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A Review on Recent Trends in Laser Cladding Process

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***Abstract*: Cladding on a surface may serve two fold functions; one is to improve surface dependent properties like resistance to wear under abrasion, erosion and corrosion, and the other is to enhance the bulk dependent properties like hardness, strength, etc. that is known as hard facing. Clad components are expected to have capabilities of serving its specific function in a hostile environment for a sufficiently long time economically. For this, there is increasing demand of clad components in various industries like chemical, naval, mining, agriculture, power generation, etc. day by day. On the other hand, tool manufacturers use cladding techniques more and more in producing tools like rollers, dies, jaws, etc. which should possess high hardness and large compressive strength. Cladding through welding is one popular and versatile method. In this paper, various methods, especially, different welding techniques, used for depositing a layer to cover a surface, and in particular, cladding, are discussed mentioning their applications. Various characteristics of clad components are reviewed with reference to parametric optimization, microstructure and corrosion resistance properties.**

***Keywords*: Cladding, Welding, Microstructure, Corrosion resistance**

1. Introduction

Cladding is used to improve hardness of the surface of a component, it is called hard facing. In case of alloy steel, cladding on low carbon steel by means of welding, heat input plays a significant role for achieving higher hardness of the surface. Basically weld cladding is permanent joining of two dissimilar ferrous or non-ferrous metallic materials in which one is known as substrate and the other is clad material deposited through coalescence formation. Different aspects are to be considered while undertaking weld cladding without any defect. One major difficulty is the possibility of formation of cracks caused by dissimilar contraction of cladding materials as well as the substrate. To overcome this problem, different crack prone elements could be eliminated from the electrode, and multilayer deposit along with the provision of buffer layer was tried to reduce the possibility of formation of crack. Use of tubular electrode and suitable preheating were also done to help prevent crack propagation. For successful dissimilar metal joining between carbon steel and stainless steel, fatigue crack growth behavior was explored in another work.

2. Laser cladding process

The powder used in laser cladding is normally of a metallic nature, and is injected into the system by either coaxial or lateral nozzles. The interaction of the metallic powder stream and the laser causes melting to occur, and is known as the melt pool. This is deposited onto a substrate; moving the substrate allows the melt pool to solidify and thus produces a track of solid metal. The motion of the substrate is guided by a CAD system which interpolates solid objects into a set of tracks, thus producing the desired part at the end of the trajectory.

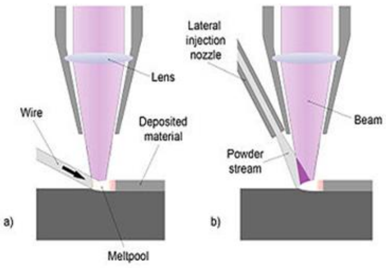

Fig. 1. The different feeding systems available

A great deal of research is now being concentrated on developing automatic laser cladding machines. Many of the process parameters must be manually set, such as laser power, laser focal point, substrate velocity, powder injection rate, etc., and thus require the attention of a specialized technician to ensure proper results. However, many groups are focusing their attention on developing sensors to measure the process online. Such sensors monitor the clads geometry (height and width of deposited track), metallurgical properties (such as the rate of solidification, and hence the final microstructure), and temperature information of both the immediate melt pool and its surrounding areas. With such sensors, control strategies are being designed such that constant observation from a technician is no longer required to produce a final product. Further research has been directed to forward processing where system parameters are developed around specific metallurgical properties for user defined applications (such as microstructure, internal stresses, dilution zone gradients, and clad contact angle).

A. Experimental Procedure

At first, the surface of AISI 304 stainless steel plate of100 ×

45 × 8 mm3was polished with 220-grade emery paper and cleaned with ethyl alcohol and acetone respectively to remove any contamination. Commercially pure Ni and TiC powder in equal weight ratio were mixed thoroughly with specific amount of acetone and a Polyurethane based organic binder to prepare a semi-solid solution. This semi-solid solution was then dispersed on the steel surface uniformly and dried at room temperature to evaporate the acetone and cure the binder. To deposit a predefined thickness, volume of the powder requires to cover a specific area (here, 100 mm × 45 mm × 0.35 mm) was calculated and accordingly the amount of powder was mixed with the acetone and polyurethane based organic binder. Thus, Thickness of the preplaced layer was measured from the thickness difference of the substrate after and before the preplaced coating. A TIG welding machine accompanied with a welding torch containing 2.4 mm diameter tungsten electrode was used to create an arc for the coating pro-cess. The TIG welding torch was attached to a speed controlled linear moving trolley to obtain a variable arc scan speed. Processing parameters i.e. welding current and scan speeds were varied to obtain an optimum condition that enables to produce a feasible coating layer having sufficient bond with the substrate. On each pre-coated steel substrate, single line scan of TIG arc was executed as per the experimental planning demonstrated in shows that due to scanning of arc over the pre-deposited TiC-Ni powder layer, a composite coating form on the steel substrate.

