Techno-Commercial Analysis and Industrial Applications of Laser Cladding

[1]Nair Suraj, [2]Abirami.R, [3]Sreemathi.R
1. Student, Department of Mechanical Engineering, Hindusthan Institute of Technology, Coimbatore.
2. Student, Department of Electronics and Communication Engineering, Rajalakshmi Engineering College, Chennai.
3. Student, Department of Electronics and Communication Engineering, Coimbatore Institute of Technology, Coimbatore.

***Abstract* — Laser Cladding [LC] is been in use nowadays for their high accuracy in metal cutting and deposition, robustness and for their non-contact nature of operation. LC has its applications in manufacturing, medical, electronic, automobile and aerospace sector. The introduction of Laser Cladding for material deposition over conventional processes has led to increase in production rates. The Metal Addition rate [MAR] and Heat Affected Zones [HAZ] are comparatively low.**

Keywords : Laser beam, metal binding, Types Applications.

I. INTRODUCTION

Laser Cladding is a processing technique used for adding one material to the surface of another in a controlled manner. A stream of a desired powder is fed into a focused laser beam as it is scanned across the target surface, leaving behind a deposited coating of the chosen material as shown in Fig.1. This enables the applied material to be deposited selectively just where it is required. It is often used to improve mechanical properties, increase corrosion resistance and repairing of worn out parts

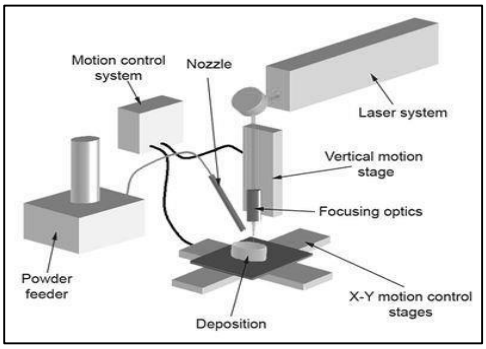

Fig 1: Laser Cladding.

II. PRINCIPLE

Laser cladding consists melting a metallic filler material with a very thin surface layer of the substrate to make a metallurgical bonding. Material is brought mainly as a powder which can be injected laterally or coaxially to the laser beam.

III. TYPES

Types of Laser cladding processes include
1. Pre-placed powder laser cladding
2. Wire feed laser cladding
3. Powder Injection laser cladding

1. Pre-Placed Powder Laser Cladding

Pre-Placed Powder Laser Cladding method [Fig 2] involves covering the substrate material with the coating powder. The incident laser beam causes the powder to melt by heating it, the molten coating material transfers heat to the base metal and helps form strong bonds with it. The most common type of laser used for heating the coating material is CO_2 laser Chemical binders are mixed to the coating material powder so that powder sticks to the substrate surface during the whole process.

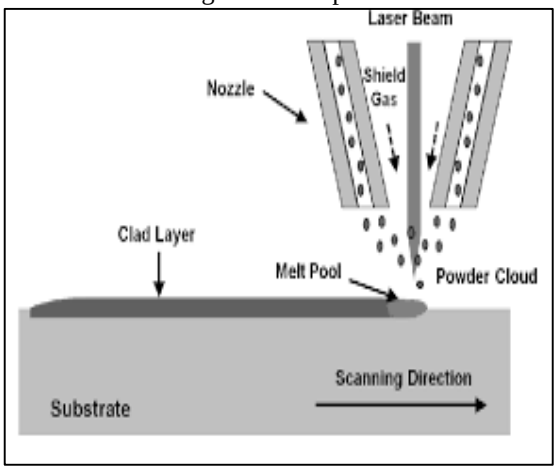

Fig 2: Pre Placed Laser Cladding

2. Wire Feed Laser Cladding

Wire method [Fig 3] uses a drum to feed the coating material as a thin wire to the laser. The laser melts the wire and a coating is coated on the substrate material. Unlike pre placed powder method, this method doesn't involve two stage process and the speed of the feed of coating material via wire feed can be controlled thus we can get more thickened layer and much uniform layer of metal coated on the substrate.

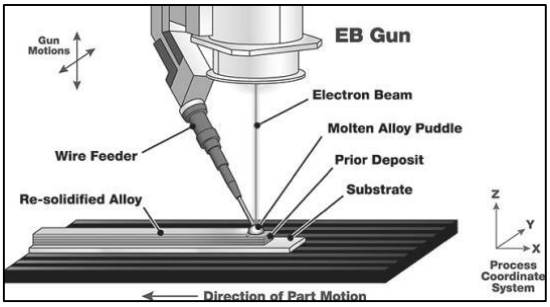

Fig 3: Wire Feed Laser Cladding

3. Powder Injection Laser cladding

In Powder Injection Laser Cladding [Fig 4], the powder is injected through a co-axial nozzle; the powder will be heated by the heat of the laser as it is injected into the path of the beam and forms the clad region. The movement of laser over substrate surface is guided by CAD/CAM system. There are two different takes on the clad delivery system. The first method is online method in which the powdered metal is delivered to the substrate through the use of a coaxial system. The alternative to the online method is the lateral injection method. The lateral injection method has the feed nozzle position to the side of the laser. The powder is commonly injected with the help of inert gases such as argon, helium or nitrogen.

