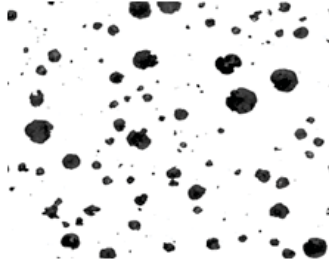


Nodule Analysis of Ductile Cast Iron Using the LECO IA44

LECO Corporation; Saint Joseph, Michigan USA

Because of their cost effectiveness and versatility, cast irons remain a popular choice for many products today. Because the graphite in gray cast iron is shaped like potato chips, items made from it can be prone to cracking if subjected to impact. Ductile cast iron was specifically developed, in the 1940s, with its graphite in the form of spherical "nodules". This shape makes crack initiation much less likely and yields a much more ductile material; hence its name: Ductile Cast Iron.



Metallurgical Background Information

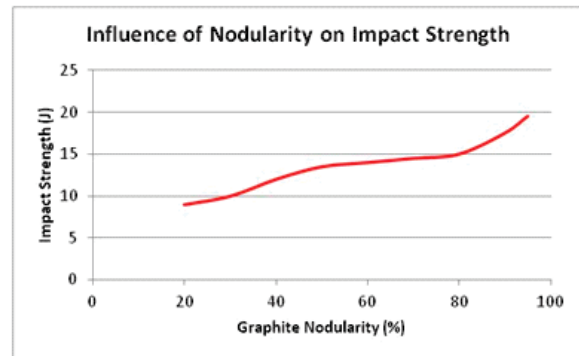
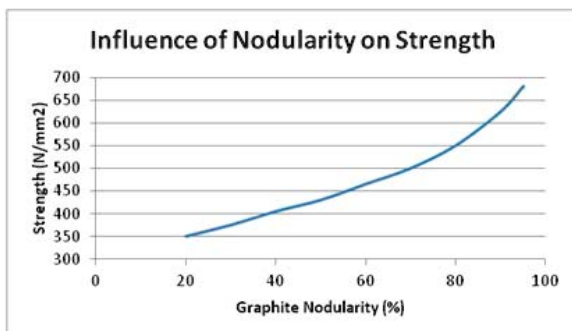
The spherical shape of the graphite in ductile cast iron does not come naturally; it requires a little help from man to make that happen. The formation of nodules is achieved by the addition of a "nodulizing" element to the molten metal bath. The most common of these elements is Magnesium, but Cerium is also used.

Quick Definitions

Nodularity: The degree to which the shapes of all graphite particles in a cast iron approach that of perfect spheres.

Roundness or Sphericity: A calculated value used to quantify how closely an individual particle's shape approximates that of a circle/sphere. There are a number of different methods for establishing "roundness" using, for example, nodule cross sectional area, nodule aspect ratio (L/W), nodule perimeter, etc.

Determining a ductile cast iron sample's nodularity is of great importance to a foundryman... but why? As can be seen in the plots below, the strength and impact resistance of ductile cast iron can be improved by increasing the percentage of very round graphite nodules. In general, having a large number of small, very round, nodules improves the strength, toughness and fatigue life of the final cast iron product.



To assure the quality of a particular batch of ductile cast iron, it is a smart practice to test representative samples for "nodularity" and "nodules per mm²". Usually these must meet an industry standard or a customer's own home-grown specification.

Sample Preparation

Analyzing ductile cast iron for nodularity is usually performed optically, in the as-polished condition. A typical metallographic procedure for preparing cast iron samples is detailed below:

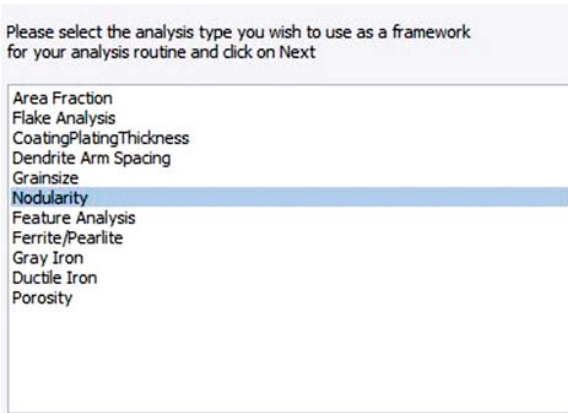
Sample Identification: Ductile Cast Iron		Work Order Number: N/A				
Sample holder #809-902						
<input checked="" type="checkbox"/> Fixed Holder	<input type="checkbox"/> Single Sample					
Grinding GPX200 (10" Wheel)	Time (Minutes:Seconds)	Head Direction	Head Pressure (Pounds)	Head Speed (RPM)	Wheel Direction	Wheel Speed (FPM)
Platinum #1 812-337/ Water	2:00	CW	35	100	CCW	300
Pre-Polishing FAS Magnetic System - 10" (812-382)	Time (Minutes:Seconds)	Head Direction	Head Pressure (Pounds)	Head Speed (RPM)	Wheel Direction	Wheel Speed (FPM)
Silver Disk, 6 µm Cameo Suspension, Microid Extender, 810-345, 812-356, 811-003	2:00	CW	35	100	CCW	200
Polishing	Time (Minutes:Seconds)	Head Direction	Head Pressure (Pounds)	Head Speed (RPM)	Wheel Direction	Wheel Speed (FPM)
1 µm Premium Suspension, Ultra Sil, Microid Extender, 810-997-016, 812-436, 811-003	3:00	CW	35	100	CCW	200
1 µm Premium Suspension, Red Felt, Microid extender, 810-998-016, 812-225, 811-003	0:30	CW	30	100	CCW	200

Microscopic Analysis

Analysis of the polished specimen can be accomplished manually, using a comparison wall chart; but this technique is labor intensive and highly dependent on operator skill. An automatic measurement system, such as LECO's IA44, can yield very accurate measurements in a very short time. IA44 allows an operator to analyze as many fields of the specimen as necessary, without taking the time to capture images of each field.

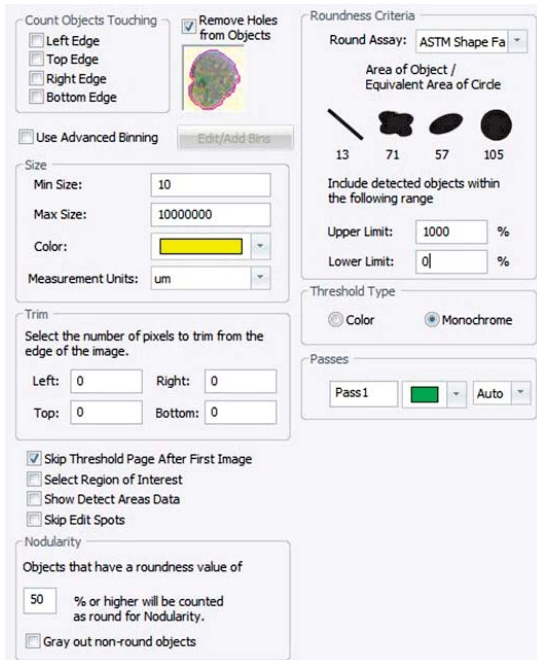
Setting up an IA44 Nodularity Application

The IA44 system uses a "Script Wizard" to walk the user through the process of creating a unique application. The first decision is to pick what type of analysis will be accomplished with the application being created:



Within the "Nodularity" application, a user has the opportunity to tailor the settings to meet specific needs. In the end, these unique settings can be saved for easy implementation at any time in the future. The IA44 system is capable of analyzing ductile cast iron specimens to meet a wide variety of standards. For example, there are six choices for how the roundness of a particle will be determined. In the screenshot below, the "ASTM Shape Factor" method has been selected.

It is also possible to exclude features from the analysis based on size or shape. There are settings that will allow for faster analysis of samples when time is in short supply. These include the "Skip Threshold Page After First Image" and the "Skip Edit Spots" check boxes. Also included in the settings are particle size limits (to filter out very small features) and a "Roundness Cut-off" value with which the % Nodularity is calculated.



