SOME STUDIES ON CHROMIUM CARBIDE HARDFACING WITH SELF SHIELDED FLUX CORED WIRE

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Detailed investigations have been carried out to study the effect of welding parameters on the charecteristics of hard metal deposited by self shielded flux-cored wire.
The various characteristics of the deposited layer such as dilution, hardness, chemical composition etc. have been evaluted with respect to variation in the welding voltage, current and speed.
It has been found that welding parameters have difinite influence on the above mentioned characteristics of the deposited layer of the hard metal as well as on the efficiency of the deposition.

INTRODUCTION

Hardfacing is the process of applying a layer or edge of wear resistant metal onto a metal part to incerase its resistance to abrasion, corrosion and impact or any other type of combined wear. Surface treatment is used to increase the life of engineering components, operated under condition of wear. It makes large economics possible, where advantages can be taken of superior properties of an expensive alloy by applying it as a coating to a low cost base material (1).

Hardfacing may be applied to new parts to improve their resistance to wear during service or to worn-out parts for the purpose of restoring them to serviceable condition. It is frequently used in application where systematic lubrication against wear is not feasible or inadequate to give desired service life (2)

Following information is required for hardfacing a component (3) ;

i. Nature of wear

ii. Qualities of hardfacing material.

iii. Welding process which is most economical to deposit the selected material.

iv. Welding variables and proper technique.

A wide range of materials are available for hardfacing such as alloy steels and cast irons, Ni-alloys, Cobalt alloys, Chromium carbides, Tungsten carbides and mixed carbides (3-5).

Hardfacing can be done with a variety of processes. Manual, semiautomatic and automatic arc welding processes such as manual metal arc welding, gas metal arc welding, flux cored arc welding, tungsten inert gas welding, submerged arc welding, plasma arc welding, oxy-acetylene welding and thermal spraying. For practical application the cost factor has to be prior examined carefully. Most of the processes involve fusion welding, where both the hardfacing metal and the base metal melt, join and resolidify to provide the continuous metallurgical bond. Molten metal is shielded from atmosphere either by flux or by sheilding gas (1, 5).

The welding with self sheilded flux cored wire, offers various advantages as compared to other processes such as economy, good uniformity of alloys in deposit, higher deposition rate, low operating current, reduction in penetration and dilution etc.(6,7).

Some important aspects of hardfacing are dilution, cracking, distortion, surface roughness and bead pattern.

To reduce the dilution proper selection of process and welding parameters, is a must. Generally hardfacing is done in two or more layers to minimise the effect of dilution. Technique of increasing the degree of overlap of adjacent bead is also useful in reducing dilution(4).

At high level of hardness the ductility is reduced and cracking as well as distortion can occur as a result of welding contraction strains. Such cracking may not significantly reduce the service life of the component as abrasion resistance is the main consideration. To avoid cracks the most common preventive measure is to apply preheat or to provide a buffer layer between base metal and hardfacing metal (1,6,8,9).

Welding generally produces a fairly rough surface. For some components like rock crusher a perfectly smooth surface is not required but for some components like gear wheel or valve seat, perfect surface is required. In that case machining or grinding is essential. If smooth surface is not a specific requirement then bead pattern is an important factor in hardfacing. It forms pockets which holds abrasive material and improves the wear characteristic. One hardfacing pattern will not perform equally well under all wear conditions. The most effective pattern can only be determined by trials (3,10,11).

Experimental work

The hardfacing material used is in the form of self shielded flux cored wire having diameter of 2.8 mm. The substrate material is 0.21 % mild steeel.

Single layer and single bead deposits on the plates in flat position, were made by using a SAW equipment with DC power source. The experimental work was carried out as follows:

* Weld deposits were produced by varying the arc voltage (3 steps) 25,30,35V and welding current (3 steps) 250, 325, 400A and welding speed (3 steps) 300, 400, 500 mm/min at fixed electrode extension of 30 mm.
* Preheating was not used and the welds were allowed to cool in air at room temperature.
* The investigations include the study of dilution of hardfacing mateiral with base metal, chemical composition of weld deposit, hardness of weld deposit and its variation of hardness from weld bead to base metal, efficiency of deposition, cracks and porosity in weld beads.
* For evaluation of dilution, the macro photographs of polished and etched samples were taken and surface areas of bead and reinforcement were measured. Anaysis of chemical composition was done on carbon sulpher analyser and atomic absorption spectrometer. Hardness measurement was carried out on Vicker hardness tester with a load of 5 Kg. Deposition efficiency was measured by weighing the test plate before and after deposition of material. For crack detection dye penetration test was used.

