

## Microstructure Characterizer Software

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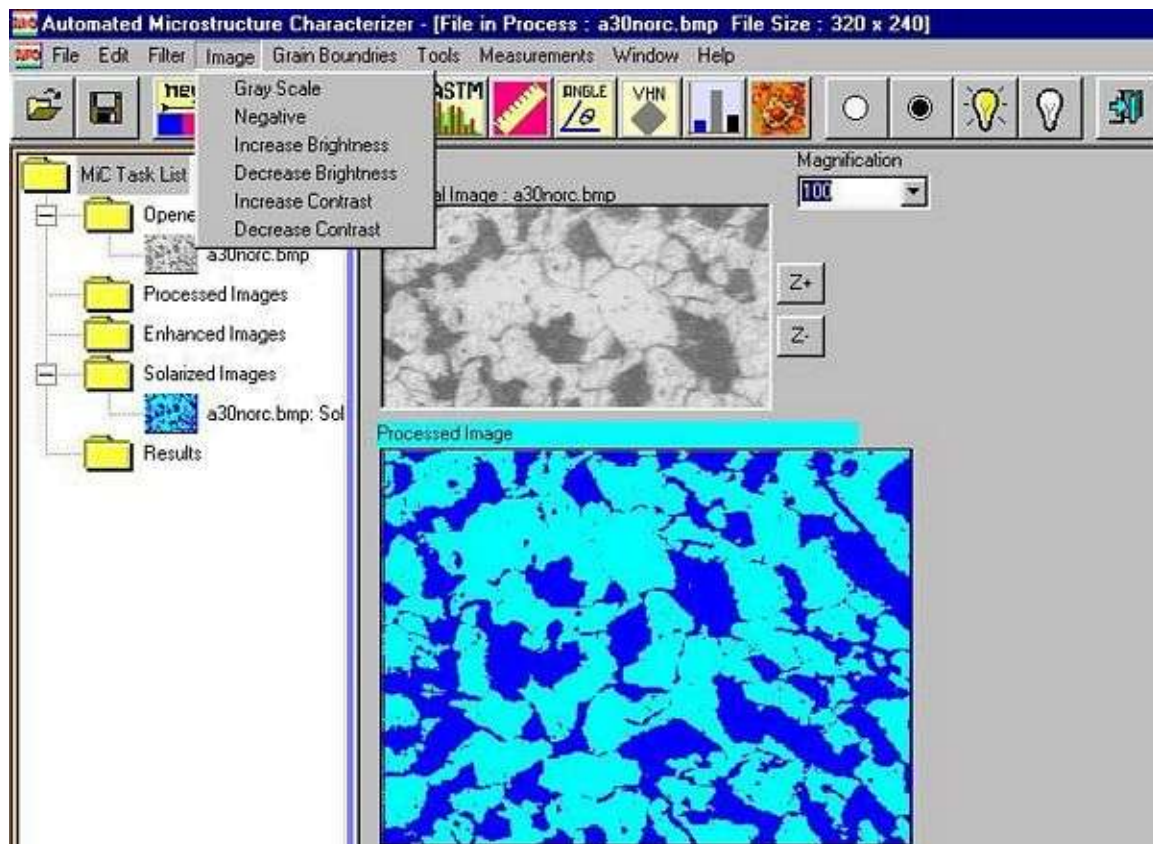
## Executive Summary

Developed in-house by expert metallurgists and material science engineers at TCR Engineering and TCR Advanced Engineering the Microstructure Characterizer (MiC) 2.0 is the powerful image analysis software for Metallurgical use.

Digital images taken from a Microscope are analyzed by Microstructure Characterizer, the software for microstructure interpretation. Using this software, a Material Science engineer can characterize different types of micro structural images for grain size, coating thickness and phases; get images from one or more files; and intensify the image using the filtering and enhancement features.

Microstructure Characterizer Software version 2.0 offers following modules:

- Grain Size Measurement and Distribution Plots (Automatic and Manual modes)
- Volume Fraction (Automatic and Manual modes)
- Inclusion Rating (Automatic and Manual modes)
- Graphite Morphology (Automatic and Manual modes)
- Nodularity Assessment
- Bulk or micro Hardness Measurement and generating profile
- Particle Size Measurement and generating histogram of size distribution
- Linear and Angular Dimensioning.
- Percent of 'Delta Ferrite' phase present in the microstructure for color Metallography.
- Acquire images manually from one or more files.
- Increasing image detail using the filtering and enhancement tools.
- Create reports in 'Rich Text Format' or 'Custom Made' as per users' choice.
- Easy to operate - One Touch Calibration for different image resolutions.



Microstructure Characterizer Software (MiC) characterizes microstructural features using standard methods of material characterization such as ASTM grain size measurements, coating thickness, linear and angular measurements, comparison of super imposed grain size reticules, inclusion rating as per IS and ASTM standards, nodularity measurements, powder particle size distribution and so on.

It helps generate custom made formatted reports of live and stored images and offers results as the computer display as well as hard copy multicolor printouts.

