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Effect of GTAW Process on Wear Properties and Microhardness Test on the behaviour of Mild Steel and HB-600HT Filler Rod

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Abstract—*Hard facing filler rods HB-600HT, mild steel and two types of flux were used to study the effect of gas tungsten arc welding (GTAW process) of hard facing parameters on wear properties and micro hardness test. Two fluxes titanium and chromium oxides used were packed in powdered form and the flux powder was mixed with acetone to produce paint like consistency and then a coating was made on the plate surfaces. The experimental result indicated that the weight loss is decreased as compare to mild steel.As compare to mild steel, Out of two electrodes, HB 600-HT rod gives better result in micro hardness as compare to mild steel.*

Keywords*: Micro hardness, wear, Gas tungsten arc welding, heat input, filler rod, flux.*

1. INTRODUCTION

Hard facing is a technique which may be applied to a new part during production to increase its wear resistance and also increase the microhardness value or it may be used to restore a worn-down surface. Hard facing by arc welding is a surfacing operation to extend the service life of industrial components, on new components, or as part of a maintenance program. Mild steel preserve numerous applications in different industries because of its good combination of strength and toughness, high fatigue endurance, good machining ability and low cost. Wear is one of the most commonly encountered problems in industry which requires frequent replacement of components. For example, pipe components used in pneumatic conveying systems of powder materials in various fields of industry, where serious erosive wear may occur at the bends, elbows, valves, etc. and steel components usually exhibit short service life in such cases. Enhanced wear properties with desirable toughness should guarantee longer service life of the units and components. The quality of the machine components prone to wear depends on their surface characteristics, which include surface roughness, microstructure, and surface hardness. Surface modification is used to form wear resistant coatings on the surface of structural base materials.

2. LITERATURE REVIEW

In this presented work on wear study, the Gas Tungsten Arc Welding (GTAW) method of making surface modification to improve the wear properties of mild steel materials has been used. The mild steel is hard faced with different activated flux and filler deposited at different heat input. The mild steel is frequently used material for hard facing due to its low cost, which at same time soft material with poor wear properties.

To reduce this wear problem, the hard facing was done by application of flux and filler metal on the mild steel plate and were investigated with regard to their wear and micro hardness.

The wear and corrosion related problems can be minimized mainly by following two methods:

1. By using high cost wear and corrosion resistant alloys/metals better than the existing low cost ones.

2. By improving the wear and corrosion resistance of the existing metals and alloys by applying certain modifications to the surface.

Amirsadegh et al. (2008) investigated the Effects of TIG surface melting and chromium surface alloying on microstructure hardness and wear resistance of AD1**.** Micro hardness and wear resistance of different microstructures formed by TIG (tungsten inert gas) surface melting and chromium surface alloying (using ferrochromium) of AD1 (austempered ductile iron) were studied. Surface melting resulted in the formation of a ledeburitic structure in the melted zone, and this structure has hardness up to 896 HV as compared to 360 HV in that of ADI.

Crespoa et al. (2008) studied the operational behavior of experimental coated tubular electrodes for hard facing, comparatively to a conventional commercial coated electrode. Bead-on-plate welds were carried out, covering a wide range of setting current. Fusion and deposition rates, and respective deposition efficiency, were measured by weighing electrode and test plates before and after welding. The geometric parameters were taken from cross sections from the weldments and the dilution was calculated. It was concluded that, from the operational point of view, the coated tubular electrodes present a favorable performance in comparison to the conventional coated electrode, making possible to reach lower dilutions yet keeping the same deposition rates.

Coronado et al. (2009) studied the effect of welding processes on abrasive wear resistance. In this work, four kind of hardfacing alloys deposited with two different welding processes viz FCAW and SMAW in the pattern of single and triple layer. Results showed FCAW process presents better wear resistance in single and triple layers. Abrasion wear mechanisms were micro-cutting, micro-ploughing and wedge formation. Carbides and matrix microstructure has more importance than hardness in abrasion resistance of deposits.

