A STUDY OF SG IRON WELD METAL

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The effect of nickel and aluminium on the microstructure and mechanical properties in SG iron weld metal have been investigated.

It is found that both nickel and aluminium influence the microstructure. Nickel increases nodule count and pearlite content. Aluminium decreases nodule count and promotes ferrite formation. Addition of nickel in SG iron weld metal upto 3.95 percent, results in an increase in tensile strength and decrease in ductility. Further inprovement in tensile strength and marginal drop in ductility have been observed with the addition of aluminium in SG iron metal containing nickel.

INTRODUCTION

Application of SG Iron has increased to a great extent due to the development of new varities of high strength SG Iron. These include SG Iron alloyed with nickel which has high toughness even at low temperature, high strength bainitic iron and iron alloyed with silicon for high temperature applications (1-5). Attempts have also been made (6.7) to improve the properties of SG Iron by adding suitable amount of nickel and aluminium which are responsible for precipitation hardening effect.

It is. however. probable that the new SG Iron will be used on an increasing scale in the field of general and constructional engineering and its usefulness for fabrication purposes will be further enhanced if component parts can be joined by a welding process. The attainment of this objective may call for the development of new welding techniques and welding materials; since the unique properties of the SG Iron will not be fully realised unless the strength and ductility of the welded joint approach those of the parent material.

Iron-nickel welding consumables (E Ni Fe type) find extensive use in the welding of SG Iron (8.9). Manganese. copper and carbon have been used as alloying substitute to reduce the nickel content in the welding consumables used in the joining of SG Iron (10.11). It was found (12.13) that Fe-20 Mn-20 Ni were very satisfactory in welding SG Iron. However, it is apparent that these consumables are not necessarily appropriate for recently developed alloy S G Iron particularly the precipitation type. This study examines the addition of nickel and aluminium on the microstructure and properties of weld metal in S G Iron.

Experimental Procedure

A series of submerged arc bead-on-plate welds were produced on 25 mm thick pearlitic spheroidal graphite cast Iron plates. The weld metal compositions were systematically varried by powdered metal additions such as nickel and aluminium to the flux using a mild steel welding wire (ER 70-S3). The chemical compositions of those weld metals are shown in table 1. Heat input was held constant at approximately 3.25 KJ/mm.

The welds were then sectioned to provide transverse metalographic study and hardness testing. All weld tensile testing were conducted using specimens extracted in the longitudinal direction. The effect of post weld heat treatment (P W H T) on microstructure and hardness was also examined. The P W H T conditions were 950°C x 0.5 h followed by water quenching and tempering at 500°C for varying periods e.g. 30 mts. 60 mts. 120 mts and 180 mts. The percentage of weld metal microstructural constituents e.g. percentage of pearlite, ferrite, graphite and carbide were performed by point counting method at a magnification of 200X. Hardness values were measured by a Brinel hardness tester under a load of 187.5 Kgs. using 2.5 mm diameter ball. Tensile testing was made in an universal Tensile testing machine of capacity 10T. Fractured surfaces of tensile testing specimens were examined in a Scanning Electrode microscope.

Results And Discussion

Microstructure of weld metal

A comparison of the proportion of microstructural constituents for different weld metals is shown in Table 2. This comparison shows that the alloying elements such as nickel and aluminium, exert significant influence on nodule count and matrix microstructure. Nickel addition results in an increase in the nodule count and pearlite content in the as-welded microstructure. With about 4.0 percent nickel (alloy W3) nodule count increases by 25 percent over unalloyed weld metal. Some martensite forma-

Table 1 : Chemical Composition of Submerged Arc Weld Metals

Weld No.	Element Wt% C	Mn	Si	S	P	Ni	Al
W1	3.25	0 60	3.0	0.02	0.02	-	-
W2	3.20	0.62	3.1	0.02	0.02	1.95	-
W3	3.18	0.57	3.0	0.018	0.02	3.95	-
W4	3.26	0.56	3.1	0.02	0.02	2.0	0.41

Table 2 : Percentage of Weld-Metal Microconstituents for different Weld Metals

Weld No.	Ferrite %	Pearlite %	Graphite %	Nodule Count (mm^2)
W1	40	40	20	408
W2	34	50	16	476
W3	22	60	18	515
W4	29	55	16	424

Table 3 : Hardness and Tensile Properties of different Weld Metals

Weld No.	Hardness (BHN)	Ultimate Strength Kg/mm	Elongation %
W1	212	51	8.2
W2	245	62	5.1
W3	334	70	3.5
W4	238	66	3.2

