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"Excellence in Metallurgical Engineering"

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Case Study: Austempered Ductile Iron Casting

By

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Subject

Examination of ductile iron casting to determine if it was made from unalloyed Austempered Ductile Iron. The casting was examined to determine chemical composition, hardness, and microstructure. There is an overlap in the hardness range between 120-90-02 ductile iron and Grade 1 Austempered Ductile Iron. The major difference in the two grades is the difference in microstructure. Austempered Ductile Iron is Bainitic, and 120-90-02 is martensitic.

Hardness Testing

The hardness testing was done according to ASTM E384, using a Vickers indenter and a 500 gram load. The results of the testing are given in the table that follows. The specified hardness range for this part was 269 to 341 Brinell Hardness Number.

Hardness Test Data
(Brinell Hardness Number)

Location	Vickers	STD DEV	MAX VALUE	MIN VALUE	BHN
Core	355.00	18.15	374.00	331.00	336.00

The average hardness of the Casting was 336 Brinell Hardness Number, which is near the top end of the range for Grade 1 Austempered Ductile Iron, ADI.

Chemical Analysis

The chemical analysis was done according to the following ASTM Specifications: E1019 for carbon and sulfur, and E415 for other elements. The results of the analysis are given in the table that follows.

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Chemical Analysis Comparison (Percent by Weight)		
Element/Location	Test Bar	Casting
Carbon	3.05	3.72
Manganese	0.45	0.40
Phosphorous	0.048	<0.005
Sulfur	<0.005	<0.005
Silicon	2.89	2.54
Nickel	0.03	0.03
Chromium	0.02	0.02
Molybdenum	0.01	0.06
Copper	0.08	0.16
Magnesium	0.04	0.11
Carbon Equivalent	4.03	4.49

The chemical analysis of the casting and test bar is shown in table above. The carbon level for the casting was typical of Grade 1 ADI. The cast iron used was unalloyed and similar to the test bar. The test bar carbon level is somewhat low.

Metallographic Examination

The graphite shape in the casting was very good. Figures 1 and 2 show a comparison of the graphite distribution in the casting and the test bar.

In order for ductile cast iron to properly heat treat to ADI, the graphite nodule count needs to exceed 100 nodules per square millimeter. The nodule count of the casting was determined to be 4800 per mm^2. For the test bar, the nodule count was 12,000 per mm^2. The nodule count for the test bar and casting was very good. Unalloyed castings with a similar chemistry and nodule count can be heat treated to Class 1 ADI.

