50 HARDFACING TIPS

The best advice in hardfacing from Stoody - Innovation to Shape the World™

Hardfacing is the most economical way to improve the service life and efficiency of metal parts subject to wear. Simply choosing a premium quality product will not by itself guarantee the desired result. Being familiar with the type of base metal, the type of wear, the welding process, and how to control the application are all equally important factors in achieving success. The following guidelines will assist in maximizing the benefit of your hardfacing applications.

BASE METAL IDENTIFICATION

1) Know your base metal before welding. The type of steel being welded on, and the carbon and total alloy content, will determine how the base metal must be treated. Some base metals tolerate temperature changes and extremes in hot and cold well, others do not. The following are some common base metals that will be encountered: low, medium and high carbon steels; alloy steels and high strength low alloy steels; wear resistant and (AR) abrasion resistant steels; manganese steels, stainless steels, both 300 and 400 series; tool, die and mold steels; and cast Irons.

2) Preheating is often required when welding on higher carbon and alloy steels, wear resistant/abrasion resistant steels, all tool steels, cast irons and 400 series stainless steels. Preheating minimizes distortion, shrinkage, cracking, spalling (lifting) of the weld deposit, and greatly reduces thermal shock to the part. Preheat temperature is influenced by the carbon and alloy content of the base metal. The higher the carbon and alloy content, the higher the required preheat temperature recommendation. Reference Metals Handbooks for preheat recommendations, or see Stoody Bulletin No. 2112 for preheat recommendations for many common base metals.

3) In addition to the above advantages, preheat is most often used to retard the cooling rate of the base metal. Quick cooling from arc welding temperatures will often result in the part becoming brittle in the heat affected zone from rapid air quenching. Preheating will greatly reduce this tendency in higher carbon and alloy steels.

SPECIAL CONSIDERATIONS FOR MANGANESE STEEL

4) Austenitic manganese steel is a non-magnetic alloy that is very tough and will work harden under high impact loads. For this reason, manganese steels are often found in equipment and machinery that use high impact loads to render and crush rock, as in roll and impact crushers, swing hammers, and car shredders. Manganese steels are often used alone, if the impact loads are very severe. Manganese steel is low in abrasion resistance, prior to work hardening. This may require that hardfacing be applied in some applications, to ensure good wear life.

5) The tough properties of manganese steel can be lost if base metal temperature exceeds 500°F (260°C). Avoid prolonged and concentrated heat input in any single area. Overheating manganese steel leads to a brittle condition.

6) Manganese steel does not require preheat, except in cold weather conditions. Then only warm the base metal to 70° to 80°F (21° to 27°C).

7) Manganese steel base metals should only be welded with manganese alloy consumables. Avoid using carbon steel materials, which will cause the weld deposits to be brittle and result in spalling (lifting of the deposits).

8) When rebuilding manganese steel it is good practice to remove approximately 1/8" (3.2mm) of the workhardened surface prior to welding. Failure to do this may result in underbead cracking, and weld metal spalling. (If not possible, contact Customer Support or your Stoody Technical Sales Representative)

WEAR FACTOR IDENTIFICATION

9) Types of Wear: ***Technical Bulletin Available***.
- Abrasion-Gouging (high impact); high stress grinding; low stress scratching
- Adhesive Wear (usually a metal to metal condition); scuffing; scoring; galling and seizing (frictional wear)
- Cavitation Erosion - metal loss due to implosion of vapor cavities at the metallic part surface, in liquid systems: pumps, impellers, propellers and hydroturbine runners
- Fretting Corrosion - encountered when closely fitted metal parts are subjected to vibrational loading and stress
- Corrosion, both Galvanic and Chemical
- High temperature
- High compression loads

Individually or in combination, the above factors will determine the choice of material for the best wear life.

ALLOY SELECTION

10) If restoration of dimension is required prior to hard facing, select a build-up material that is compatible with both the base metal and the final overlay.

11) The overall alloy content of hardfacing materials determines hardness and the percentage of carbide present in the matrix. Generally, the higher the carbon and alloy content, the higher the wear factor for that alloy.

12) Hardness is not the major factor in determining wear resistance of a hardfacing alloy. The percentage of carbide and carbide structure present in the matrix will determine how well a hardfacing material will resist wear.

13) Hardfacing alloys may contain one or more of the following types of carbides in the matrix: Iron, chromium, molybdenum, tungsten, columbium (niobium), vanadium, or titanium. When an alloy has a design chemistry with more that one type of carbide former present, it is called a complex carbide.

14) Weld deposit hardness shown in Stoody literature, unless otherwise specified, is normally based on two layer weld deposits. Some alloys are designed for multiple layers or for single layers only.

15) As a general rule, the higher the deposit hardness, the fewer the number of layers that can be applied.

Deposit Hardness	Number of Layers
62 - 66 HRc	1
55 - 62 HRc	2
50 - 55 HRc	3
40 - 50 HRc	4
20 - 40 HRc	4+

The above limitations may not apply if the deposit has a regular, evenly spaced cross checking (crack) pattern, running across the weld.

