

# Comparative Study of Hard facing of AISI 1020 Steel by Three Different Welding Processes

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## Abstract

Hard facing by welding techniques are used mainly to improve the service life of machine parts either by rebuilding or by fabricating in such a way as to produce a metallic/alloy wall section to withstand the problems of wear, erosion, corrosion, etc. An attempt has been made in this paper, to determine a better welding process to weld hard face AISI 1020 steel based on wear analysis. In the present paper three different welding processes are compared. Based on the study, the specimens prepared using TIG welding process yielded better wear properties compared to the specimens prepared using Gas welding and Arc welding processes until certain sliding velocities. The Gas welding and Arc welding processes yielded better wear properties for still higher range of sliding velocities. The factors contributing to achieve the said results were interpreted.

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*Index terms*— AISI 1020 steel, hardsur facing, gas welding, arc welding, TIG welding, wear property.

## 1 Introduction

ardfacing or Hardsurfacing, is the application of build-up of deposits of specialized alloys by means of welding process to resist wear and tear by abrasion, corrosion, high temperature, or impact. Such deposition can be done on the surface, or edge, or merely at the point of a part where it is subjected to wear [Pradeep et al., (2010)]. Welding is a key technology to fulfil these requirements and to apply hardfacing alloys [Kirchgaßner et al., (2008)]. These welding deposits can help to reclaim the components by extending their service life [Agustín et al., ??2010)]. A hard-faced part is like a laminate, with the base material contributing for strength and economy, and the hardfacing material contributing for the specific wearing conditions to which the part will be subjected in service. Hard facing may be applied to new parts during, or to worn parts to restore a worn-down surface. Hard-facing extends the lifetime of machinery equipment efficiently by increasing the service life of its parts,.

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Author ? : Dept. of Mechanical Engg, JNTUCEA, Anantapur, India. E-mail : mukdhad@yahoo.com [Kirchgaßner et al., (2008)]. In order to avoid costly downtimes and to reduce the cost of expensive spare parts, the core components that are exposed to heavy wear, require efficient surface protection measures [Kirchgaßner et al., ??2008)]. Weld hard facing has been adopted in many industries like Mining, Steel, Petro-chemical, Cement, Power, Food and Sugar cane [Kirchgaßner et al., ??2008)]. In recent years, these processes have been developed rapidly and are now applied in numerous industries, such as nuclear and steam power plants, chemical and fertilizer plants, agriculture machines and pressure vessels, railways, and even in aerospace components [Richard LL (1990)]. Hard facing is mainly done to improve the surface properties of the base metal [Gourd LM (1998)].

A number of welding processes can be used to hardface the components. The various factors that control the selection of the most suitable welding process for a given job are: Size and shape of component, Base metal composition, Nature of work to which the component to be Hard-faced is subjected to, Accessibility of weld equipment, Function of the component, Number of same or similar items to be hard-faced and cost of replacement of the part, State of repair of worn components, etc [Pradeep et al., (2010)].

The following processes are compared in the present study:

? Hardfacing by Gas welding -Deposition by Oxy-Acetylene Gas welding [Buchely et al., (2005)].

### 3 Hard Facing Processes Used

(maximum) sulfur. These steels can be easily welded with any of the welding processes. The other low-alloy high-strength steels of the AISI designation system include low-manganese steels, low nickel-chromium steels, low-to-medium nickel steels, nickel-chromiummolybdenum steels, chromium-molybdenum steels, molybdenum steels etc. [Wang et al., (2008)]. These alloys are included in AISI series 2315, 2515, and 2517. They contain 0.12-0.30% Carbon, 0.40-0.60% manganese, 0.20-0.45% silicon and 3.25-5.25% nickel.

In the present study AISI 1020 steel has been used for experimentation. In order to facilitate easy assessment of the effect of different welding processes on the wear of hard-faced components, same material has been used as base material and deposit material.

IV.