## Grain size Measurement and Distribution Plots

### ASTM Grain Size Number

Dimensions of the grains or crystals in a polycrystalline metal exclusive of twinned regions and subgrains when present. Grain size is usually estimated or measured on the cross section of an aggregate of grains. The common units of grain size are:

- Average diameter, Average Area
- Number of grains per linear unit, Number of grains per unit area, Number of grains per unit volume

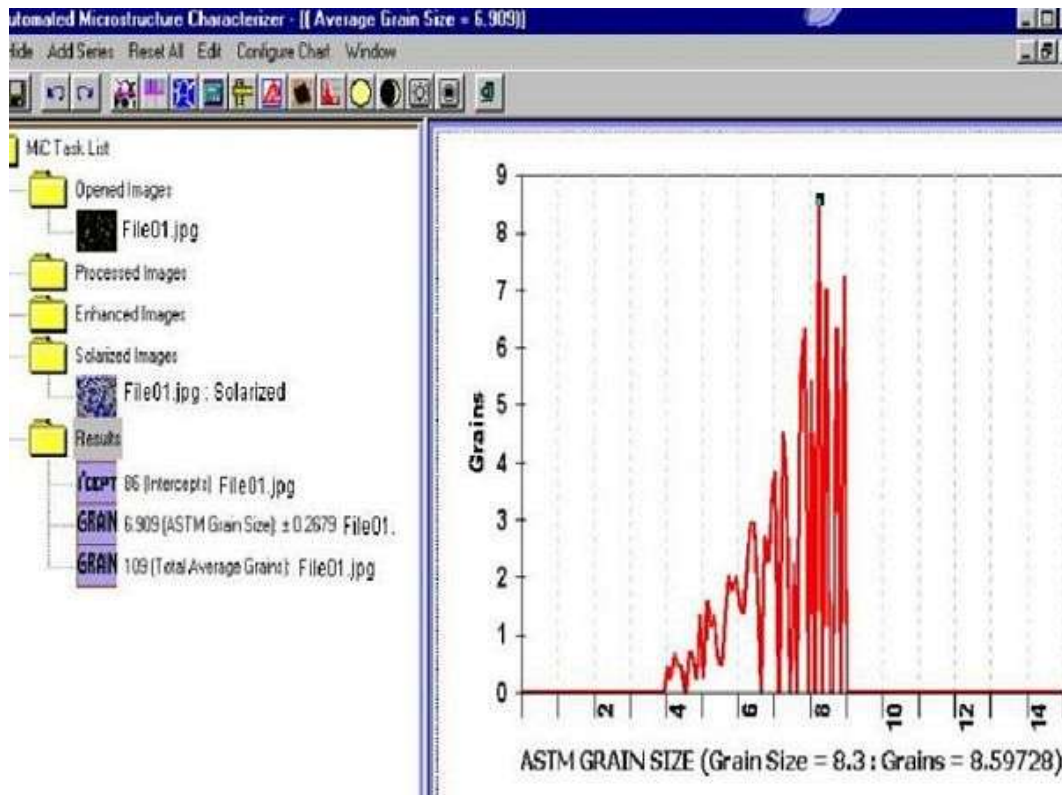
### Grains size number

A grain size designation bearing a relationship to average intercept distance at 100 diameters magnification according to the equation:

$G = 10.0 - 2 \log_2 L$  (where  $L$  = average intercept distance in millimeters at 100 times magnification)

To obtain the grain size measurement in the Microstructure Characterizer Software:

1. Open the image and solarize it to isolate grain boundaries from the matrix.
2. Press of a button will produce the Result in the form of a chart.