16) The hardness of weld deposits is most often reported using one of three different tests: Brinell, Rockwell and Vickers. A simple approximate conversion is to multiply a Rockwell C number by 10 to get the approximate Brinell hardness number; or to divide a Brinell number by 10 to get the approximate Rockwell C number. Vickers hardness is used to measure the hardness of the microconstituents in the deposit, both carbides and matrix.

17) The weld deposit analyses shown in technical bulletins are, unless otherwise specified, all-weld-metal analyses; there is no base metal dilution assumed.

18) A loss in deposit hardness and wear resistance may occur if a hardfacing alloy is routinely exposed to temperatures that exceed the maximum recommended use.

19) High carbon, high chromium alloys have very good abrasion resistance, moderate impact resistance properties, and moderate resistance to heat and corrosion. Use cobalt or nickel based alloys for applications involving abrasion with high temperature and/or corrosion.

20) The more wear resistant deposits, with higher alloy contents, have a tendency to "cross check" (form hairline cracks across the weld beads). A regular check pattern is desirable in many applications: it will reduce and possibly eliminate the tendency for distortion. Irregular crack patterns, or cracks running alongside the weld beads, can result in spalling, especially if high impact is encountered.

21) Tungsten carbide is the best choice for severe metal to earth and fine particle abrasion resistance. However, it should not be used above 1000°F (538°C), in hot wear conditions. The surface of the tungsten carbide particle will begin to form tungsten trioxide, which will reduce the wear resistance.

22) Where abrasion resistance is the primary requirement, but deposit cost is a limiting factor, then the use of the iron based, high carbon and high chromium alloys should be considered. (Group 3, chromium carbide alloys).

23) To determine the amount of material needed for a job, use the following rules of thumb: (a) a 1/8" (3.2 mm) thick deposit, covering one square foot requires 6 pounds (2.7 kg) of welding wire; (b) the same square foot will require 7 pounds (3.2 kg) of stick electrode; (c) for tungsten carbide deposits: a 1/8" (3.2 mm) thick deposit, covering one square foot requires 8.3 pounds of wire or electrode.

24) **Contact your local Stoody Technical Sales Representative, Customer Care or Stoody distributor for assistance in selecting the correct hardfacing alloy for your application needs.**

25) Some hardfacing wires are designed to eliminate interpass cleaning. These alloys produce little or no slag and allow a second pass to be applied without cleaning.

WELDING PROCESS SELECTION

26) Select the most suitable welding process for the job. Each process may have an advantage for your application.

- OFW - Oxy-Fuel Welding
- Spray and Fuse - powders, for Thermal Spray
- Thermal Spray - Electric twin arc
- SMAW - Shielded Metal Arc Welding
- GMAW - Gas Metal Arc Welding
- FCAW - Flux Core Arc Welding
- OAW - Open Arc Welding
- GTAW - Gas Tungsten Arc Welding
- SAW - Submerged Arc Welding

27) If maximum wear resistance is desired and only a single layer of surfacing material can be applied, then the level of base metal dilution becomes very important. High levels of dilution will reduce wear resistance, and overall carbide percentage in the deposit.

28) Dilution will vary with the welding process. The average dilution for each process is:

Oxyacetylene	5%
Gas Tungsten Arc	15%
Gas Metal Arc	20%
Open Arc	20%
Shielded Metal Arc	30%
Submerged Arc	40%

29) When preparing a job quotation, be familiar with the deposition rates of the process being used. Average deposition rates, at 100% duty cycle are:

Type of Process	Lbs./Hr.	Kg./Hr.
Oxyacetylene	3-5	1.4-2.3
Gas Tungsten Arc	4-5	1.8-2.3
Shielded Metal Arc	4-6	1.8-2.7
Gas Metal Arc	8-25	3.6-11.3
Open Arc	8-30	3.6-13.6
Submerged Arc	18-35+	8.2-15.9+

30) The deposition efficiencies of various welding processes can be quite different. The efficiency of Manual Shielded Metal Arc Welding is about 65% (the flux coating, smoke, spatter and electrode stub end do not form part of the deposit). With Open Arc Welding, or Gas Metal Arc Welding, efficiency is increased to the 90 percentile range. This means that with each 100 pounds (45 kg) of wire purchased, 90 pounds (40 kg) will be deposited as weld metal.

31) In oxyacetylene hardfacing applications, it is recommended that an excess acetylene flame be used. The outer envelope should be 3 to 4 times longer that the inner bright blue cone at the tip. This is called a 3X or 4X feather; may also be called a carburizing or a reducing flame. This type of torch setting lowers the surface melting temperature, protects that base metal surface form excess oxidation, and adds carbon to the hardfacing deposit. All nickel base hardfacing alloys should be applied with a neutral flame.

32) Most self-shielding flux cored/alloy cored/ metal cored tubular wires can be used with either DC constant current (CC) or constant potential (CP) power sourced. Constant voltage (CV) is another term for constant potential.

