FCAW Welding Consumables for typical rebuilding applications in Steel Plants

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Introduction

Repair and rebuilding using welding techniques has been an accepted practice in many industries, to improve the service life of components and to combat wear, because of its inherent advantages in many applications. An ever increasing number of components are being repaired, rebuilt using various welding techniques to achieve better service life and reduce down time. This has been made possible to a large extent by the developments in the welding field also, like development of new, improved welding consumables, processes, techniques to suit the variety of components, service conditions encountered, base materials and the typical deposition constraints of various industries. While manual electrodes still continue to be the favorites for many applications, the other processes like open arc FCAW, FCAW with SA Flux have also made in roads in several typical applications.

The steel industry, with a host of typical components and service condition offers wide ranging challenges for the maintenance welding personnel. Over the years in this industry several repair, rebuilding applications have been studied and have used welding techniques, consumables to resist wear and achieve improved service life of the components. Many of these applications have been found to be cost effective and are being used by this industry. This paper details some of these applications together with the welding consumables, techniques for the rebuilding, repair work. There are several repair and rebuilding applications in steel industry covering a number of materials, service conditions, using several welding processes, techniques and consumables and it is very difficult to present all of them in a paper of this nature. Therefore in this paper an attempt has been made to highlight some of the typical applications involving flux cored wires (both open arc and with sub-arc flux).

FCAW Process

The flux cored wire process is a welding process in which a flux cored wire is used :

a) with a gaseous shielding – in most of the hard facing applications this is not preferred; this is preferred in joining applications.

b) without any shielding – This is an open arc process; mostly this type is preferred for hard facing applications.

c) with a sub-arc flux shielding – this gives a dual shield. This is also a preferred method in hardfacing applications; the arc is not visible; less fumes; good bead shape.

In this paper we will be discussing on the open arc versions and the sub-arc versions.

Advantages of FCAW process

As said earlier, even though SMAW is quite popular in several maintenance welding applications, FCAW because of its inherent advantages has scored over the SMAW process in several typical applications. The advantages can be

a) higher deposition rates as compared to SMAW; large volumes can be deposited in short time.

b) ease of automation.

c) ability to produce variety of compositions even in small lots.

d) adaptability to in-situ applications.

e) ideal for certain typical components.

Because of these advantages and with the shorter shut down periods for maintenance in industries, FCAW process is becoming popular by the day and is being considered for several applications.

FCAW Consumable Development

The development of welding consumable, especially for repair, rebuilding applications, requires a careful study of several factors including base material composition, service condition, deposition requirements, heat treatment requirements, ultimate mechanical properties desired etc. It is an accepted fact today that a mere hardness alone cannot produce the wear resistance and an evaluation of the micro-structure is absolutely necessary to design the most appropriate weld metal for a specific application. Therefore the development of weld metal should not only take into account the composition, hardness but also the consistent achievement of the desired microstructure taking into account the deposition constraints on the actual job including heat treatments.

Another constraint in development of consumable is the lack of any direct correlation between the laboratory tests and actual wear resistance, service life of the component. While there are several wear tests available through which the weld metals, base materials can be graded, there is no actual correlation of this data with the service performance of the component. The varying actual service conditions of the component, only add to the uncertainties and many times correlation becomes remote.

Therefore in development of consumable the following steps are very vital.

a) Analyzing the base material composition, service conditions, wear factors and job requirements and constraints.
b) Arriving at a weld metal chemistry, property and micro structure requirements and producing the FCAW wire which can produce that weld metal.
c) Establishing the weld metal at the laboratory level to suit the service condition through suitable wear tests etc.
d) Field trials to assess the actual performance.

Having understood the process, & steps in consumable development let us now take a look at some of the applications in steel plants, which use FCAW wires.

Rebuilding of concast rollers

The continuous slab castor rollers in steel plants are subjected to severe wear due to severe thermal, mechanical, cyclical stresses, abrasion, adhesion, oxidation and corrosion and the severity of each factor varies depending on the actual location of the rolls. Normally a low alloy steel forged roll is used for this application. The typical specifications include 13 Cr Mo 44, 21 Cr Mo V 511, 16 Cr 44, 42 Cr Mo4. One typical composition is given in Table 1.

