INNOVATIVE WEARFACING / RECLAMATION TECHNIQUES

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Wear and tear of Bowl Mill - Crusher grinding Rolls and pulverized Fuel bends, very much depend on quartz (SiO_2) particle size distribution and quartz content in Coal. In Indian coal, quartz is considered to be most important constituent causing wear and tear. Coal used in thermal power plants contain high ash which while being carried pneumatically in pulverized form causes extensive wear/ erosion on components viz. P.F. bends, Mill parts, Coal burner nozzle, orifice etc.

Many a times, it is observed that, wear parts are discarded, even when the total weight loss in these vital, machinery components is only to extent of 10 to 15%. That means, nearly 85 to 90% materials is scrapped and remetted again in foundries. Similarly, single steel alloys, which are traditionally used to combat wear are not capable of withstanding devastating effect of abrasive wear when it is coupled with tension, compression, torque and shock leads. Therefore, the metallurgist is compelled to design the material which balances interdependent properties viz. hardness, toughness, and strength. There is a growing need now to conserve industrial goods/components by adopting latest technically and commercially viable Reclamation/Wearfacing Techniques. This paper presents :-

1. Weld overlaying on metals/alloys, which are considered to have absolutely poor weldability, e.g. Bowl mill crusher, grinding rolls of Ni-hard Grade, IV, or chrome iron.
2. Composite wear plate concept, when a wearing part is subjected to both stress and abrasive wear, the same should be made of two alloys fully bonded together i.e. a strong, tough base metal and hard wear resistant overlay. Though, this is performed by employing conventional hard facing welding consumables regularly, the fact that composite wearplates offer not only just unmatched wear resistance property, but also, it provides muscles on metals/machinery components, to combat wear very efficiently and economically.

INTRODUCTION

The crusher rebuild / special purpose machine :

It is designed to rebuild roll crushers bowl and mantile configurations as well as circumferential welding.

The basic principle is this :-Centrally locate a guid bar which follows the contour of your spool or fitting. Attach a weld head to a current carrying sleeve which is mechanically controlled to follow the guide bar at the correct travel speed, incorporate adjustments for stickout, bead width, voltage and wire feed speed. Mount this equipment on a sturdy frame.

Typical statics are as follows :

1. **Deposition rates**

   = 7kg/hr. - 2.8mm

   = 5 kg/hr. - 1.6 mm

These figures are based on weighted average for a SOL (single overlay)

- **Travel speed, volts, amps are predetermined by the wire used.**

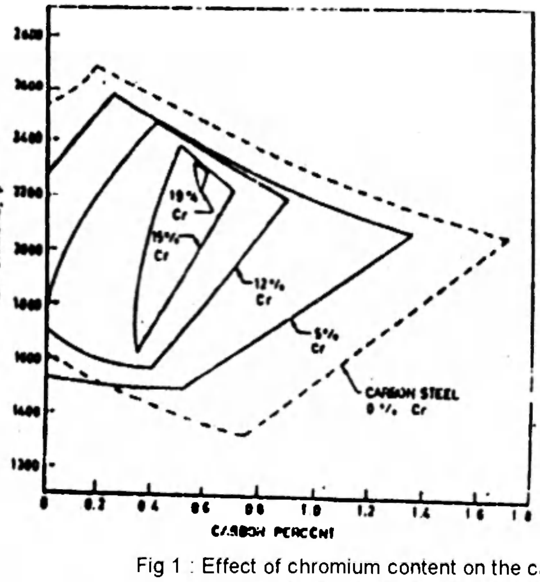


Fig 1 : Effect of chromium content on the carbon range for austenite at elevated temperature

