Hardfacing and Wear Resistant Use

Hardfacing General Review

Hardfacing process is the most economical way to allow a work to achieve maximum application and usage longevity. As it name suggests, hardfacing is to build up upon the softer base metals' surface one or multi-layers of hardfacing alloys according to specific needs.

There are commonly three types of welding process to restore abrasive of wear out work :

1. Build-up

If the project base metal suffers great abrasion, use the proper filler metal to restore the base metal back to its original dimension on the working piece prior to hardfacing welding.

2. Buttering

When the filler metal for hardfacing layer and the base metal's mechanical properties along with physical property have great variation, it is difficult to weld the two together; hence, it is essential to select the proper filler metal for the project base metal to serve as a buffer in reducing the incompatibility.

3. Hardfacing

Hardfacing also known as surface hardening welding is achieved by welding the wear resistant layer onto base metal or surface layer for the purpose of extending the longevity of mechanical equipment. It is normally limited to two to three welding layers.

How to select the proper hardfacing filler metal :

Welding filler metal is selected according to the following criteria :

1.Base metal will affect the selection of filler metal for base (root) layer, for example:

a. Mn Steel: for equipment suffered severe impact condition. Use high Mn content filler metal to restore the base metal to its original size.

b. Carbon steel or low alloy steel: directly use low alloy hardfacing filler metal to restore its size.

2. Abrasion types as following :

a. severe abrasion:

Severe abrasion is often accompanied by high stress concentration and low impact level. The work could possibly involve rolling over rigid minerals or serving as surface blocking corrosive material. The usages typically are agricultural machinery equipment, metallic sieve, filter, pulpous material conveyor pump.

b. severe impact:

Severe striking or pounding could cause the metal surface to crack, crush, or cratering. The usages typically are repair welding on coned mining crusher, hammering crusher, impactor bars, rail frogs and crossings.

c. metal to metal (friction or stick to) :

Metal to metal spinning or sliding against each other. Usages such as roller, fly wheel, razor, scissors, or bearing surface.

d. metal to sand (impact and abrasion) :

The main cause of wearing is sand which has mild impact character. The wear comes from simultaneous movement of impact and wearing. Usages are excavator, agriculture or industrial equipment's shovel teeth, cutter, etc.

e. wearing at elevated temperature:

This type of wear is accompanied by high temperature during working. Examples are hot forging die, steel milling shop, hot press roller, heat exchanger blade, die tool, continuous casting guide roller, etc.

f. wearing under corrosion environment (ablation) :

Chemical corrosion in usages such as chemistry lab apparatus and equipment. Actually many abrasions occur not just due to a singular cause, but possibly two or more simultaneously; thus, the selection of hard facing filler metal must use abrasion type as the main consideration in determining selection priority.

3.welding process

The main determinant of selecting welding process is based on the restoring equipment's measurement and quantity; welding position; available welding equipments; and the necessary frequency of hardfacing; with its common welding processes as the following :

(1) SMAW (Shielded Metal Arc Welding) :

Using stick electrode requires minimum tools, least consideration of welding location and welding position.

(2) Semi Auto Welding :

Using wire feeder, self shield or gas shield flux cored wire has comparable higher deposition efficiency than SMAW.

(3) Automatic Welding :

This requires more complicated welding equipment and pre-welding preparation, but due to its high deposition efficiency, the productivity is greatly enhanced which can be acquired through the methods below :

(A) Neutral flux pairs up with alloyed wire (also commonly known as composite wire).

(B) Alloyed flux matches up with carbon steel wire.

(C) Using partial self-shield flux cored wire, flux may be used or not depending on the need.

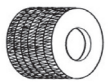
4. The polarity illustration :

DCEP (DC+): Electrode positive or DC reverse polarity.

DCEN (DC–): Electrode negative or DC straight polarity.

Welding consumables selection

Abrasion Type	Alloy Type	Weld Metal Microstructure	Properties	Application
severe impact	High Mn Steel	austenite structure	High impact toughness and superior work hardening ability. As welded condition application with no need to measure hardness, and no welding layers limitation.	13%Mn Steel, crusher hammer, impacter, rail coupling.
buffer layer and welding joint repair	low alloy content	bainite + pearlite	Use as surface layer; serve as buttering of buffer layer; sometime it is used as final hardfacing layer especially in good crack resistance weld metal or when good machining ability is called for.	gear, shovel roller, chain roller, clutch rod, guide roller and buttering for buffer layer.
metal to metal abrasion (sticky abrasion)	medium and low alloy content	small to large quantity of martensite	To be used for metal to metal friction or sliding (no lubrication). Holds medium to high hardness and high wear resistance.	bulldozer fly wheel, conveyor connecting parts, shovel cutter edge, screw type conveyor.
metal to sand abrasion (impact and wearing)	medium alloy contents (containing carbonate)	medium carbonate content alloyed type	Good resistance for metal to sand impact and abrasion. Contains sufficient carbonate, able to resist wearing at very low stress condition.	bulldozer cutter edge, shovel teeth, impact hammer, sand agitator blade, sieve, cement agitator , dredge cutter, agriculture shovel.
severe abrasion	carbonate	large quantity carbonate alloy	Good resistance for metal to sand stone or rock crushing or grinding; or use in severe metal surface wear condition. Normally used in environment with high press stress and medium to low impact characteristics.	sand blast nozzle, coal crusher, crushing roller, auger, conveyor screw rod, crusher parts, agricultural tools, shovel teeth, hot ash elbow.
metal to metal of heat fatigue resistant abrasion (high temperature or corrosion condition)	13% Cr series stainless steel	13% Cr martensite	Holds superior corrosion resistance and heat fatigue resistance characteristics.	heat exchanger fin blade, die tool, turbine blade, heat resistant valve gate, chemical containers, equipment and continuous casting rollers.

