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REPARING OF TURBINE INNER CASE BY MANUAL METAL ARC WELDING

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ABSTRACT:- The research consisted of performing the maintenance on the internal cover (shell) of the electric power generating unit turbine which was made of nodular cast iron that was achieved by replacing the damage part, with cast carbon steel, using manual metal arc welding, and AWS ENiFe-CI filler metal electrode. Pre-heating and post-heating were implemented to avoid the formation of brittle phase in the welded zone or Heat Affected Zone (HAZ). The weldments mechanical tests showed that the welded zone mechanical properties were better than that of the original metal of the internal cover.

INTRODUCTION

The welding of nodular cast iron is not largely practiced in the foundry industry for the reclamation or fabrication of castings due to the inconsistency of the mechanical and physical properties achieved. While the welding of steel casting is common practice, Nodular cast iron contain higher amount of carbon which diffuses into the ausyenite during welding, forming hard brittle phases, namely martinsite and carbides at the welding interface giving rise to poor elongation properties and high hardness values (1,2,3,4).

For successful welding of nodular cast iron different properties at the heat affected zone must be eliminated to give similar properties to those of the parent metal. The extent of the heat affected zone can be minimized by using welding processes which give a low heat input or by use of a preheat treatment, total removal of the hardened zone can only be obtained by post annealing (5, 6).

Nodular cast iron are available in a wide range of tensile strength. Although all classes may be considered weldable, the most experience and the best results have been achieved with the lower strength irons. Good joint efficiency is possible with established procedures with iron up to and including the 414 MPa (60,000 psi) tensile strength grades. Above that level-matching strength is increasingly difficult to achieve in a welded joint . At all strength levels matching ductility is seldom possible. In all cases irrespective of the welding method, best results are obtained only by the use of carefully developed and qualified welding procedures [7,8].

Nodular cast iron can be readily welded by shielded metal arc welding process using **ENiFe-CI** welding electrode. The electrode deposits metal that is higher in ductility and strength. Sound heavy – section welds can be made using ENiFe – CI electrodes with preheating [2].

Excellent results are obtained also when using ENiFe – CI electrode to join nodular cast iron to dissimilar metals. Strong crack – free joints have been made between nodular cast iron and a number of alloys including mild steel, stainless stee. When welding nodular cast iron iron to other alloys, the nodular cast iron should be handled in the same manner as in welding nodular cast iron to itself [2].

EXPERIMENTAL WORK

Figure (1) shows the upper half of the inner case of steam turbine which subjected to a sever damage during operation with total weight approximetlay 42 ton.

According to the manufacturer manual the material of the turbine inner case is Ferritic nodular cast iron with chemical composition and mechanical properties are shown in tables (1, 2).

Table (1): Chemical composition of nodular cast iron inner case.

% C	% Si	% Mn	% Cr	% Mg	% S	%Fe
3.55	2.38	0.2	0.03	0.06	0.005	Rem.

TABLE (2) : Mechanical properties of nodular cast iron

UTS MPa	Y.P (0.2%) MPa	% Elongation	%Reduction Area	Hardness HB
426	309	16.6	19	161

Various codes and specifications were required in order to achieve a satisfactory welding procedure. Procedure qualification tests for groove welding are illustrated in figure (2).

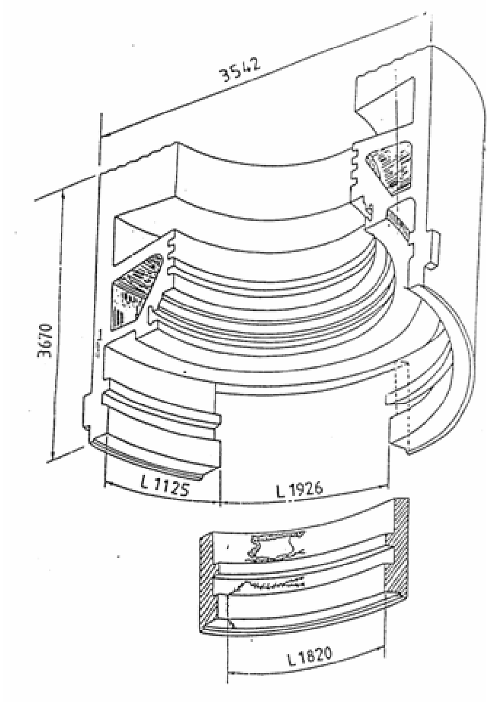


Fig. (1): Steam turbine inner case (dimensions in mm).