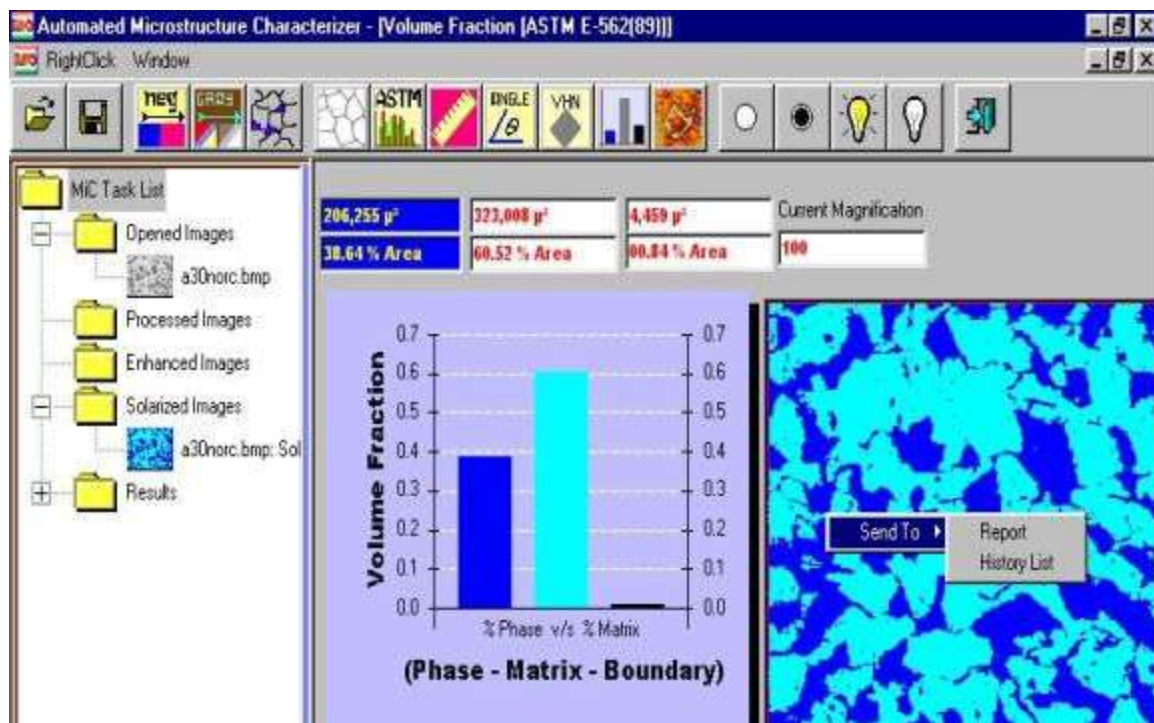


## Volume Fraction

Microstructure Characterizer Software (MiC) ships with a great feature of finding Volume fraction numbers (percentage and absolute area). These numbers are determined by automated point counting procedure for statistically estimation on a grid of one to one pixel resolution bases.

Microstructure Characterizer Software is a user friendly tool that needs only dragging of color map counts volume fraction. The user can add up to five images for counting of volume fraction.

Following screen snap shot demonstrates how you get the result on screen using the Microstructure Characterizer Software.



## Inclusion Rating

### Inclusion Rating (ASTM)

Inclusions - Foreign material held mechanically, usually referring to non-metallic particles, such as oxides, sulfides, silicates etc are considered as inclusion.

Inclusion Count - Determination of the number, kind, size and distribution of non-metallic such inclusions.

As per E-45 of ASTM "Determining the inclusion content of steel", determination of nonmetallic inclusion content of steel is accomplished by Macroscopic methods include macroetch, fracture, step down and magnetic particle tests, and Microscopical methods include four generally accepted systems of examinations.

Inclusion rating engine of the Microstructure Characterizer Software is based only on microscopical method. In Microscopical method, inclusions are assigned to a category based on similarities in morphology, and not necessarily on their chemical identity.



Inclusions such as carbides, nitrides, carbonitrides, borides and intermetallic phases may not be rated using this method.

### Inclusion Rating (IS)

Inclusion Rating as per Indian Standard IS 4163 1982 can be done from the comparison chart given below. All the frames are as per the standard but at lower magnification.

Microstructure Characterizer Software ships with standard IS rating frames with inclusion type, subtype and ratings, which is to be compared with image whose rating is to be done. Matching frame is the rating number and type and subtype.

Use of this method is recommended for imprecise but rapid and bulk approach for Inclusion Rating.

Live image may be floated on screen by selecting 'stay on top' option from the frame grabber card window. MiC version 2.0 provides 'on screen' rulers which are useful to find distance between two cursor locations. These distances are provided considering magnification / objective factor and are true to the scale in the unit of micrometers.

The screenshot displays the 'INCLUSION RATING' window. It features a table for ASTM Rating and a table for Object No. with columns for Inclusion Category, Area (Sq. Micron), Length (Micron), Width (Micron), and Aspect. Below the tables are two micrographs: the left one is the original image at 100x magnification, and the right one is a solarized image revealing different objects. A mouse cursor is hovering over a tag in the solarized image.

Specimen No.	A (Thin)	A (Thick)	B (Thin)	B (Thick)	C (Thin)	C (Thick)	D (Thin)	D (Thick)
ASTM Rating	01.1	01.5	00.0	00.0	03.1	00.0	04.1	00.0
Upset	02.0	02.0	00.0	00.0	01.0	00.0	13.0	00.0

Object No.	Inclusion Category	Area (Sq. Micron)	Length (Micron)	Width (Micron)	Aspect
01	Type D Thin	7.0	2.6	2.6	1.0
02	Type A Thick	64.8	17.2	5.3	0
03	Type A Thin	54.3	37.0	2.6	0
04	Type D Thin	7.0	5.3	1.3	4.0
05	Type A Thin	7.0	2.6	2.6	0
06	Type C Thin	379.0	205.1	4.0	22.1

Original image at 100x of a carbon steel as polished specimen having red state of oxides. (Reduced to 70% of normal size)

Solarized image of the same as left, reveals different objects as Type A, B, C and D distinguished sub-types. Hovering mouse over tags the object number.

### Inclusion Rating (JIS)

The Japanese International Standard specifies the test method to measure the types of and the quantity of non-metallic inclusions in steel with a microscope and judge its cleanliness.

For terms and definitions on this standard, refer to G0555 and G0202 of JIS.

