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SURFACING

Today's industry is required to manufacture components with superior properties for longer service life and in an economical manner. The aim is to achieve an improvement in surface properties by altering surface characteristics in a component.

Components often fail their intended service not only because of fracture, but because of additional factors such as wear, abrasion and corrosion which cause them to lose dimension and functionality.

The service conditions most commonly experienced by components are:

A. Abrasion B. Impact C. Oxidation D. Metal to metal wear E. Erosion F. Corrosion

Out of the above modes of wear, Abrasion occurs in about 50% of cases. Then impact, metal to metal wear, corrosion and others in decreasing order.

Most of the components fail from a combination of modes, such as abrasion and impact. This decides the welding product/s to be used.

SURFACING:

Surfacing involves deposition of filler metal on a base metal to obtain desired properties or dimensions. This broad definition can include processes like electroplating and metal spraying. In metallurgical terms, surfacing is depositing a filler metal on base metal to build up wear resistant or corrosion resistant overlay by welding or spraying. It is composed of one or more stringer or weave beads, on a surface to obtain desired properties or dimensions.

Welding consumables designed for wear-resistant applications are commonly referred to as hardfacing consumables, in spite of the fact that hardness is not always a true measure of wear resistance.

It is apparent that surfacing consumables are meant to be used as much in the design of new components as in the reclamation of used and or worn-out components in order to reduce their wear and tear in service.

Based on application requirements surfacing can be classified as:
I. Hardfacing Overlay II. Corrosion Resistant Overlay

I. HARDFACING OVERLAY:

Hardfacing is process of the deposition of thick coatings of hard, wear-resistant materials on a worn-out or a new component surface that is subject to wear in service. Welding and Thermal Spraying are the processes generally used to apply hard facing layers.

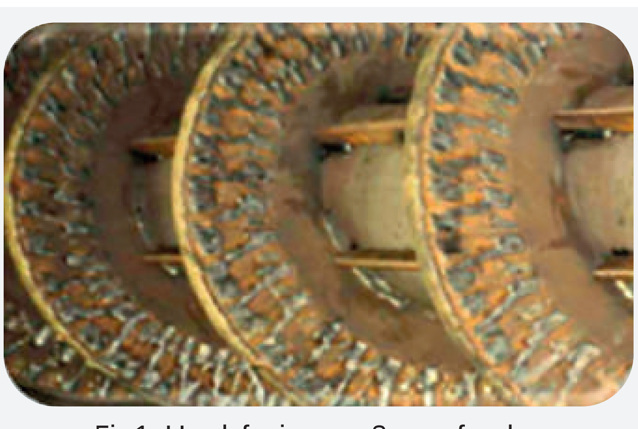
Fig1. Hard-facing on Screw feeder

Thermal spraying is preferred for applications requiring minimal thermal distortion of the component and good process control. Cermets such as WC-Co and alumina-based ceramics are deposited by thermal spraying. These coatings are applied to a thickness of about 0.3mm and have limited usage.

Weld hard facing by conventional welding processes is used to deposit very thick up to 10mm dense layers of wear resistant material with a good metallurgical bond.


Fig. 2 Hardfacing on Pipe

Most commonly used alloy system for hardfacing is iron based chromium carbide alloy with Cr>17% and C>3%. These type of alloy can resist wear upto 350°C. With various proportion of chromium carbides in combination with refractory metals such as Nb, W, V can achieve high temperature hardness and wear resistance upto 750°C.

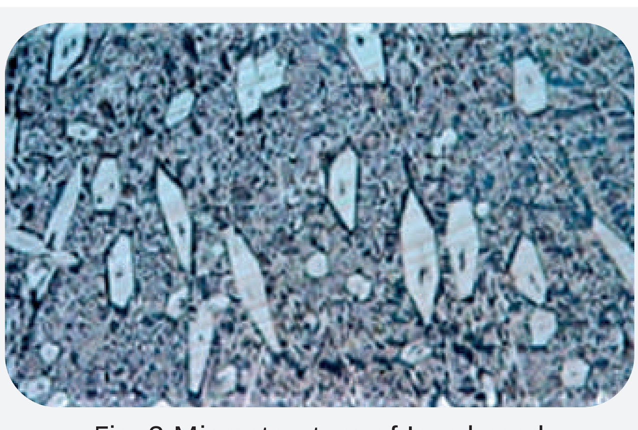
Fig. 3 Microstructure of Iron based Chromium Carbide alloy

Typical hardness data:

Bulk hardness : 55-60 HRc

Carbide hardness : 900-1200 VPN

Matrix hardness : 500-700 VPN

Apart from bulk hardness, the volume fraction of carbides, its shape and distribution in a matrix decides wear resistance of an alloy.

