Exploring Trends in Hardfacing

BY WOLFGANG WAHL

Virtually any weldable material can be hardfaced, and this modern process extends the service life of major components

Hardfacing is used where the surface of parts subject to abrasion is damaged by wear, corrosion, or the effects of heat (Table 1).

This occurs in all fields of mechanical process engineering such as in crushing, conveying, mixing, and separating in mining; cement industry; coal-fired power stations; civil and structural engineering; recycling; and environmental protection. In the chemicals industry, it is wherever highly abrasive minerals are processed.

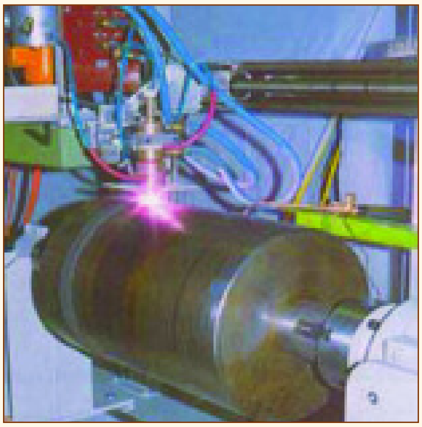

Fig. 1 — Plasma arc welding with powder containing an extremely high share of carbides.

The importance of hardfacing has grown significantly in the last ten years because downtime is becoming more and more expensive as a result of increased wages and salaries, and also integrated processing in major factories.

The different hardfacing processes can generate thicknesses between 2 and 200 mm, whereby the deposition rate can vary from 0.5 to 50 kg/h, with fusion zones between 0.5 and 10 mm.

The hardfacing processes include the following:

- Oxyacetylene welding
- Manual welding with shielded metal arc electrodes
- Gas metal arc welding
- Gas tungsten arc welding
- Plasma arc welding
- Submerged arc welding
- Electroslag welding
- Special welding procedures

The individual welding processes differ furthermore in the degree of fusion with the base metal, which as a rule increases as the deposition rate increases.

Virtually any weldable material can be hardfaced. Practically all known wear-resistant metals can be used in combination as hardfacing material.

Hardfacing cannot be applied to ceramic materials, which can only be sprayed on in thin layers.

Trends in Welding Processes

Shielded Metal Arc Electrodes and Tubular Wires

Shielded metal arc electrodes will continue to be used, in particular for in-situ repair work, since they can be handled out of position. Their disadvantage is the limited deposition rate, which is why costs of over $50 per kg are incurred per kg of weld deposit.

WOLFGANG WAHL (wahl@vautid.de) *is president of Vautid-Verschleiss-Technik, Dr. -Ing. Hans Wahl GmbH.*

Fig. 2 — Submerged arc welding of rolls.

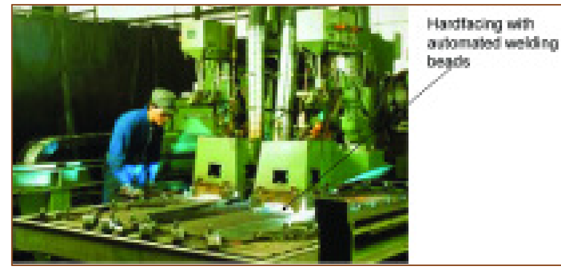

Fig. 3 — Manufacturing hardfaced plates.

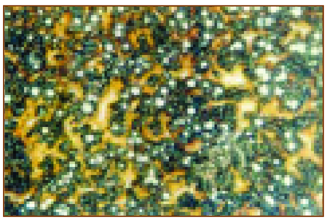

Fig. 4 — Titanium carbides in a martensitic matrix, 1.8% C, 2% Mn, 7% Cr, 0.6% Mo, 5% Ti, balance Fe (VAUTID-Delta). Recommended for combined impact and abrasive wear.

Fig. 5 — Chromium carbides, niobium carbides in an austenic matrix, 5.5% C, 20% Cr, 6% Nb, 6% Mo, VAUTID 145. Recommended for severe abrasion.