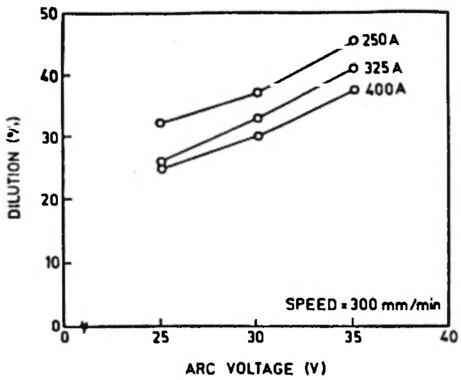

Fig 1 : Effect of Arc Voltage (V) on dilution (%) at 300 mm/min welding speed

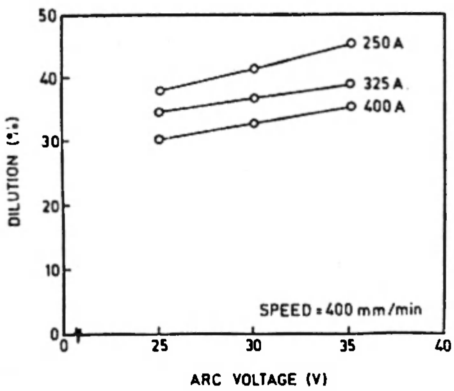

Fig 2 : Effect of Arc Voltage (V) on dilution (%) at 400 mm/min welding speed

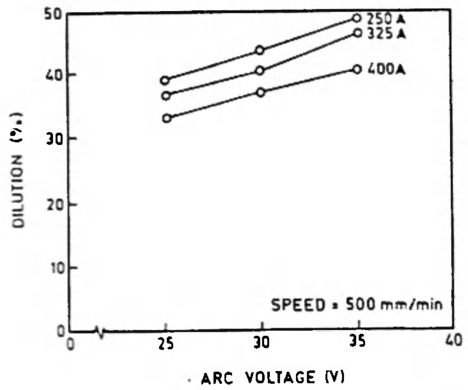

Fig 3 : Effect of Arc Voltage (V) on dilution (%) at 500 mm/min welding speed

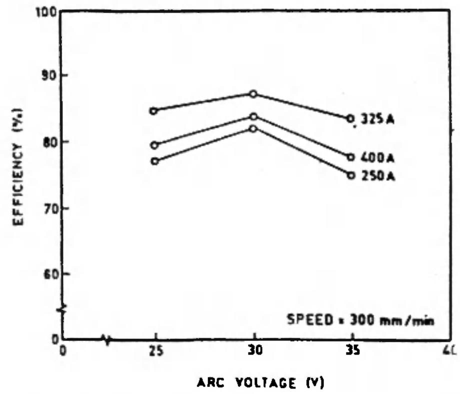

Fig 4 : Effect of Arc Voltage (V) on efficiency (%) of deposition at 300 mm/min welding speed.

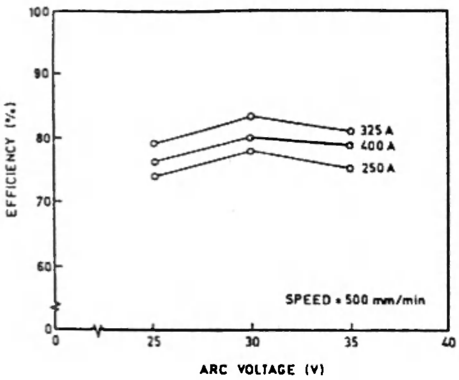

Fig 5 : Effect of Arc Voltage (V) on efficiency (%) deposition at 500 mm/min welding speed