The bulk hardness requirements for wear resistant applications generally vary from 50 to 68 HRc.

For hard facing applications, weld deposits are normally restricted to up to two to three layers. Limited-layer products usually are in the metal carbide families such as chromium carbide, complex alloy carbides and tungsten carbide. For multi layer applications there are austenitic alloys and some martensitic alloys too are used.

STRESS RELIEF CRACKS:

The brittle nature of the metal carbides leads to stress relief cracking, and as multiple layers are applied, stress continues to build which concentrates at the root of the cracks, until separation or spalling occurs between the parent metal and the hardfacing deposit. These are the result of high stresses induced by the contraction of weld metal as it cools. These cracks always occur perpendicular to the bead length (Fig.4). The cracks propagate through the thickness of the weld bead and stop at the parent metal, as long as it's not brittle. In cases in which the parent metal is hard or brittle, there is need to apply a buffer layer of a softer, tougher weld metal. The austenitic family is a good choice for a buffer deposit.

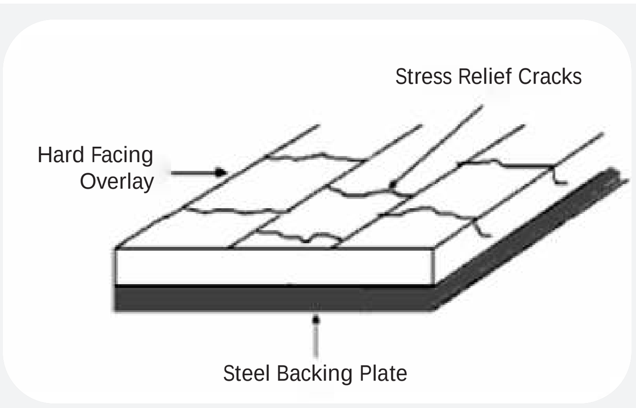

Fig. 4 Stress relief cracks on hardfacing weld

Many metal carbide alloys shows stress relief cracks when cooled to moderate temperatures; this is normal. Alloys from austenitic and martensitic families do not show this phenomenon when applied with proper welding procedures.

II. CORROSION RESISTANT OVERLAY:

These overlays are used to improve the service life of components made with an otherwise corrosion-prone material.

Surfacing for corrosion resistance is recommended for use of one layer only. However, for certain applications of wear areas of pump linings a second layer of surfacing is applied.

In this process, weld metal dilution is very important to control which affects ferrite percentage especially in case of stainless steel overlays.


Fig. 5 Corrosion resistant overlay cladding

OVERLAY PATTERNS:

Depending on the type of wear, there are several types of surfacing patterns can be used viz.; stringer, weave, zigzag, dot or a combination of all.


Fig. Straight bead with weaving


Fig. Zigzag pattern

BASE METALS:

Carbon and low alloy steels, Stainless steels, Mn steels, Cast irons, Nickel and Copper base alloys can be hard-faced. For steels with carbon content above 1% a suitable buffer layer is required. For corrosion resistant applications, Carbon and low-alloy steels are most popularly used.

WELDING TECHNIQUES:

Various welding techniques used for surfacing are listed in order of popularity. The major factor which affects the economics of hardfacing is deposition rate. Below table shows the estimated deposition rate for each process.

Process	Deposition Rate, Kg/Hr
Flux cored arc welding (FCAW)	3.5 to 11
Gas metal arc welding (GMAW)	2.3 to 5.5
Shielded metal arc welding (SMAW)	1.3 to 2.3
Submerged arc welding (SAW)	3.5 to 11
Gas tungsten arc welding (GTAW)	1.3 to 2.3

Strip Cladding (Electro Slag or Submerged Arc) is another technique for corrosion resistance overlaying of Stainless steel and Nickel based alloys. The other special surfacing processes are Plasma transferred arc welding (PTA), Laser cladding, Thermal spraying, and Brazing. With the Oxy-fuel welding (OFW) process too surfacing can be done but this technique is less popular.

