Present International Trend in use of Techno-Economic Products, "Tubular Hardfacing Electrodes" for Wear-resistance

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Abstract

This paper describes in brief the Hard Surfacing Processes and Consumables with more emphasis and details on "Tubular Stick Electrodes" which are now considered as more Techno-Economic Products for Hardfacing of components against Wear in preference to "Conventional Solid-Core Stick Electrodes". The present International trend in using THF electrodes is gaining more popularity for techno-economic advantages associated with such Products.

The construction of **"Tubular Hardfacing Stick Electrodes"** including its salient features, advantages, economics & also the manufacturing process have been described in this article.

Keywords

Hardfacing, Hardfacing Processes, Tubular Hardfacing Stick Electrodes.

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1. Introduction

1.1 "Wear" is an insidious problem that makes the machinery or component useless after only a very small amount of the initial weight of the component is lost. The reduction in life of component / machinery because of such wear involves costs. Hence, application of **tribological principle** through 'Wear Resistant' coatings on such worn-out components by weld deposition is most widely used. The 'Wear Resistant' coatings are usually 'Hard'. Hence such type of welding is called 'Hardfacing'.

1.2. The present trend is to develop better wear-resistance surface having **"Carbides"** rather than **"Martensites"**. Such **Plain Carbides / Complex Carbides** in weld-metal need high alloying elements. To achieve such weld-metal having very high alloying elements ranging from 20% to more than 45% the most Techno-Economic Process is through Powder-Metallurgical method i.e., "Tubular Electrodes" having very thin outer flux-coating containing no alloying elements in preference to "Solid-Core Electrodes" having very thick outer flux coating containing all the high alloying elements.

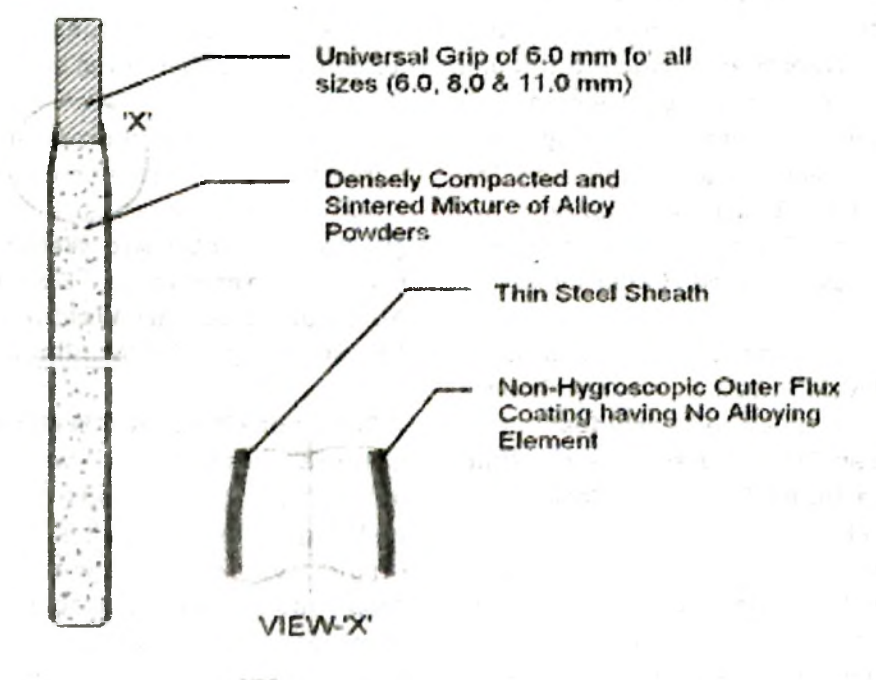
2. HARDFACING PROCESS AND CONSUMABLES.

2.1. To combat wear of components different processes of Hardfacing along with general nature of consumables are described in the chart given below.

2.2. Among all the processes of Hardfacing the most common & widely used processes are **(i) Manual Metal Arc Welding (ii) Automatic / Semi-Automatic Open Arc Welding & (iii) Submerged Arc Welding.**

2.3. Manual Metal Arc Welding is more versatile since welding on assorted jobs in **positional welding** is possible at sites. Also, larger variety of welding consumables are available at reasonable and competitive prices. This process is also less expensive since it involves cheaper Power Source.