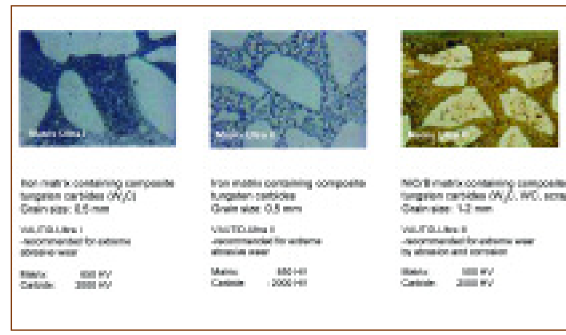

Fig. 6 — Welding fillers containing tungsten carbides.

If a company uses more than 1 ton of material annually, tubular wire is an indispensable welding process.

As a rule, the deposition rate is somewhere between 3 and 6 kg per hour, which is why the costs per kg of weld deposit fall to around $20 per kg.

The disadvantage of this process is that in practical terms it is easiest to use with a positioner, which means that the machine parts to be protected must be moved accordingly and that, consequently, in-situ welding is often not performed.

Recent developments in the filler wire sector have led to an improvement in deposition rates of up to 15 kg per hour, thereby reducing the costs per kg of weld deposit to some $10 to $15 per kg. It is particularly important with wire welding that the air cleaning equipment is working well.

Table 1 — Definition of Hardfacing (DIN 1910).

Characteristics	Description
Hardfacing of linings -Hardfacing	Hardfacing with material that is preferably more wear resistant than the base material.
Hardfacing of platings -Cladding	Hardfacing with material that is chemically more persistent than the base material
Hardfacing of buffer layers -Buffering	Hardfacing with material that provides a wear-resistant link between different materials

Plasma Arc Hardfacing with Powder

Plasma arc hardfacing made its mark with outlet valves for the automobile industry. This process enabled continuous mechanized hardfacing, with minimal fusion and high surface quality, which cut material usage in half as compared with the previously manufactured continuously cast rods.

A further advantage of this process is that it is suitable for introducing tungsten carbides, which can be added behind the arc to the molten material so that they do not remelt — Fig. 1. This makes it possible to achieve a higher carbide proportion, which in hardfacing means a far longer service life when dealing with highly abrasive minerals.

A special version of this process is used extensively by lignite producers, and it is also used in processing tar-sand and in drilling for oil. Where the trend will go from here seems to be quite open.

Submerged Arc Hardfacing

Compared with tubular wire welding using an open arc, submerged arc welding offers the opportunity to achieve high deposition rates when fully mechanized, often reaching the order of 8–10 kg — Fig. 2. Used with wire or strip, this process is mainly for hardfacing larger pieces such as blast furnace bells, as well as for the remanufacture of earthmoving equipment, in particular in the Far East. In Europe, it might be regarded as more economical to use new parts and to scrap them once they have worn out their built-in wear reserve.

Hardfacing is a labor-intensive process. In countries in Western Europe where wages are high, its use can only be justified where this technology actually reduces operating costs, or where the functionality cannot be achieved in any other way.

Use of Prefabricated, Weld-On Plates

Instead of welding directly onto the piece itself, more and more often prefabricated hardfaced semifinished products are used — Fig. 3. Plates of this type produced using multiple-torch technology and high deposition rates are far more economically produced than hardfacing the pieces themselves.

Fig. 7 — Worn and regenerated segments of rolls. Up to 50 layers of hardfacing.

Fig. 8 — Sinter crusher blades hardfaced with a composition that exchanges molybdenum with chromium.

By using plasma cutting and shaping for such plates, components such as bunkers, hoppers, feed chutes, sieves, pipes, ventilators, separators, and other pieces can be fabricated.