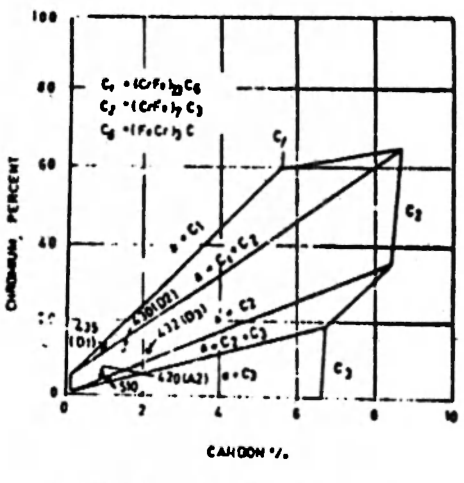


Fig 2 : Isothermal section of the iron-chromium - carbon system at 1290°F

- All processes are FCAW (Flux cored arc welding) using self shielded flux-cored wires and are "Open arc".
- Power sources :

  Conventional constant voltage machines for automatic welding with 100% duty cycle rating in the 350 to 450 amp. range.
- Control Capacity - Main console :

  Wire Feed speed - variable electric-mechanical 0 to 150 mm/sec.

  Electrical stickout - adjustable manual 0 to 80 mm

  Travel Speed - Variable electro-mechanical - 0 to 110 mm

  Bead overlap (Indx.) - variable electro-mechanical - 0° to 360°.
- Weld technique :

  Single bead deposition with no oscillation - for grinding rolls Multi wire deposition with no oscillation - for composite Plates.
- Positions : Flat to horizontal

Fe - Cr - C

Effect of Chromium on Structure

%	Cr Structure
0%	Ferrite and coarse graphite
0.3%	Ferrite + pearlite and finer graphite
0.6%	Fine graphite and pearlite
1.0	Fine Graphite and small amount of (Cr_3C) carbides
3.0	Disappearance of graphite, formation of Cr_3C) carbides and alloy cementite.
5.0	Much massive carbides Cr_7 C_3 and alloy cementite unstable.

10-30%Fine carbides - primary carbides of Cr_{23}, C_6, C_7,C_3 is displaced by Cr_{23},C_6

Welding Process

First grind, blast and clean the above wornout components and steel plates. Then check for surface defects by "Dye penetration test".

	Crusher grinding rollers	Composite wear plates
a)Base	NiHard Fr.II, Gr.IV, High chrome or any Alloy Iron /Alloy steel	Any type of steel plate with carbon equivalent less than 0.3 % or IS2062 plates
b) Welding Process	Open arc welding Fully Automated electronically controlled Alloy overlay Welding	
c) Filler Material	Self shielded FCAW wires of 1.6, 2.8mm (weld deposits shall be a. Chrome - Cardide b. Tungsten Carbide c. Complex Carbide depending on applications)	
d. Polarity Electrode (+) Ve DCRP		
e) Welding Technique single bead with out oscillations		Multiwire oscillations
f. Feed rate	0-15 mm/sec/vairable	
g. Travel	0-150mm/sec. vairable	
h. Stickout	40 mm or more	
i. Position	Flat / Horizontal	
j. V/A	40-45 / 600 - 650	
k. Hardness of weld over lays	575 - 625 BHN	

- Chrome Carbide - C - 5%, Cr - 27%, Min - 3%
- Tungsten Carbide - 60% Tungsten Carbide in Stainless steel matrix.
- Complex carbides - Mixed carbides of C, Cr, Mo, V, Ti/Nb, W etc.

Metallurigical Considerations 3 Alloy weld Deposit [3]

The composite wear plates, where in mild steel base plate is cladded with high carbon high chrome Iron like weld deposits. Therefore, it will be interesting to look into -

* Effect of Cr on carbon range for Austenite. (Fig.4.1) [1].
* Isothermal Fe-Cr-C, (flg. 4.2) [2]
* Fe-Cr Binary and (Fig. 4.3) [3]
* T T T diagrams (flg. 4.4) [4]

Chromium is a powerful carbide and ferrite former and contracts gamma - iron. Chromium/Vanadium forms isomorphous solid solutions in Alph Iron and delta iron at higher temperatures but forms "Sigma phase" at lower temperatures.

Carbides of Chromium

Chromium is unique as it forms three carbides having three different crystal structures.