This method works on the principle of Point Counting. A grid of 20 x 20 lines is virtually drawn on the frame. Each point occupying any kind of inclusion is determined based on Threshold Setting. Threshold by default is set to an adequate value near to 85. However, operator is responsible for suitable thresholding of image. Type of inclusion is determined in accordance to JIS guidelines given in

G0555 and three different types of cleanliness. Rating is automatically found out by MiC. The result of JIS would, typically look like:

dA60 x 400 = 0.15%

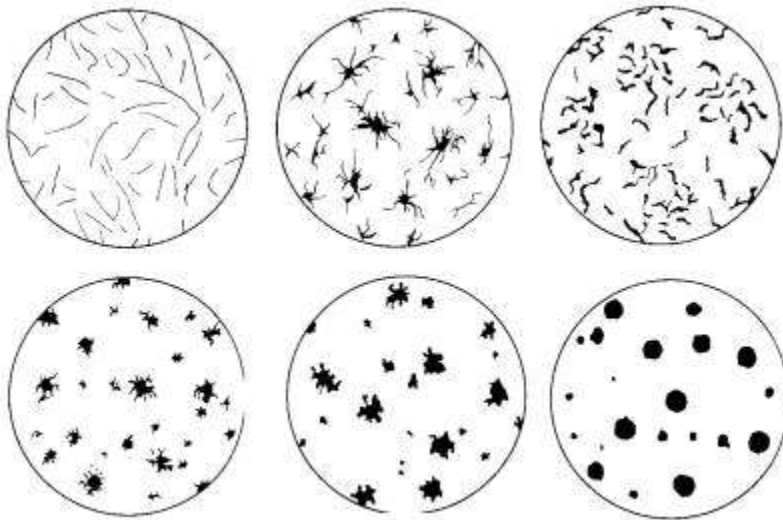
dB60 x 400 = 0.02%

dC60 x 400 = 0.09%

### Graphite Morphology

MiC has built-in engine to recognize the shape of phase in case of cast iron it is Graphite Morphology. There are six base types of presence of Graphite in the cast irons. MiC has adopted the path as per guidelines given in Japanese International Standards number JIS 5502.

Following six standard types are provided.

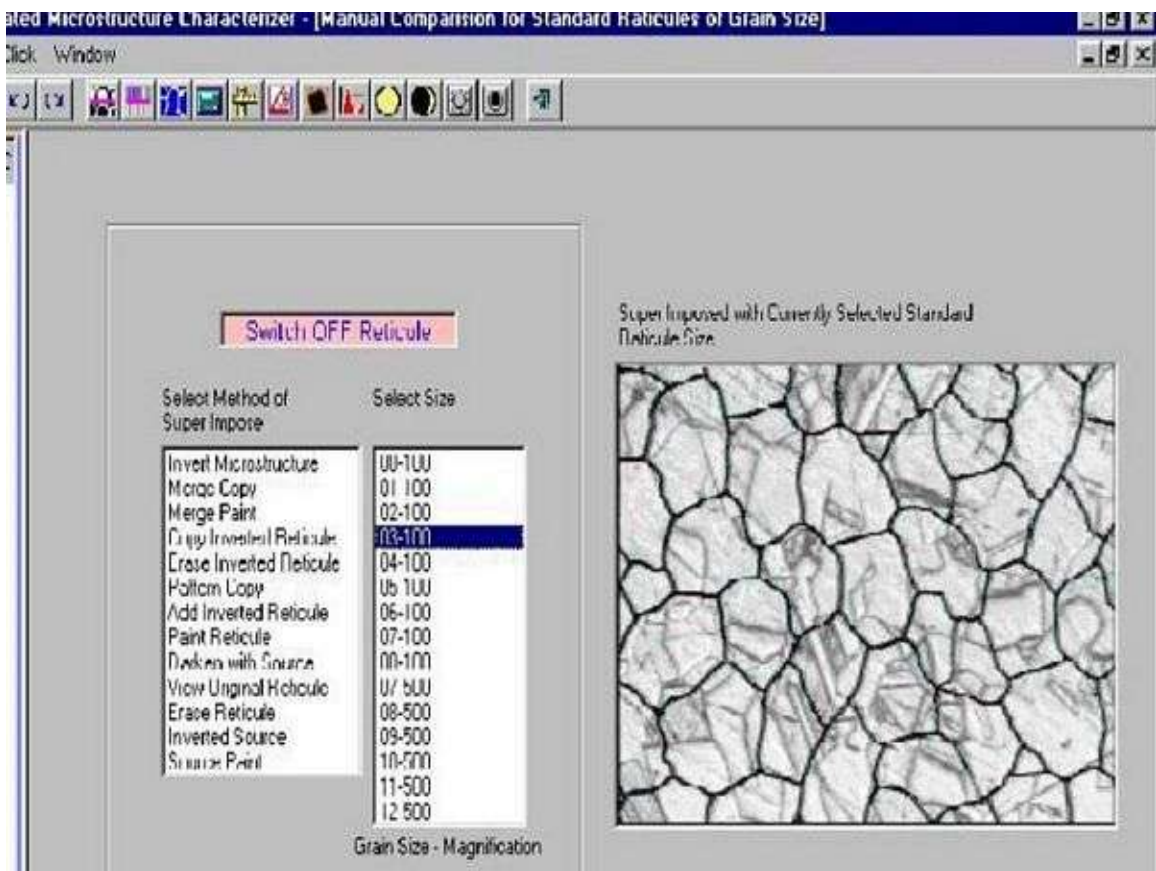
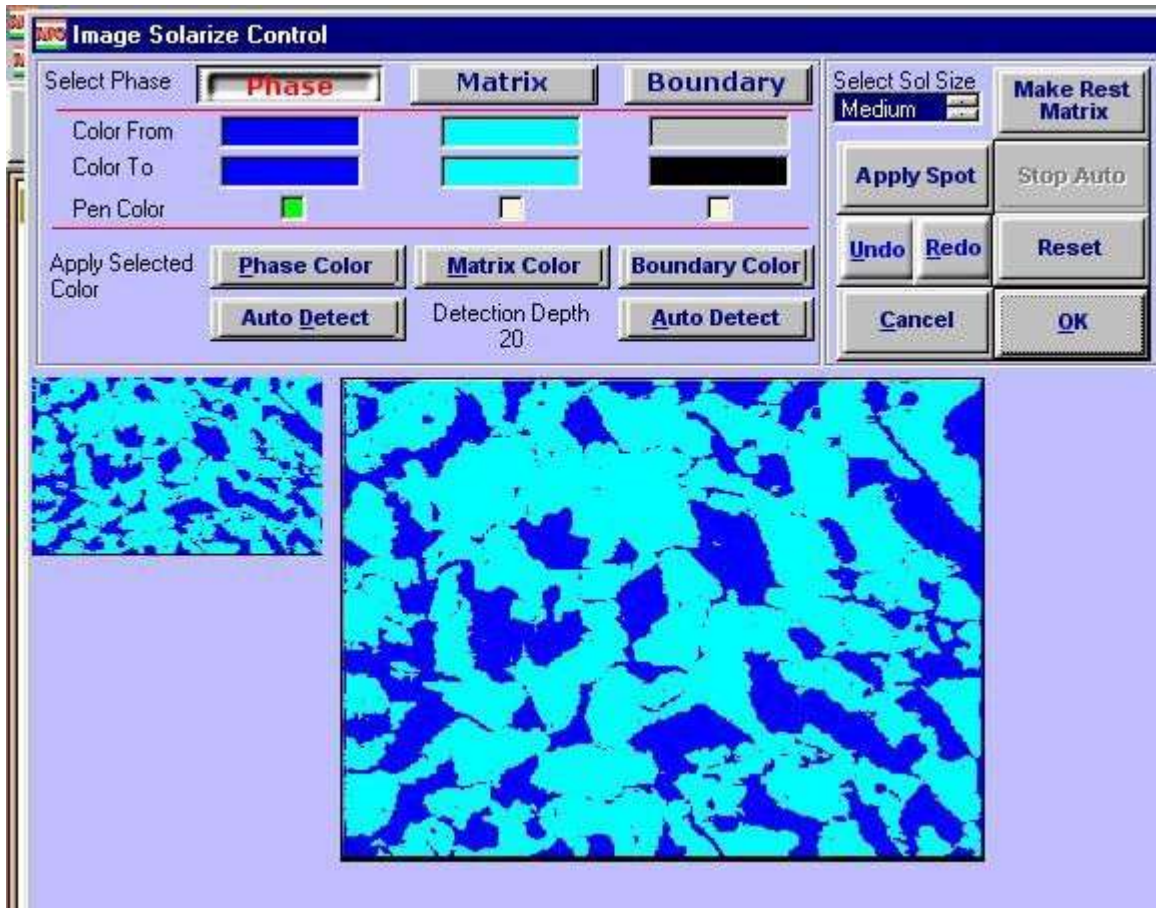