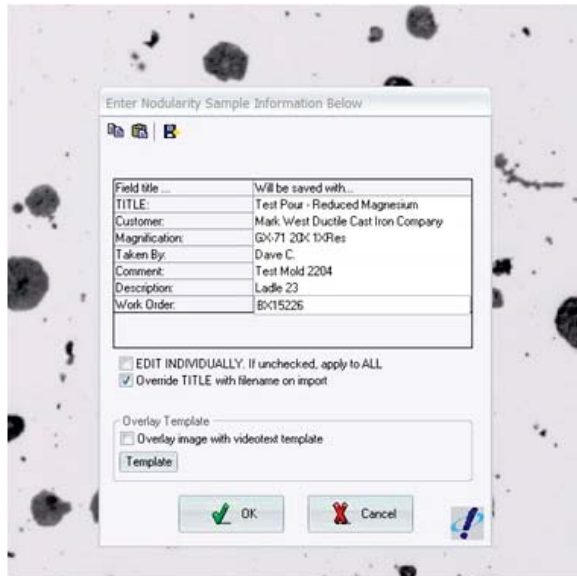
For all IA44 applications, the user has the choice of creating a report, or simply viewing the results when the analysis is complete. In the example below, an Excel report template named "Nodularity-MW-10" has been selected to report the analysis results:



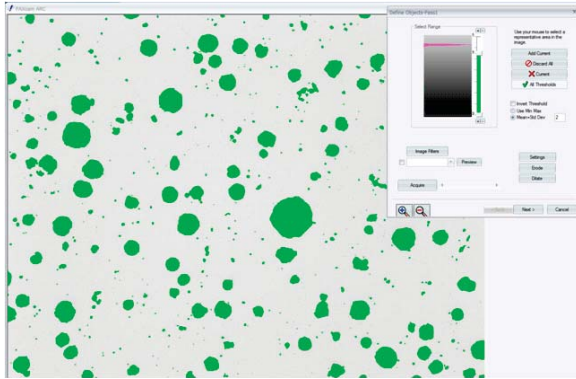
When the user is ready to start the analysis, the assigned script bar button is pressed:



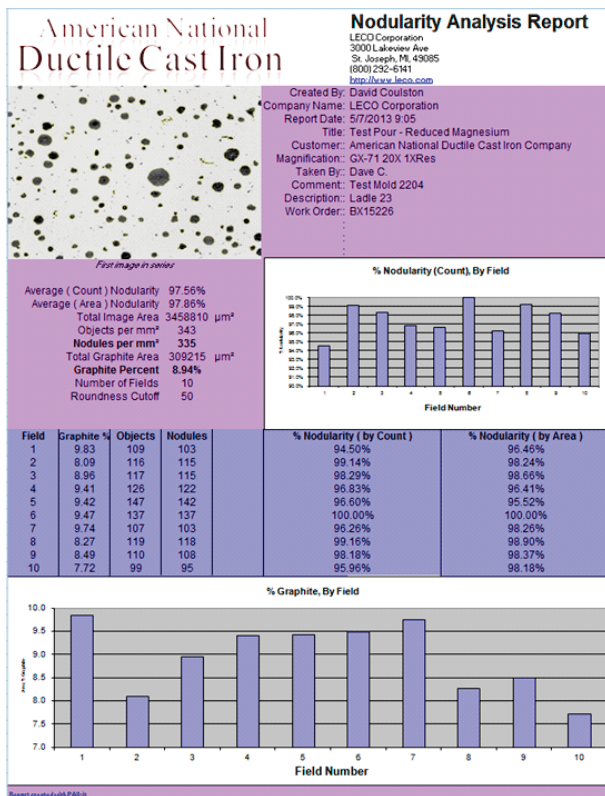
Pressing the button initiates the nodularity application and opens the appropriate camera interface. Prior to analyzing the first field of view, the user is prompted for sample information. The entries made here will automatically appear on the finished Excel report.



From this point forward, the analysis process proceeds quickly. As a sample field is brought into view, it is checked for focus and illumination, the ANALYZE button is pressed and the thresholded objects are automatically measured and each one's size, roundness and area are measured.



This process is repeated until the prescribed number of fields are analyzed. After the last field is analyzed, the data is automatically exported to the Excel template and the report is created:



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