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Review Article

A BRIEF OVERVIEW ON CLADDING TECHNIQUES WITH A REFERENCE TO WELD CLADDING USING GAS METAL ARC WELDING

Anup Kumar Verma[1] and Dr. Santanu Das[2]

[1]M.Tech Student, Department of Mechanical Engineering, Kalyani Government Engineering College, Kalyani-741235, email: anupkgec@rediffmail.com
[2]Professor and Head, Department of Mechanical Engineering, Kalyani Government Engineering College, Kalyani-741235, email: sdas.me@gmail.com

Abstract: Components working in a corrosive environment get corroded, and wear out fast.It requires frequent repairing or replacement. This results in low service life of the system, and adds to the capital cost. To overcome this problem, certain surface treatment technologies are used to improve surface properties of components working in corrosive environment. Cladding is one of the surface treatment techniques.Thermal spraying, laser-based methods, and arc welding are the techniques usually used for cladding. Among various arc welding techniques, gas metal arc welding (GMAW) process offers cost effective good quality weld clad. In this paper, a brief overview of different cladding techniques is made with a special reference to GMAW based cladding.

Keywords: Surface treatment, cladding, GMAW

1. Introduction

Many engineering components are exposed to corrosive environment which reduces their service life. There are numerous industries, such as, chemical and fertilizer industries, nuclear and steam power plants, food processing and petrochemical industries, etc. where corrosive environment is inevitable. In such engineering applications, materials (like duplex stainless steel) having high strength and corrosion resistant properties are desirable for long term reliability, and performance of the whole system [1]. Materials possessing the above properties are, however, costly. Consequently, their use to manufacture components will add to their cost. To overcome this kind of situation, so that the service life of a component can be increased by keeping the cost of the material reasonable, the process of surface treatment is used. In this process, a filler metal or alloy is deposited on the parts that will impart to them resistance to wear, corrosion, heat, cavitation, etc. Thus, the particular requirement for the material surface is met without using large quantities of expensive metals or alloys. There are several types of surface treatment processes among which cladding is one important process.

2. Cladding

Cladding is a type of thermal surface treatment process in which a layer of hard or corrosion resistant alloy is placed on a cheaper substrate, so as to increase the corrosion resistance,wear resistance, and hardness of a component with an objective of increasing the service life of the same [2].

Unlike hardening in which the properties of the surface layer of substrate to a certain depth is changed, cladding creates a new surface layer with different composition than the base material. In other words, cladding does not influence the microstructure of the base metal; it simply provides a protective layer of the filler material having different composition to that of the base material. It is a process which finds its way in various industries for the improvement of wear, or corrosion, resistant properties of components [3].

Weld cladding is not only used to increase corrosion resistant properties of a surface [4], but also is employed to repair a worn out component to restore its original working condition [5], such as turbine blades in a power plant.

Technologies commonly used for cladding are:

- Thermal spraying
- Laser-based methods
- Arc welding

2.1. Thermal spraying

In this technique, the base material is coated with the clad material (metal, ceramic, or plastic). The clad material is melted by a heat source, and is projected as a spray on the surface of the substrate [3]. Here the bond between the base metal and the deposited metal is purely mechanical [6]. This gives rise to the problem of poor wear resistance, and the dilution is zero. The most common types of this technique are:

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

2.2. Laser-based methods

In laser cladding, fusion between the clad material and the base metal is obtained by the thermal energy obtained from a laser source. Compared to other processes, laser cladding needs quite low rate of dilution, since the base metal to a small thickness is required to be for achieving the required metallurgical bonding with the clad material [7]. Following type of lasers are used for cladding:

- CO_2 laser
- Various forms of Nd:YAG lasers
- Fibre lasers
- Diode lasers

Application of laser cladding is limited by fairly high initial investment, and in some cases, the requirement of the size of the setup (as in CO_2 lasers) creates certain limitations in its application [3].