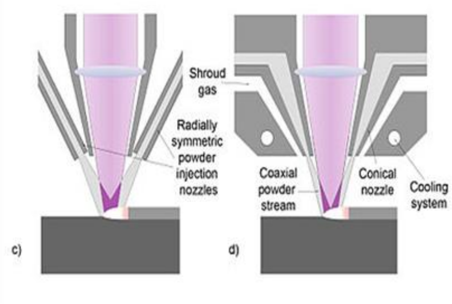

Fig. 2. The different feeding systems available

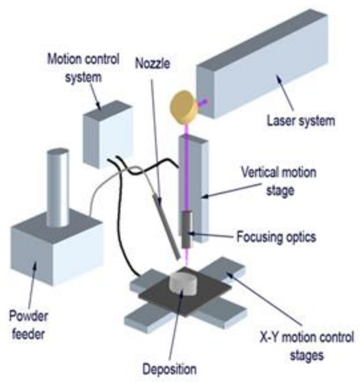

Fig. 3. Cladding by welding process

After performing the TIG coating, the coated samples were cleaned and cut by wire EDM at perpendicular direction to the arc scanning for further analysis. The cross-section of the coated samples were then polished with different grade SiC abrasive papers and diamond paste suspended cloth. To analyse the microstructure of the coating, scanning electron micrographs.

B. *Types of metal cladding*

Metal cladding is extremely sturdy and durable and has a very long lifespan depending on the metal cladding types. Walls can be finished with a wide array of metals and techniques which provide excellent resistance and coverage against weather conditions while being completely resistant to abrasions, UV rays and staining. Today, Metal wall cladding is one of the most preferred cladding materials for newer homes. They not only improve the value and appearance of your interiors or exteriors but are also lightweight, fireproof and waterproof whilst also providing excellent acoustic performance. Types of metal cladding range for interior and exterior cladding are:

- Zinc Cladding
- Copper Cladding
- Galvanized steel Cladding
- Aluminium Cladding
- Brass Cladding
- Bronze Cladding
- Titanium Cladding

Metal cladding can be painted too and is available in a wide range of textures and patterns to replicate the look of different materials. With the right maintenance, it can increase the service life of any structure while also proving to be one of the best investments you can make to improve the value of your house. Metal cladding generally has a long lifespan varying from metal to metal. For instance, Zinc and stainless steel can easily last up to 60-80 years, while copper cladding can have a life in excess of 100 years in normal environments.

