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Overview of Laser coating

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Abstract- The paper describes increasing interest 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 maintain 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 various 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.[Ref- S. Zhang, C. Zhang, W. Wu and M. Wang (2001)[1]]

2. DIFFERENT TYPES OF LASER SURFACE TREATMENTS

Initially we saw different types of surface engineering techniques. Among these we found that laser surface engineering technique was the preferred one.[Ref- A. Mchimann , S.F. Dirnfeld and I. Minkoff (1990)[2]] Again the laser surface treatment can be classified as follows:

- Laser treatment without use of external material

I. Laser transformation hardening

II. Laser melting

- Laser treatment with use of external material

I. Laser alloying

II. Laser dispersing

III. Laser cladding

- Laser cladding is again done by two methods:
  i. By powder feeding method
  ii. By preplaced powder method

3. DIFFERENT TYPE OF LASERS THAT ARE USED FOR LASER SURFACE TREATMENTS

There are many different types of lasers. The laser medium can be a solid, gas, liquid or semiconductor. Lasers are commonly designated by the type of lasing material employed: [Ref- P.H. Chong, H.C. Man and T.M. Yue (2002)[3]]

A. Solid-state lasers:

These are the lasers having lasing material distributed in a solid matrix (such as the ruby or neodymium: yttrium-aluminium garnet "YAG" lasers). Solid state laser operate at a lower wavelength which improves absorption characteristics i.e. metal surface absorbs better energy from laser beam. Nd: YAG laser cladding process is twice as energy efficient as the CO_2 laser cladding process.

B. Gas lasers:

Helium and helium-neon are the most common gas lasers. These lasers have a primary output of visible red light. CO_2 lasers are most traditional high power lasers. They have characteristics of very high power and power density, moderate efficiency, reliable operation and excellent beam quality. They have high wavelength 10.6 μm which results in lower absorption of laser beams by metals.

C. Diode lasers:

With the advent of diode laser, High power diode lasers (HPDL) in the kilowatt range and with larger rectangular beam profiles (almost uniform intensity distribution) become appropriate tools for laser surface engineering.

In addition, due to high optical efficiency, and low running costs diode laser become relatively less expensive compared to CO_2 and Nd: YAG lasers. The wavelength of the emitted radiation in case of diode laser allows higher absorption by metallic surfaces than CO_2 laser.

D. Fibre Laser:
In these lasers the active gain medium is an optical fiber doped with rare earth materials like erbium, yttrium, neodymium, thulium etc. delivery of the beam doesn't require any complicated or sensitive optics. Beam quality is very high with very high power generation.

4. LASER COATING METHODS

Depending on the way the coating powder is added to the substrate surface before or during the laser processing, the laser coating technique is classified as given below which is illustrated in fig 1.

- Pre-deposition laser coating
- Blown powder laser coating

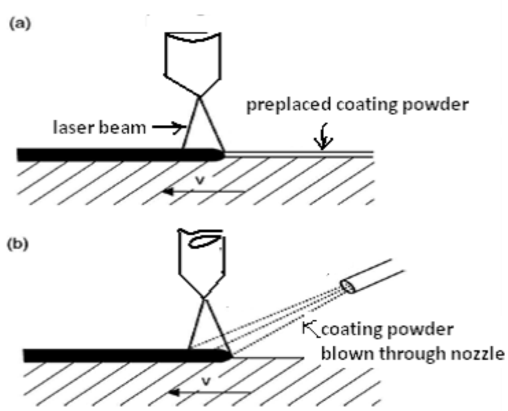

Fig.1: Laser coating by (a) Preplaced powder method and
(b) Blown powder method [Ref-H. Gedda, 2004 [4]]

Laser coating with preplaced powder:

Preplaced powder method is the simplest method of the two mentioned above provided that the powder can be made to remain in place until melted. The powder is thus mixed with a binder. The working area is shrouded by an inert gas. The preplaced powder method involves scanning of the laser beam over the powder bed. Figure 2 depicts the preplaced technique [Ref- X. Wu(1999)[5]]

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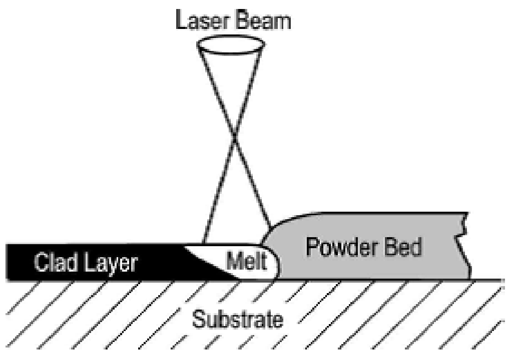

Fig .2: The preplaced powder cladding technique.

4.1. Preplaced powder coating technique is a three stage melting process. Its three stages are as follows:
I. The laser beam rapidly melts the coating powder before the melt touches the substrate. This is because, prior to contact with substrate, the melt is surrounded by powder which has low conductivity.

II. As the melt touches the substrate it loses a maximum amount of heat by conduction which leads to partial solidification of the melt. As a result the melt liquid interface does not move into the body of the substrate.

III. If the laser energy continues to irradiate from the top surface of the melt, the energy will gradually move the melt/solid interface back through the clad layer and across into the body of the substrate. [Ref- S. Tomidaa, K. Nakatab, S. Sajic and T. Kubod (2001)[6]]

Advantages of preplaced powder coating:
- It is cost effective
- Its procedure is simple
- It can be used for testing purposes for small scale production of coated materials

Blown powder method of laser cladding:

Blown powder method produces a high quality coating layer with minimum dilution. In this method powder is injected into the melt pool by using a carrier gas and the nozzle is directed at an angle of 380 to 450 (from the base) towards the substrate. The powder particles get heated when they pass through the laser beam. At the interface melting starts and the molten coating powder particles are trapped in the melt pool.

The basic system of blown powder laser coating set up is made up of

- Laser device which generates the beam of optics and direct it
- a powder feeder
- and a part manipulator

5. APPLICATIONS OF LASER SURFACE COATING TECHNIQUE

I. It is the best technique for coating any shape

II. Ideal for repair and distortion: preferably used for restoring worn blade tips and labyrinth seals (particular depositions for repairing parts).

III. Most suited technique for graded material application.

IV. Optimal part design by dissimilar metal deposition.

V. Material research and development.

VI. Wear resistance and fatigue life improvement.

6. CONCLUSION

The aim of this paper was to describe briefly the basic of laser coating (also called laser cladding or laser spraying) process and to highlight the potentials of laser coating and the laser coating processes. Laser coating is a novel coat process, which produces coatings with high density, metallurgical bonding and low heat input to the substrate. Laser coating types were reviewed. Main benefits of laser coatings are their significantly improved corrosion properties and coating adhesion typical application zones of laser coatings were also presented.

Future scope

Study the tribological behaviour (wear resistance, coefficient of friction) of the developed TiC coating. Development of in-situ laser cladding process for exhibiting benefits of production of coating powder within the laser system itself and using TiC as reinforcement and along with it some other metals which serve as matrix and improve the surface properties further.Use of continuous working high power diode lasers, fiber lasers and sophisticated knowledge based controllers that help in producing uniform laser coating which is less susceptible to variations in process parameters.

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