### 4 Sample Preparation and Testing

The material used for the sample preparation is AISI 1020 steel. The chemical composition, physical and mechanical properties of the material are given in Tables 1 & 2 ASTM standards were used to prepare the test samples. 10 mm diameter round rods of AISI 1020 are taken and cut in to cylinders of required lengths as per ASTM standards. Finishing of samples is done by removing the burr and thorough cleaning of oil and dirt. AISI 1020 material is deposited on the flat face of each sample using three different welding processes-Gas welding, Arc welding and TIG welding (with Argon as Inert Gas). Turning is done with fine cuts to get smooth cylindrical finish and also maintain the required size as per ASTM standards. As the POD testing requires perfect contact, the ends of the samples are rubbed on a sand belt machine by holding the sample in drilling machine so that the test surface is perfectly flat. The Weld deposit height is maintained at least 5 mm in the total sample length as shown in figure 1. Computerized Pin on Disc Wear testing Machine with the sample as test material and High Carbon EN31 steel (HRC 60) as counter-surface equipped with LVDT and digital display system was used to record the wear height loss. From the results it was observed (figure ??) that TIG welding sample was showing better the values of Wear Volume at Sliding Velocity of 0.9426m/s, compared to remaining three samples i.e, plain sample without welding, Gas welded sample and Arc welded sample. It was also observed that the values of these three samples are very close. Further it was also observed that at higher Sliding Velocities (above 1.256 m/s) the Wear Volume values of TIG welding sample were better than Gas Welding Sample and Arc Welding Sample even though all the values of these samples are closer to each other. May be the narrow heat affected zone of higher hardness than the base material in TIG welding might have offered resistance to wear and resulted in enhanced wear properties at lower sliding velocities compared to Gas Welding and Arc welding. However at higher sliding velocities of 1.571 m/s, the Wear Volume values of Gas welded samples and Arc welded samples were better compared to TIG welded samples. This may be due to broader heat affected zone of higher hardness in Gas welding and Arc welding which might have offered resistance to wear resulting in enhanced wear properties at higher sliding velocities. At higher velocities, the narrow heat affected zone of higher hardness in TIG welding might have reduced the resistance to wear, as the heat generation is higher, which in turn makes the metal to peel out in the form of chips. It was also observed that at higher sliding velocities of 1.571 m/s, Gas welding samples were showing slightly better Wear Volume values compared to Arc welding up to sliding distances of 1500 m at still higher sliding distances higher than 1500 m, the Arc welded samples were showing better Wear Volume values compared to Gas welded samples b) Effect on Wear Factor From the results it was observed (figure ??) that at Sliding Velocity of 0.9426m/s, the values of the Wear Factor for TIG welding sample were better than Gas welded sample and Arc welded sample. Also at higher Sliding Velocities (above 1.256 m/s) TIG welding sample was showing better wear factor values compared to the values of Gas welding sample and Arc welding sample even though all these values were observed to be very close. Further at higher sliding velocities of 1.571 m/s, Gas welding samples were showing slightly better values of wear factor compared to Arc welding up to sliding distances of 1500 m. At still higher sliding distances higher than 1500 m, the Arc welded samples were showing better Wear Factor values compared to Gas welded samples.

### 5 c) Effect on Friction Coefficient

From the results it was observed (figure ??) that at Sliding Velocity of 0.9426m/s, the values of the Friction Coefficient for TIG welding sample were better than Gas welded sample and Arc welded sample. However the Friction Coefficient values of Gas welded samples and Arc welded samples were enhanced compared to TIG Welding samples at higher sliding velocities of above 1.256 m/s. Also it was observed that at higher sliding velocities of 1.571 m/s, Gas welding samples were showing slightly higher values of Friction coefficient compared

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102 to Arc welding up to sliding distances of 1500 m. At still higher sliding distances higher than 1500 m, the Arc  
103 welded samples were showing higher Friction coefficient values compared to Gas welded samples.