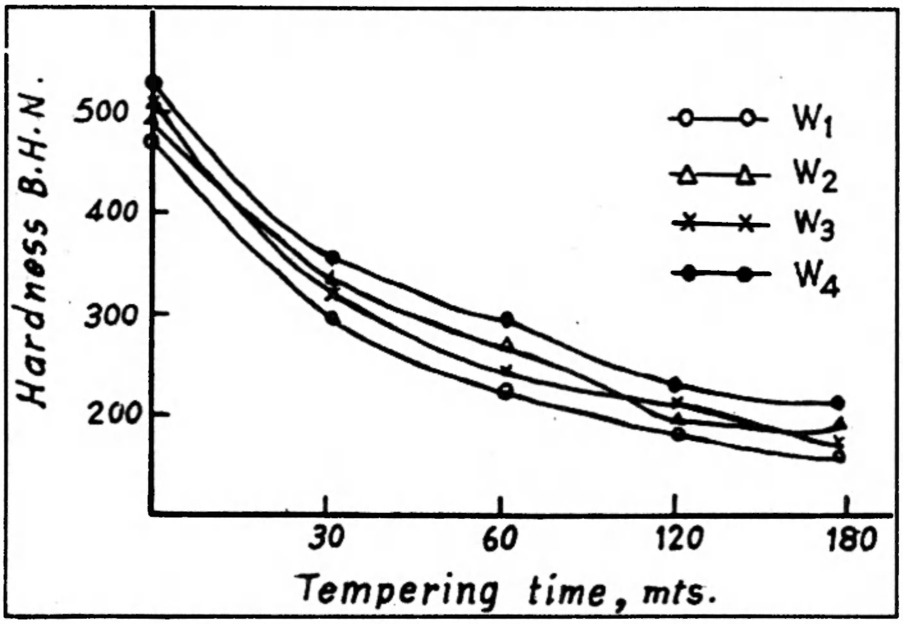

Fig 1. Hardness versus Tempering time plot for different S.G. Iron Weld metal

tion was observed in the areas of the original austenite dendrites in alloy W3 (containing 4.0. percent nickel). Aluminium addition on the other hand, decreased the nodule count and increased ferrite content. Several authors have reported that denodularization sets in and amount of free ferrite increases with increasing aluminium content (14,15) due to ferritising action of aluminium.

Results of Tensile test

As shown in Table 3, by adding nickel content in the weld metal the tensile strength increases and ductility decreases. With same amount of nickel, aluminium addition increases tensile strength and marginally decreases ductility. The difference in weld metal tensile strength as a function of these two alloying elements is attributed to their intrinsic effect on as-weld microstructure.

The increase in tensile strength for the addition of nickel (sample No.W3), as compared to the sample No.W1, is related to the presence of more pearlite and less ferrite, this being the most obvious distinction between the two, otherwise similar microstructures. In addition, nickel also contributes towards solid solution. Improvement in tensile strength and marginal drop in ductility with the addition of aluminium at the same amount of nickel content could be due to the formation of some martensite in the areas of original austenite dendrites. Moreover aluminium addition may give rise to the formation of Al N which refine the structure by providing as nuclei.

Effect of PWHT

Applying PWHT of 950 C X 0.5 h followed by water quenching and tempering at 500 C for varying periods to all the SG iron weld metal samples changed hardness shown in Fig (1) the hardness versus tempering time plot. After heating to 930°C followed by quenching in water, martensite was formed (Fig. 2). Tempering process exerts a softening effect on the matrix. Metallographic examination of the tempered samples indicates the decomposition of carbide to ferrite and graphite (Fig.3). It is observed from Fig.1 That weld no.

W4 mildly retards the tempering process as compared to other samples.

This may be attributed due to the presence of alluminium which decreases activity of carbon in ferrite and increases in cementite. Both these effects act to retard cementite precipitation from martensite matrix (16).

Fractographic Study

Due to the structure's complexity and heterogeneity, also the morphology of the fracture surface at room temperature is quite complex.

From the examination of the fractographies obtained at S E M, it is possible to drive some indications as to the initiations phenomenology and on the crack's propagation.

It seems certain that the fracture begins at the graphite matrix interface as shown in Fig. 4. The crack spreads from graphite into the metalic matrix which, around the graphite particles, is generally made of ferrite. The fracture surface has mainly a ductile morphology. Zones of brittle fracture by/ transgranular cleavage and intergranular decohesion are also visible (Fig. 5).

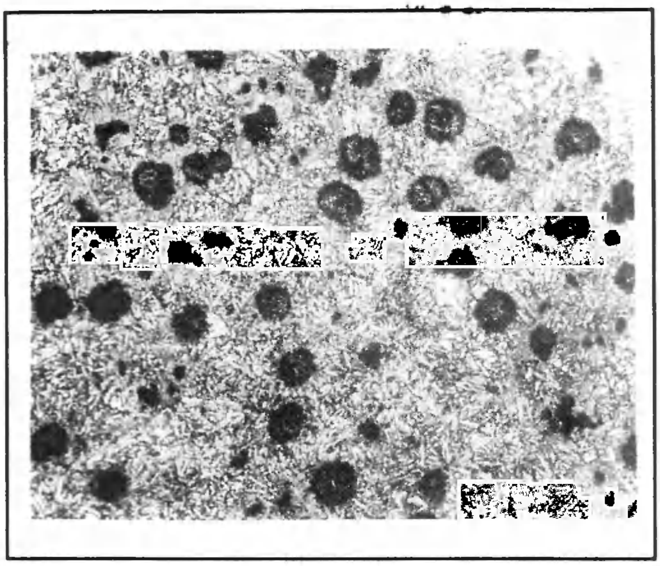

Fig 2 : Microstructure of weld No. W3, austenitised at 930oC and then quenched in water, 150X