Jones and Roffey (2009) Investigated Abrasive wear is of particular significance in ground engaging applications and increasingly tools are being modified with wear resistant hard facings to extend operational lifetimes. A hard facing alloy which can be applied to tools as slurry and then sintered was modified by the addition of hard powder materials has been modified using a range of WC additions. WC powders of differing sizes were added at various levels and the resultant hard facings were characterised in terms of physical properties, microstructure and wear resistance.

Wear resistance was measured using several techniques; micro-scale abrasive wear (MASW) using SiC and SiO2 abrasives and rubber wheel tests using sand abrasive in both dry and wet conditions. A correlation between the size of the hard addition and the size of the abrasive particle was observed and significant improvements in wear resistance due to the presence of the WC are demonstrated.

Pandey et al. (2010) studied the effect of paste thickness and weight% of its constituents on element recovery using E6013 SMAW electrode on mild steel and founds that increase the coating thickness of paste increase the carbon and chromium recovery and increasing in Ferro chrome content, it increase carbon and chromium transfer and oxide initially decrease carbon and chromium both, after that increase both.

Shamanian et al. (2010) investigated the effect of austenitic stainless steel cladding on improving the wear behaviour of ductile iron was studied. Samples made of ductile iron were coated with steel electrodes (E309L) by manual metal arc welding. The effect of coated layer thickness on microstructure, hardness, and wear resistance of the surface were investigated.. The results showed that a film of white chromium-enriched iron formed at the interface between the substrate and coating which contained iron–chromium complex carbides. It was, therefore, concluded that enhanced properties would be obtained if the coating thickness and the carbides deposited on the surface were reduced. In samples with a thin coating, surface hardness rose to above 1150 HV (five times higher than that of the substrate) and wear resistance increased significantly.

Tarng et al. (2002) investigated the grey-based Taguchi methods for the optimization of the submerged arc welding (SAW) process parameters in hardfacing with considerations of multiple weld qualities is reported. The grey relational analysis is adopted to solve the SAW process with multiple weld qualities. A grey relational grade obtained from the grey relational analysis is used as the performance characteristic in the Taguchi method. Then, optimal process parameters are determined by using the parameter design proposed by the Taguchi method. Experimental results have shown that optimal SAW process parameters in hardfacing can be determined effectively so as to improve multiple weld qualities through this new approach.

Tingquan et al. (1995) investigated the wear mechanisms of steel 1080 and the wear behaviour of various microstructures in the steel were systematically studied by wear testing, and by SEM and TEM observations of worn surface and wear particles. The experimental results show that three dominant wear mechanisms appeared in succession with increasing normal load and/or speed during unlubricated sliding. The transitions of the wear mechanisms depend mainly upon the conditions of testing, and changes in microstructure of the steel have no marked effect on the transitions. The experimental results also indicate that the differences in wear resistance of the various microstructures were caused by the differences in microstructure thermal stability, resistance to plastic deformation, resistance to nucleation and propagation of micro cracks and especially by the differences in energy consumption in these layers during wear.

3. EXPERIMENTATION

3.1 Materials and welding conditions

Mild Steel was selected as for hard facing purpose, as we know that is mainly used in wild application in the fabrication industry. Mild steel with the chemical composition (in wt. %) of 0.29% C, 0.284% Si, 1.52% Mn, 0.012% P, 0.009% S and balance Fe was used as base metal. Eight mild steel plates (150×50×25) mm has been selected. The mild steel specimens were taken as the base metal or substrate material upon which the hard facing material was deposited by GTAW welding after the application of paste. Before depositing the hard facing material the specimens were thoroughly prepared cleaned mechanically and chemically in order to avoid experimental errors (Emery paper, acetone, grinding etc).

The hard facing electrodes were applied onto flux coated mild steel plates according to the manufacturer's directions. The nominal chemical composition of mild steel and HB-600HT can be seen in Tables 1 and 2 show the main features and composition of each electrode and figure 1 show the mild steel plate after deposition, the samples were cooled in air.

Table No.1. Nominal composition of mild Steel

C	Mn	P	Si	S	Fe
0.29	1.52	0.012	0.284	0.009	Bal

It is a mild steell plate after deposition and the samples were cooled in air.