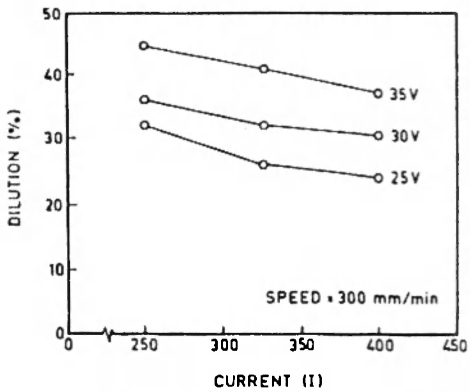

Fig 6: Effect of Current (I) on dilution (%) at 300 mm/min welding speed

Results and Discussions

Influence of welding parameters on dilution and deposition efficiency

The results show an interesting aspect of arc behaviour using self shielded flux cored wire as compared to the solid wire. For all welding currents and speeds, the increase in the arc voltage leads to the increase in depth of penetration and also dilution with flux cored wire (Fig. 1-3), while with solid wire depth of penetration remains either constant or decreases with the increase in the welding voltage. Therefore, for hardfacing using self shielded flux cored wire, it can be recommended to use lower welding voltage. With lower welding voltage (25V) good arc stability, less spatter and uniform bead shape have been obtained as compared to higher welding voltages i.e. 30 and 35 volts. However, the deposition efficiency is the highest almost in all cases at 30 volts (Fig. 4-5).

With the increase in welding current, dilution decreases (Fig. 6-7). This behaviour of welding with self shielded flux cored wire for hardfacing is opposite to that obtained with solid wire. If we consider the criterrion of dilution only, then 400 A welding current can be suggested as the best solution,, besause for this welding current lower dilution is obtained for different welding voltages and speeds.

By increasing the welding speed the dilution increases (Fig. 8-9). This is more or less similar behaviour as that obtained with solid wire.

Considering only the dilution aspect it can be suggested that the lower welding voltage and speed and higher range of current can give the acceptable degree of

