A STATE OF ART ON HARDFACING PROCESSES AND BASE MATERIALS USED IN STEEL

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ABSTRACT
The life and performance of machine is reduced mainly due to wear. Wear depends upon various factors namely corrosion, friction, hardness, surface layer, abrasion and erosion. Most of machines are not worn due to single factors, but a combination of various factors. According to numerous researchers reliable and cheapest way of reducing the wear phenomena is hardfacing. In the previous years hardfacing became a topic of intense development correlated to wear resistant applications. Welding deposits can improve surface property and extending their service life. Different studies have been made by the researchers focusing on various aspects of hardfacing of different alloy. In present paper an attempt has been made to review the various heat facing method and base alloy used for steel.
Keywords: Wear, Surface properties, hardfacing, base metal

Introduction
The steel industry is considered an indicator of economic and industrial progress, due to the crucial role played by steel in infrastructure and general economic development. Steel is classify by two standard SAE and AISI classification systems. Two primary numbering systems have been established to classify the standard grades of steel, including both carbon and alloy steels. These systems classify the types of steel rendering to their basic chemical composition. One classification system was established by the Society of Automotive Engineers (SAE) and the other system is by the American Iron and Steel Institute (AISI).

The numbers used in both systems are currently approximately the same. Though, the AISI system uses the letter before the number to designate the process used in the manufacturing of steel. Both numbering systems generally have a four digit series of numbers. In particular cases, a five digit series are used for definite alloy steels. The entire number is code to the approximate composition of the steel.

In both steel classification systems, the first number generally, but not compulsory, refers to the basic type of steel as follows:
1XXX Carbon
2XXX Nickel
3XXX Nickel chrome
4XXX Molybdenum
5XXX Chromium
6XXX Chromium vanadium
7XXX Tungsten
8XXX Nickel chromium vanadium
9XXX Silicon manganese

The first two digits collectively indicate the series within the basic alloy group. There may be numerous series within a basic alloy group, dependent upon the amount of the principle alloying elements. The last two or three digits denote the approximate acceptable range of carbon
content. For example, the metal designated as 1050 would be 1XXX carbon steel with a XX50 0.50% range of carbon content and 7170 would be 7XXX tungsten steel with an XX70 0.07% range of carbon content [1].

The letter in the AISI system, if used, indicate the manufacturing process as follows:
E- Electric furnace alloy steel
C- Basic open hearth or electric furnace steel and basic oxygen furnace steel

Steel is very prone to oxidation and corrosion, so to protect steel from erosion hard facing, heat treatment and some grain refiner is added to material [2]. Hardfacing is done on material in layers. Three-layer intricate carbide deposits showed the excellent abrasive wear resistance of all the tested hardfacing alloys. However, when only single layer was deposited the high dilution stages changed the microstructure and intensely reduced the wear resistance. Tungsten rich hardfacing alloys revealed a very decent abrasive wear resistance with single layer, due to their unique grouping of hard and tough M6C, huge MC carbides in eutectic matrix environment. M7C3 carbides played a critical role in the abrasive wear resistance of the layer deposited, because they act as actual barriers to ploughing and cutting by abrasive particles.

The main mass removal mechanisms identified after examination of the worn surfaces were micro-cutting, ploughing and brittle fracture of carbides. Plastic deformation was also significant, especially in eutectic microstructures [3].

**Hardfacing**

Hardfacing is a commonly used method to treat surfaces exposed to severe wear, oxidation or corrosion which has been converts an important field of application and industrial development for the manufacturing of innovative and new components, their repair and their service life extension for the most diverse industries [4].

Welding is a vital technology to accomplish these requirements and to apply hardfacing alloys. The most common processes are gas metal arc welding (GMAW), oxyacetylene welding (OAW), submerged arc welding (SAW), shielded metal arc welding (SMAW), laser beam welding (LBW) and some hybrid (combination of two welding processes) welding processes like CO2-laser-GMAW. State of the art hardfacing alloys include cost efficient Fe–C–B or Fe–Cr–Calloys on one side, but on the other side more costly multiphase composites reinforced with tungsten carbides for example are available. Above that, complex Fe-based alloys with molybdenum, titanium, niobium combination with carbon and boron added importance by attaining wear resistance due to the precipitation of different abrasion resistant hard layers and by improved matrix properties [5,6].