PROCESS	CONSUMABLES
1) Oxy-Acetylene	Alloyed Wires Cast Rods Cast Inserts
2) Manual Metal Arc Welding	Solid-Core Electrodes Tubular Electrodes
3) Submerged Arc Welding	Alloyed Solid Wire and Fused Flux Solid Wire & Alloyed Agglomerated Flux Alloyed Flux Cored Wire Wire-Wound Flux Coated Wire
4) Automatic / Semi Automatic Open Arc Welding	Alloyed Solid Wire Alloyed Flux Cored Wire Self-Shielded Alloyed Flux Cored Wire.
5) TIG Welding	Alloyed Solid Wire Cut Lengths Cast Rods Flux Cored Rods
6) Spraying Oxy-Acetylene Flame Spraying Arc Spraying Plasma Spraying	Alloyed Wire in Coils Metal Powders Composite Rods Carbides Refractory Oxides



4.1Schematic drawing of Tubular Hardfacing Electrodes.

Manual Metal Arc Welding is also commonly used because of its versatility with respect to weld-chemistry, hardness etc. which can be altered as per requirements of the Users. Even a small quantity can be manufactured economically for R & D trials required by different Research-Institutes.

However, **Automatic / Semi-Automatic / Submerged Arc Welding** in case of **large and or repetitive jobs** become more cost effective because of high productivity due to mechanisation. These processes are mostly used in **down-hand / horizontal position.**

3. Concept of Tubular Electrode

3.1. The advent of Solid-Core Electrode for joining took place about 100 years ago. Then came Solid-Core Electrode for Hardfacing since high alloy contents in the weld-metal were the primary conditions to impart wear-resistant surfaces on base metal. Since high alloying elements need to be transferred across the arc to the weld-metal **the thick flux coatings** of such Hardfacing Solid-Core Electrodes became the necessity. As a result of such thick flux coating the characteristics like **i) high operating current ii) high slag volume iii) spatter** etc were involved. **Also, positional welding with such thick-coated Solid-Core Electrodes is difficult.**

To get over such difficulties of operations the concept of making of high-alloying

elements containing electrodes through Powder-Metallurgical method came to the minds of Developers, which has finally given rise to the present form of Tubular Hardfacing Electrodes.

4. Construction of Tubular Electrode.

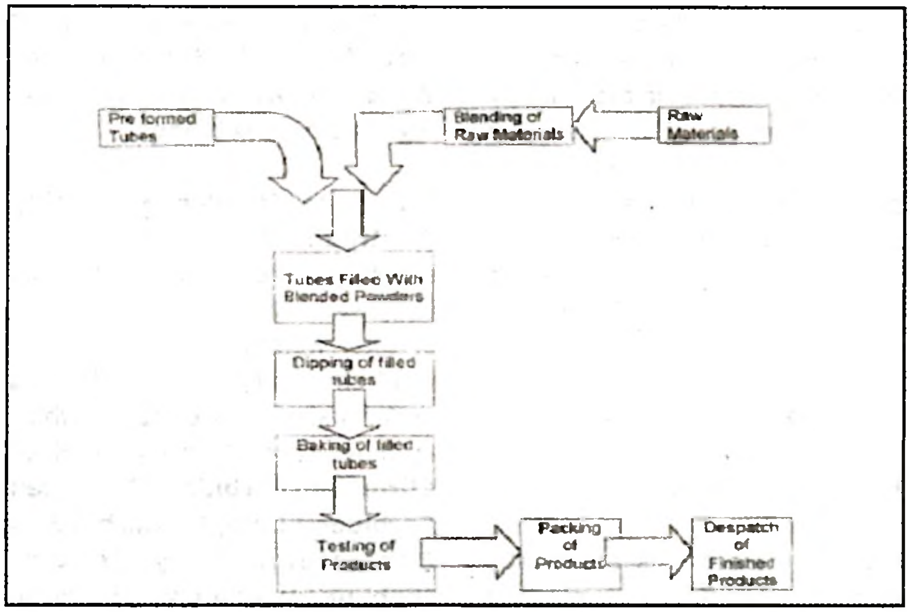
Specially formulated metal alloy powders, minerals, chemicals etc., are densely compacted into a thin steel sheath. There is a thin outside coating composed of minerals, chemicals etc. This thin outside coating is non-hygroscopic in nature. Such coating is imparted to bare electrode by the process of **Dipping.**

6. Advantages of Tubular Hardfaing Electrodes.

The inherent construction of Tubular Hardfacing Electrode gives many practical advantages over Solid-Core Hardfacing Electrodes, which are enumerated below.

6.1 Low Operating Current - The lower operating currents used with Tubular Hardfacing Electrodes ensures less heat-input which causes less distortion of the base metal. It also reduces the risk of burn through while welding on thin section. The dilution of base metal in case of Tubular Hardfacing Electrode is around 15 to 20% against 30 to 35% in case of Solid-Core Hardfacing Electrodes.