These types may be identified manually or automatically. MiC graphite morphology detection engine can isolate any of these with subclasses.

MiC routines are provided to identify the shape of graphite; hence depending on presence of majority of the shape classification is assessed. It is mandatory to solarize the image before getting the result.

Normally, "Phase" auto detection mode with detection depth of 20 provides satisfactory result however, if found improper manual Solarization for isolation of graphite flakes / nodules is required by considering graphite as primary phase and make background as matrix.

Experiments at MiC Laboratory concludes that graphite morphology detection accuracy increases when microstructure is kept in 'as polished' condition. Graphite morphology detection as per ASTM shall be provided soon.



## Nodularity Assessment

Nodularity as per Japanese International Standard refers to number of nodular (rounded) graphite particles in microstructure against total number of graphite particles. Meaning thereby 80% nodularity consists of 80 particles qualifying under nodular (round or globular) in nature out of 100.

Nodularity as per ASM is mentioned as "The volumetric proportion of spheroidal or nodular graphite to total graphite in a ductile iron or a compacted graphite iron matrix".

The term Nodularity is useful for acceptance / rejection of inventory material. Higher is the nodularity more is the Cast Iron's ductility.

As such, cast irons are famous for their good wear resistance but at the same time they possess less toughness. Malleable cast irons are having optimized property for toughness.

Normal acceptance value for a good Malleable cast iron is 80% nodularity. However, this figure does not bind to all the cases. Actual figure may be agreed between buyer and seller.

ASM states that very high nodule counts are sometimes associated with low hardenability and non-uniform tempering.

Generally, a nodule count of 80 to 150 discrete graphite particles per square millimeter appears to be optimum.

MiC shape identifier engine works on the principle of two-dimensional projection of particles. Especially, graphite particles possess quite a different morphology. For qualifying them to be nodular, their two dimensional projection is compared to the normal circularity index. Index of 80 is considered for qualification to be called "nodular". This guideline has been adopted from the Japanese International Standard.