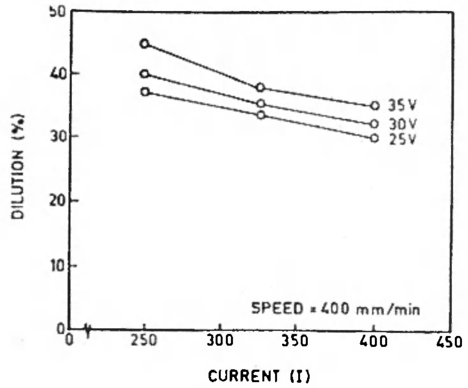

Fig 7 : Effect of Arc Voltage (I) on dilution (%) at 400 mm/min welding speed

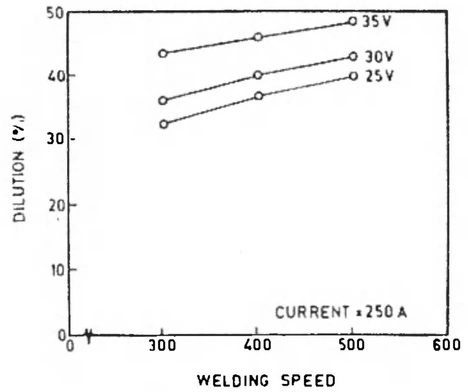

Fig 8 : Effect of welding speed on dilution (%) at 250 A welding current

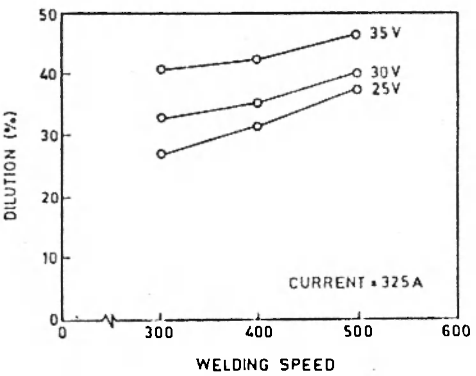

Fig 9 : Effect of Welding dpeed on dilution (%) at 325 a welding Current

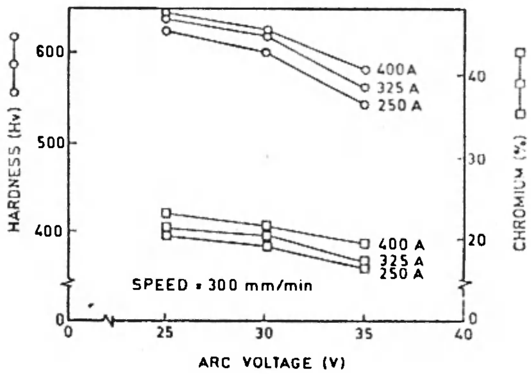

Fig 10 : Effect of Arc Voltage (V) on hardness (Hv) and Chromium content (%) at 300 mm/min welding speed

overlay with minimum dilution. However, the deposition efficiency aspect suggests that higher efficiency will be obtained at medium range of welding voltage and current. Welding speed seems to have no appreciable influence on the efficiency of deposition as it either decreases or increases by small amount with the increase in the welding speed, depending upon the other welding parameters.

Chemical composition

For hardfacing procedure the main task is to deposit in the weld bead as much as possible the alloying elements from wire core as carbon and chromium, combined in the form of chromium carbide, usually during the welding process to get the maximum hardness and wear resistance.

The element transfer in case of hardfacing with a self shielded flux cored wire, depends on welding parameters. Figures 10-12 show the influence of welding parameters on chromium content in the deposited metal. It can be observed that the chromium content in the weld metal decreases with the increase in both the welding voltage & speed while increase in welding current increases the weld metal chromium content due to decrease in dilution. Almost same pattern is observed for carbon and Manganese in the weld metal.

The efficiency gives the first information regarding the loss of elements especially by spatter. The chemical composition of weld deposit reflects one other aspect, namely the level of alloying elements transferred into the pool, naturally this proportion corroborates with dilution.

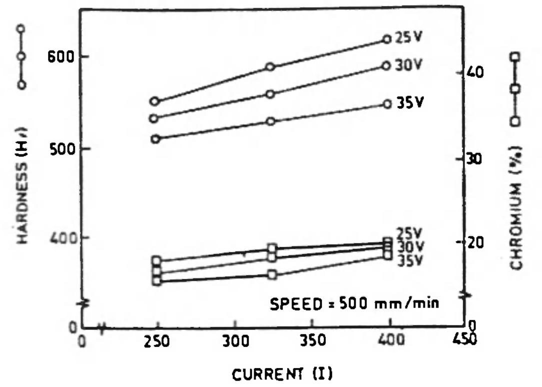

Fig 11 : Effect of Current (I) on hardness (Hv) and Chromium content (%) at 500 mm/min welding speed

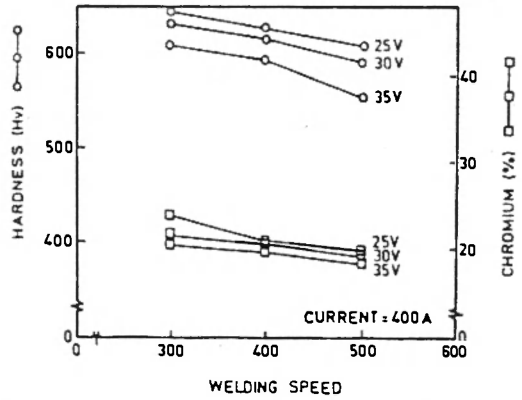

Fig 12 : Effect of Welding Speed (V) on hardness (Hv) and Chromium content (%) at 300 mm/min welding speed

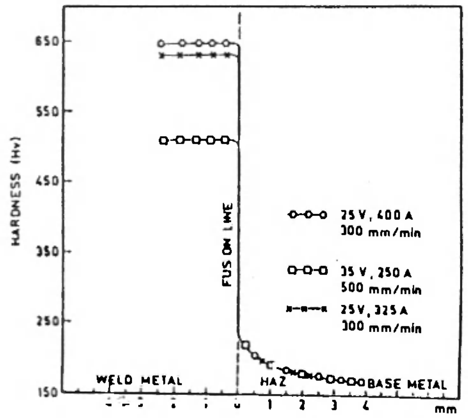

Fig 13 : Vairation of hardness in weld metal and base metal for different set of welding parameters

