Comparison of Laser Cladding And Thermal Spraying Techniques Used For Wear Control

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Abstract

Wear determines the service life of the components/equipment during the different applications. Wear is the progressive damage, involving material loss, which occurs on the surface of a component as result of its motion relative to the adjacent working parts. Because of wear there are the economic and money related misfortunes because of drop in proficiency, constrained shutdowns and repair are massive. Occurrence of wear depends upon many methods like geometry of the surface, applied load, the rolling and sliding velocities environmental conditions, mechanical, thermal, chemical and metallurgical properties and physical, thermal and chemical properties of the lubricant. So it is necessary to control the wear of the components. There are different methods/ techniques are available to control the wear. In this study, compare the laser cladding and thermal spraying process, their principle, process parameters to control the wear of components that are used in diverse applications.

Key Words: Wear, Laser cladding, Thermal spraying, Applications.

1. INTRODUCTION

Wear is the progressive loss, including material loss, which happens on the surface of a component as effect of its motion relative to the adjacent working parts. Occurrence of wear depends upon many methods like geometry of the surface, applied load, the rolling and sliding velocities environmental conditions, mechanical, thermal, chemical and metallurgical properties and physical, thermal and chemical properties of the lubricant. It is of different types according to the application where the component is used like abrasion, erosion, adhesion, fatigue, corrosion wear etc. shown in Fig. 1.

2. LASER CLADDING

Laser cladding is a process where a high power laser beam is used as a source of heat to melt the coating material and subsequently overlay it on the surface of the substrate with minimum dilution at the interface [1–3].Las r cladding method is having extreme importance for various industrial purposes where different shapes of nozzles used which continuously emits the laser beam and different powder mixtures comes in contact with laser beam and melts and produce a layer of powder coating on surface. Nowadays cladding, also known as as hard facing or surfacing, is a deposition process with a purpose of improving the properties of the substrate (base metal) and are proficient either using laser beam or arc as the heat source for the process. Filler material used in the process is deposited layer-by-layer until covering needed thickness

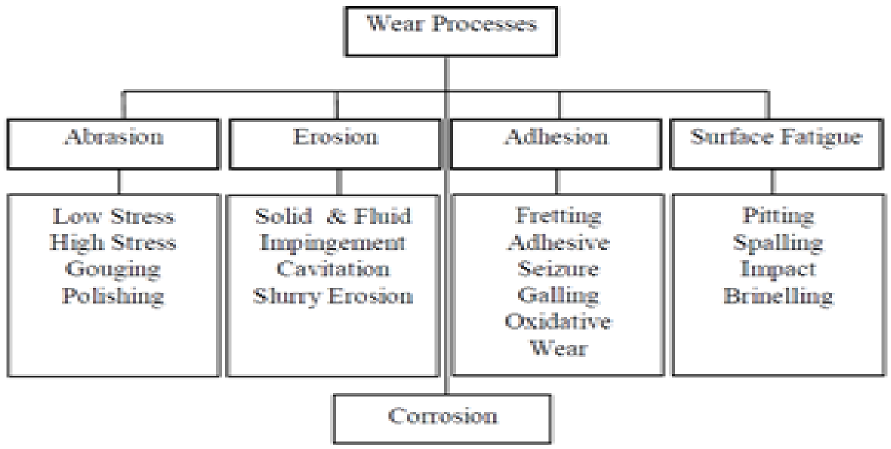

Fig -1: Types of Wear

before being machined to attain the final dimension. Laser cladding has several advantages over the different conventional coating processes. In this coating obtained by laser cladding is much better quality than other methods. It offers the potential to develop such a repair technology. The process has been used to repair of mechanical parts [4].

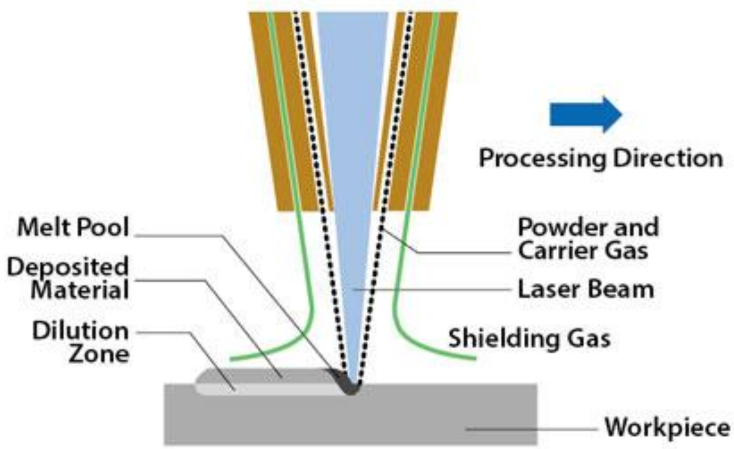

Fig-2: Laser Cladding Process

The quality of clad developed is assessed by studying the microstructure, crack formation, the bonding between the layer and the substrate and variation of hardness along the clad depth [5-9]. Following type of lasers are used for cladding:

- CO2 laser
- Various forms of Nd: YAG lasers
- Fibre lasers
- Diode lasers

Dhanda et al. 2014 [10] developed a multicomponent coating by laser cladding process using preplaced powder on Ti-6Al-4V substrate. The wear behavior of composite coating was assessed by ball on disc type wear. D. Gupta et al. [11] studied wear resistant of stellite 6 clad layer using CO_2 laser clad layer on surface of an EN 19 steel substrate by means of laser surface cladding. The micro hardness of clad layer showed a significant improvement and increased up to 1200 VHN. G. R. Desal et al. [12] studied the effect of clad powder colomony-6 and Inconel-625 on AISI 316 L steel and AISI 304 L steel by laser cladding method. The clad geometry, dilution, microstructure and micro-hardness of cladded layer have been examined to ascertain the clad quality. C. P. Paul et al. [13] investigated the solid particle erosion performance of WC reinforced Ni matrix based clad layer to increase the performance of industrial components for power plant applications. The morphologies of damaged surfaces were used to predict the wear mechanism. Manna et al. [14] developed a clad surface on an AIAI 1010 steel structure with Fe-B-C, Fe-B-si and Fe-BC-Si-Al-C of bulk metallic glass composition. Although an amorphous layer was not retained in the microstructure, a significant improvement in the wear resistance was nevertheless achieved and composition corresponding to maximum improvement in the wear resistance was established. L. St. Georges [15] investigated the effect of process parameters on cladding quality and microstructure is observed using clad material WC + Ni-Cr on low carbon steel AISI 1020. Cladded surface has six time’s higher abrasion resistance then the hard faced material. E. Harati et al. worked on ductile iron and deposited the layer of stellite 6 by laser cladding process using low power pulsed Nd:YAG laser. D. Wang et al. [16] compared the different microstructure obtained by the laser cladding and laser induction hybrid cladding. Metal silicate based composite coating was applied to the tool steel by using continuous wave CO_2 laser. Microstructure and phases are observed by optical electron microscope and XRD. B. carcel et al. [17] investigated the effect of different process parameters like laser power, powder feeding rate, scanning speed and preheating temperature on Ti-6Al-4V substrate with Ti-Al intermetallic coating. Micro-hardness is increased and crack are reduced by preheating. Z. Izdinska et al. [18] evaluated the tribological properties and microstructure of clad coating of Ni based with matrix of WC particles by pin on disc wear test and scanning electron microscope. H. Tan et al. [19] investigated the effect of Al_2O_3-M_7C_3/Fe metal matrix composite coating on steel substrate by laser cladding method. The microstructure of composite coating was investigated by the different methods. With the Vickers hardness and block on ring dry sliding wear test, hardness and dry sliding wear was investigated.

2.1 Applications of Laser Cladding

Typical applications of laser coatings are:

- shafts, rods and seals
- valve parts, sliding valves and discs
- exhaust valves in engines
- cylinders and rolls
- pump components
- turbine components
- wear plates
- sealing joints and joint surfaces
- tools, blades

3. THERMAL SPRAYING

In this technique, the base material is coated with the clad material (metal, ceramic, or plastic). The clad material is melted using a heat source, and is projected as a spary on the surface of the substrate. Here the bond between the base metal and the deposited metal is purely mechanical. This gives rise to the problem of poor wear resistance, and the dilution is zero [20].

Thermal spray processes are broadly classified upon the basis of the feedstock and heat source for melting. In any of these line of sight processes, melted or semi-melted particles are transported at high speeds within a heat source in the direction of a surface upon which deposition occurs to form a coating. As the spray torch (or 'gun') is traversed over the substrate, a coating is built up from the repeated deposition of micrometre sized solidified droplets; often referred to as splats, lamellae, or pancakes. Splats undergo spreading and create a mechanical bond to the underlying surface, although there have been instances where a certain degree of chemical bonding has been noticed at the nanostructure level. It is essential for the coating to remain attached to the substrate throughout its service life [21] and, therefore, measurement techniques for the physical properties of coatings are an important area that quantifies assessment criteria.