6.2 High Deposition Rates and High Yield - The construction of Tubular Hardfacing Electrode ensures that virtually all of the electrode is the available alloy. **No**



5. Manufacturing Process

heavy slag is produced; **no wastage** created and there is no need to **de-slag** between runs. Hence, application is **fast and efficient.**

At 100% duty cycle the weld-metal deposition with Tubular Hardfacing Electrode (8.0 mm x 450 mm) is around 4.0 Kg / Hr as against around 2.5 Kg / Hr in case of Solid-Core Electrode (4.0 mm x 450mm).

Thus, **high metal recovery** and very **low slag** content enable **multiple-layers** to be welded **without de-slagging between runs**. This means **faster deposition, less wastage** and **very high alloy contents generally unobtainable with conventional Solid-Core Electrode.**

6.3. No Pre-drying before use & No-need for Special Storage - Since outside coatings of THF electrodes are moisture resistant these do not require pre-drying before use and also do not require special storage. The coating will not flake-off when damp and it will resist mechanical damage due to rough handling in use because of good bond.

7. Some Misconception About THF Electrodes.

7.1 SIZE.

7.1.1. THF Electrodes are normally manufactured in large (most common) sizes like 6.0, 8.0 & 11.0 / 12.0 mm whereas SCHF Electrodes are normally manufactured in 3.15, 4.0, 5.0 & 6.3 mm sizes. This gives an impression to the users that while Hardfacing smaller jobs possibly these large sizes of **THF** Electrodes will not be suitable.

7.1.2 It may be kept in mind that the current required for THF

Electrodes is much less than similar size of SCHF Electrodes. It is now commonly accepted in the industry that 6.0mm of THF Electrode (current required 75 to 110 amps) is equivalent to 3.15mm of SCHF Electrode; 8.0 mm of THF (current required 100 to 140 amps) is equivalent to 4.0mm of SCHF; 11.0 mm of THF (current required 130 to 180 amps) is equivalent to 5.0 / 6.3 mm of SCHF.

7.2. Relief Checks

7.2.1 THF Electrodes are mostly used for High-Alloy containing weld-metal to increase Wear-life. In such cases **Relief-Checks** on Weld-Metal are sometimes wrongly interpreted as **Cracks.** Infact, these **Relief-Checks** should not be considered as **Cracks** as in the cases of Joining Electrodes.

7.2.2. These Relief-Checks are associated with high alloying elements and high hardness of weld-metal which do not have Toughness Property. It is also be noted that such Relief-Checks are Superficial in nature i.e., restricted to surface only and do not penetrate into the base-metal.

7.2.3. Such **Relief-Checks should occur perpendicular to the direction of Welding** & should not take place on the surface in different orientation.

7.2.4. In fact it is now universally accepted that Relief-Checks in Weld-Metal deposited with THF Electrodes are desirable to reduce thermal stresses during / after welding.

8. Weld-Chemistry and Metallurgical Structure of Weld-metal with Tubular Hardfacing Electrodes.

8.1. Since **Tubular Hardfacing Electrodes** are made with thin sheath of steel along with thin unalloyed outside coating (7 to 8% of total weight of electrode) the weld-chemistry has high and uniform alloy- concentration which in most cases is **composed of Chromium Carbides / Tungsten Carbides / Complex Carbides of Chromium, Molybdenum, Niobium, Vanadium, Tungsten / Borides etc., in Austenitic / Martensitic Matrix.** Sometimes such high alloy containing weld-metal becomes difficult to achieve through Solid-Core Hardfacing Electrodes.

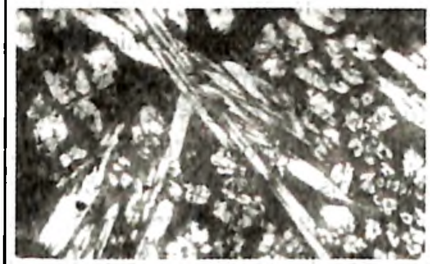
In most of the **cases these extremely hard alloys impart outstanding resistance to Wear due to Abrasion / Erosion / Friction or their combinations both at ambient and elevated temperature upto 1000 deg C.**

8.2. However, **in case of Wear due to Impact the work hardening types of weld-metal deposit containing high Manganese or high-Manganese with high Chromium in Austenitic matrix is also obtainable with Tubular Hardfacing Electrodes.**

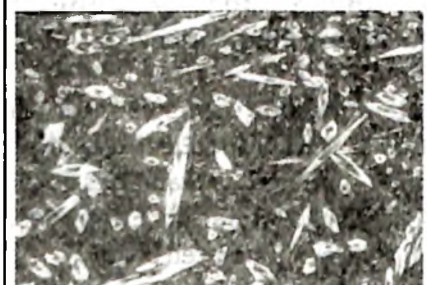
8.3. The **touch-type THF Electrodes** for direct - arcing of Sugarcane Crusher Rolls both in dry and juice-on conditions are now manufactured which was thought impossible in earlier years.