$Cr_{23} C_6$	-	F.C.C.
$Cr_7 C_3$	-	Hexagonal
$Cr_3 C_2$	-	Orthorhombic
$Fe_3 C$	-	Orthorhombic
$M_6 C$	-	B.C.C.

Chromium is particularly of great importance in composite wearplates because of formation of various carbides and its different behaviours.

Cr_{23}, C_6 - A low temperature form of the carbides, This has tendency to precipitate at grain boundaries in the form of globules, platelets, lamellar or cellular growth. It goes into solution at 1050°C.

Low ductility of alloys is attributed to the grain boundary precipitation of $Cr_{23} C_6$.

$Cr_7 C_3$: The temperature range of stability of $Cr_7 C_3$ is greater than that of $Cr_{23} C_6$. The solid solubility of iron in $C_{17} C_3$ is so extensive that it does not permit formation of $C_{13} C_2$ in ferrite matrix and causes precipitation of $C_{17} C_3$ to precede that of $Cr_{23} C_6$ even in binary Cr-C system.

$Cr_{23} C_6$: forms eutectic with Chromium. However, formation of $Cr_{23} C_6$ can be suppressed by rapid cooling when a metastable equilibrium prevails between Cr - $Cr_7 C_3$, In presence of Iron, formation of $Cr_{23} C_6$ carbides is very sluggish. But $Cr_7 C_3$ may transform to $Cr_{23} C_6$ after long ageing times.

High Chrom Irons contain pro-eutectic carbides which are very stable. As the Chromium content exceeds over 10%, the carbide formation will depend on :

1. Chromium to carbon Ratio - Cr_3 C cementile is the only one present less than 3 : 1

2. Chromium to carbon Ratio - Chromium rich Carbides $Cr_{23} C_6$ or $C_{17} C_3$ more than 3 : 1 or both present. Molybdenum or tungsten adds to the effective chromium contents and tend to stabilize $Cr_{23} C_6$ carbides.

The composition of the carbides found, varies depending on over all alloy Composition. The remarkable feature of Eutectic carbides present in High Chrome irons is their discontinuous form, which leaves matrix more continuous. This improves toughness to a great extent as compared to the toughness when the Carbides are present in a massive and continuous form. Wnen Chromium is more than 10%, high chrome iron offers improved abrasion and heat resistance. In addition discontinuous form of carbides improve toughness too.

High chrome irons, when air cooled, retain more austenite, than when these are quenched in oil/water due to cooling rate stabilization.

Metallugrical Microstructural Examination

Micrograph shows the alloy carbides (long white) - Micro Hardness 1621 HV, martensite - Micro hardness 720 HV and smaller white carbides in grey matrix - Micro Hardness - 1000 HV in case of DW STD and DW FW Alloy.

Micrograph shows dentritic cast structure containing Martensite micro hardness 720 HV and white carbides micro hardness - 1621 HV in case of DW HT Alloy. which is designed for high Temperatures services.

Weldability of Composite wearplates

Composite wearplates on account of mild steel base plate have very good weldability.

Three tier welding procedure is designed to perform satisfactory weld joints of high strength. The same is explained pictorially in Figure 6.1.

Weldability is improved when an austenitic S.S.filler wire used to take the advantage of low yield strength and good ductility of the weld metal. The weld deposit yields during welding and this ensures minimum of the stress/ strain on the hardened HAZ. With low hydrogen welding consumables, stress/strain is reduced further in weld metal and hence provides addititional advantege in restricting hydrogen diffusion to the base metal on cooling. No preheating or post weld heat treatment is required after the welds are made.

Engineering Properties

CUTTING AND FORMING

Composite wearplates are usually cut by argon/nitrogen air plasma cutting machines. It can be cut by gouging/cutting electrodes or by carbon arc. The quality of cut of composite wearplates is best with Plasma/Air plasma equipment. Composite wearplates can be cold rolled for large diameters or formed by way of a brakepress for smaller diameters.

Minimum bend radius

Hardface outside : 1000mm

Hardface inside : 200mm

FIXING
Composite wearplates can be welded to any existing metal structure by welding the mild steel base with low hydrogen of stainless steel electrode depending on the metal structure.