Design of weld metal

To resist the wear on these rollers, several weld metals have been used

Specification	Composition %									
	C	Mn	Si	Cr	Ni	Mo	V (Ksi)	UTS (Ksi)	Ys	%Ei
21 Cr MoV 511	0.17-0.25	0.3-0.5	0.3-0.6	1.2-1.5	0.6 max.	1.0-1.2	0.25-0.35	110-150	100	18

Table 1 : Composition of some roll materials

Weld metal	% Composition							Hardness HRC
	C	Mn	Cr	Si	Ni	Mo	N	
Buffer	0.06	1.30	17.50	0.70	-	-	-	20 - 24
Working	0.04	1.30	12.50	0.70	4.00	0.40	0.12	40 - 44

Table 2 : Typical properties of weld metal developed for concast rollers

Process	Open arc FCAW ; automatic machine
Preheat temp.	150 – 200°C.
Inter pass temp.	150 – 200°C.
Post heating	None ; but slow cool
Stress relieving	None ; if required to be done at 550-600°C.

Table 3 : Welding procedure for concast rolls

Plant A	Life obtained	0.8 MT
	Observations	Appearance of fire cracks
	Life obtained with earlier methods	0.3 – 0.4 MT
Plant B	Performance	Crossed 0.6 MT; still in service
	Observations	Very low crack intensity

Table 4 : Performance of the weld metal in concast rolls

Base Material	Cast Steel
Temperature	350°C
Hardness	50-55 HRC at RT 45 HRC at 550°C
Deposit	Crack free
Weld metal compositior	0.10 C – 1.5 Mn – 0.55 Si – 5 Ni – 5 Mo

Table 5 : Crack free Weld metal for Bell

over the years, the typical ones conforming to AISI 420, 423 compositions. The process used is submerged arc welding process. The rolls reclaimed using these consumables, process, had typical problems like fire cracking, poor service life and to over come these, a fresh look at the weld metal was necessary. Further investigations in this direction led to the development of nitrogen bearing welding metals, which offered advantages like

a) substituting C; Carbon could be lowered with the addition of nitrogen, which improved the weldability; better corrosion resistance;

b) inhibiting grain growth.

c) Uniform microstructure.

d) Softer microstructure resulting in improved crack resistance; reduction in pre & post weld heat treatment temperatures.

Hence, weld metals with nitrogen additions were developed for rebuilding concast rollers. Table 2 will give details of the weld metals developed for buffer layers and working layers.

Welding Procedure

As it can be observed from the above discussions, not only chemistry is important, achieving the desired microstructure is also important. For the concast rollers it is preferable to have a martensite / tempered martenite structure with minimum of austenite, ferrite etc. This is possible only with carefully controlled welding procedures, parameters since the weld metal chemistry can produce mixed structures also. Table 3 will give the details of the welding procedure to be adopted for open arc FCAW process. Both open arc as well as FCAW with sub arc flux can be used for deposition.

Service performance

The developed wires were used for reclamation of concast rolls and the actual service performance was evaluated. Table 4 will give the details on this. Several tons of this wire has been used in this rebuilding application with satisfactory service life.

Blast furnace bell

Bell is one of the important components in steel plants and worn out bells require rebuilding from time to time. The component is subjected to a combination of abrasion and impact. Several weld metals have been used to resist this type of service condtion, the Cr-carbide type being the most common one. However, these weld metals exhibit a typical crack pattern which may not be desirable. Therefore crack free deposition is preferred in some cases. Table 5 gives details of a crack free weld metal for this application.

BLT Chutes

The bell less top arrangement uses these chutes which are fabricated out of M.S.Plates. Table 6 givesdetails of the service condition and the weld metal for this application. Substantial quantities of this weld metal from open arc FCAW wire has been used for this application with satisfactory results.