For Cold-welding of Cast Iron (joining & surfacing) **Iron-Nickel electrode conforming to A.W.S. 5.15 E Ni Fe-CI ; A.W.S. 5.15 E Ni Fe-Mn-CI are developed in Tubular Electrode form.**

8.5 Typical Microstructures of Weld-metal with THF.



x 200 magnification
Chromium Carbide in
Austenitic Matrix



x 200 magnification
Chromium Carbide in
Martensitic Matrix

X 200 magnification
Complex Carbides in
Austenitic Matrix

It may be noted that there is uniform Carbide distribution in Periphery and Center.

9. Status of Tubular Hardfacing Electrodes.

9.1 Past Scenario

9.1.1. The Manufacturing Technology of THF Electrodes was very much restricted to few Companies in the World.

9.1.2. Various types of THF Electrodes required for different applications in industries were not available.

9.1.3. There was also a restriction in use of THF Electrodes which were suitable in Down hand and Horizontal Position Welding only.

All the above factors have made THF Electrodes unpopular in earlier years.

9.2. Present Scenario

9.2.1. More manufacturers in the world are now manufacturing THF Electrodes.

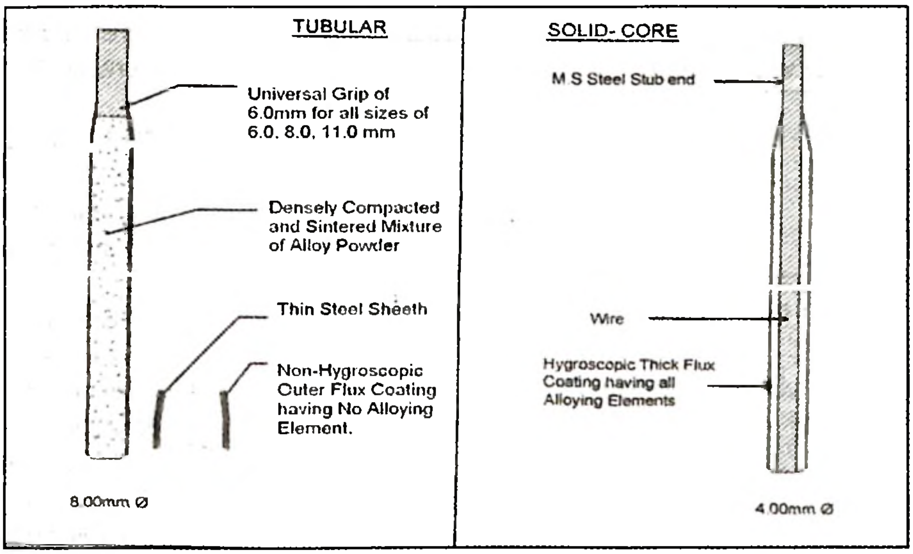
9.2.2. Wide range of THF Electrodes for all types of wear mode in different industries are available.

9.2.3. THF Electrodes can be used in All-Position welding & also for Touch-Type welding.

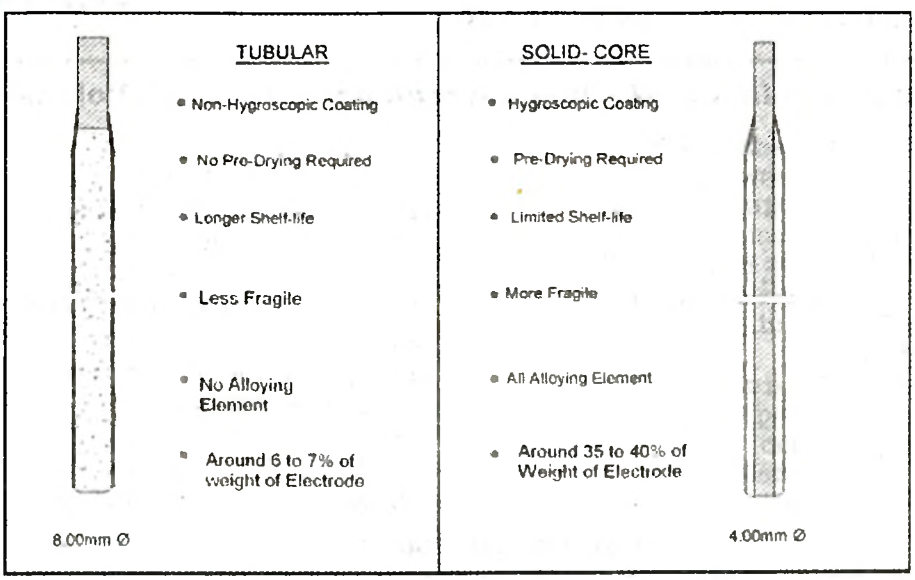
All the above factors along with Techno - Economy have now made THF Electrodes more popular than earlier years.