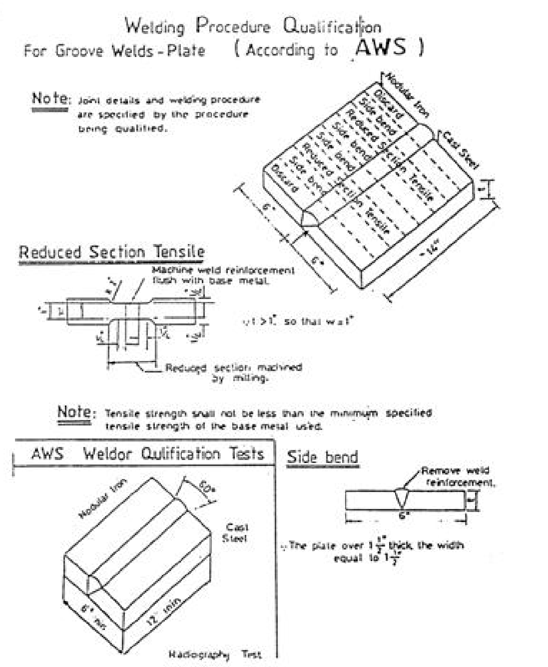


Fig. (2): Procedure and weldor qualification according to AWS.

The damaged part was removed and compensated by cast steel with chemical composition and mechanical properties shown in tables (3, 4), because of the difficulties associated with production of nodular cast iron in Iraq.

Table (3): Chemical composition of cast steel.

% C	% Si	% Mn	% S	% P	%Fe
0.29	0.25	1.1	0.022	0.03	Rem.

Table (4) : Mechanical properties of cast steel

UTS MPa	Y.P (0.2%) MPa	Elongation %	Reduction Area %	Hardness HB
449	332	18.5	45	148

Figures (3, 4) show joints design used in the present work which selected in order to reduce the amount of weld deposit, heat input, the width of (HAZ), and shrinkage forces.

Manual Metal Arc Welding (MMAW) process with ENiFe–CI used after achieving a local preheating of 300 – 350 °C and stress relieving at 600 - 650 °C.

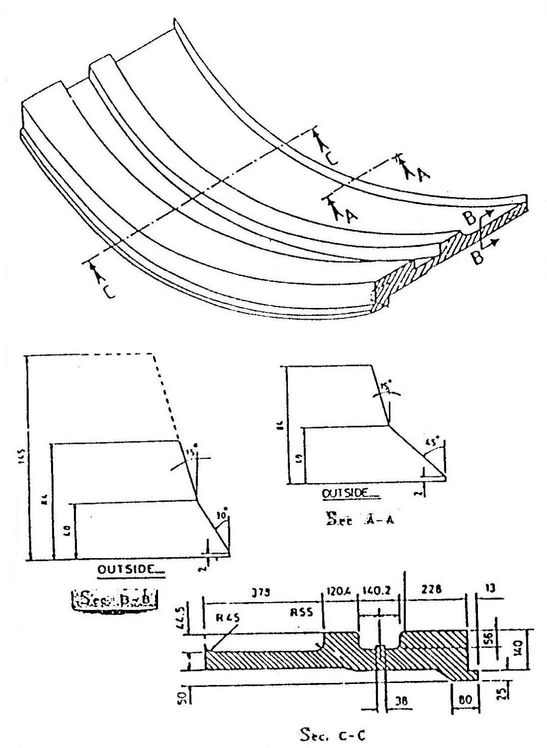
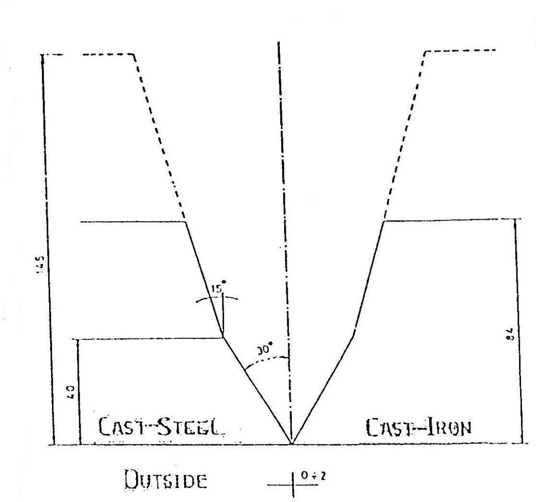
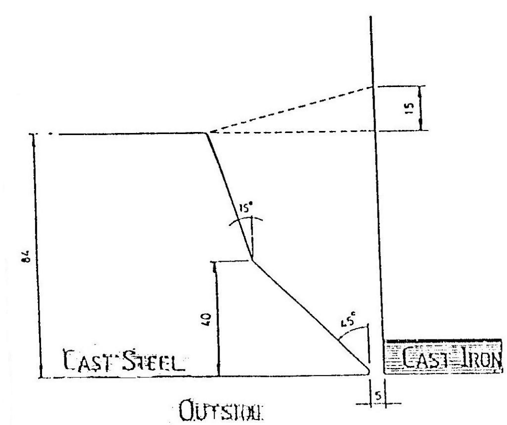


Fig.(3): Compensated cast steel with joints preparation.