Fig. 1: Mild steel plate used for hard facing

HB-600HT with the chemical composition (in wt. %) of 0.5% C, 0.75% Si, 15% Mg, 8% Cr and balance Fe was used as base metal

Table 2: Nominal composition of filler rod

S. no	C	Mg	Si	Cr	other	Fe
HB-600HT	0.5	15	.75	8	3	Bal.

There are various different welding methods which can be used for hard facing. Gas metal arc welding (GTAW) is mostly used for hard facing due to its best quality result amongst the arc welding process. Welding can be done on any size and shape of job, in any position and at any location. The welder can control heat input rate, dilution by base metal and can easily cover irregular areas. Stringer bead technique can be used to minimize heat input or weave technique to maximize heat input. The welder can direct the arc on the molten puddle and control the size of the puddle to minimize dilution by the base metal.

Table : Process parameters and their limits

Parameters	Units	Symb-ols	Upper limit (+)	Lower limit (-)
Act. flux	-------	F	TiO2	Cr2O3
Filler rod	C%	W	1	1

Table 4: Design matrix

Sample no	Designations	Activated flux	Filler rod
1	A1	-	-
2	A2	+	-

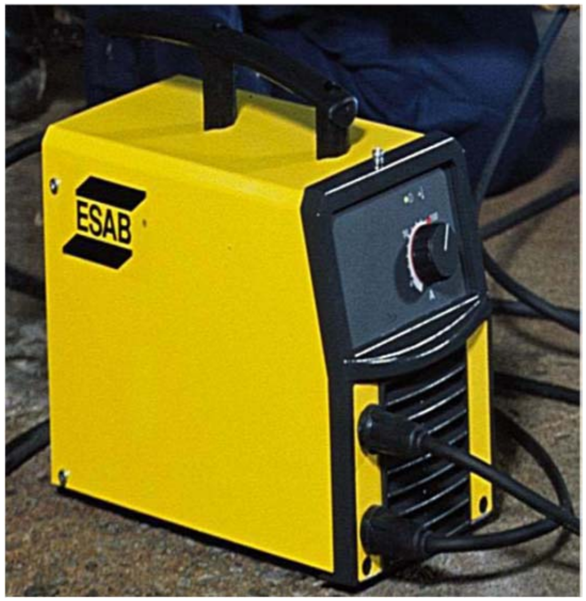

Fig. 2: Specification of GTAW machine

Table 5: Technical specifications of GTAW power source

Model	Origo Arc 200
Manufacturer	Esab india limited, Kolkata
Mains voltage V/ph, Hz	230/1 50
Setting range (DC), A	5-180
Open circuit voltage, V	60-75
Dimensions (mm)	380x180x300
Weight (kg)	8

3.2 Wear Test

The wear analysis for all the specimens is done on Pin on Disk apparatus. For calculating the wear rate, the work piece was weighed before and after the wearing of a pin on the rotating disc and the difference between the initial and final weight was calculated. The weighing was done on a weighing machine with a least count of 0.0001gm. The sample was mounted perpendicularly on a stationary vice such that its one of the face is forced to press against the revolving disc. A standard specimen of cylindrical shape having dimensions (Length-30mm, Dia-7mm) of welded mild steel is prepared for the metal to metal wear (Pin on Disk) test. The test is performed at Wear and Friction monitor TR-201 machine. The different parameters of pin on disc rotating machine are shown in table.

Table 6: Wear resistance test parameters

Applied load (N)	30
Disc Diameter (mm)	60, 80
Time (min)	4, 3
Specimen size	25 mm length, 9 mm dia.
Sliding distance (m)	377.142

Fig. 3: Pin on disc apparatus

3.3 Micro hardness Test

Vicker hardness tester is used to measure the hardness at different levels. We check the hardness value at three stages are weld bed,HAZ(heat affected zone and BM(base metal).

Fig. 4: Vicker hardness tester

4. DISCUSSIONS

The best wear resistance was obtained in the specimens that were coated with HB 600HT than mild steel. The experimental result indicated that the weight loss is decreased as compare to mild steel.

HB 600 filler rod gives better result in abrasive wear than mild steel and improved the best wear resistance was obtained in the specimen up to 70% than mild steel. The amount of carbon percentage is more in HB-600HT as compare to mild steel. With the help of micro hardness test, the hardness is increased with the layer of filler rod on work piece .The experimental result indicated that the HB-600HT filler rod hardness is increased as compare to mild steel.