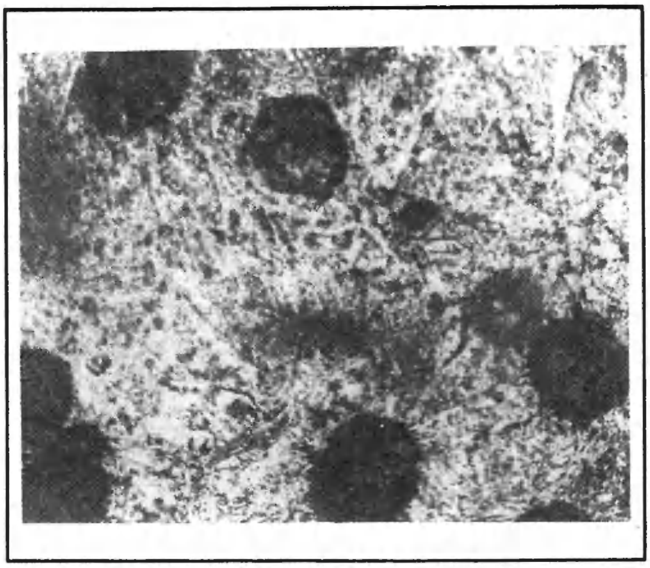

Fig 3 : Microstructure of weld No. W3, tempered for 60 mts, at 500°C, 300X

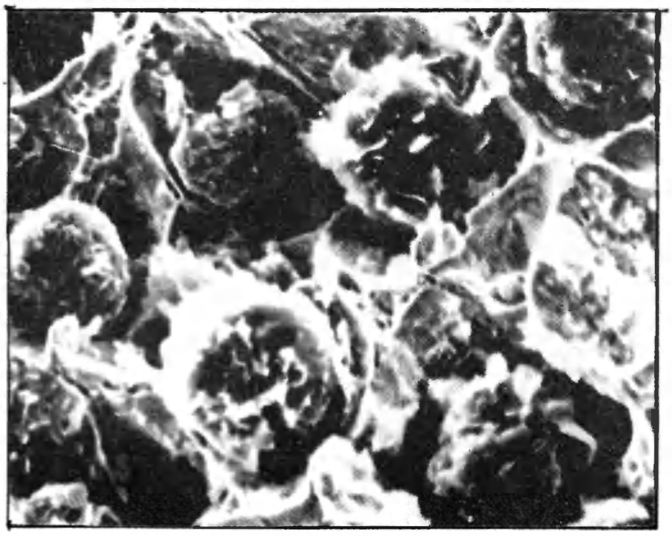

Fig 4 : SEM fractographs for weld No. W2 showing the presence of hollow graphite shells which indicates decohesion at the graphite matrix interphase.

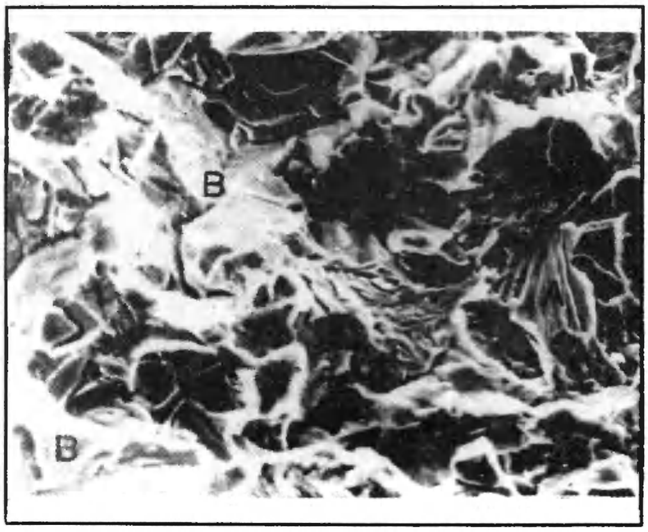

Fig 5 :SEM fractographs for weld No. W4 showing mixed mode of intergranular and transgranular fracture.

CONCLUSIONS

1. Both nickel and aluminium influence the microstructure of SG iron weld metal. Nickel increases nodule count and pearlite content. Aluminium decreases nodule count and promotes ferrite formation.
2. Addition of nicies in S G iron weld metal upto 3.95 percent, results in an increase of tensile strength and decrease in ductility. At a given amount of nickel content, improvement in tensile strength and marginal drop in ductility with the addition of aluminium has been observed.
3. All the S G iron weld metals respond the PWHT. The tempering process exerts a softening effect on the matrix. Addition of aluminium in S G iron weld metal mildly retards the tempering process.

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