Effect of Section Thickness on Nodule Count and Corrosion Properties of a Few ADI Samples

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ABSTRACT

In the present investigation, the effects of section thickness, 0.5% Cu addition and different austempering temperatures on the microstructure and corrosion properties of ADI samples have been studied. ADI of base composition was inoculated with barium containing Minets. Barium is supposed to increase the nodule count. The casting was so designed that its cross-section varied from 1mm to 7 mm. Samples were austenitised at 900^{0}C and austempered at 365^{0}C, 390^{0}C and 350^{0}C.

It was found that while graphite nodule count decreased with increase in section thickness, matrix remained more or less the same, that is, of austenite and acicular ferrite. While in the base composition, ferrite was very fine and its distribution was uneven in the matrix, the Cu based ADI showed slightly coarse ferrite distributed uniformly throughout the matrix. The amount of austenite is found to decrease with decrease in section thickness.

Corrosion properties of the alloys were tested with and without chloride ion containing base solution of 1N H_2SO_4.

Corrosion properties were measured electrochemically using a GAMRY potentiostat. There was remarkable change in the corrosion properties with the change in the section thickness. Corrosion rate increased with increase in nodule count. Even the passive current density also increased with nodule count. It was interesting to note that with 0.5% Cu addition there was decrease in corrosion rate and even with chloride additions also there was no appreciable change in the corrosion rate.

EXPERIMENTAL DETAILS

Material Specifications

The samples were prepared by alloying the base material with 0.8 and 0.5 Cu respectively. The chemical analysis in weight per cent is given below :

Base ADI

Sample No.	C	Mn	Si	Cu	S
1	3.5	0.23	2.8	0.5	0.025
2	3.5	0.23	2.8	0.8	0.025

The ADI samples were inoculated with Barium containing minets.

The samples were austenitised at 900^{0}C. The ADI sample 1 was austempered at 390^{0}C and 350^{0}C. The ADI sample 2 was austempered at 365^{o}C only.

The casting cross-section varied from 1mm to 7mm.

Nodule Count

The samples were properly polished and examined under the microscope at 100X in the unetched condition. The variation in nodule count with section thickness was determined. The nodule count is shown in Table-1.

Microstructure

The samples were etched in 2% Nital solution (2% HNO_3 + 98% Ethanol).

Fig. 1: 0.8% Cu ADI (austempered at 365^{0}C) etched in 2% Nital and seen at a magnification of 400X.

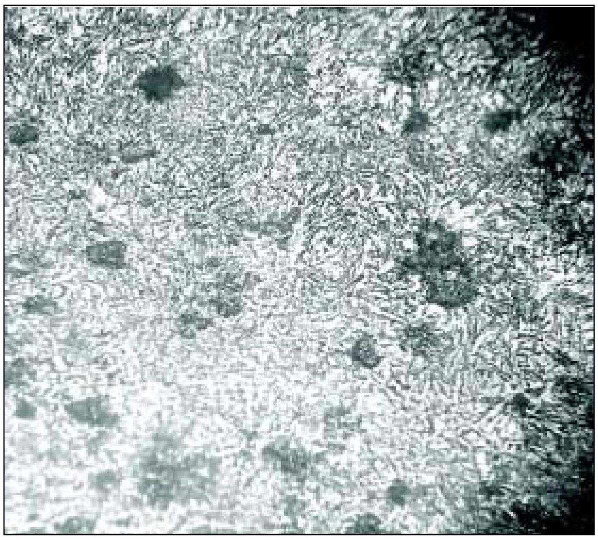

Fig. 2: 0.5% Cu ADI (austempered at 390^{0}C) etched in 2% Nital and seen at a magnification of 400X.

Hardness :

The Vickers hardness of the samples were determined by applying a load of 10 kg. The hardness values have been shown in Table-2.

Corrosion Testing: The corrosion testing of the alloys was done electrochemically using GAMRY potentiostat. This is a three electrode system with SCE as the reference electrode, graphite as the auxiliary electrode and the sample as the working electrode. The tests were carried out in three different solutions, namely

1. 1N H_2SO_4

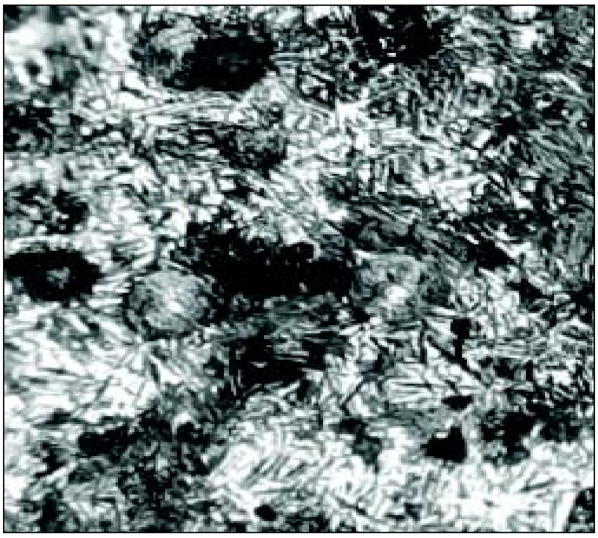

Fig. 3: 0.5% Cu ADI Austempered at 350^0 C X400.

