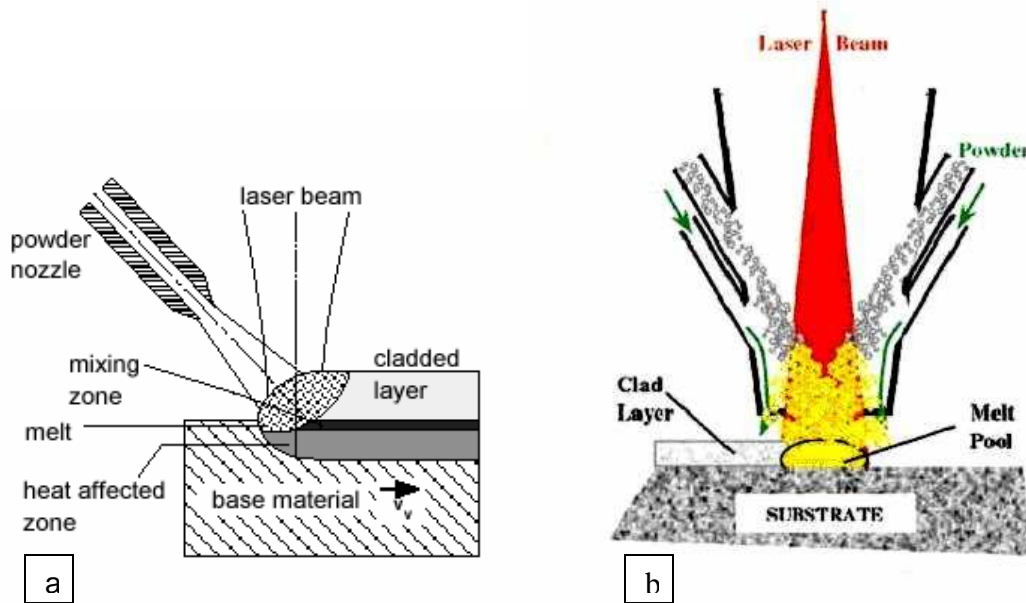


Figure 1: Schematic illustration of the process with an off axis nozzle (a) and coaxial nozzle (b)

Laser cladding is typically performed by supplying a consumable in the form of a powder by means of a nozzle to a laser generated weld pool on the surface of a metal substrate. Two types of powder nozzles can be used for laser cladding namely the off axis nozzle and the coaxial nozzle.

The off axis nozzle is very economical but does not provide a good powder efficiency and shielding when compared to the more expensive coaxial nozzle.

The characteristic low heat input, low dilution and excellent control limits distortion, allows cost effective utilization of more expensive materials and offers superior metallurgy, surface chemistry and reproducibility.

In cooperation with Columbus Stainless a selection of components were chosen for the investigation. The components consisted of rolls, distance sleeves and a shaft. The components were all of cylindrical geometry which simplified the programming of the laser equipment.

The purpose of this investigation was to demonstrate the techno-economical feasibility of laser based refurbishing of steel mill components. Although laser cladding is relatively expensive compared to alternative refurbishing processes it is expected that superior lifetime and reliability of refurbished components will more than compensate for the extra cost. It should be emphasized that the material that is presented should be seen as a first attempt which concentrated on process optimization. Optimization of the material selections will require further investigations

2 PROCEDURE

The supplied components were all worn and free of cracks. They were manufactured from the following steels:

Table 1: Steel mill components

Component	Material type
Foot rolls	ST55
Descaler cassette	ST50
Foot roll shaft	ST50-2
Distance Sleeve	ST35
Idler roll	ST50-2

At the beginning of the refurbishment process, the service conditions and resulting wear mechanisms of the various components were considered before choosing the powder consumables. The powder consumables were selected to offer improved wear resistance when compared to the original materials from which the components had been manufactured.

The dimensional specifications of the components also have to be taken into consideration, because these are standardized and the refurbished component must adhere to the specified requirements.