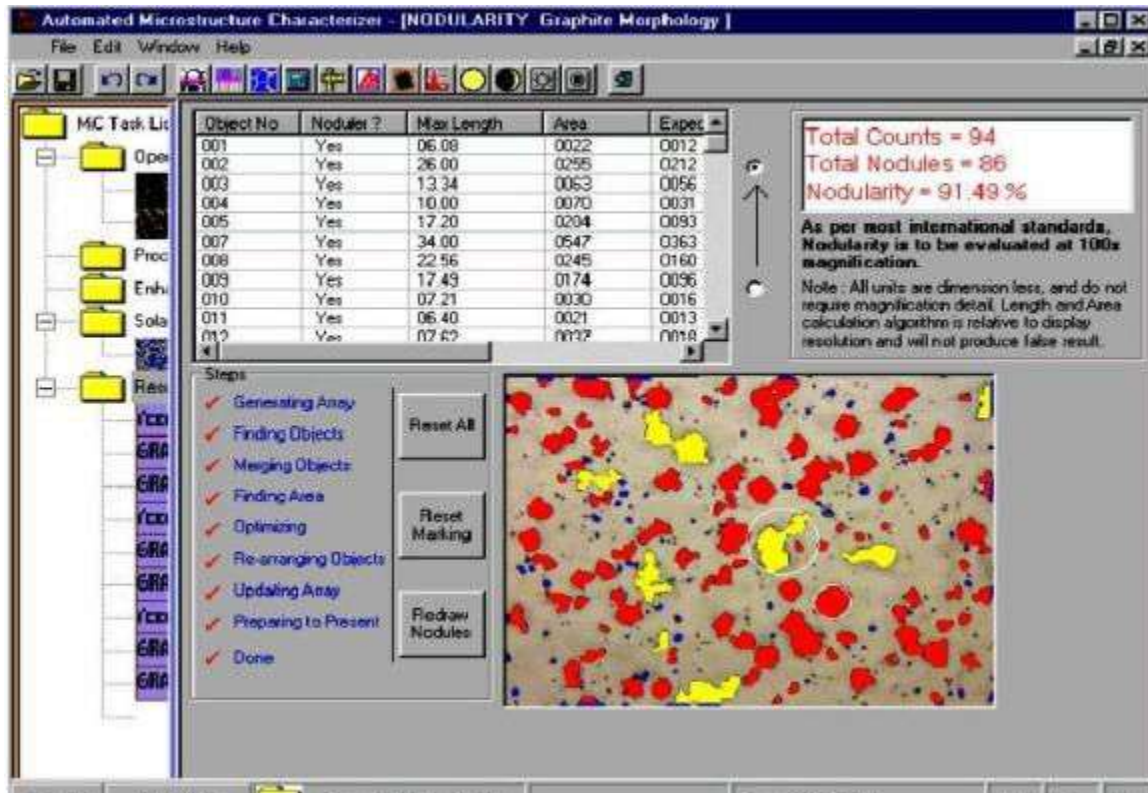
MiC provides three distinguished results.

- (1) Total count
- (2) Total nodular count
- (3) Nodularity as percent of nodules of total counts in a given image.

Besides a list of all the particles is provided for reference to find which particle on the screen identified as nodular and irregular; with area covered under each discrete particle is listed.

Any strength of customization is possible with MiC, right from new detection logic concept or image resolution or simultaneous image processing or with regard to reporting. What ever wished by the customer can be fulfilled with highest accuracy and repeatability algorithms.





## Hardness Measurement and Profiling

MiC provides you a module named "Hardness Measurement". This module is helpful to measure the hardness provided you have indented a diamond pyramid impression on a sample and grabbed the image. Measurement of diagonal indentation sometimes becomes difficult using microscope eyepiece rulers. Particularly, when indentation is made at lighter weight of about 10 to 200 grams.

Before proceeding to the detail of this module, let us go through some definition of known test methods for hardness measurement.

### Rockwell Hardness Test

An indentation hardness test using a verified machine to force a diamond sphericoconical indenter (diamond indenter), or hard steel ball indenter under specified conditions, into the surface of the material under test in two operations, and to measure the difference in depth of the indentation under the specified conditions of preliminary and total test forces.

### Rockwell Hardness Number

A number derived from the net increase in the depth of indentation as the force on an indenter is increased from a specified preliminary test force to a specified total test force and then returned to preliminary test force.