**Steps of hardfacing [7]**

1. Identify the base metal- First identify the chemical composition of base material before choosing the composition.
2. Identify the dominant factor of wear- Identify the wear factor such as abrasive wear, impact load, friction, corrosion, thermal load.
3. Select the hardfacing base alloy and process- The better the choice of hardfacing alloy and the application, more the wear life of the coating is expected to be. Tests are often necessary to authenticate the choice, since the carbon percentage and abrasion resistance of alloy is not enough. Other constraints such as the microstructure and the type of
carbides that will form must also be considered.

4. Prepare the surface- Coating success depends on cleanliness of surface prior to weld. All traces of oil, dirt, paint and grease needs to be removed.

5. Preheat- Preheating is done to avoid cold cracking, to reduce shrinkage stress and to allow trapped hydrogen to escape from the weld metal pool.

6. Rebuild- For damaged components, it is necessary to repair the original shape and size of the base metal surface before hardfacing.

7. Establish a buffer layer- Once returned to its original shape, a buffer layer is generally applied. Its main objective is to prevent cracks from shifting from the hardfacing surface deposits to the base metal.

8. Hard surface- The main concern regarding the weld deposit of the hard-surfaced coating is low dilution. It is controlled using the welding parameters, such as current, welding speed and polarity settings.

9. Post-weld heat treatment- Heat treatment is regularly applied to relieve residual welding stress and to reduce hardness and microstructure differences across the surface.

10. Control the quality- The complete hardfacing process needs to be controlled at every phase of the way.

Hardfacing process and base alloy used in coating

- 1XXX steel- This type of steel is hardfaced by SAW, spray hardfacing, TIG, Plasma electrolysis, SMAW and arc welding and alloy used for this coating is silicon carbide, Ni-based hardfacing alloy (Ni-Cr-Br-Si), Co-base alloy, niobium and titanium [8,9,10,11,12,13,14,15]. Every type of process and substrate has their unique effect. SAW process is used for repeated layer of deposition [11] and borax aqueous solution increases micro hardness [9].

- 2XXX steel- Generally used Gas tungsten arc welding (GTAW), Plasma transferred arc (PTA) and CO₂ laser welding process for hardfacing and alloy used for this coating is tungsten carbide, chromium, Ni-Cr-C and Ni-Cr-B [16,17,18]. Ni-based alloy used in prototype fast breeder reactor (PFBR), Ni-Cr-B is much more weldable than the Ni-Cr-C, if wear resistance coefficient is only criteria for selection [18].

- 3XXX steel- This type of steel hardfaced by plasma electrolysis and gas tungsten arc welding (GTAW) and alloy used for coating is Ni-Cr-B-Si and borax aqueous solution [9,19].

- 4XXX steel- Hardfacing is done by shield manual arc welding (SMAW) and plasma electrolysis and alloy used for hardfacing is TiC-VC-Mo₂C and borax aqueous solution [9,20].

- 5XXX steel- This type of steel hardfaced by gas tungsten arc welding (GTAW), Gas manual arc welding (GMAW) and induction hardening and alloy used for coating is Cr-C filler alloy [4,21,22].

- 6XXX steel- This type of steel hardfaced by induction hardening and alloy used for coating is V-Cr-Mn-Ni [23].

- 7XXX steel- This type of steel hardfaced by Shielded metal arc welding (SMAW) and alloy used for coating is tungsten carbide, it is
generally used in turbine blades [24,25].

- 8XXX steel- This type of steel is already very hard, for reducing crack heating is done and generally used for anvil [26].
- 9XXX steel- This type of steel is hardfaced by shielded metal arc welding (SMAW) and generally Co alloy used for coating [27, 28].

Conclusion

From the above discussion, it is clear that numerous techniques have been established for producing a hardfacing on every type of steels. Different welding processes, such as plasma electrolysis, SMAW, GMAW, LBW, GTAW, etc. and some combination of two welding processes, like LMDT, CO2-laser-GMAW, etc. have been developed to achieve hardfacing. Therefore hardfacing can be done on any steel using wide range of welding processes and different alloy can be used for coating. Hardfacing is a powerful tool to make surface corrosion less without compromising with toughness, strength, elasticity and required mechanical property for any process. It increases the use and life of steel in every field of industry. The success of hardfacing application lies upon the selection of welding process and alloying elements for coating used for a particular application.

References-


