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Experimental Investigation of Strength and Microstructural parameters of Mild steel specimen Hard-faced by Chromium zedalloy-350 using shielded metal arc welding (SMAW) process

DIGAMBAR BENNE[1], SANGAMESH SIRSGI[2]
[1,2]Research Scholar, Mechanical Engineering Dept. GNDEC BIDAR Karnataka, India 585403

Abstract -- In the present experimental study the hardfacing of mild steel components was done by the chromium alloy steel i.e ZEDALLOY-350 . using the shielded metal arc welding process by varying the welding process parameters like welding current, welding voltage and welding speed. The experimentation has been carried out by using Taguchi's L9 orthogonal array and the output responses were noted down and investigation of strength parameters like hardness and impact strength was done along with microstructural study of hard-faced samples. Finally after the investigation it was concluded that the hardness and impact strength of the components was increased and the grainsize and phase distribution is also changes and which leads to high internal strength of the hard-faced components.

Index Terms: Wear, Hardfacing, Shielded Metal Arc Welding (SMAW)

I. INTRODUCTION

Hard facing or surfacing is a process of applying a metallic coating on the base metal with a harder metal to obtain certain specific properties like resistance to Impact loading, erosion and corrosion, abrasion, cavitations etc. Hard facing, also known as "Hard surfacing", is the process of build-in deposits of specialized alloys by means of a welding process to obtain specific advantages as mentioned above. Such an alloy may be deposited on the surface, an edge, or merely the point of a part subjected to wear. Welding deposits can functionalize surfaces and reclaim components extending their service life. This process has been adopted across many industries such as cement, mining, steel, petro-chemical, power, sugar cane food etc.

A hardfaced part should be thought of as a composite, with the base material selected for strength and economy, and the hardfacing material (which might be unsuitable as well as too costly for use in fabricating the complete part) selected to sustain wearing conditions to which the critical sections of the part will be subjected in service.

Hardfacing may be applied to a new part during its production, or it may be used to restore a worn-down surface. A large number of components such as balls and rollers of mill etc. are exposed to heavy wear and require efficient surface protection measures to avoid costly downtimes and to reduce costs for expensive spare parts.

II. EXPERIMENTAL PROGRAM

Control parameters of shielded metal arc welding process

- Welding current
- Welding voltage
- Welding speed

Selection of process parameters and their range

Parameter	Range
Current	200-350 amps
Voltage	30-50 volts
Welding Speed	1.2 – 2.5 cm/s

III. BASE METAL AND ITS CHEMICALCOMPOSITION

Mild steel:

Mild steel is most commonly and widely used in engineering manufacturing sector. It is soft and highly ductile and therefore easily shaped in to any shape. It is easily forged, welded and machined. It is used

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extensively in structural fabrication and making of chains, rivets, bolts, nuts, pins, shafts etc. it can be forged, pressed and drawn in hot and cold conditions, it can be easily machined using high speed cutting tools.

Chemical composition

CARBON 0.16-0.18%
SILICON 0.40 Max %
MANGANESE 0.70-0.90 %
SULPHUR 0.040 max %
PHOSPHORUS 0.40 x

Advantages of mild steel
- Cost –effective
- Easily wieldable
- Ductile in nature
- Recyclable
- Can be reworked easily etc

IV. HARDFACING MATERIAL AND ITS CHEMICAL COMPOSITION

Chromium alloy steel (ZEDALLOY-350):

A chromium alloy heat treated by annealing process will be used as a hardfacing metal for the coating on the selected base metal. This metal is in the form of electrodes will be used for the joining and hardfacing of the components. The weld deposit of this alloy has 350 Brinell hardness approximately and is machinable with carbide tools.

Chemical composition:
CARBON = 0.20%
SILICON = 0.30%
MANGANESE = 0.65%
CHROMIUM = 2.8%

Welding parameters and their levels

levels	parameters		
	Current (amps)	Voltage (volts)	Welding speed (cm/sec)
1	250	40	1.2
2	300	45	1.8
3	350	50	2.5

V. DESIGN OF EXPERIMENT

- No of parameters= 3
- No of levels for each experiment=3
- Complete level of opportunity for 4 parameters =3× (3-1) =6
- There for least no of experiment= aggregate DOF for parameters+1=6+1=7
- There for the closest orthogonal cluster is L9
- For the above parameters and levels the base numbers of trials to be led are 7.
- Henceforth the closest orthogonal exhibit is L9

Experiment Number	Welding parameters and their levels		
	Current (amps)	Voltage (volts)	Welding speed (cm/sec)
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