(a) At section A-A



(b) At section B-B

Fig. (4): Joint preparation in figure (2).

Welding sequences followed in the present work were:

a) Three welders working at the same time.

b) Electrodes dried at 250 °C for one hour.

c) Welding started at position No. 1 (figure -5) with the following procedures:

- Pass No.1 with ENiFe-CI, 2.5 mm diameter and DC^+ current.
- Pass No.2 with ENiFe-CI, 3.5 mm diameter and DC^+ current.
- Pass No.3 with ENiFe-CI, 4 mm diameter and DC^+ current.

d) Welding at position No. 2 with the same sequence of position No.1, and the same for other positions.

e) Interpass temperatures to be between 300 °C – 350 °C.

f) X – ray inspection was done when the weld thickness approximately 40 mm.

g) The root passes to be removed by Arc–Air Gouging, when welding thickness approximately 40 mm, and chipping before X – ray inspection.

h) The root was checked by dye penetrates.

i) Use electrode type ENiFe – CI, 3.25 mm diameter or 4.00 mm DC^+ to weld root pass.

j) Ultrasonic inspection was done for thickness more than 40 mm up to 145 mm each 20 mm thickness.

k) A qualified welder of 6G class should handle the welding process.

l) To increase the safety of the welding joint a plate of DIN St37-2 with thickness of 38 mm, fixed by M20 screws, to be used to cover the inner case from outside fig. (6).

m) Local stress reliefing at 600-650 °C for 12 hrs using special heater types.

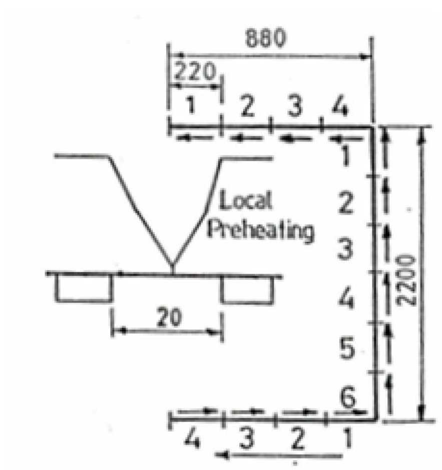


Fig. (5): Welding Sequences.

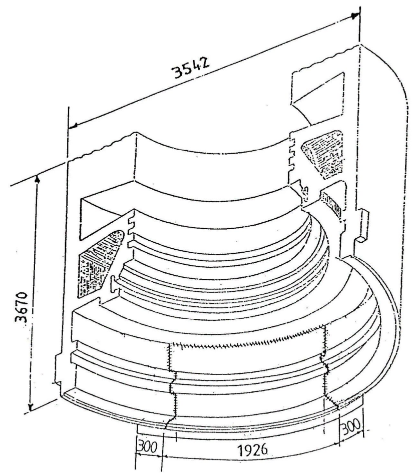


Fig.(6): case after welding with DIN St37 cover plate.

RESULTS AND DISCUSSION

To ensure the success of the welding procedure , the ASME section IX procedure qualification tests was implemented [9]. Two pieces were selected one from casting steel (table-3) and the other from ferritic nodular cast iron by dimension shown in figure (2) , to perform the qualification tests to determine whether the welding zone had mechanical properties equal or more than the inner case nodular cast iron .

MMAW process was used with ENiFe-CI electrode for it has preferable mechanical properties with a good machinabilityfor the required subsequent machining works.

The welding was done on prototype (figure-2) with the same technology that was mentioned to perform the maintenance.

It is worth to mention that the prototype weldment test plate was of 25mm (1-inch) thickness, so an electrode of 3.25mm diameter and a DC^+ polarity was selected .All the process was done by one qualified weldor. Preheating and postheating were adopted within the range explained earlier.

Two tensile test specimens with four side bending speicemens were manufacturing from the prototype weldment after testing the weldment with X-ray photoghraphy and was sure that the weldment free of defects .

The results of tensile test showed that average tensile strength was equal to 435 MPa with yield strenth of 321 MPa which are more than the properties od inner case base metal.

The side bending for the four specimens were passes without any cracks at weldin zone or the HAZ. So, the welding process to compensate the damage zone was qualified .