The refurbishment process basically entails the following steps:

- Inspection of the components to be refurbished by identifying all damaged areas.
- Specification of pre-machining required to remove surface imperfections prior to laser cladding.
- Evaluation of service conditions and wear mechanisms.
- Selection and sourcing of a suitable powder consumable to be used
- Process optimization which would include the production and metallographic analysis of test pieces. Microstructure, chemistry, porosity, cracks, bonding defects, layer thickness and layer roughnesses are considered and optimized resulting in a set of process parameters. These include laser power, laser spot size (which determines track width), powder feed rate (which determines layer thickness), step-over, shielding gas type and flow rate.
- CNC programming of robotic manipulators and laser equipment.
- Laser cladding of the components to a size that allows for post machining to the required surface finish and dimensional tolerance.
- Visual inspection of the cladded component and Non destructive testing
- Mechanical Machining of the component to the required size

The typical set up of the laser refurbishment process of the rolls can be seen below:

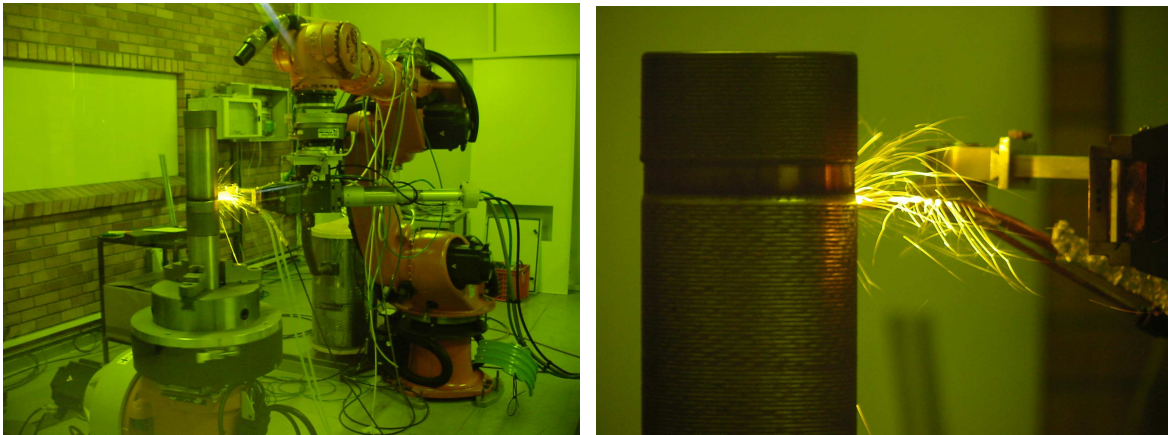


Figure 2: Laser refurbishment set-up for a Roll

3. RESULTS AND DISCUSSION

3.1 Laser Cladding

Laser cladding was performed on the distance sleeve shoulders, foot rolls, descaler cassette, idler sleeve and foot roll shaft. Laser cladding parameters are shown in Table 2.

High speed cladding was performed on the foot roll shaft and idler sleeve to minimise distortion and overheating. High speed cladding is a process through which a relatively thin layer (~0.5 mm) is applied at relatively high feed rate (~3 m/min). Multiple passes are required for thicker layers. This process minimizes heat input and consequential distortion.

The figures below show the repaired distance sleeve and idler roll.



Figure 3: Damaged and repaired distance sleeve

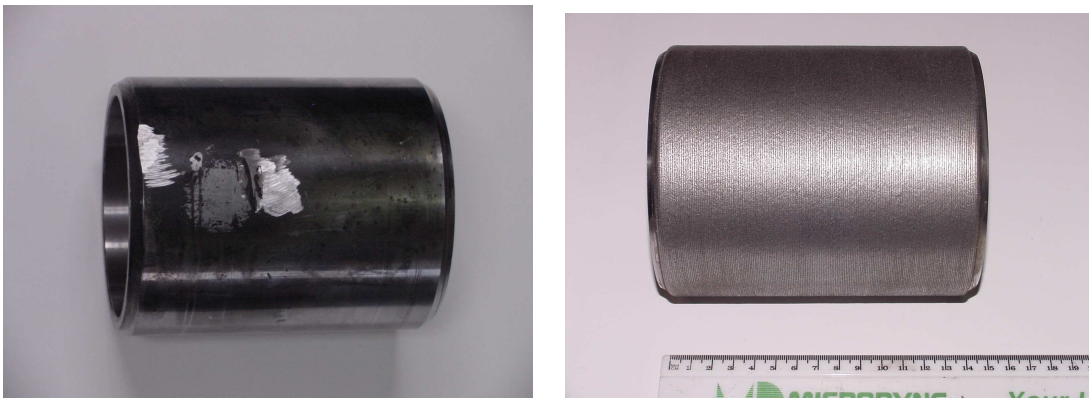


Figure 4: Damaged and repaired idler roll

The processing parameters are summarised in the table below:

Table 2: Laser cladding parameters

Component	Material	Laser power (W)	Cladding speed (m/min)	Welding head (mm)	Nozzle	Powder feed rate (g/min)	Gas	Flow rate (l/min)
Distance sleeve	316L	1000 Nd:YAG	1	300	Off axis	5	Ar	3
Foot roll (300)	Diamalloy 1008	3300 Nd:YAG	0.6	200	Off axis	14	He	4
Foot roll (630)	431	2200 Nd:YAG	0.6	200	Off axis	25	He	4
Descaler cassette	60S	1650 Nd:YAG	0.6	200	Off axis	20	Ar	3
Idler sleeve	431	1000 Nd:YAG	3	300	Coaxial	15	Ar	5
Foot roll shaft	316L	2000 (CO2)	3	200	Coaxial	8	Ar	5

The typical chemical composition and hardness properties of the various alloys used cladded onto C-Mn steel flat bar substrate can be seen in table 3.

Table 3: Chemical composition and hardness of cladding alloys (single layer)

Material	C	Mn	Si	Cr	Ni	Mo	Hardness (HV1kg)
316L*	0.026	1.33	0.51	16.23	12.36	2.28	160
Diamalloy 1008*	0.4	-	3	17	3	11	940
431	0.19	0.18	0.8	14.3	1.64	0.32	520
60S	0.54	0.13	4.67	16	75	0.04	880

Since the locating shoulders on the distance sleeves and the foot roll shaft are not subjected to extensive wear and damage, these were cladded with 316L austenitic stainless steel to obtain a clad layer that could be readily machined and which possess relatively good toughness properties.

Foot rolls were cladded with 431 martensitic stainless steel (630 mm) and Diamalloy 1008 (300 mm) hardfacing alloy with an off axis nozzle. Diamalloy 1008 is an Iron based hardfacing material developed for corrosive wear applications below 650°C (1200°F).

431 stainless steel provides a corrosion resistant coating used mostly for repair and wear applications requiring a hard ground finish.

The macrographs of the cladded layer for the Diamalloy and 431 martensitic stainless steel on a test piece can be seen below:

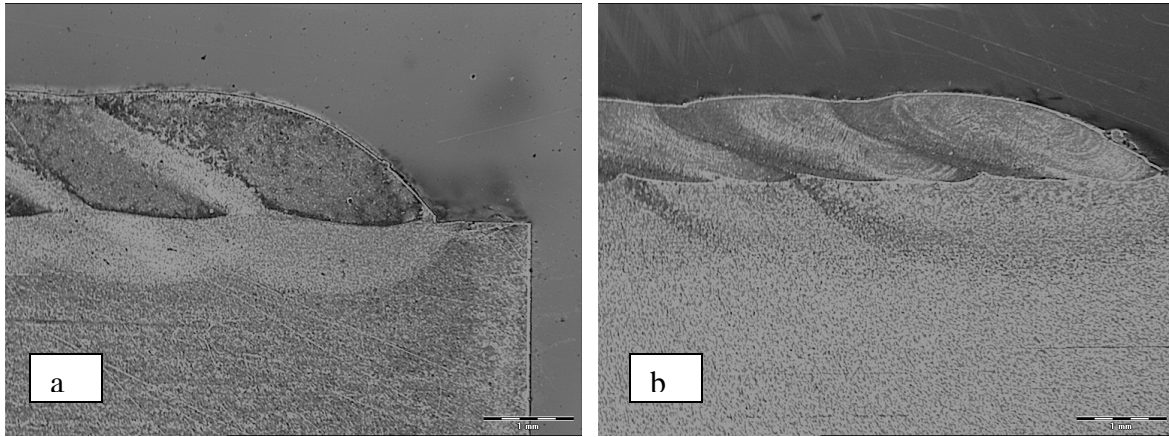


Figure 5: Daimalloy (a) and 431 martensitic clad layer

These materials were chosen to determine cracking susceptibility on full scale components and in-situ performance during production. No cracking was observed with cladding of 431 martensitic stainless steel. Transverse cracking was observed with the Diamalloy 1008 hardfacing alloy.

Two layers were deposited on the 630 mm foot roll and one layer onto to 300 mm footroll. No pre-heating was performed on the 630 mm foot roll but a 300°C preheat was applied to the 300 mm foot roll.

The descaler cassette was cladded with a self-fluxing Ni-base hardfacing alloy without any pre-heat. This material exhibits excellent wear resistance. It also resists oxidation and corrosive gases at high temperatures.

3. CONCLUSION

Laser refurbishment capabilities were demonstrated and promising results were obtained for repair of distance sleeves, foot rolls, descaler cassette, idler rolls.

Based on the cost projections and the results of the in-situ testing, components which can be refurbished economically would be identified for further optimization particularly in the selection of the powder consumable.

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