### Vickers Hardness Test

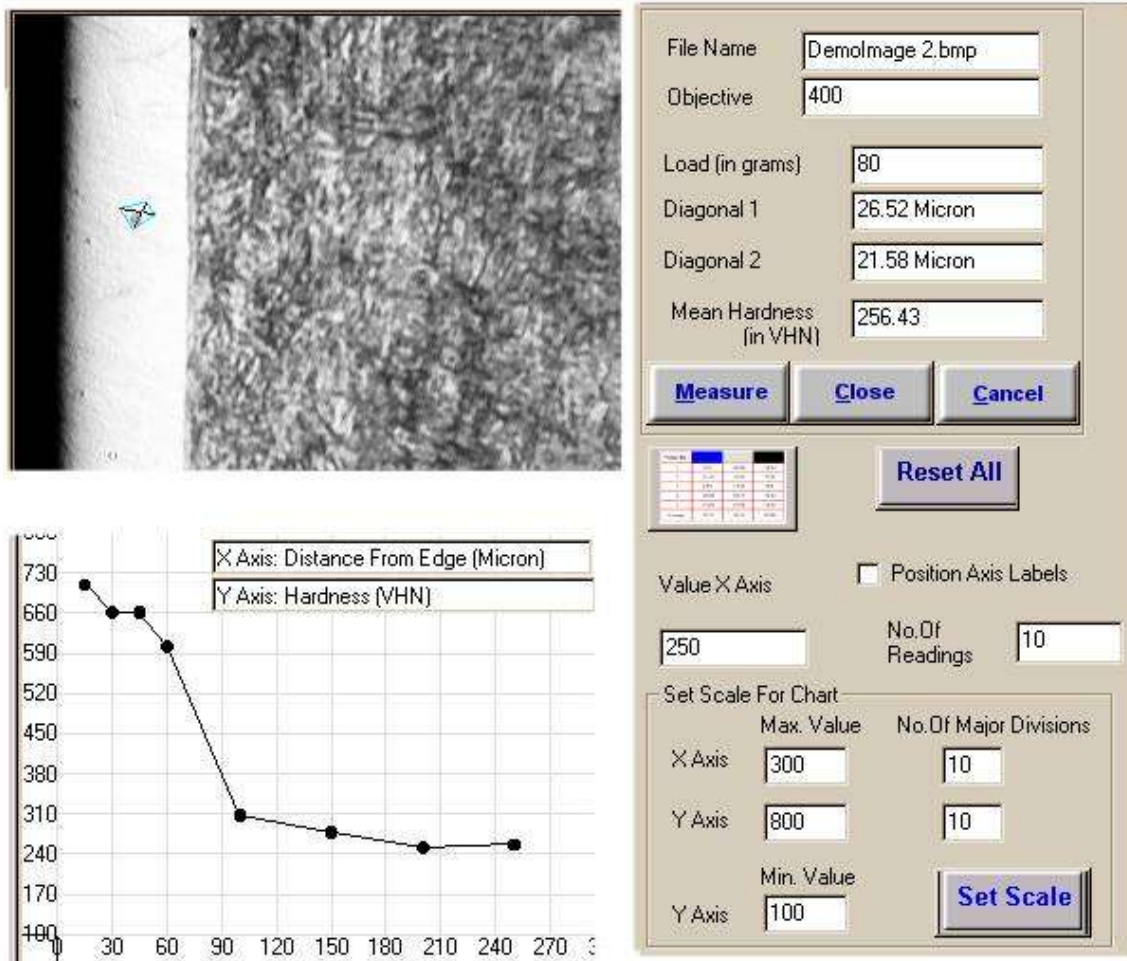
An indentation hardness test using calibrated machines to force a square - based pyramidal diamond indenter having specified face angles, under a predetermined load, into the surface of the material under test and to measure the diagonals of the resulting impression after removal of the load.

## VHN

A number related to the applied load and the surface area of the permanent impression made by a square - based pyramidal diamond indenter having included faces angles of 136deg computed from an equation.

Using Microstructure Characterizer Software hardness measurement module you can accurately measure the diagonal of the Vickers hardness pyramid indentation. Enter the magnification of image and load applied to indent the sample. Position the image at corner to corner and edge to edge mating with nicely interfaced square "scroll ruler". Press the 'measure' button and you shall get the resultant hardness number in VHN. Along with hardness number, if you enter the distance in X-axis (mm / micron) between the edge of sample to indentation, you shall get a plot of hardness versus distance on screen. You can experiment with different scales on X and Y-axis and suitable range and get nicely arranged hardness measurement profile for samples showing depth of Case Depth of nitriding or carburizing etc.

The figures below show a brief summary.