33) Selection of the proper size welding cable, such as 1/0, 2/0, 3/0 or 4/0, depends on the amount of amperage used in the application, and the overall length of all the cable in the system. Weld quality can be affected if the cable size is too small (over heating), and/or too long (voltage drop).

34) Submerged arc fluxes affect the deposit chemistry, hardness, bead shape, and surface appearance. Test flux/ wire combinations to assure required performance. No flux is absolutely neutral. Contact your local Stoody Technical Sales Representative, Customer Care or Stoody distributor for specific recommendations.

35) Use new and properly screened flux to prevent contamination and creeping chemical changes in the weld deposit. Reused and reground fluxes will affect deposit chemistry if not properly controlled.

36) Excessive flux overburden (depth) and a high percentage of fines will result in trapped gas under the slag, porosity and altered surface appearance.

37) Excessively high interpass and preheat temperatures will adversely affect the slag removal characteristics of many submerged arc fluxes

APPLICATION RECOMMENDATIONS

38) Never put a tough ductile weld deposit on top of a harder, more brittle hardfacing deposit. Such deposits will spall, and lift off of the part. The hardfacing alloy should always be applied on top of the more ductile material.

39) When using self-shielded open arc wires, pay close attention to the amount of electrical stickout used (contact tube to work distance). Short stickout dimensions under 1/2” (12.7mm) or less can result in porosity. Most open arc wires can be operated at stickout dimensions of 5/8” to 3/4” (15.8 to 19 mm) for .045” (1.2 mm) diameter wires; and 3/4” to 1 1/4” (19 to 31.7 mm) for 3/32” (2.4 mm) 7/64” (2.8 mm) and 1/8” (3.2 mm) diameter wires.

40) For manual welding, the backhand welding technique is preferable. Forehand welding can produce porous weld deposits when hardfacing.

41) When hardfacing parts that have been previously overlayed and still have hardfacing present on the surface, options include:

a) One additional layer of hardfacing of a similar composition to the residual layer may be applied if the existing layer is a sound layer not exceeding 1/8” (3.2mm) thickness.

b) Remove the old layer of hardfacing if deep cracks or foreign debris are present down to sound base material and apply two new layers of hardfacing.

42) The fastest way to remove old hardfacing deposits from parts is with an Air-Carbon-Arc (ARCAIR) system. This is also the best way to prepare grooves to place hardfacing into. Grinding is a secondary method which can be used, although much slower in metal removal rates.

43) When thin edges and base metals are required to be hardfaced, first consider the advantages of using the Stoody Jet Spray Powder Torch, with nickel base buildup and hardfacing powders. Extremely thin parts and edges can be hardfaced without affecting the base metal dimensions.

44) The next most popular process for thin edges and base metals that require hardfacing is the oxyacetylene process. Dilution is very low, and the heat input to the base metal is easily controlled. This is also the best process for applying superior tungsten carbide deposits.

45) If electric arc welding must be accomplished on thin edges and base metals, consider: (a) use of tubular fabricated electrodes; these alloys will operate at lower amperage settings than solid core electrodes; and (b) use of .045"(1.2 mm) diameter wires.

BEAD PATTERNS

46) Hardfacing weld beads spaced from 1/4" (6.3 mm) to 1-1/2" (38.1 mm) apart and against the flow of an abrasive material will improve the wear life without resorting to solid hardfacing coverage. Opposing the material flow across the part works very well for finely grained sands and soils.

47) When larger pieces of rock, ore or slag are being handled, apply hardfacing beads parallel to the material flow. These weld beads will act as directional runners, allowing the abrasive material to ride high on the weld beads, and protect the base metal from erosion.

48) Waffle or herringbone patterns work well in sand or dirt which may have some clay content. The over burden will tend to pack into the spaces between the weld beads, and offer further base metal protection.

49) Apply a dot pattern at areas that do not see heavy abrasion but are subjected to wear; and use a dot pattern on thin base metals, where distortions and warpage may be a problem.

50) In some applications, hardfacing deposits applied to surfaced and edges of parts are vulnerable to spalling from impact and high compression side loadings. By applying the hardfacing into grooves cut into the base metal or into grooves surrounded by high impact resistant weld metals (manganese steels), the resistance to spalling is greatly improved. This method alloys good service life of brittle hardfacings operated under high impact conditions.

Over the years, several alloys have been proven to be extremely versatile in solving similar wear problems with many different metal components. Some of these products are:

STOODY 35	STOODITE 6	Dynamang
STOODY 100HC	965-G	Self-Hardening
STOODY 101HC	964-AP-G	Build-Up
STOODY 110	ThermaClad 102	Tube Borium
STOODY 600	Nicro-Mang	
STOODY 2110	CP-2000	

Already having these very capable products does not mean that Stoody does not approach each wear problem separately. STOODY started the hardfacing industry in 1921 by developing specific hardfacing solutions to customer requests. The philosophy of putting technical service first continues today.

For the Best Technical Support in Hardfacing Call 1-800-426-1888