2. 1N H_2SO_4 + 0.1 N KCl
3. 1N H_2SO_4 + 0.2 N KCl

These tests were done in three different portions of the samples with varying section thickness. The portion under study was exposed while the remaining portion was covered using Teflon tape. The area of the exposed part was measured and was supplied as an input to the GAMRY software in order to develop the V vs log I plots. The corrosion rates were expressed in terms of E_{corr} and I_{corr} values determined by Tafel's extrapolation method.

The E_{corr} and I_{corr} values are shown in Table-3.

RESULTS AND DISCUSSION

In this work, there were three variables, viz., austempering temperature, amount of copper and section thickness Hardness, microstructure including nodule count and corrosion resistance properties have been analysed with respect to the experimental variables.

From Table-1, it may be noted that small variation in copper and austempering temperature did not have any significant effect on the nodule count. But the matrix microstructure varied to some extent.

Hardness is found to increase with increase in copper content, increase in austempering temperature and increase in cross section (Table-2).

Hardness is directly related to the microstructures which are shown in figures 1 – 3. Amount of austenite is found to decrease with decrease in austempering temperature.

Table 1 : Nodule Count (No./mm²)

Sample 2	Tip	500
	Middle	457
	Top	400
Sample 1Austempered at 350	Tip	500
	Middle	450
	Top	400
Sample 1Austempered at 390	Tip	510
	Middle	450
	Top	410

Table-2 : Hardness in VPN under 10 Kg Load

Sample 2	Tip	373
	Middle	376
	Top	387
Sample 1Austempered at 350	Tip	268
	Middle	272
	Top	274
Sample 1Austempered at 390	Tip	330
	Middle	345
	Top	351

Table-3 : Corrosion Properties

		1N H_2SO_4		1N H_2SO_4 + $0.1Cl^-$		1N H_2SO_4 + $0.2Cl^-$	
		E_{CORR}(V)	I_{CORR}(mA/cm²)	E_{CORR}(V)	I_{CORR}(mA/cm²)	E_{CORR}(V)	I_{CORR}(mA/cm²)
Sample 2	Tip	-0.45	4.5	-0.48	8.0	-0.45	6.0
	Mid	-0.45	3.0	-0.43	0.8	-0.4	2.0
	Top	-0.46	0.4	-0.6	0.09	-.0.45	1.0
Sample 1 Austempered at 350	Tip	-0.44	3.0	-0.41	2	-0.4	0.3
	Mid	-0.44	2.0	-0.43	1.0	-0.43	0.5
	Top	-0.44	0.5	-0.43	2.0	-0.43	0.2
Sample 1 Austempered at 390	Tip	-0.53	1.014	0.56	1.011	-0.56	1.01
	Mid	-0.51	1.004	-0.68	1.0	-0.77	1.003
	Top	-0.41	1.0	-.019	1.002	-0.81	1-006

It is reported in literature[1] that ADI austempered at low temperature give high hardness, high strength and low ductility. It is also reported[1] that austempering at temperatures above 350°C give upper ausferrite microstructure comprising of broad blades of ferrite. Length of ferrite needles is said to increase with increasing austempering temperature[1]. In this work ferrite is found to be finer and broken at higher austempering temperature. It may be pointed out that the higher austempering temperature reported in the literature was 450°C where was it 390°C in this case.

From Table-3, it can be seen that low copper ADI are more active than higher copper but corresponding corrosion rates are just opposite. It seems change in the austenite amount is compensated by the extent of carbon stabilisation. Higher austempering temperature improves corrosion resistance by making it nobler and decreasing corrosion rate. This is in compliance with the findings of earlier work[2]. Corrosion resistance becomes poorer with decrease in cross section. It can be correlated with nodule count.

CONCLUSION

1. Copper increases hardness and affects the microstructure but does not indicate a definite trend in corrosion properties.
2. Austempering temperature affects microstructure and corrosiom properties to a great extent.
3. Thinner the cross section higher is the nodule count.

REFERENCES

1. P. Prasad Rao and S. K. Putatunda, Matl Sc. & Engg. A, 2005, 406, 217.
2. J. Hemanth, J. of Mater. Process. Tech., 200, 101, 159. ■