As per the catalogue of supplier, the pure weld deposit contains 4.5 carbon 30% chromium. However, the carbon and chromium level have not been achieved in one layer technique due to dilution with base metal. The highest level of carbon and chromium achieved by welding with 25 V and 400 Amp. is approximately Cr-22% and C-3.23% at a dilution of an average of 30% . The weld deposit without dilution shall reach the catalogue levels for all elements.

Hardness of weld deposit

The results of the hardness testing of weld deposits, reflect the same trend as observed in the case of chemical composition for chromium and carbon contents. With the increase in the welding voltage and speed the hardness of deposited metal decreases and with increase in the welding current the hardness increases (Fig. 10-12).

The highest hardness level has been achieved using the lowest voltage and higher current welding parameters and it is around 650 HV as the average of five measured values. Even in the case of highest dilution the hardness level is above 500 HV. Figure 13 shows the hardness from weld bead (650-520HV) to base material (160 HV) for different set of welding parameters . At defferent locations of the weld deposit the hardness is meausred and it is found more or less the same. This shows that the alloying elements are uniformly distributed in the weld deposit.

Cracks and porosity in weld deposit

Transverse cracks are observed on certain beads (Fig.14). it reflects that higher the carbon and chromium level in the deposit, the cracks appear due to lower plasticity of the chromium carbide. This aspect is common for most of high hardness alloys deposited by welding. For paractical applications this is not a negative aspect of hardfacing and does not have adverse influence on the wear life.

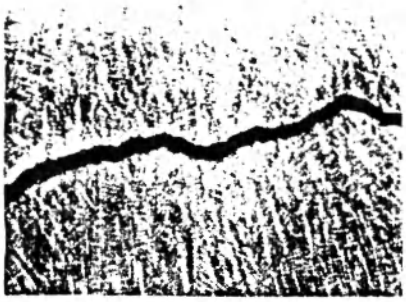

Fig 14 : A typical crack in weld deposit (x 100)

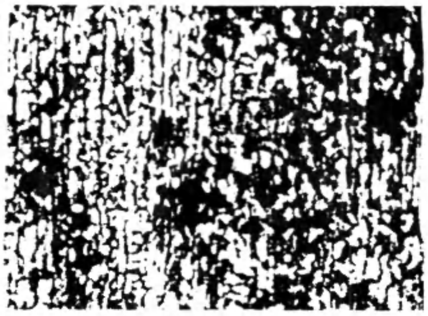

Fig 15 : Microstructure of base metal (x 100)

Fig 16 : Microstructure of weld deposit (x 100)

Porosity is a negative aspect of weld deposit either in welding or cladding process. In the present experimental work, the porosity has been observed in three cases where the specimen were welded with high voltage, low current and high welding speed. It confirms the same conclusion to avoid such group of parameters. It means that during welding with too high arc voltage, as the length of arc being longer, the protection of arc and pool from atmospheric air becomes difficult and insufficient for the gases generated by wire core ingredients.

Microstructure

The microstructures of the parent metal and weld deposit are shown in Fig. 15-16. The weld metal microstructure mainly consists of chromium carbide.

CONCLUSIONS

The most important aspect in hardfacing by welding is the dilution of weld metal with base metal. To study this aspect the one layer welding technique gives the real image of the influence of welding parameters on it. It has been found that the weld deposit with lower arc voltage and weld speed and higher weld current gives the minimum dilution and in turn higher chromium and carbon contents in weld metal. So for hardfacing above combination of parameters is recommended. The hardness of weld deposit is reflecting the dilution level and is directly influenced by it. The hardness is only an immediate aspect of hardfacing by welding. It has to be supplemented with wear test and evaluation of wear coefficient as weight loss of hardfaced alloy compared with the loss of mild steel under same wear conditions.

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