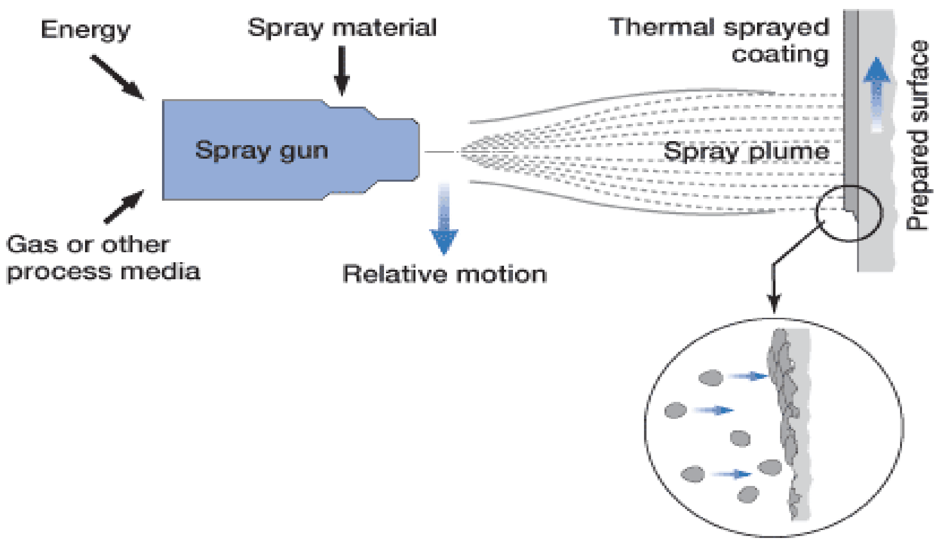

Fig-3: Thermal Spraying Process

The most commonly types of this technique are:

- Flame spraying
- Arc spraying
- Plasma spraying
- High-velocity oxyfuel technique

Barthwal et al. [22] investigated the effect of WC-Co and Cr_3C_2-NiCr coatings on Die Steels by HVOF process under abrasive wear conditions. After the experiments, it is conclude that HVOF thermal spray process is suitable for carbide coatings on Die Steels. Oksa et al. [23] reviewed HVOF thermal spray techniques, spraying process optimization, and characterization of coatings. Procedures and parameters for controlling the spray process are studied as well as their use in optimizing the coating process. He has mentioned the three generations of HVOF systems. Singh et al. [24] explored the Slurry Erosion Behavior using Plasma Thermal Sprayed (50%) WC-Co-Cr and Ni-Cr-B-Si coatings of diverse thickness on CA6NM turbine steel material. The relationship has been done for mass loss for coated and uncoated materials at different situations. The study reveals that the impact velocity, slurry concentration and impact angle are most important among various factors influencing the wear rate of these coatings. Padhyay et al. [25] conducted experiments to determine slurry erosion characteristics of AISI 316L, 15 wt. % Cr-15 wt. % Mn stainless steel and satellite powder alloy applied as overlay to cast ferrite stainless steel of CA6NM type, which was used as a normal turbine runner material. The different wear rates of the alloys were enlightened in terms of the microstructure, hardness and work hardening rate.

3.2 Applications of Thermal Spraying

Typical applications of thermal spraying coatings are:

- Road and rail vehicles
- ships
- aircraft
- pumps
- valves
- printing presses
- electric motors
- paper making machines
- chemical plant
- food machinery
- mining and quarrying machinery
- earthmovers
- machine tools
- power generation
- aerospace turbine repairs

4. CONCLUSION

On the basis of the comprehensive literature review it is clear that development of wear resistant surfaces using conventional surface engineering techniques such as weld surfacing and thermal spraying have their own limitations like high dilution rates, distortion of substrate, high cost and interfacial cracking etc. Several researchers have reported the non-uniform microstructures in the regions close to the interface [51, 52]. Comparision of both process is given in table no. 1.

Table No.1: Comparison between thermal spraying and laser cladding

Process	**Thermal Spraying**	**Laser Cladding**
Heat Source	Combustion flame, electric plasma arc	High intensity laser radiation
Bond Strength	Low to moderate, mechanical bonding	High metallurgical bonding
Coating structure	Lamellar, from porous to nearly dense	Dense, crack and pore-free layers
Heat load to work piece	Very low to moderate	Low to moderate
Dilution	Nil	Low
Coating thickness	0.05-some mm's	Typically 0.5-3mm
Coating materials	Wide range of metals, alloys, hard metal, ceramics, polymers	Metals and alloys, alloys with hard particles, hard metals, ceramics
Productivity	Low to high	Low to moderate/ high
Cost	Low to high	Moderate to high

The non-uniform microstructure has a tendency to decay the useful properties of the engineered surfaces. It is observed that thermal spraying is a mainstream course to create wear safe surfaces, yet thermal spray deposits are mechanically anchored to the surface. Thermal spray deposits often present problems like low strength, exfoliation, cracking and spalling while exposed to wear conditions. Thermal deposits additionally require post processing to enhance their thickness, increment homogeneity and lessen porosity. Further, nanostructured coatings developed through thermal spraying route are popular to combat wear in engineering components attributed to their improved mechanical, physical and functional properties. These enhanced properties are because of vast interface and nanoscale impacts related with these materials. In these materials an extensive volume part of molecules are situated in the interface where their conduct is not the same as the mass. Be that as it may, the degradation of the essential carbide phase during the thermal spraying leads to poor tribo-mechanical properties of the coatings.

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