2.3. Arc welding

In arc welding techniques for cladding, the required metallurgical bond between the base metal and the clad material can be obtained by melting them by an arc, and subsequent fusion of the molten metal forms the clad layer.In most cases, a shielding gas is used to isolate the metal pool from the atmosphere. Arc welding techniques used for cladding are [3]:

- Plasma arc welding (PAW)
- Plasma transferred arc (PTA)
- Gas tungsten arc welding (GTAW)
- Gas metal arc welding (GMAW)
- Submerged arc welding (SAW)
- Flux cored arc welding (FCAW)
- Electro slag welding (ESW)

Arc welding process offers high productivitywith a strong metallurgical bond, but it suffers from high dilution rate which is undesirable for a good cladding.

3. Gas Metal Arc Welding Used for Weld Cladding

Among various arc welding processes for weld cladding, gas metal arc welding (GMAW) is considered as one of the best processes due to its various advantages to produce good quality weld. One of the various advantages of gas metal arc welding is its adaptability to weld different metals, and cladding is a process which basically involves coating of base material with a layer of a different material superior in hardness, and others properties than the base material. In this process, problems like slag inclusion, porosity, etc. does not arise because flux is not used [8,9].

This GMAW process allows to have a control over the mode of metal transferas per requirement by proper selection of shielding gas (or combination of the shielding gases), voltage, welding current, electrode composition, and electrode extension to ensure quality of weld. Research works done on metal transfer control show that the amount of the metal transferred as well as the time of stay of the droplets inside the plasma (which determines the temperature of the droplets) can be controlled by separating the process of heating of the base plate, and transfer of the metal droplets across the arc. For achieving this purpose, methods like pulsed-power welding, vibration of the electrode, etc. are proposed. The use of electrode vibration for the early detachment of the metal droplet from the electrode tip proved to be more advantageous than the pulsed-power welding, where the former process requires less current than the latter. This process is also useful with DC power source where the metal droplets are heated too much; the early detachment of the metal droplets prevent them from getting overheated, and the extra heat of the arc plasma is utilized for melting more of the electrode whereby reducing the current requirement [10]. Here, flux is replaced by a shielding gas of Ar, He, CO_2 or N_2 which ensures that any contact of the molten weld metal with the atmosphere does not occur. As a result, the molten metal is shielded from oxygen and nitrogen, which otherwise will react with the two gases to form oxides and nitrides leading to several welding defects like porosity, slag inclusion, etc [11]. Again, as no flux is used, there is no possibility of slag formation which also adds to the quality of the weld.

Arc welding processes suffer from the problem of high dilution; for gas metal arc welding process, it has been experimentally established that extra preheating of the filler wire reduces the dilution of the weld metal noticeably. This extra preheating reduces the welding current which is mainly responsible for the heat generated at the welding zone, thus lesser amount of the base metal is melted reducing the dilution [12]. In some recent experimental investigations, it is reported that cladding with flux cored duplex stainless steel electrode and austenitic stainless steel, substantial improvements in anti-corrosive properties are obtained with good strength of clad portion at certain process conditions [13,14].

Moreover, this process can be easily automated which eliminates defects like waviness of bead that can occur during manual welding. All these advantages makes gas metal arc welding (GMAW) process more productive and economical than other welding processes for cladding.

4. Concluding Discussion

Cladding is well applied as a surface treatment process. Three methods are used for cladding, namely thermal spraying, laser based methods, and arc welding process. Of the three methods, laser based methods provides a good quality clad layer, but its set up cost is fairly high limiting its use. Arc welding processes are more productive, and economical. In gas metal arc welding process, control of variables is allowed that affects the mode of metal transfer. By pulsed-welding, and electrode vibration technique, the shape and temperature of metal droplets can be controlled, and thus, melting of the electrode and heating of the base plate can be isolated to some extent. High dilution related to arc welding processes can be lowered by the use of preheating in case of gas metal arc welding.

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