Welding Overlay & Automation

By **James Rodrigues**

Welding overlay is a term used to describe a group of techniques also called hard facing, cladding or surfacing. Various welding processes are commonly used with a purpose to restore dimensions of worn surfaces of used components by depositing new and improved material or metal same as the component to extend their useful working life. In this case, it would be referred to as surfacing or reclamation.

Alternatively, when applied to a new or worn part, to protect a common low cost metal with a layer of a complex costlier alloy presenting different characteristic properties that better resist wear, abrasion, impact thereby improving the usefulness of the original component it will be called hardfacing.

Corrosion and high temperature scaling has a major influence on the rate of wear in certain environments and become significant factors in selection of hard facing material. To effectively combat a range of wear conditions, a large number of different hard facing alloys have been developed and modern welding process technology applied for best results.

Hardfacing Benefits

- Building new parts with assured longer life of elements subjected to wear and abrasion.
- Rebuilding worn parts at a fraction of replacement cost.
- Producing more economic parts by placing costly hardfacing alloy only where needed.
- Reducing breakdown time and increasing work efficiency.

This article will briefly describe the common welding processes which are used for automatic welding overlay.

The importance of welding automation for hard facing is

1. Skilled welder is not required.

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Valve stem hardfaced with PTA

2. Repeatable and consistent defect free results.
3. Highly improved smooth weld finish reduces post weld machining.
4. Highest possible deposit rates, deposit efficiency, shorter arcing time, lower labour cost and high productivity.

Commonly used processes with their benefits and applications are listed below.

1. PTA or Powder Plasma Arc Welding

This is a true welding process although sometimes also clubbed with the thermal spray processes. The plasma torch is unique in that the tungsten electrode is enclosed by the copper anode and the argon gas made to pass in the intervening space.

This produces a hotter more directionally stable arc than that produced by GTAW or GMAW. Argon gas also transports the powder which is fed into the arc as well as shield s the weld from oxidation during deposition. Plasma arc welding fits well into high speed production applications requiring thin weld overlays but heavy deposits upto 14 pounds per hour can also be made. Deposits from 0.25 mm to 6.4 mm can be made in a single pass. High deposit rates along with smooth deposits which require less finishing significantly lowers total cost as compared to most other deposition methods.

Automated TIG weld

Typical application areas of the PTA technology are extruding machine screws, valves, valve seats of internal combustion engines (motorcar, marine, locomotive etc.), accessories for ships, petrochemicals and power generation, cutting tools (milling cutters, broaches, knifes), Equipment for mining, crushing, rolling, road building and tunneling, Process equipment in ceramics and cement production, Moulds and forging dies, Pulp and paper industry equipment, Agricultural equipment, parts for nuclear plants, and parts for chemical plants.

PTAW can be adapted for overlay in bores. For precise very thin layers with very low dilution, powder fed PTAW is the best process for bore surfacing.

2. GTAW or Gas Tungsten Arc Welding

In this process, gas, either argon or helium, flows between a non-consumable tungsten electrode and the base metal protecting the tungsten and the deposit from oxidation. GTAW can be used to produce defect-free, high quality welds. With the help of a cold or hot wire feeder the process can be automated usually for applications requiring small wear resistant deposits. GTAW torches have been modified for bore welding applications. For example, a gas cooler shell from offshore oil rig has been weld cladded with Inconel 625, the main bore with automatic GMAW and the branches and nozzles by automatic GTAW.

Applications in oil and gas industry

3. FCAW/ GMAW

Manufacture of Fully Automated System Using MIG/SAW Process for Hardbanding of OD Wear Protection on Drill Collars

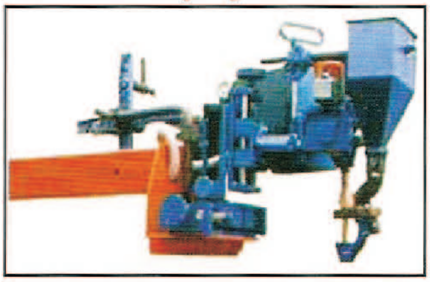
Flux cored arc welding or gas metal arc welding is a semi-automatic/automatic consumable electrode process that uses an inert gas to protect the electrode, the weld puddle and the surrounding area from oxidation. The electrode is in the form of solid or flux cored wire, and is fed automatically maintaining a constant arc length. Relatively high deposition rates with excellent quality welds are normally obtained. The process is suitable for automated repetitive weld overlay requirements. The shielding gas can be argon, helium or mixtures with CO_2 etc depending on the requirements. The consumable is in the form of a wire typically 1.2 mm or 1.6 mm. One variation is the use of tubular metal cored wires containing metallic alloying elements plus de-oxidants in powder form in the core. The process is extensively used for repair and resurfacing of railway crossings, crushing hammers in cement plants, coal crushing hammers in power plants and concast rolls in steel plants. GMAW can be used to clad bores of pipes and

valves with openings less than 25 mm with wear and corrosion resistant alloys.

4. Submerged Arc Welding

Submerged arc welding is a semi-automatic or fully automatic consumable electrode arc process in which the arc is protected by a granular, fusible flux which blankets the weld puddle and surrounds the base metal to protect it from the atmosphere.