Composite wearplates are provided with countersunk holes or plug weld holes by a specially designed metal arc disintegrator system.

Studs are welded by stud welding machine on the mild steel base of composite wear plates.

PUNCHING/SHEARING
Not recommended due to tool damage.

MACHINING
By spark erosion system

GRINDING
Possible with considerable pressure. Use hardwheel grits with soft bond.

SCALING RESISTANCE
Excellent upto 1000°C.

HEAT TREATMENT
Not required. Carbides in hard layer are stable at all temperatures upto melting point - 1260°C

CORROSION RESISTANCE
Comparable with 18% chrome steel but not recommended for severe corrosive applications.

Application

MINING
Dump truck body trays, ore cars, dipper shovel lining, apron feeders, mine and quarry skips, deck and skirting plates, buildozer mould boards, ore scrapers, grizzly bars and side plates, slurry pipes, dragline buckets.

STEEL MILLS
Bunker liners, pallet chute liners, recalim buckets, hot discharge chutes, vibratory feeders, down corner pipes, travelling hearth, control gates, chain guides, rolling mill guides, burden liner plates.

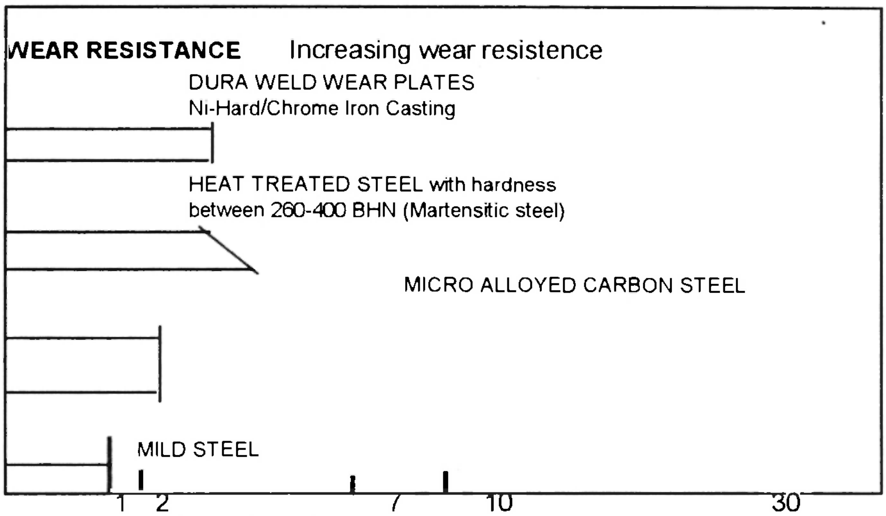
POWER PLANT
Cyclone blades and housing, receiving hoppers, inlet vanes, screw conveyers, pipe lines for ash, I.D.fan runners, impellers, bowl mill liner plates.

EARTH MOVING
Bucket teeth, bulldozer blades,

Cost of benefits of wearplates

1. Ni-Hard/Cr.cast Irons — Composite wearplates
2. Heat treated steels
3. MS plate/Micro alloyed carbon steel.

	1. / 2. / 3.	Composite wearplates
Weight :	1 or 100 Kgs.	0.75 or 75 kgs. (This improves efficiency of M/c)
Fabricability/ weldibility	a) Very Bad. b) Moderately good c) Very good	Very good, can be fabricated welded in desire shapes.
Down Time	Repairs take long time. Machineries brought to workshop.	Can be filled at site on short notice. Hence, Negligible downtime
Mode of Repairs/ Reclamation	By welding, using hardfacing elecrodes high heat inputs, brings material fatigue closer, resulting in early scraping of compo nents.	Fixing of wear plates with studs or nut-bolts or Welding involves negligible heat inputs.



