

## **Ductile Iron Nodularity Assessment: A Comparison Between Various Manual Procedures and Image Analysis.**

O.D. Baron\* G.M. Lucas\*\*

\*Akebono Corporation, 34385 West Twelve Mile Road, Farmington Hills, MI 48331

\*\* Buehler, Ltd. Customer Service Laboratory, 41 Waukegan Road, Lake Bluff, IL 60044

The nodularity rating of ductile iron castings is important to a foundry and its customer for two reasons: first, because the degree of nodularity relates directly to the strength and ductility of ductile iron castings and, second, because it is a relatively fast and inexpensive method for determining such properties. Customers often supply a minimum nodularity requirement to their foundries in the form of a specification. Such a specification will normally contain a method for rating and reporting the nodularity as a number with the intent that there is little chance for misinterpretation. Nodularity can be rated by either a metallographic examination of a cut and polished specimen or via resonant frequency techniques (ultrasonic testing). When using metallographic techniques most people follow a standard method such as a comparison chart per the American Standards for Testing and Measurement (ASTM) A 247, or some other national standard method, for example the Japanese Industrial Standard (JIS). Yet other companies may modify an existing standard so that it is compatible with using an image analysis (IA) system. Even though these methods are created with expedience in mind, care must be taken that the method is performed the same way each time and the same way by each individual to obtain consistent and accurate assessment. Otherwise there is a great risk of misinterpretation between a foundry and its customer. This paper shows that if care is not taken, nodularity rating can vary widely between various organizations. Additionally, a fast semi-automatic measurement system used to accurately rate nodularity is assessed.

The influence of percent nodularity on the physical properties of tensile strength, yield strength, elastic modulus, fatigue limit and impact strength has been established through the experimentation performed by Gary F. Ruff and Bharat K. Doshi. The paper that resulted from their experimentation, Relation Between Mechanical Properties and Graphite Structure in cast Irons, Part II – Ductile Iron, shows clearly that a ten percent difference in nodularity can have a significant impact on these mechanical properties [1]. This fact justifies the existence of specifications for percent nodularity by companies for their cast ductile iron products and standard test methods to establish nodularity

An experiment was undertaken to determine if the different methods used to determine nodularity produced the same results on the same material as well as to determine the repeatability of results within a method performed by different people. It was decided that the most expedient way to perform the experiment was to have different suppliers, foundries, customers and commercial laboratories rate the same set of five photomicrographs in the form of a survey. The photomicrographs had varying degrees of nodularity. It was understood that the survey would exclude ultrasonic testing as a method. The participants were requested to rate the nodularity of the five images via the method they most often use. The methods used were comparison to the American Foundry Society (AFS) chart referenced in ASTM A 247, manual count and IA. If they required digital images for IA those were provided. In addition, the AFS comparison chart plates were digitized and then sent to several laboratories, with their published rating concealed to be rated by manual count and IA in an effort to establish a standard baseline for the three methods.

The results of the survey of the five photomicrographs point toward several areas of concern:

1. The comparison to the AFS chart, manual count and IA methods did not correlate well to one another, see Figure 1.
2. There is a wide spread in results using the AFS comparison chart method without showing a trend. According to the survey this is the most prevalent method for nodularity determination See Figure 1
3. Although nodularity results from the manual count and IA methods are not the same there is a relationship between the two, see Figure 1.

The results from rating the AFS plates in a blind study suggest that the nodularity ratings assigned to the plates do not agree with the true nodularity.

References

[1] G. Ruff, B. Doshi, Relationship Between Mechanical Properties and Graphite Structure in Cast Iron, Modern Casting, July 1980

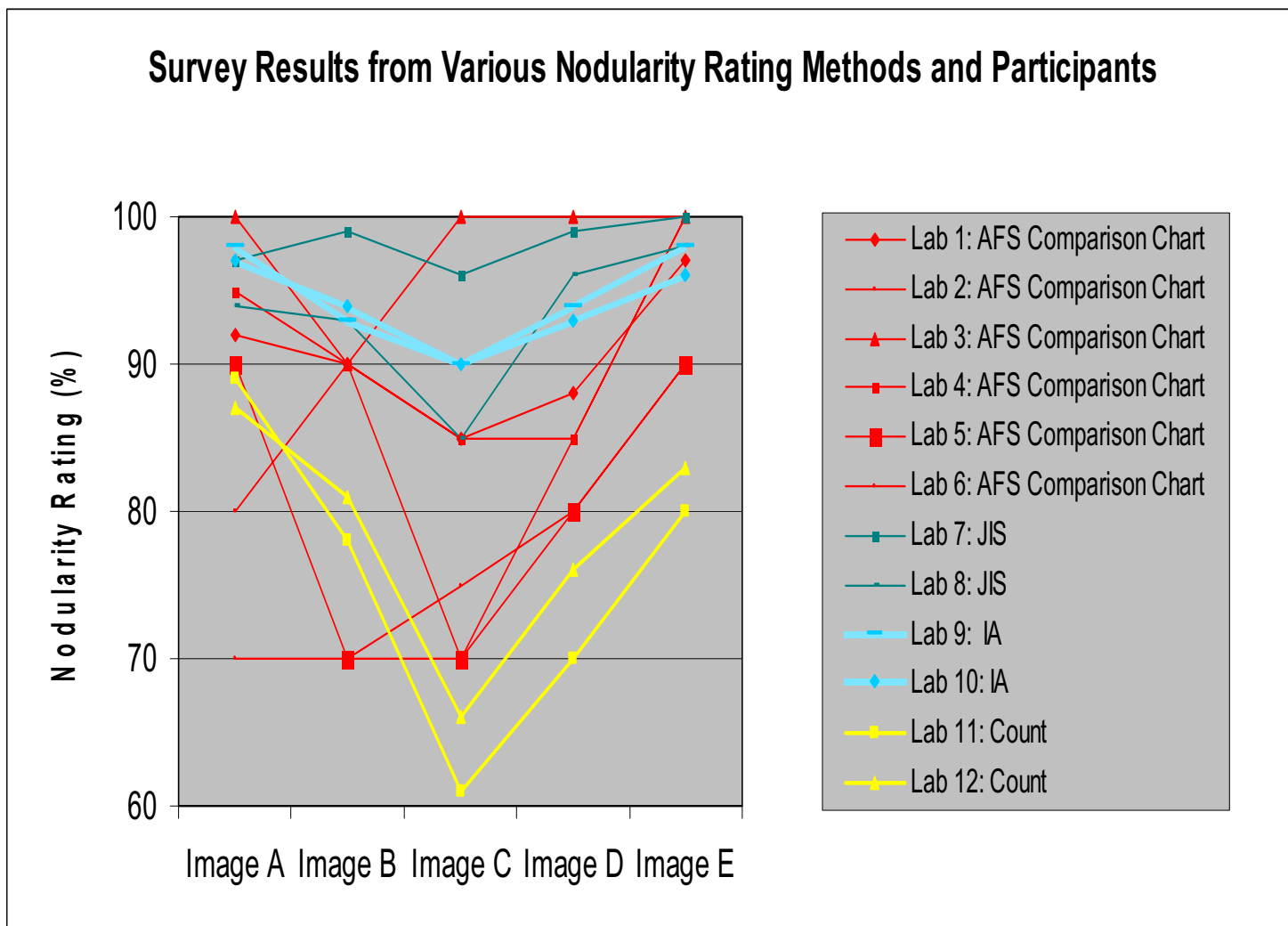


Figure 1: Survey results from all methods and participants.