Crane wheel rebuilding

The constant rolling friction between the rail and the crane wheel produces wear on the wheel whichrequire rebuilding frequently. The Open arc FCAW process offers a faster, easier, automated method for rebuilding. Table 7 gives details of this application.

Sinter plant components

In sinter plant components like sinter star, sinter breaker spikes are rebuilt regularly using Open arc FCAW process and consumables. The weld metals for buffer layer (wherever required) and working layers are indicated in Table 8.

Back up rolls – HSM

They form an important component in steel plant, which can be rebuilt and improved service life can be obtained. The typical base material chemistry of back up rolls is given in Table 9. The intense cyclic, compressive stresses, frictional and abrasive wear makes this component wear out during service and sometime spalling also occurs. These rolls can be reclaimed using a buffer layer, working layer technique with either open arc or FCAW + SA flux process. Table 10 will give details on the procedure and the weld metals. But however, as far as the author's knowledge goes, established data on the actual performance of these reclaimed rollers with these weld metals not yet available in India.

Pinch rolls

The pinch rolls are subjected to metal to metal wear oxide scale abrasion and material sticking. The normal practice is to fabricate the roll using M.S and hard face the same. With the development of nitrogen bearing weld metals, these components can be rebuilt using these type of weld metals. Table 11 gives details on this weld metal.

CONCLUSION

Repair and reclamation is a continuous activity in steel plants to reclaim components for achieving increased service life and to resist wear effectively. Welding techniques, consumables, available today, take into consideration several aspects of the problem before arriving at a suitable solution. With a proper understanding and application of welding technology, it is feasible to achieve a better wear resistance and improved service life for several components in steel plants.

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Base Material	M.S.
Temperature	350°C approx.
Service condition	Severe abrasion
Hardness	60-65 HRC
Deposit	Cheek cracks & Two layers
Weld metal composition	5-3C – 22 Cr – 0.8 V – 1.3 Mn – 6.5 Nb – 2 W – 1.0 Si – 6 Mo
Service Life expected	18 months / 3.5 MT

Table 6 : Weld metal for BLT Chutes

Base Material	Cast Steel
Deposition	Crack free, two layers
Hardness	30 HRC
Weld metal composition	0.15 C – 1.5 Mn – 0.6 Si – 1.5 Cr

Table 7 : Weld metal for crane wheel

Weld Metal composition	0.12C - 4.3 Mn 0.55 Si - 16.5 Cr
Weld Metal Hardness	As Welded : 225 BHN Work Hardened : 550 BHN

Table 8(A) : Weld metal for Sinter components for Buffer Layers

Weld Metal composition	5.3C-22 Cr- 0.8V - 1.3 Mn - 6.5 Nb - 2W - 1Si-6 Mo
Weld Metal Hardness	60 - 65 HRC

Table 8(B) : Weld metal for Sinter components for Working Layers

C	0.85 - 0.95
Si	0.2 - 0.5
Mn	0.2 - 0.7
Cr	1.4 - 1.7
Ni	0.3 max.
V	0.10 - 0.25
Hardness	50 - 55 HRC
Weight	45 T

Table 9 : Composition of Back up roll base material

Buffer Layer (one)	0.1C - 1.2 Mn - 1.0 Ni - 0.5 Si
	0.3C - 0.65 Si - 1.3 Mn - 5.5 Cr 4.5 Mo - 0.6 Ni - 0.4 V Hardness - 50 / 55 HRC
Flux	Basic
Build up	Can be up to 50 mm on dia
Preheat & Inter pass temp.	350°C
Post weld heat treatment	Tempering at 550°C

Table 10 : Back up roll rebuilding

Base Material	M.S.
Buffer layers	0.06C - 17.5 Cr - 1.3 Mn - 0.7 Si
Working layers	0.03 C - 12.8 Cr - 0.5 V 0.13 N - 5 Ni - 0.8 W - 1.2 Mn - 0.6 Mo - 0.6 Si - 2 Co Hardness : 43 - 48 HRC
Process	Can be open arc or with SA flux

Table 11 : Weld metal for Pinch rolls.

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