For Hardfacing

A guide for selecting welding consumables

Weld metal microstructure and main alloying elements determine the performances of welding consumables for hardfacing as summarized in Table 1. In addition, PF-200S/US-63B is good for reclamation of mill rolls.

Table 1 Welding consumables and their characteristics

Weld metal microstructure and alloying formula	Hv	Features	Type of wear (1) MTM	ABR	HTW	CAV	COR	HRT	IMP	SMAW	FCAW	GMAW	SAW
Pearlite	200-400	▪Good crack resistance ▪Good machinability	○	△	×	-	-	×	○	HF-240 HF-260 HF-330 HF-350	DWH-250 DWH-350	MG-250 MG-350	G-50／USH-250N G-50／USH-350N
Martensite	350-800	▪Good wear resistance	○	○	△	-	×	△	△	HF-450 HF-500 HF-600 HF-650 HF-700 HF-800K	DWH-450 DWH-600 DWH-700 DWH-800	-	G-50／USH-400N G-50／USH-450N G-50／USH-500N MF-30／USH-550N MF-30／USH-600N
13%Cr stainless steel type	350-500	▪Good resistance to oxidation, heat and corrosion ▪Good wear resistance	○	△	○	○	○	○	△	HF-13	-	-	-
Semi-Austenite	500-700	▪High toughness and good wear resistance	○	○	△	△	△	△	△	HF-12	-	-	-
High Mn Austenite: 13%Mn	150-500	▪High toughness and good impact wear resistance ▪High work hardenability	×	○	×	△	×	×	◎	HF-11	DWH-11	-	-
High Mn Austenite: 16%Mn-16%Cr	200-400	▪High hardness at high temperatures ▪High toughness	○	△	○	○	○	○	○	HF-16	DWH-16	-	-
High Cr-Fe	600-800	▪Excellent erosion resistance ▪Good resistance to corrosion and heat	△	◎	◎	×	○	○	×	HF-30	DWH-30 DWH-30MV	-	-
Tungsten carbide type	800-1200	▪Excellent resistance to heavy abrasion	×	◎	×	×	×	×	×	HF-950	-	-	-

Note (1) MTM: Metal-to-metal wear, ABR: Abrasion, HTW: High temp. wear, CAV: Cavitation,
COR; Corrosion wear, HRT: Heat resistance, IMP: Impact wear
◎: Excellent resistance, ○:Good resistance, △: Slightly inferior, ×: Inferior,
-: Not used for general application

For Hardfacing

Tips for better welding results

Common to individual welding processes

Important points in hardfacing are to obtain sufficient hardness and to minimize cracking. In order to achieve them, proper selection of welding consumables and proper welding procedures mentioned below are necessary.

1) Preparation of base metal:
Rust, oil and soil attached on the base metal may cause blowholes. Cracks in the base metal may cause cracking of the weld metal; therefore, they must be removed completely beforehand.

2) Preheat and interpass temperature:
In order to minimize cracking, control of preheat and interpass temperature is a key technique. Table 1 shows a rule of thumb for proper preheat and interpass temperatures in relation to the carbon equivalent of the base metal. In practice, size of work, type of welding consumable and method of hardfacing should be taken into consideration to determine the most appropriate temperatures.

Table 1 A rule of thumb for preheat and interpass temperature in relation to base metal carbon equivalents

Type of steel	Carbon equivalent [1]	Preheat and interpass temperature (°C)
Carbon steel and Low alloy steel	Less than 0.3	100 max.
	0.3-0.4	100 min.
	0.4-0.5	150 min.
	0.5-0.6	200 min.
	0.6-0.7	250 min.
	0.7-0.8	300 min.
	Over 0.8	350 min.
High-Mn steel (13%Mn steel)		Use no preheat and cool each weld pass with water
Austenitic stainless steel		Use no preheat and control the interpass temperature 150℃ or lower
High alloy steel (e.g., High-Cr steel)		400 min.

Note (1) Carbon equivalent = C + Mn/6 + Si/24 + Cr/5 + Mo/4 + Ni/15

3) Immediate postweld heating:
Heating the weldment at 300-350°C for 10-30 minutes just after welding was finished is effective to prevent cold cracking. Control the temperature carefully, or the hardness of the weld will be decreased by excessive heating.

4) Postweld heat treatment:
Postweld heat treatment (PWHT) at 550-750°C is effective to prevent cold cracking and distortion in service, and to improve properties of the welds. It is important to set the PWHT conditions taking into account that the hardness of the weld is normally decreased by PWHT.

5) Underlaying:
Underlaying is effective to prevent cracking in welds where low-alloy steel having high hardenability is hardfaced or where high-hardness weld metal is deposited on carbon steel. For underlaying, mild steel type welding consumables or austenitic stainless steel type welding consumables should be used.

6) Penetration:
In hardfacing, the properties of the weld metal will considerably be affected by welding penetration into the base metal, because the chemical composition of the welding consumable is generally very different from those of the base metal. In order to use sufficiently the desired properties of the welding consumable, welding penetration must be controlled by using an appropriate welding procedure, for instance, multi-layer welding.

7) Welding distortion:
Intermittent and symmetrical welding sequences are effective to minimize welding distortion. Restraint of the work is also effective to minimize welding distortion.

SMAW

1) Control the arc length as short as possible.
2) Use the backstep method for arc starting to prevent blowholes.
3) Control the weaving width less than 3-4 times the diameter of a covered electrode.
4) Re-dry covered electrodes before use.

FCAW, GMAW

1) Control shielding gas flow rates within 20-25 l/mm for general applications. Note that poor shielding due to low flow rates and wind can cause blowholes and pits in the weld metal.
2) Refer to proper currents for individual wire sizes as shown in Table 2.

Table 2 Proper welding currents

Type of wire	Diameter (mm)	Polarity	Welding current (A)
DWH series	1.2	DC-EP	120-360
	1.6	DC-EP	200-420
MG series	1.2	DC-EP	120-320
	1.6	DC-EP	200-420