The microscopic examination for nodular cast iron fig. (7) shows complete ferritic structure , where as it was ferrite and pearlite from cast steel fig. (8). Despite the necessity of compatibility for the microstructure of both cast steel and nodular cast iron yet, using a a complete ferretic casting, would lead that the replacement part would lose the required properties, where the tensile strength would become less than 300MPa, so decision was taken to use cast steel with chemical composition and microstructure shown in table (3) and fig. (8) respectively .

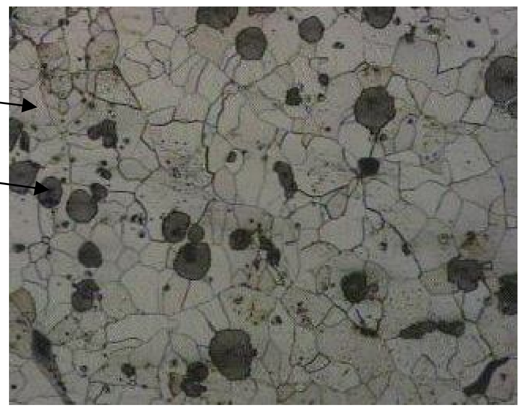


Fig. (7): Microstructure of nudulare cast iron (Mag.X 65).

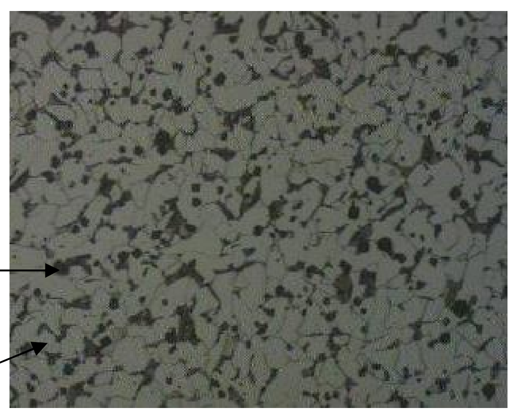


Fig.(8): Microstructure of nudulare cast steel (Mag. X130).

As ENiFe-CI electrode was used, the microstructure was mainly austenite with small amount of graphite which is in line with the condition of the use of that electrode [figure (9)].

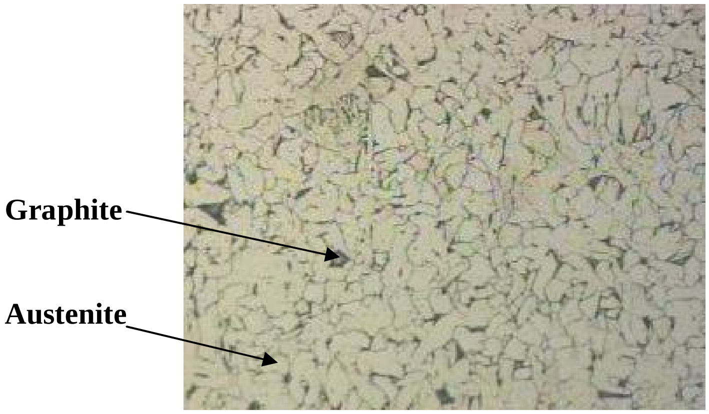


Fig.(9): Microstructure of welding zone (Mag. X65).

CONCLUSIONS

1. It is possible to repair the damaged part in steam turbine inner case by compensating the damaged part made of nodular cast iron by cast steel.
2. The welding using MMAW with ENiFe-CI electrode is satisfactory.
3. The importance of using preheating (300-350 ^{o}C) and postheating (600-650 ^{o}C) to avoid the formation of brittle phases at weldind zone and H

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صيانة الغطاء الداخلي لتوربين بأستخدام لحام القوس الكهربائي اليدوي

عطا جلال محمد عطا

مدرس مساعد

الكلية التقنية / بغداد

الخلاصة

اشتمل البحث على صيانة الغطاء الداخلي لتوربين محطة توليد طاقة كهربائية مصنع من حديد زهر ذي كرافيت كروي باستبدال الجزء التالف منه بمسبوكة من فولاذ كاربوني. استخدمت طريقة اللحام بالقوس الكهربائي اليدوي وسلك لحام نوع **AWS ENiFe-CI** مصحوبا بالتسخين المسبق واللاحق لتجنب تكون اطوار هشة في منطقة اللحام او المنطقة المتاثرة بالحرارة.اوضحت اختبارات تاهيل وصلات اللحام ان منطقة اللحام حققت متطلبات المواصفة القياسية بخواص ميكانيكية اعلى من معدن الغطاء الداخلي.