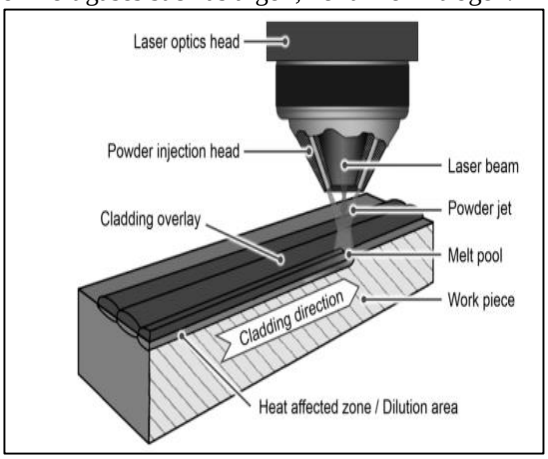

Fig 4: Powder Injection Laser Cladding

IV COMMERCIAL ANALYSIS

The comparative analysis of laser cladding over other metal coating processes such as thermal spray, pulsed vapour deposition (PVD) and chemical vapour deposition (CVD) are tabulated in Table 1.

Table 1: Comparison of Processes

Feature	LC	Therm. Spray	PVD	CVD
Bonding Strength	High	Mod.	Low	Low
Dilution	High	Nil	Nil	Nil
Coating Thickness	Upto 2mm	Upto 50µm	Upto 50µm	Upto 50µm
Heat Affected Zone(HAZ)	Low	High	Very Low	Very Low
Cost	High	Mod.	High	High

V. ADVANTAGES

1. Coatings of materials such as various alloys and carbides which are not available in wire form can be obtained.
2. More flexibility of the deposition angles of coating material on the substrate.
3. It offers high surface finish.
4. Thermal input can be precisely controlled.
5. Low maintenance and low deformation of the substrate.
6. Low dilution and porosity rates.

VI. DISADVANTAGES

1. The system is not portable as it requires large equipment size.
2. Chemical binders used cause porosity of the clad region which affects the whole process.
3. Sometimes uneven distribution of laser heat on the substrate causes uneven coating thickness of clad on the substrate surface.
4. Uneven feed of wire or powder for deposition leads to altered coating thickness.

VII. INDUSTRIAL APPLICATIONS

Laser Cladding of Steam Turbine Blades

Steam turbines which are used in power generation and in industries are normally subjected to wear and corrosion when used for a long period of time reducing their life. With the help of laser cladding process, a coating of chromium or zinc is made on the blade surface so that their life gets increased and can operate with same efficiency. The laser Cladding of Steam turbines is shown in Fig 5.

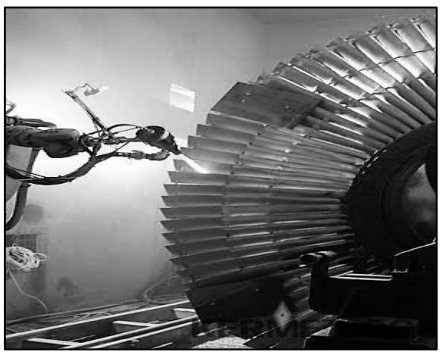

Fig 5: Laser Cladding of Steam Turbines

Repairing of Worn Out Parts

Shafts, Propellers and Impellers used in automobile and aerospace industries gets worn out after a particular amount of time usage, thus a protective coating of Stellite and Triballoy T-800 is applied on them using laser cladding technology. Application of a protective LCV-Corroslide on agricultural machineries helps reduce its corrosion and Coating of two Ni-based alloys and one CO-based alloy are deposited by laser cladding on steel pipes in the oil and petroleum industry [Fig 6].

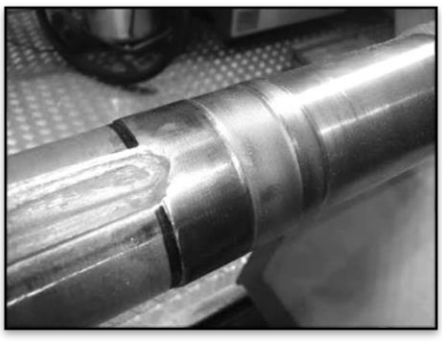

Fig 6: Repairing of Worn Out Parts

Coating of Nickel or Chromium on Cylinder Block

Cylinder Blocks of Internal Combustion engines are usually subjected to high temperature forces due to combustion of fuels and wear due to reciprocating action of the piston inside the cylinder, thus laser cladding of Nickel or Chromium on Cast Iron made cylinder blocks shown in [Fig 7] helps increase its life by reducing its wear rate.

Fig 7 : Nickel / Chromium coated Cylinder Blocks.

Laser Cladding on Piston Rods

Piston Rods are used in Internal combustion engines to convert reciprocation motion of piston inside the cylinder block to rotary motion of the crank, the piston rods or connecting rods are called as heart of the IC engines and are normally made up of plain carbon steel material and has to laser cladded with nickel or chromium [Fig 8] so that they don't wear when used for a prolonged period of time.

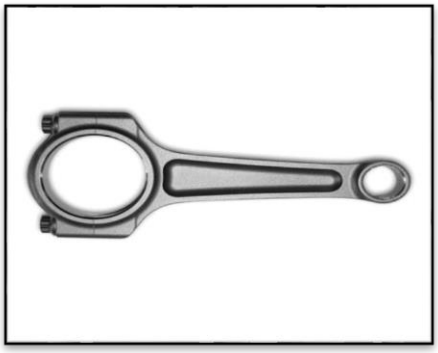

Fig 8: Laser Cladded Piston Rods

VIII CONCLUSION

Thus this paper covers the basics of Laser Cladding, it's various industrial applications, it's pros and cons over the conventional material deposition methods. In comparison to the other processes ,Laser Cladding proves to be an efficient method and offers high quality of material deposition, the process is quite simple and as it's a non-contact process the amount of material deposited, the heat affected zones can be controlled easily. The use of robotic arms and CAD/CAM systems help reduce the error rates in Laser Cladding operation.

IX. REFERENCES

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