Composite wearplates offer wear resistance
30 : 1 over M.S.
20 :1 over M.S. at 600°C (Ore Chutes in Steel Mills)
12 :1 over Heat Treated and Manganese Steel.
3 :1 over Traditional Ni-Hard or Hard welding alloys. (this enhances availability of machine for production by reducing down time.)

ABRASIVE WEAR TEST CARRIED OUT

Experimental Conditions :

1. Abrasive Wheel	Coarse (V 108)
2. Test Time	40 min 2400 revolutions
3. Test load	4,400 kgs
4. Track length	105504 cms

Sample Code	Mass wear / unit area
IS 2062 Plate	19,2655 grms / cm^2
Micro alloyed C.S. plate	13,8869 grms / cm^2
Composite wear plate	0.21566 gms/cm^2

SIZE AND GRADE SELECTION Plate Thickness

Thickness			Weight
Hardfacing Overlay MM	Mild Steel Base MM	Total ±1mm	kg.Sq.m.
4	6	10	81
6	6	12	95
7	8	15	122
7	10	17	132
9	10	19	144
9	12	21	160
12	6	18	140
17	10	27	217
6	25	31	238

* Standard sheet size	:	2800 mm X 1400 mm
*Larger Sheet	:	Made to order.
* Composite wearplates	:	Supplied as per drg. reddy for installation.

PLATE GRADE

Grade	Typical use	Relative Cost
DW STD Alloy	High stress abrassion and heavy impact use upto 450°C. Plate can be rolled to 200 mm radius. Hardness - 55 - 60 RC	1
DW FW Alloy	Fine particle erosion, extremely tough matrix, Hardness - 62-67 RC	1.2
DW-HT Alloy (a)	High stress abrasion at upto 800°C Hardness - 63 - 65 RC	5.8
DW-HT Alloy(b)	Complex nodular chromium carbide High impact resistance Upto 500°C Hardness - 58-62 RC.	1.7

(COMPOSITE WEARPLATES are available in various grades and sizes.)

compact rollers, scrapers, ripper teeth and shanks, loader buckets, excavator shovels.

MISCELLANEOUS

Cultivator tips, concrete mixers, clinker chutes, mixer paddles, pathways, suction sweeper blades, asphalt mixer plant spouts and troughs.

CONCLUSION

COMPOSITE WEARPLATES

- The wear resistance of composite wearplates is just unmatched and cannot be compared with conventional lining materials of similar hardness.

- Composite wearplates are made in various grades, which can resists impact abrasion and heat resistance upto 800°C.

- Composite wearplates have strong, tough base metal and wear resistance over lay fully bonded together.

- Hard deposit of composite wear plates has Cr_{23} C_6 and Cr_7 C_3 carbides in the matrix of pro-eutectic carbide and martensite, the hardness in the range of RC 60-65 and primary carbide contents upto 75%.

Grinding Rolls

Applied to all grades of mild steel or cast steel pipe or fittings with less than 0.3% carbon equivalent.

Extra layer of alloy can be overlayed in fully line item, as specified to areas of extreme wear - or overlay can be selectively laid only to specified areas in single or double layer.

Most fittings can be relined over again even if worn through.

Wear can be detected by ultra-sonic inspection.

Weldable for emergency field re-pair without loss of hardness.

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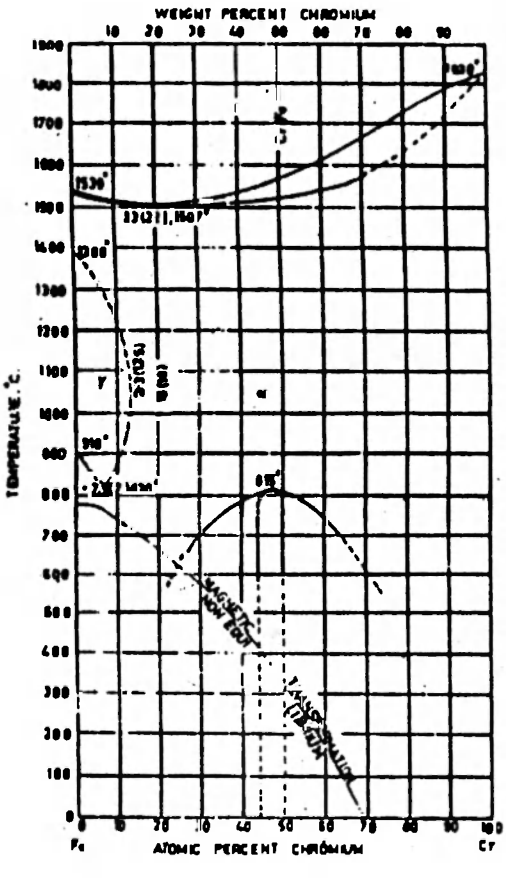