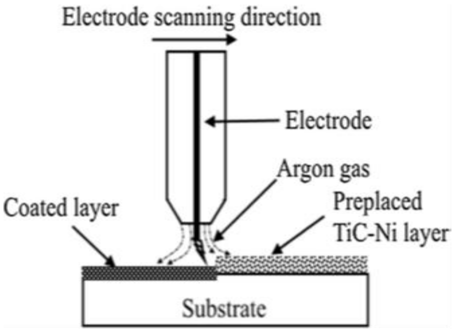

Fig. 4. Cladding

3. Cladding microstructure

Microstructural analysis of the TiC-Ni composite layer produced on AISI 304 steel substrate by TIG cladding process for different current setting (i.e. 40, 50,60, and 80 A) and arc scan speed of 5.3 and 6.5 mm/s respectively.. The images revealed that a thick and almost uniform layer of dark particles reinforced in a white shaded matrix formed on the steel substrate for using 40 to 60 A current at both scan speed condition. However, at relatively higher current, the intensity of the dark particles are found non-uniform distribution of the particles. It is evident that TiC particles are diluted in the steel substrate and distributed to a larger depth when the coating was produced at higher current (80 A). In TIG cladding process, the pre-deposited TiC-Ni layer melted and a convective flow of molten layer followed, that resulted in melting of a thin layer of substrate surface along with the TiC-Ni powder layer. Thus, a dense and uniform layer of TiC along with Ni and distinguishable amount of steel matrix produced on the steel substrate. It can be also be noted that at lower current (40–60 A),the heat input during TIG coating process is reasonably less, which may leads to partial melting of the TiC powder in conjunction with complete melting of Ni powder. Thus, the produced coating shows large size TiC particles within the matrix. In contrast, the coating processed with higher current (80 A), induces higher heat in the processed region, resulted in full melting of TiC particles. During solidification, these molten TiC particles are fragmented into a smaller size and distributed in the matrix of steel-Ni solid solution. Owing to excess heat, these tiny TiC particles are diffused within the steel substrate to a larger depth. This phenomenon is more clearly observed for the coating produced with lower scan speed, where input heat energy is relatively higher than those of coating produced at higher scan speed.

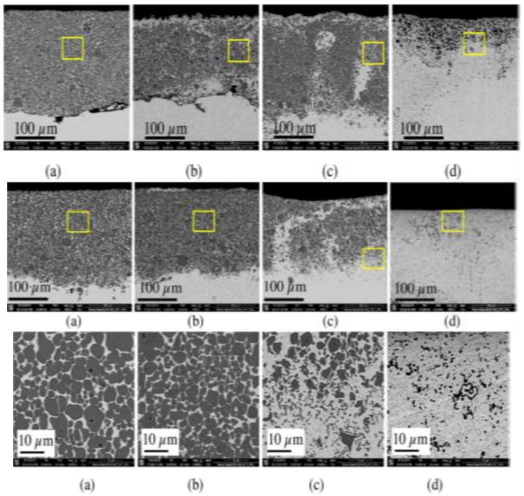

Fig. 5. Detail analysis of the microstructure of TiC-Ni

4. Cladding and their application areas

- Cladding by explosive welding uses an explosive detonation as the energy source to produce a bond between metal components. It can be used to join virtually any metal combination, that are metallurgic ally compatible or that are known as non-wieldable by conventional processes
- Cladding by rolling is a much popular and an old process. More than 90% of worldwide clad plate production relates to hot roll-bonding [25] or by accumulative roll bonding process. In recent years, weld cladding processes are being applied widely in numerous industries such as chemical, and fertilizer plants, aviation, mining, agriculture, power generation, food processing, etc. as a cost effective engineering solution. These are used to deposit a surface protective layer on corrosion-prone low carbon or low alloy steel against corrosive environment.
- Weld overlay cladding techniques were originally developed for applying on Defense (Navy) components subjected to extreme pressure and shock loading. These clad components come in contact with sea water, but needed less maintenance.
- Cladding techniques were employed in sub-sea components for making outer layer to be corrosion resistant against corrosive saltwater solution. A number of parts of the submarine pressure hull were clad with Inconel 625.
- Pressure vessels used in power plants were reportedly clad to provide anti-corrosive as well as strong surface layer to survive severe working conditions at elevated temperature. Residual stresses developed in clad pressure vessels were evaluated, and these data were used in its designing process.
- Cladding was also tried to provide for enhanced performance of components in service, or to repair worn or corroded components. Large worn out gears could be preliminarily repaired by depositing metallic materials using a cladding technique. Among different cladding techniques, laser coating/cladding.
- Among different cladding techniques, laser coating/cladding can be done on shafts, rods and seals, valve parts, sliding valves and discs, exhaust valves in engines, cylinders and rolls, pump, turbine components, wear plates, sealing joints and joint surfaces, tools, blades, molds, etc. These clad rods and rolls are used in paper, textile, and food industries. Clad tools can be used as cutting, punching, or die tools.

5. Conclusion

From the above discussion, it is understood that several techniques have been developed for producing a clad layer on low grade steels. Different welding processes have been employed to yield quality weld cladding to be used in a wide spectra in various sector industries for enhancing mechanical properties like hardness, cold-toughness, etc. as well as corrosion resistance. Mechanical properties of clad part could be improved by providing proper heat input. Heat input is set by controlling by controlling welding current, welding voltage and weld travel speed. On attaining desired microstructure of clad part, mechanical properties as well as anti-corrosion properties under different reactive environment could be improved significantly. Some new developments regarding weld cladding techniques, their areas of application, microstructures obtained and corrosion resistance properties in clad components are also discussed in this paper.

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