WELDING FILLER METALS:

Surfacing filler metals available in the form of bare rods for Gas welding, GTAW, GMAW, SAW (to be used with agglomerated flux), coated electrode for SMAW process, strips for Strip cladding process.

Types of Surfacing Alloys:

Sr. No.	Alloy Base	Application/Hardness
I	Iron Base	
	a.	Austenitic typeCorrosion resistance, Impact resistance, Work hardening
	b.	Martensitic typeMetal to metal wear resistance, Abrasion and Impact resistance, Hardness: 20 to 60 HRc
II	Carbides	Severe abrasion resistance, Hardness: 40 to 65 HRc
III	Nickel Base	High temperature Oxidation-Abrasion resistance
IV	Cobalt Base	High temperature Oxidation-Impact-Corrosion resistance, Hardness: 25 to 55 HRc
V	Copper Base	Corrosion resistance and low frictional wear resistance

ADOR WELDING SURFACING CONSUMABLES

HARDFACING OVERLAY:

Application	SMAW	FCAW	SAW
Moderate Abrasion Impact	Zedalloy 250/350/350 LH		(Automelt H25 and Automelt H35) + Automelt EL8
High Abrasion-Moderate Impact	Zedalloy 550/550 LH/600	Automig FC 580	Automelt H55 + Automelt EL8
Work Hardening High Impact	Zedalloy 12Mn/16Mn		
Severe Abrasion	Super Zedalloy, Zedalloy VB, Zedalloy 16		
Abrasion-Corrosion	Zedalloy Bell, Zedalloy K, Zedalloy 17Cr NS Plus		
High Temperature Metal-Metal Wear	Nimoten Plus 535 A, Nimoten Plus 535 B, Nimoten HFD	Automig FC 400	
Sugar Mill Rollers	Maganacane		

CORROSION RESISTANT OVERLAY:

Base Material/ Application	SMAW	MIG/TIG	SAW
Stainless Steel			
Dissimilar Joining, Buffer Layer	Betanox D, Betanox DL, Superinox 312	Miginox-Tiginox 309/309L	Automelt S76+Subinox 309/309L
High temperature Corrosion Resistance	Betanox C	Miginox-Tiginox 310	Automelt S76+Subinox 310
Martensitic Alloy	Betachrome 13Cr, Betachrome 13/4, Betachrome 13/4 LB	Miginox-Tiginox 410/410NiMo	Automelt S76+Subinox 410
Ferritic-Martensitic Alloy	Betachrome 17Cr	Miginox-Tiginox 430	Automelt S76+Subinox 430
Mn steel	Betachrome N/ND		
Automotive Exhaust System		Miginox 430LNb	
Nickel based			
Nickel 200/201	Nicalloy 1	Automig-Tigfil Ni-1	
Inconel 600	Nicalloy Fe-2/Fe-3	Automig-Tigfil NiCr3	
Inconel 625, Inconel 825	Nicalloy Mo-3	Automig-Tigfil NiCrMo-3	Automelt S76+Automelt NiCrMo-3
Alloy C-276	Nicalloy Mo-4	Automig-Tigfil NiCrMo-4	
Inconel 625, Inconel 800	Nicalloy Mo-5		
LNG storage system for cryogenic application	Nicalloy Mo-6/Mo-12		
C-22	Nicalloy Mo-10		
Monel	Supermonel	Automig-Tigfil NiCu-7	
Cobalt Based			
Elevated Temperature Oxidation-Abrasion	Zedalloy CoCr-A		
Copper Based			
Copper-Steel joining	Bronze		
Corrosion, Erosion, Cavitation	Super CuNi	Automig-Tigfil CuNi	
Brazing			
Copper-Steel-Cast Iron	Bracc 2211		
Cu & Ni based alloy, Steel, SS, CI, CuZn20Al, CuNi10Fe, CuNi30Fe	Bracs 3343		
Surfacing of steel, bronze, CI	Bracc 7700		

BENEFITS:

For saving time and money on equipment maintenance and repair, surfacing is best available option.

The benefits of surfacing are:

I. Minimizes downtime required for replacement of worn-out components

II. Reduces inventory by reducing the amount of replacements needed.

III. Saves money

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