Powder alloys can be added with the flux. This utilises the existing heat produced by SAW to melt powders and thereby increase deposition rates. The flux stabilises the arc, provides slag coverage, and also controls the properties of the deposit. Consumables are in the form of wire or strips. High deposition rates using current upto 2000 Amps in AC or DC mode, deep penetration, easy slag removal and smooth and excellent quality welds are common with this process. SAW is a highly productive process for surfacing large areas.

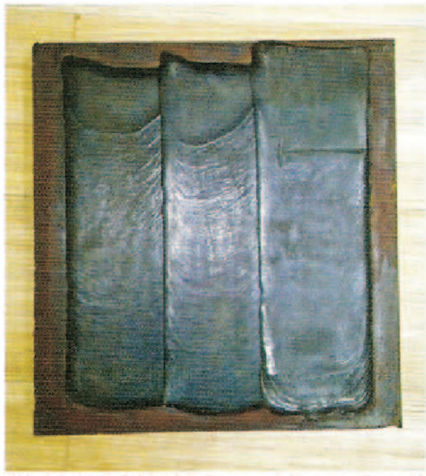


Fully automatic systems are used for heavy depositions in various areas such as surfacing continuous casting rolls, blast furnace bells, forging die block, inside of ball mill shell, etc.

5. Electro Slag Welding

Electro slag welding is initiated by starting an arc between the electrode and base metal. The heat of the arc melts the added granulated welding flux. With the formation of sufficiently thick molten slag layer all arc action stops. The passage of welding current through the conductive slag leads to ohmic heating of the consumable, base metal and flux. The electromagnetic action leads to vigorous stirring of the molten slag. Heat diffuses through the entire cross section being welded. The electrodes used are wire or strips. As there is no continuous arc ESW produces 50 % less dilution than SAW. ESW has been used in similar applications as SAW with far superior results.

Materials for hardfacing are mostly sold as proprietary alloys. They are only partially covered by specifications like

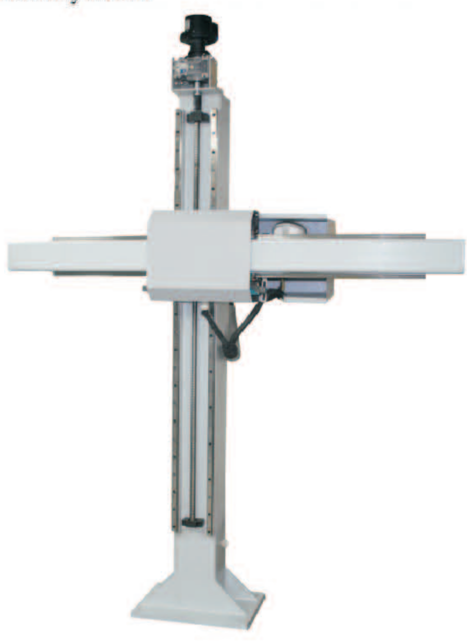


AWS A5.13 Surfacing welding rods and electrodes. A5-21 covers tungsten carbide alloys and other alloys in composite form.

Common Consumables Used in Hardfacing

Hardfacing is good for substrate materials that are suitable for welding, such as low-carbon steel. The most common hardfacing materials are nickel alloys and iron/chromium alloys used in wear resistance and high stress abrasion. Common materials for hardfacing are listed in Table 1.

Common SPM used for automating the welding process are Column and Boom, Positioners, Turntables, Rotators, Oscillators, Seam Trackers, AVC , Robots , welding lathes, and many others. These can be simple relay and contactor operated systems to sophisticated digital and computer controlled programmable systems.



Column and boom

Metal Alloy	Purpose
Cobalt-base alloys	Wear and corrosion resistance
Copper-base alloys	Rebuilding worn machinery parts
Iron chromium alloys	High stress abrasion
Manganese steel	Impact resistance
Nickel based alloys	Low stress abrasion, corrosion and heat resistance
Tool steel	Tooling, wear application
Tungsten carbide	High stress abrasion

Table 01

From the above common processes and consumables, more than one selection will be likely to provide adequate service for a given application, although the most economical solution may not be evident easily enough.

Adequate thought has to be dedicated to the type of base metal, to preparation and preheating, if needed, and to final stress relieve or slow cooling. "As-welded" hardness is a useful datum to know and check, although it may not be the most important element determining the success of alloy and process selection for the application.

The use of hardfacing to extend usefull life of components is firmly established where the economics are obvious despite relatively high cost of consumables and labour .

The cost of its application can and should be estimated, with some assumptions, so that the comparison of alternatives becomes possible. Selection of process and of welding consumables has a major influence on the total cost. The following cost elements should also be taken into account:

- Volume of material to be deposited.
- Process to be used.
- Deposit efficiency (Ratio of deposited material to consumable material used).
- Operating efficiency (Ratio of deposit time to total time including setup, preparation, preheating, transport, finishing etc.).
- Consumable costs (Flux, gas, power, welding material, labour and overhead).

Deposition labour cost are amenable to reduction through automation and engineering control of deposition rates and deposition efficiencies.

Welding positioner

In those applications where total hard facing economics are not obvious the decision to hard face or replace a component subject to wear is a complex decision involving component life, cost of repair or replacement, unscheduled downtime, scheduled downtime, spare parts inventory cost plant output and overheads.

Experience and careful application of lab data are required to identify the most cost effective hard facing system for a particular service application. ■