5. RESULT AND CONCLUSION

5.1 Micro hardness Test

Table no. 7 abd fig. no. 5 represent the micro hardness value of samples top to bottom of the bead and in each pieces, the three layes are make firstly weld bead, HAZ and base metal. Filler rod HB 600-HT hardness value is more then mild steel.

Table 7: Micro hardness value of samples top to bottom of the bead.

S. no. VHN	A1	A2
1	615	670
2	601	610
3	550	588
4	504	501
5	497	486
6	240	236
7	218	215
8	217	210
9	216	198
10	190	188

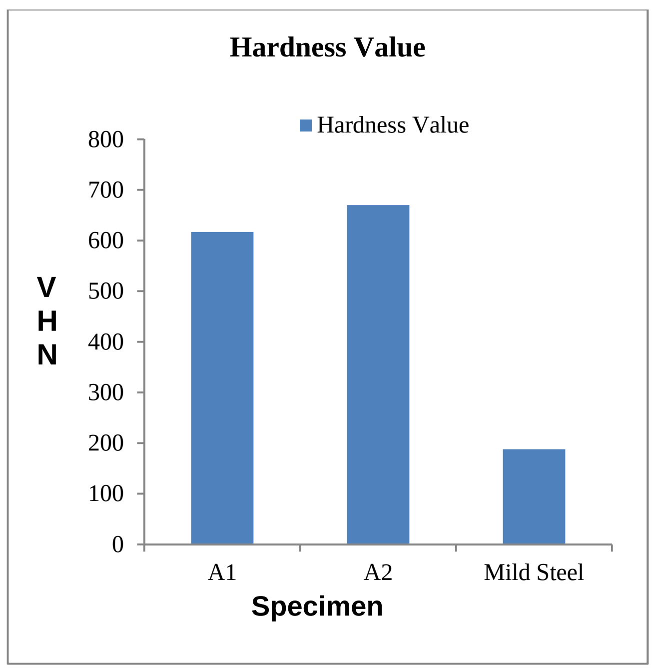

Fig. 5: Micro hardness value

5.2 Wear Test

Table 8 and Fig. 6 represent the general weight loss and abrasive wear resistance results from the Wear and Friction monitor TR-201 machine and corresponding wear resistance of filler rod HB 600HT & mild steel. The best wear resistance was obtained in the specimens that were coated with HB 600HT filler rod than mild steel. The experimental result indicated that the weight loss is decreased as compare to mild steel.

Table 8: Wear rate readings of all samples

S. No.	Initial Weight	Final Weight	Weight Loss
A1	9.7401	9.6909	0.0492
A2	9.8651	9.8148	0.0503
B.M.	9.5583	9.4379	0.1204

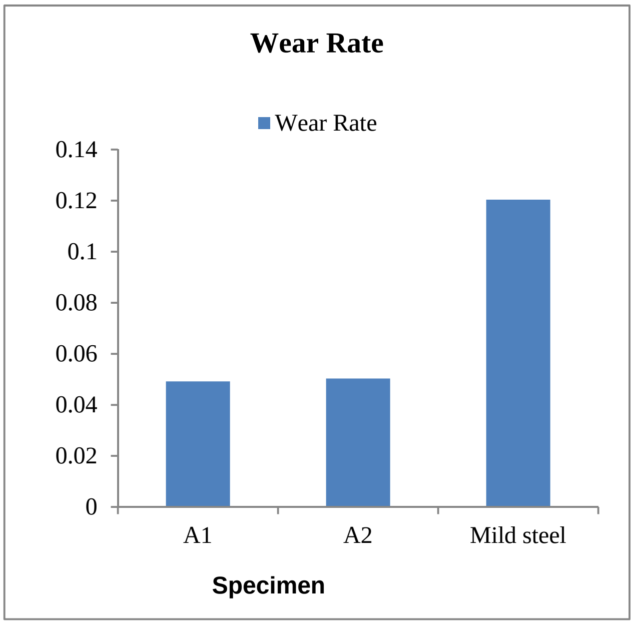

Fig. 6: Comparison of weight loss for all sample

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