VI. ORTHOGONAL ARRAY DESIGN AND OUTPUT RESPONSES

Sl no	Current (amps)	Voltage (volts)	Welding speed (cm/sec)	Depth of penetration (mm)	Bead width(mm)
1	250	40	1.2	4.5	14.2
2	250	45	1.8	4.8	14.5
3	250	50	2.5	5.0	15.6
4	300	40	1.8	5.6	15.2
5	300	45	2.5	5.8	14.8
6	300	50	1.2	6.0	16.3
7	350	40	2.5	5.2	16.5
8	350	45	1.2	6.5	15.6
9	350	50	1.8	6.8	16.8

VII. RESULTS FOR STRENGTH EVALUATION

Table 1 CHARPY TEST

SL NO.	Energy absorbed for normal material (kg-m)	Energy absorbed for Hard Faced material (kg-m)	Energy Comparison Normal – Hard Faced material (kg-m)	Main Energy Absorbed (kg-m)
1	1.3	4.6	1.3-4.6	3.3

- When we see the worth for normal steel (Before Hard facing) we get the quality is 1.3 Kg-m and When we figure out for Hard Faced steel after analysis we get the better quality is 4.6 Kg-m.
-
- The difference of energy absorbed between the normal material before hard facing and after hard facing material is 1.3 - 4.6 = 3.3 Kg-m. Hence we can say that the hard faced material is 3.3 Kg-m more grounded than the normal material at trial 3.

- In the results we can see that the minimum energy absorbed after hard facing is 1.6 Kg-m at the trial 7 and the maximum energy absorbed after hard facing is 4.6 Kg-m at the trial 3.

SL NO.	BHN for Normal Material (Mild Steel)	BHN for Hard faced material (Mild Steel)	BHN Comparison Normal-Hard Faced Mild Steel	Main BHN
1	170.39	284.85	170.39 - 284.85	114.46

- The hardness value of the specimen after hard facing varied from 187.23 – 284.85 BHN.
- When we get the worth for gentle normal mild steel we get the quality of hardness is 170.39 BHN and we get after hard facing of the specimens, the better value of hardness is 284.85 BHN at trial 7.
- The difference between without hard faced material and with hard faced material, the hardness value is 170.39 – 284.85 = 114.46 BHN.
- And, in the results we can observe that the minimum hardness value 187.23 BHN at the trials 1, 5 and 9. And the maximum hardness value 284.85 BHN at the trial 7 of the hard faced sample.

1. Micro-Structure Tests

For the normal sample we get the results as shown below which shows the uniform structure pattern of light Ferrite and dark Paralyte before Hard Facing.

	Grain Size#
ASTM Grain Size#	4.5
Intercepts	111
Mean Int.length (µm)	63.8

Table 2 BRINNEL HARDNESS TEST

And for the Hard Faced samples we get the results as shown below and they shows the structure pattern of Temper Marten site.

	Grain Size#
ASTM Grain Size#	7 (Better Grain size)
Intercepts	232
Mean Int.length(μm)	30.5

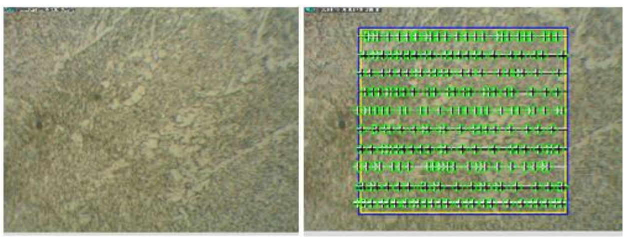

Figure 1: Base material

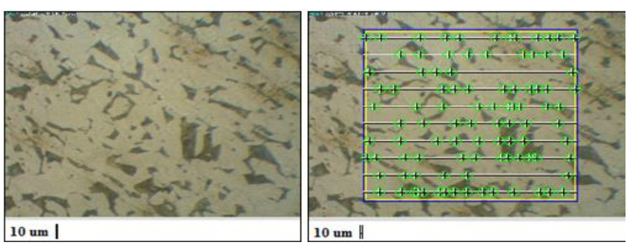

Figure 2: Hard Faced sample

- We can observe from the above micro-structural test results, that the specimen before Hard facing shows the uniform structure pattern of light Ferrite and dark Paralyte. And has the grain size 4.5, Intercepts 111 and Mean Int. length (μm).
- And we can also observe that the specimen 2.3 and 8 has the grain size 6.5 and specimen 1 has the grain size 6.
- But the specimen 7 has the better grain size value.

VIII. CONCLUSION

In the present experimental study the hardfacing of mild steel components was done by the chromium alloy steel i.e ZEDALLOY-350. Using the shielded metal arc welding process by varying the welding process parameters like welding current, welding voltage and welding speed. The experimentation has been carried out by using Taguchi's L9 orthogonal array and the output responses were noted down and investigation of strength parameters like hardness and impact strength was done along with microstructural study of hardfaced samples. Finally after the investigation it was concluded that the hardness and impact strength of the components was increased and the grainsized and phase distribution is also changes and which leads to high internal strength of the hardfaced components.

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