Microstructure Anomalies Affect Ductile Iron Properties

Cast Iron Division Quality Control Committee (5-J)
Principal Author: George M. Goodrich, Taussig Assoc., Inc., Skokie, Illinois

The microstructure of ductile iron plays a vital role in affecting the mechanical properties of the final casting. To illustrate this statement and how to determine the cause of failure, an example of a foundry’s experience with a certain casting is provided below.

In this example, the customer desired a ductile iron grade of 80/35/66 per ASTM 536. This grade is an as-cast pearlitic ductile iron with a minimum ultimate tensile strength of 80,000 psi, a minimum yield strength with 0.2% offset of 55,000 psi, and a minimum percent elongation of 6%.

Inconsistencies

The customer, who regularly purchased the casting, was confused about the inconsistencies with the test results in different heats.

- **Problem 1.** The castings failed to meet the elongation requirement, exhibiting only 3% maximum elongation.
- **Problem 2.** The castings failed to meet the yield strength requirement, with only a 50,000 psi at 0.2% offset.
- **Problem 3.** The castings failed to meet the yield strength and the elongation requirements.

Metallographic evaluation of the microstructures revealed the reasons for these inconsistencies.

In Problem 1, the microstructure at the tensile fractured surface had the required graphite nodularity (greater than 80%) and pearlite content (greater than 50%), but the structure had a high incidence of intercellular carbides (Fig. 1).

As shown in Fig. 2, energy-dispersive x-ray spectrographic analysis revealed these carbides were high in titanium, vanadium, molybdenum, and niobium. These carbides significantly detracted from the ability of the casting to meet the elongation requirements.

In Problem 2, the microstructure had acceptable nodularity, but the ferrite content was excessive. Figure 3 shows that the ferrite content was about 70% of the matrix. For this grade, the matrix should be in excess of 50% pearlite. Excessively high ferrite content detracts from the yield strength.

In Problem 3, the microstructure exhibited an acceptable pearlite content (Fig. 4), but the graphite nodularity (Fig. 5) was not acceptable. Poor nodularity negatively affects both the yield strength and elongation.

Correcting the Problem

Correcting these problems required different approaches. For Problem 1 (failing to meet the elongation requirement), closer scrutiny of the charge material was required to minimize the influx of tramp elements.

For Problem 2 (failing to meet the yield strength requirement), either an increase in the amount of pearlite stabilizers was required or the foundry needed to shake out the castings at a temperature hot enough to force rapid cooling from "red heat."

For Problem 3 (meeting both yield strength and elongation requirements), the magnesium/cerium content was not adequate as the result of fade or ineffective treatment.

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