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A Review of Improve Surface Properties by Laser Coating

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Abstract-This paper describes increasing importance in the betterment of wear resistance and hardness of surfaces that are in contact with abrasives or corrosive materials has accelerated the development of several techniques for creating protective coatings. Laser coating is one such advantageous process of modifying the surface properties of different tools, parts of long running machines.

Index Terms- Laser coating; wear resistance.

1. INTRODUCTION

Laser coating is a process in a substrate is fused, with a material (coating powder) which has metallurgical properties that are different from substrate, by using a laser beam. The peculiarity of the process is that only a very thin layer of the substrate is to be melted in order to achieve metallurgical bonding. In order to retain the original properties of the coating materials, added material and substrate should have minimum dilution. Thus it is an advanced coating technology for improving the properties of different components. Coatings so obtained by laser treatment have characteristics of extremely high density, non porous and crack free microstructure and excellent metallurgical bonding with the base material**.**

2. DIFFERENT TYPES OF LASER SURFACE TREATMENTS

2.1. *By Preplaced Powder*

This is considered to be a two-stage laser coating procedure. In the first stage the substrate is covered with the pre-placed powder to be coated on substrate. In the second stage heat transfer takes place through the powder and partially melts the substrate and provides a metallurgical bond between the coating and the substrate surface. This technique is not suitable for complex geometric shape and consuming more time than the powder blowing. In this method uniform covering of the coating material on substrate is achieved which results homogeneous and crack free coating with strong metallurgical bond to the base material.

2.2. *By Powder Injection*

In this method powder is injected into the path of laser beam. The powder is held through the tubing using an inert gas. The blown powder particles are partially melted by the laser beam. The laser creates a small melt pool on the substrate surface that fully melts the powder. The melt pool after solidification creates a clad coat. This results in a strong metallurgical bond between coating and substrate material with a minimal dilution.

There are two different methods of the powder delivery system. In first method powder particles are rendered to the substrate through a coaxial system where the laser beam and powder particles are feeding towards the substrate simultaneously.

The second method is offline method or a lateral injection method where feed nozzle is positioned to the side of the laser. The position of the lateral feed nozzle affects the clad application. If the lateral feed nozzle is positioned in the direction in which the substrate moves, the cladding becomes more capable because the powders is trapped between the substrate and melt pool.

2.3 *By Wire Feeding*

This method of clad formation is through a wire feed. The wire is fed from a wire spool to the work piece and laser interaction zone. Among all these process laser coating by preplaced method has specific advantages i.e. homogeneous and crack free coating with strong metallurgical bond to the base material. Major headings should be typeset in boldface with the words uppercase.

3. LASER COATING USING PULSED LASER

The laser surface alloying with nickel of commercial pure Aluminium using an Nd: YAG pulsed laser. Parameters in use as power 120 W, pulse width 4 ms, pulse rate 10 s-1, scan speed 2.1 mm/s, and overlapping ratio of 50%. Microstructural analysis of the laser surfaced aluminium with nickel showed non uniform distribution of the alloying element (nickel) irrespective of the amount of hardness. The alloyed layer microstructure was dependent on the composition and variation in the molten alloy pool during solidification under larger under cooling condition [1].

The studied laser alloying of AA 6061 aluminum alloy with Ni and Cr using a pulsed Nd-YAG laser through a spot diameter of 2 mm. Laser power of 100 to 300 W, pass through speed of 1 to 8 mm/s, overlapping ratio of 50 to 90%, pulse width of 4 ms and pulse rate of 10 Hz were used as processing parameters. The number and range of cracks and pores in the coatings increased with laser power and overlapping proportion. The hardness of the coating was 5 to 6 times that of the original substrate. Maximum resistance was found at a low laser power since higher powers lead to dilution of the hard phases by aluminum from the substrate [2].

Carried out an experiment using pulsed Nd: YAG to modify the surface properties of AISI 1010 steel by laser synthesis with TiB2 and Al powder. Average power of 400 W, pulse period of 0.5–2 ms, repetition rate of 20 Hz, beam diameter of 500 µm, scan rate of 84.7 mm/s and 70% overlapping proportion were used to carry out the laser surface engineering. Coating achieved had hardness of (900 HV) and surface roughness of (Ra 6.1) possess minimum wear rate (0.113 mg/ (min cm2)). Compared with the steel substrate, micro-hardness and wear resistance of the coating were improved significantly [3].

The studied laser alloying of AlSi9 Aluminium alloy with Ti wire. For laser an Nd: YAG solid state laser (2 kW, pulsed) was used and scan speed taken as 300 and 500 mm/min. Ultra micro hardness measurements performed on the Ti-alloyed Al regions showed hardness values between 81 and 98 HV0, 0008 used for the Al solid solution, and values of up to 1250 HV0, 0008 for the TiAl3 dendrites resulted in high strength and hardness, connected with high wear resistance and low friction coefficients [4].

Carried out laser surface alloying of electro less plated Ni–P coatings on Al-356 aluminium alloy using a 1-kW pulsed Nd: YAG laser (pulse duration: 200 ms and pulse rate: 5–10MHz). Alloyed layer showing good metallurgical bonding with the substrate material. The hardness of the laser surface alloyed layer was found upto 940 HV due to development of hard, fine intermetallic Ni–Al phases. The pitting quarrel of the laser surface alloyed layer was significantly improved compared to the Al-356 alloy [5].