Products				Abrasion category
Hardness HRC	SMAW Electrode	Flux Cored wire	SAW (Submerged arc welding wire)	
15 ~ 50	GH13M HARDMANG 1 HARDMANG 3	MXW MANG 1 MXW MANG 3	—	 Rail coupler
15 ~ 39	GH300 GH300R GH350R	MXW BU-O MXW BU-G	MXW K104-S	 Buffer layers before hardfacing
35 ~ 54	GH450 GH450R GH600 GH600R	MXW SUPER BU-G MXW BB-G MXW 102-G	MXW K107-S MXW K105-S MXW K102-S	 Crane wheel  Excavator
40 ~ 64	GH750 GH900 GH900W HARD D HARD 31 HARD 35 GH800	MXW D MXW DD-G MXW 969-G MXW 969-O MXW M7-G MXW R117 MXW R100 MXW R101	MXW R100 MXW R101	 Shovel teeth  Scraper cutter
55 ~ 68	HARD 35 GH800 GH900Mn GH950Nb GH950 GH950C GHCW	MXW R100 MXW R101 MXW R100D MXW R100SHD MXW 62-O MXW 63-O MXW 65-O MXW 66-O MXW 70-O	MXW R100 MXW R101 MXW R100D MXW R100SHD MXW 62-O MXW 63-O MXW 65-O MXW 66-O MXW 70-O	 Crusher wheel  Coal crusher wheel
35 ~ 55	GH13Cr-4	GMX 410NiMo	MXW K410NiMo-S MXW K420-S MXW K423-S	 Valve disk

Welding Notes

To obtain the ideal hardfacing result and minimize cracking, carefully select the proper alloyed hardfacing filler metal and welding procedure is recommended; Pay attention to the following additional points :

1. base metal preparation

Surface corrosive and impure material such as grease, dirt, etc. must be removed; otherwise blow holes will most likely to occur. In addition, when the base metal has cracked already, the weld metal will continue to suffer cracks as well; thus, the defects on the base metal must be removed before welding.

2. Heat input and temperature control

In order to lessen cracking occurring, consult the following guidance :

a. Pre-heat and inter pass temperature control

This is one effective step to avoid cracking. The chart lists base metal's carbon equivalent (Ceq) and the recommended preheat and inter pass temperature. During actual welding, the work's size, thickness, filler metal and welding process should be taken into consideration.

Table 1 : base metal carbon equivalent and preheat & inter pass temperature reference value

Steel Type	Carbon Equivalent	pre-heat and inter pass temperature
Carbon Steel	≦0.3 >0.3 but ≦0.4 >0.4 but ≦0.5 >0.5 but ≦0.6 >0.6 but ≦0.7 >0.7 but ≦0.8 >0.8	≦100°C ≧100°C ≧150°C ≧200°C ≧250°C ≧300°C ≧350°C
Mn Steel (13%Mn)	No need to pre-heat, but inter pass temperature must be controlled below 260°C.	
Austenite Stainless Steel	No need to pre-heat, inter pass temperature is below 150°C.	
High Alloy Steel (high Chromium Carbide)	Above 400°C.	

Remark :

1. Ceq % = C + Mn / 6 + Si / 2 4 + Cr / 5 + Mo / 4 + Ni / 15.
2. Post weld heat treatment is needed according to base metal alloy contents or carbon equivalent.
3. The 300 series' austenite stainless steel not included in the high alloy steel section.

b. Post heating after welding

Recommending 300~350°C post heating immediately after welding and sustain 10-30 minutes to avoid cracking. Do not over heating or might cause hardness decline.

c. Post Weld Heat Treatment

Post weld heat treatment of 550~750°C can effectively avoid cracking, less deformation and improve weld metal characteristics. Make sure hardness criteria is reasonable prior to post weld heat treatment.

3. Buffer layer

When base metal requires a layer of extreme hard high alloy content weld metal, make sure to weld on a layer of lower alloy content buffer layer to avoid cracking.

4. Penetration

During hardfacing welding operation, the weld metal's characteristics will be changed according to the degree of penetration from filler and base metal's mutual dilution. Usually the filler metal's chemical composition differs from the base metal; to achieve ideal hardness and characteristics for the weld metal, use as often as possible multi-passes technique in order to avoid high penetration and high dilution.

5. Welding deformation

To decrease work piece's deformation, use short bead, intermittent technique, symmetric welding technique, or fasten the work piece into stationary position before welding.