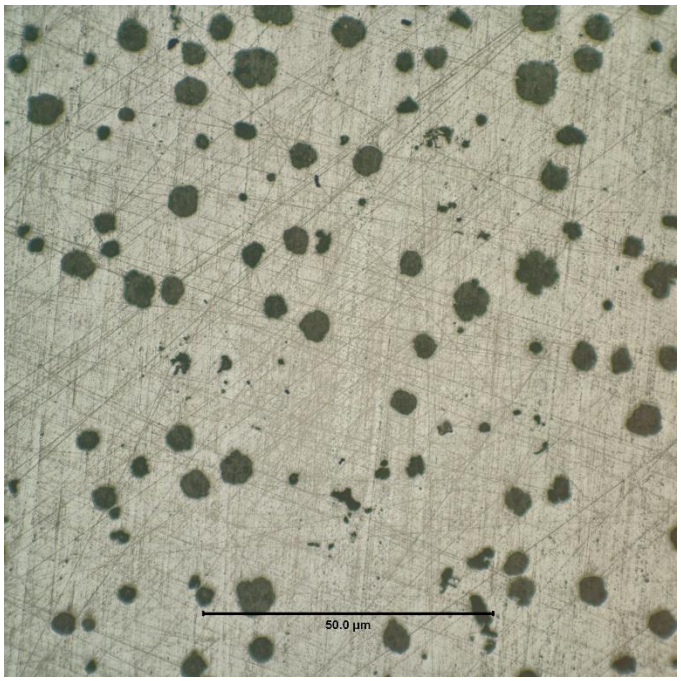

Figure 1 – 100X Graphite Distribution in Casting

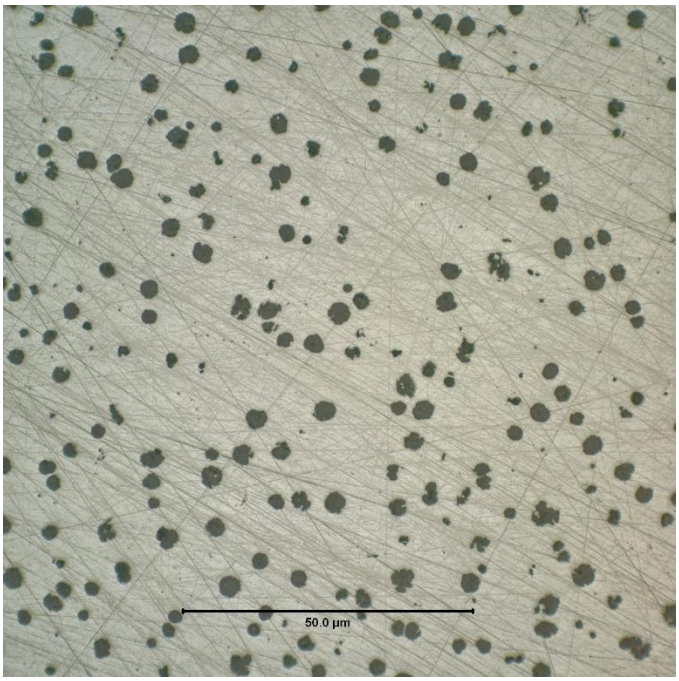

Figure 2 – 100X Microstructure in Test Bar

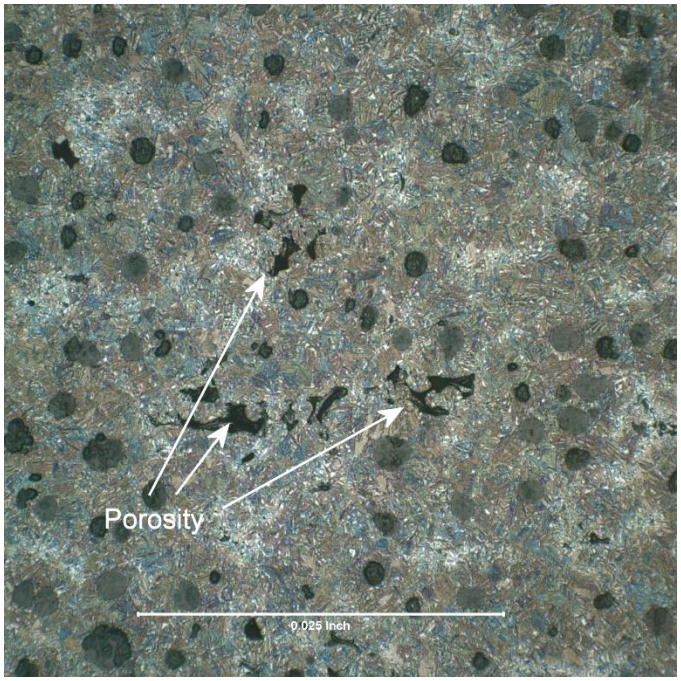

Figure 3 – 100X Porosity and Microstructure of Casting

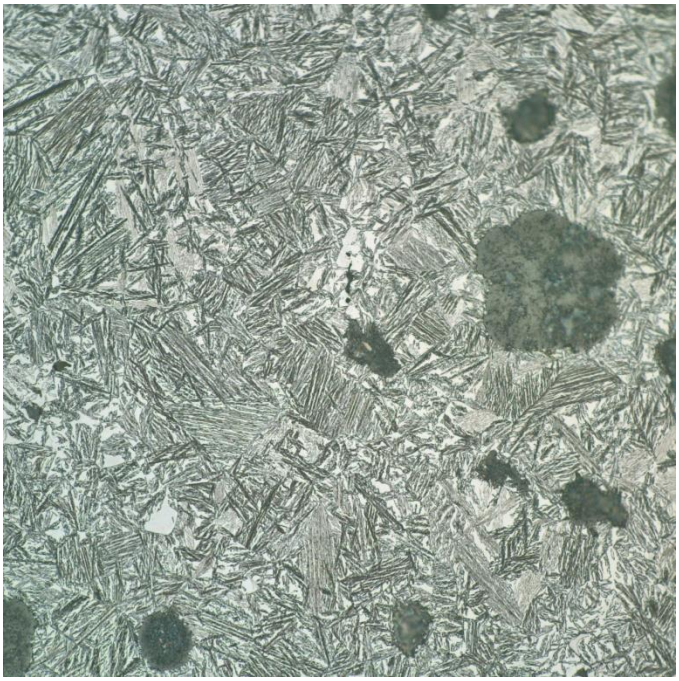

Figure 4 – 400X Microstructure of Casting

Figure 3 shows the etched microstructure of the casting. The cross section of the casting showed a considerable amount of microscopic porosity similar to that shown in the photo. Figure 4 shows the Upper Bainite microstructure, which is typical of Grade 1 ADI.

Conclusions

1. The casting was made from unalloyed ductile cast iron.

2. The hardness of the casting was at the upper end for Grade 1 ADI.

3. The casting had been heat treated to obtain Grade 1 ADI.

4. Nodule counts and compositions similar to the casting and test bar are suitable for heat treating to Austempered Ductile Iron.