## 104 **6 d) SEM Micro Photographs**

105 Scanning Electron Microscopy, which is one of the conventional characterization techniques, was employed to  
106 study the nature of the wear surface of the welded samples. Micro photographs at 50x, 200x, 400x magnifications  
107 were taken. Few sample photographs are shown in figure ?? and 6.

108 It can be clearly observed from figures 5 and 6 that at Sliding Velocities (above 1.256 m/s) the Gas welding  
109 Sample and Arc welding sample show deeper plough marks and TIG welding sample show small chips and  
110 particles, showing that TIG welding sample has better wear properties compared to Gas welding sample and  
111 Arc welding sample. However at higher sliding velocities of 1.571 m/s, TIG welding samples show deeper plough  
112 marks with delimitation compared to Gas welded samples and Arc welded samples. Hence the wear properties  
113 of Gas welded samples and Arc welded samples at higher sliding velocities of 1.571 m/s were seen enhanced  
114 compared to TIG welding samples. Hence the SEM microphotographs also support the discussion in the previous  
115 sections.

## 116 **7 e) Result Agreement with earlier researchers**

117 The results obtained are in close agreement with the earlier researchers who have compared different welding  
118 processes using AHP (Analytic Hierarchy Process Model) based on quantitative and qualitative factors,  
119 [Balasubramanian et al.,(2009)]. In their research it has been concluded that, based on both quantitative  
120 and qualitative factors, an integrated process measure (PM) for TIG welding was 0.2150 among the different  
121 processes to hard face carbon steels. The values of integrated process measure for other processes are lesser than  
122 TIG welding except PTAW. Conventional weld hard facing is done by Oxyfuel welding, gas tungsten arc welding  
123 (GTAW/TIG), gas metal arc welding (GMAW/MIG), shielded metal arc welding (SMAW), and flux cored arc  
124 welding (FCAW) processes. Percentage dilution plays a major role in determining the properties of a hard-faced  
125 surface [Gourd LM (1998)]. Dilution is defined as the percentage of base metal in the weld metal deposit. If  
126 the percentage of dilution is high, then the percentage of base metal in the weld metal deposit will be high and  
127 vice versa. At a higher percentage of dilution level, the surface properties are not enhanced to the expected level  
128 because of the presence of a higher amount of base metal. On the other hand, at a lower percentage of dilution  
129 level, the surface properties are much better compared to the base metal because of a low percentage of base  
130 metal in the deposited weld metal. Hence, the welding process which produces a low percentage of dilution is  
131 generally preferred for hard facing applications [Marimuthu et al., (2003) 1. TIG welding samples were showing  
132 better wear properties until a sliding velocity of 1.256 m/s with various sliding distances and loads, compared  
133 to Gas welding samples and Arc welding samples. 2. Gas Welding samples and Arc Welding samples yielded  
134 better wear properties at higher sliding velocities above 1.571 m/s with various sliding distances and various  
135 loads compared to TIG Welded Samples. 3. Arc Welding samples were showing better wear properties than Gas  
136 welding samples at higher sliding velocities above 1.571 m/s and at higher sliding distances higher than 1500 m.

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Figure 1: Figure 1 :

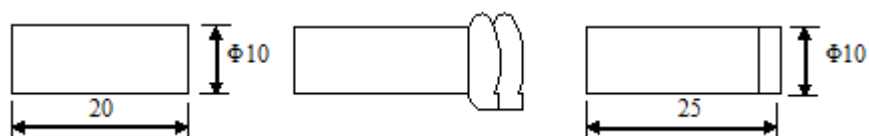


Figure 2:

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Element	C	Mn	P	S	Fe
Composition (%)	0.18-0.23	0.30-0.60	0.04 (Max)	0.05 (Max)	Balance
Property	Elastic Modulus (GPa)	Density (x 10 <sup>3</sup> Kg/m <sup>3</sup> )	Poisson's Ratio	Hardness (HB)	Tensile Strength (MPa)
Value	190-210	7.7-8.03	0.27-0.30	111	394.7

Figure 3: Table 1 :

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Figure 4: Table 2 :

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