Fig 3 : Iron Chromium Phase Diagram

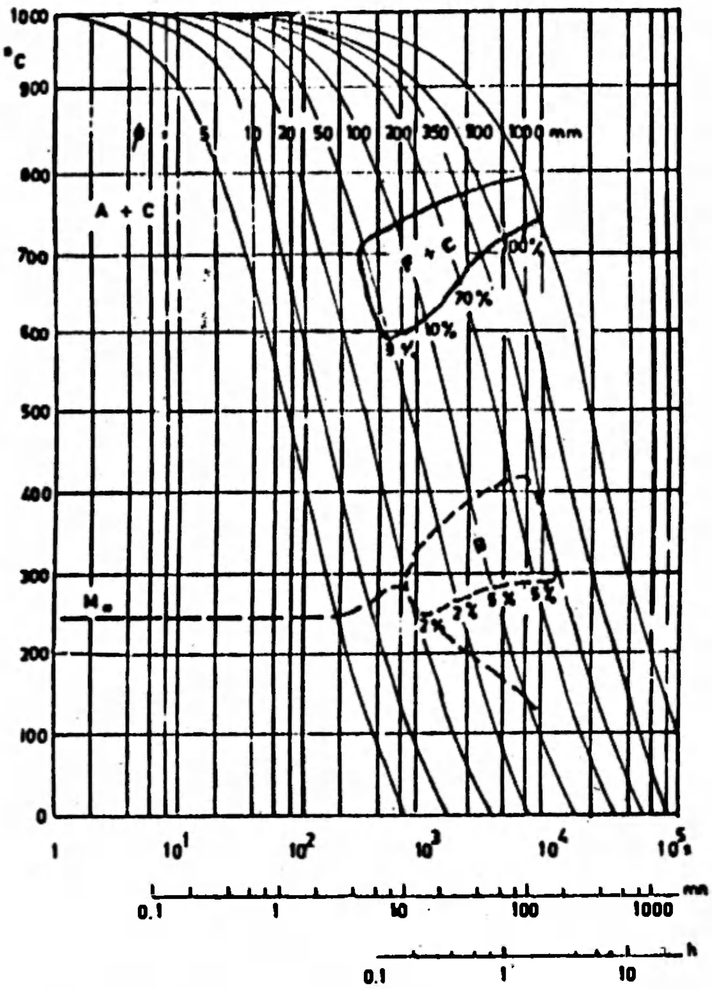

Fig 4 : TTT Diagram C-41% Cr-23.67 Mo 1.32%

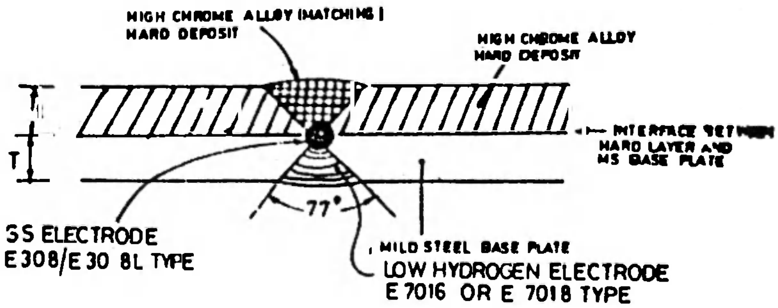

Fig 5 : Weldibility of Composite wearplates