Investigated the influence of re-scanning on tribological behavior in laser surface alloying of Al with Ni using pulsed Nd: YAG laser. Laser power of 400 W, pulse rate of 1–1000 Hz, pulse period of 0.2–20 ms and pulse energy of 0–40 J were taken for alloying progression. Though re-scanning of the laser-alloyed layers leads to the formation of pores and cracks but improve the hardness in the coating and lower the specific wear rate than a single alloyed layer [6].

The applied laser surface cladding technique to deposit (Ti, W) C reinforced composite coating on copper using pulsed Nd: YAG laser. During the process, laser power, pulse width, beam diameter, frequency and scanning speed were selected as 380W, 1.1ms, 1.5 mm, 60 Hz and 5 m/s, correspondingly. The reinforced MMC coating exhibited higher wear resistance and lower friction coefficient than that of copper substrate. Crack-free MMC coating with metallurgical bonding was produced with average microhardness almost 9 times that of the copper substrate [7].

Prepared Co-based alloy/TiC/CaF2 self-lubricating composite coatings on a Cr-Zr-Cu alloy for continuous casting mold by Nd: YAG laser cladding. During the cladding development power, scanning rate and spot diameter were selected as 390 W, 5 mm/s and 1.5 mm correspondingly. Average hardness of the self-lubricating composite of unique microstructure coating was about twice than that of the pure Co-based alloy. The composite coating decreases friction coefficient and wear rate as the volume fraction of CaF2 increases and TiC decreases [8].

4. RESEARCH WORKS TO GET BETTER SURFACE PROPERTIES OF MATERIALS

The micro-hardness of the surface was improved to 250-350 VHN as compared to 220 VHN of the AISI 304 stainless steel substrate when it is laser treated with TiB2 as coating and observed a significant improvement in wear resistance possessions. The mechanism of wear was found to be a combination of adhesive and abrasive in as-received stainless steel. However, it was mostly abrasive for laser composite surfaced stainless steel [9].

Direct laser cladding of SiC dispersed AISI304 stainless steel produced defect free and homogeneous microstructure which consists of partially dissolved SiC in grain refined austenite. The hardness increased from 155VHN to 250-340 VHN [10].

TiC exhibits a very high melting point and thermal stability, high hardness and outstanding wear resistance, small coefficient of friction and high electrical and thermal conductivities. Because of its high melting peak, TiC is a promising material to be used as first wall material in fusion reactors [11].

Hard TiC ceramics are well recognized for combining a number of special properties that have made them of particular interest for a wide variety of applications-they are used as wear resistant coating for cutting tools and inserts and as diffusion barriers in semi-conductor technology[12].

By using a mixture of 80 wt. % 431-type stainless steel and 20 wt. % titanium carbide powders which undergo laser treatment at power of 2430W, a microstructure exhibiting a homogeneous distribution of fine carbide particles was formed, and a 65% increase (724 HV) in hardness compared to a deposit made with only 431 stainless steel powders (438 HV) was observed [13].

Clad hardness is 4 times greater than substrate AISI 1030 medium carbon steel when it is treated under laser coating process with coating as a mixture of Ti (max size of 0.04 mm, 99.5% purity), graphite (max size of 0.04 mm, 99.5% purity) and iron (max size of 0.04 mm, 98% purity) powder [14].

On the substrate of AISI 4140 steel it be able to be seen that the hardness of the laser coating layers of TiC(reinforcement)/H13 tool steel(matrix) is up to 600–860HV, much higher than that of the substrate(200–250HV), the power being used is 380W [15].

The coating of mixture of three powders TiC, WC and Co (wt%—30:64:6) on 45 steel produce a laser clad of high microhardness, 1000HV0.2 [16].

A powder mixture of Ni alloy, titanium (99.7% purity) and crystalline graphite (99.5% purity) was used as the coating alloy on substrate of 5CrMnMo steel which increased its hardness to 1250 HV0.2 [17].

Laser coating of 30 vol.% TiC particulates and 70 vol.% Ni-alloy powders on 1045 steel treated under a power of 1000W produces a clad of hardness HV0.2=1300 [18].

The values of microhardness of the laser clad layers with different pre-mixed compositions of Mo/TiC are 5–10 times higher than that of the as-received Al alloy. Compared with the as-received Al alloy AA6061, the cumulative wear failure of the laser clad specimens is 20–28 times better [19].

TiC has been deposited on 6061 Al alloy using the LSE technique with laser beam power of 1.8 KW to form a coating which was even adherent, and free of cracks and porosities with considerably high hardness and wear resistant .The common surface roughness of the coating was bring into being to be 13.5 mm and the coefficient of resistance computed to be approximately 0.64 [20].

Laser alloying of AISI 1045 steel with TiC powder fed by the dynamic blowing method was carried out. By changing the laser power, scan speed and feed rate values, the depositions properties were studied. most favorable parameters considerably amplified the surface hardness, and some dissolution of TiC in the molten Fe produced a small fraction of TiC dendrites upon re-solidification of the coating [21].

5. CONCLUSION

The aim of this paper was to describe briefly the basic of laser coating process and to highlight the potentials of laser coating and the laser coating processes. Laser coating is a novel coating process, which produces coatings with high thickness, metallurgical bonding and low heat input to the substrate. Different Laser coatings were reviewed. Main benefits of laser coatings are their significantly improved corrosion properties and coating adhesion typical application areas of laser coatings were also presented.

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