Trends in Welding Materials

Increased Use of Martensitic Alloys Containing Titanium Carbide

While the main application in hardfacing used to be martensitic alloys of 400–600 Brinell, materials of this type today normally contain titanium carbide reinforcements, even though the removal of the resultant slag when processing such additives is problematic — Fig. 4. In particular, by using these materials, or materials in which niobium is added to martensitic alloys, the problems of wear in so-called high-pressure rolling mills have, to a large extent, been solved.

Application of High-Chromium Materials with a High Carbon Content as Filler Wires

Whereas earlier welding wire deposits generally had 4.5% C and 30% Cr, we recognize today more highly alloyed welding wires, because this can achieve substantially longer service life durability in the second and third layers.

These materials are typically composed of 5.5% C, 20% Cr, and 7% niobium, and include molybdenum and tungsten if used in higher-temperature ranges — Fig. 5.

To a limited extent, such materials can also be used for higher temperatures up to about 750°C, but above this temperature they tend to lose their resistance to wear due to structural alteration.

Hardfacing Containing Tungsten Carbides

While in the past such materials were extensively used in the oil exploration field, their application has greatly increased both in shielded metal arc electrodes and welding wires, as well as in plasma arc welding and special welding processes because a far higher service life is achieved for the same labor cost — Fig. 6.

Replacing Materials Containing Cobalt with Materials Containing Iron

Until fairly recently, valves were hardfaced with cobalt-based materials with nickel. More recently, the trend has been clearly in the direction of materials containing iron, which are cheaper.

Trends in Applications

Hardfacing of Roller Linings and Plates for Coal and Cement Crushing

As a rule, these types of linings consist of materials described in the literature as not weldable, and with a high carbon, chromium, or nickel content — Fig. 7.

Nevertheless, it is the second most extensive application in the world today for hardfacing with materials containing chromium. Compared with cast materials, a service life twice or three times as long can be achieved, and a far better milling result over a very long time.

In a similar manner, the tables that press against the linings can be reconditioned, and their service life thus extended.

Toothed Sinter Crushers with Cobalt-Based Alloys and Inserts of Mixed Carbides

Sinter crushers represent a major wear-and-tear problem in every steel mill around the world, and as a rule, only last between 2 and 4 months when welded on.

Tests are currently underway to see whether the service life can be considerably extended when using tungsten carbides, chromium carbides, and mixed types, and initial results appear encouraging — Fig. 8.

Admittedly, in the case of grizzly bars (the corresponding piece), such materials did not result in any increase in the service life, probably on account of the even higher temperatures encountered there.

The Application of Hardfaced Plates as a Semifinished Product

The most important trend and application for hardfacing in the world today is the fabrication of hardfaced plates in standard sizes from which ready-to-use components can be made.

Plasma arc cutting or water jets can be used to cut out and fabricate parts in accordance with drawings from such hardfaced plates. Even complicated pieces of apparatus can be fabricated by cold forming, as some examples show. In these applications, economical fabrication of the semifinished product is of great importance, which is why the mechanization of welding has such significance. This can be realized either by the use of special processes with extremely high deposition rates per welding head or through coupling several welding heads (e.g., up to 10 in wire welding).

Trends Caused by Imposition of Environmental Conditions

A particularly important trend in the sector of hardfacing, however, is environmental protection, which may pose more problems in the next few years than in the last 100. Fumes generated in hardfacing are medically speaking comparatively harmless, as they contain no (or virtually no) hexavalent chromium. However, the size of the dust particles is hazardous and therefore work should only be undertaken where there is effective fume extraction.

Added to this, there are new trends with regard to assessing the risks of nickel and manganese, which prompt speculation that major expenditures will be made in the next 10 years to extract and clean up such welding fumes.

We may therefore reasonably assume that in the future there may be fewer sites for hardfacing, and the work will be performed with excellent fume-extraction facilities or indeed in enclosed booths and using robots.

Summary

Hardfacing is a process that is mainly used today for major components in order to extend their service life. This "added value" makes the parts more valuable, and hardfacing will become more and more widely specified, because the downtime will become more costly.