10. Comparision of Tubular Hardfacing Electrodes Against Solid-core

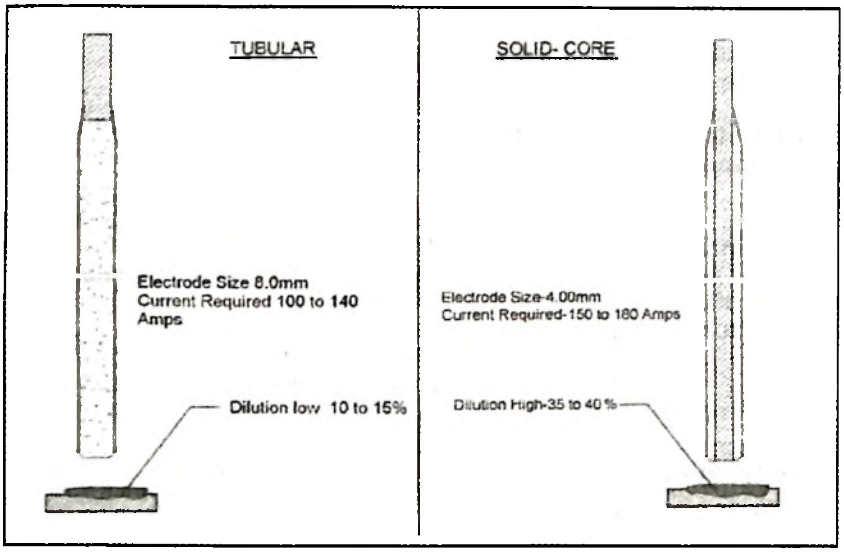
10.1. Constructional Features



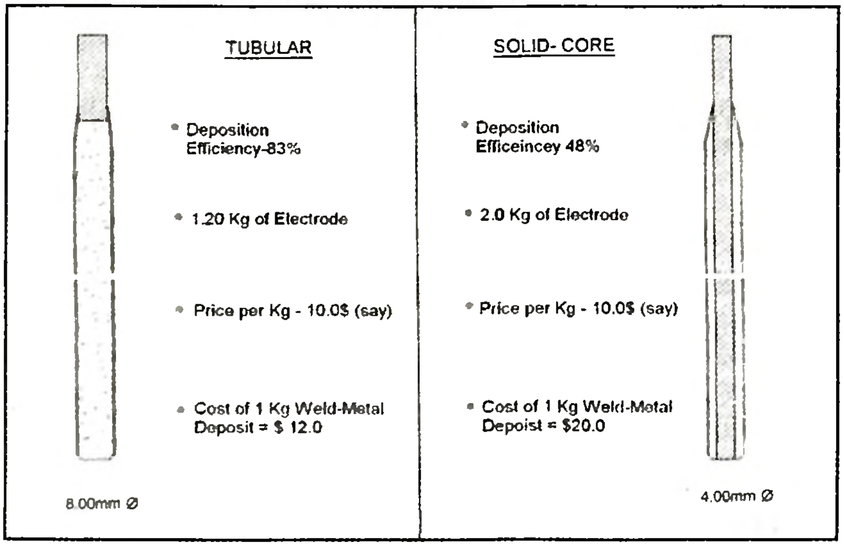
10.2.Nature of Outer Flux Coating



10.3 Base-metal Diltuion



10.4.Economics For 1 Kg Of Weld-metal



Cost Reduction by 40.0% at same price of THF & SCHF

Conclusion

1. Tubular Hardfacing Electrode is practically an Alloyed Welding Rod of desired Weld Chemistry and Metallurgical structure which gives an Over-All Economy.
2. THF Electrode can impart high Alloying Elements to the Weld-Metal which are not easily obtainable through conventional Extruded Solid-Core Hardfacing Electrode to increase Wear-life.
3. THF Electrode presently available in the Market is suitable for All-Position Welding & also for Touch-Type Welding.
4. All the above factors have now given rise to an Universally Accepted Fact that THF Electrode has almost Twice the Value for Money of Extruded Conventional Solid-Core Hardfacing Electrode.