## Particle Size Measurement

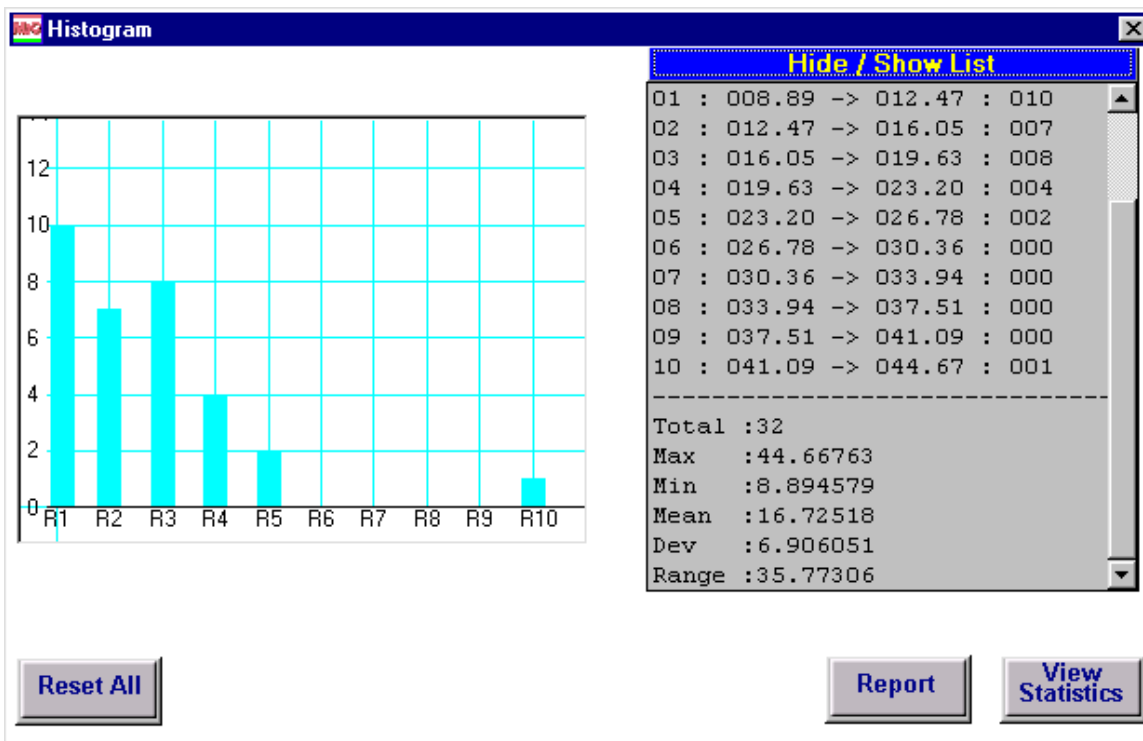
The conventional way for particle size distribution is sieving. Sieves of different mesh size are kept on one on top to other. All of them are fixed on a vibrator or shaking unit. Particles are charged on the top sieve then shaking is started for about 20 to 30 minutes. Discharge of different sieve in terms of weight provides result. The result obtained gives fairly accurate histogram of how much (weight) of charged quantity

qualifies in which range. Figure on right hand side provides a visual look to the old - traditional way of size distribution.

Microstructure Characterizer Software's particle size measurement and distribution module provides optical interface. For which you shall capture about 20 to 25 frames of particles of interest for analysis. One by one all the frames are then analyzed by MiC. Open the image in MiC then select from the menu Measurements >> Powder particles size and Distribution.

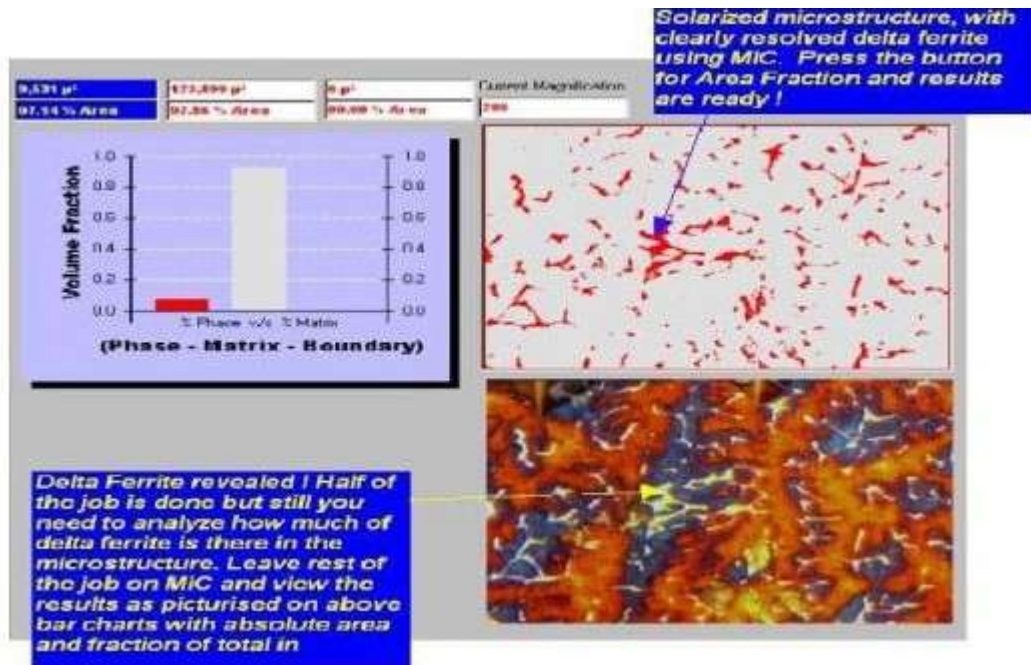
Optical microscopy method is quite feasible for particle sizing between 0.5 to 100 micron.

The MiC particle size and distribution module provides you few options to get the desired format for result. The screen shot shown below indicates an example of particles ranging in 8.89 micrometer to 44.66-micrometer size.



## Linear / Angular Measurement

Microstructure Characterizer Software provides facility to measure anything in any direction by means of click i.e one can measure Plating Thickness/PCB Layer Thickness/Nitrided Layer/Case hardened layer/Individual Nodule-Grin Diameter/Pearlite/Lamellae/Lathe Distance etc & that is with high accuracy & more precision.



## Reporting

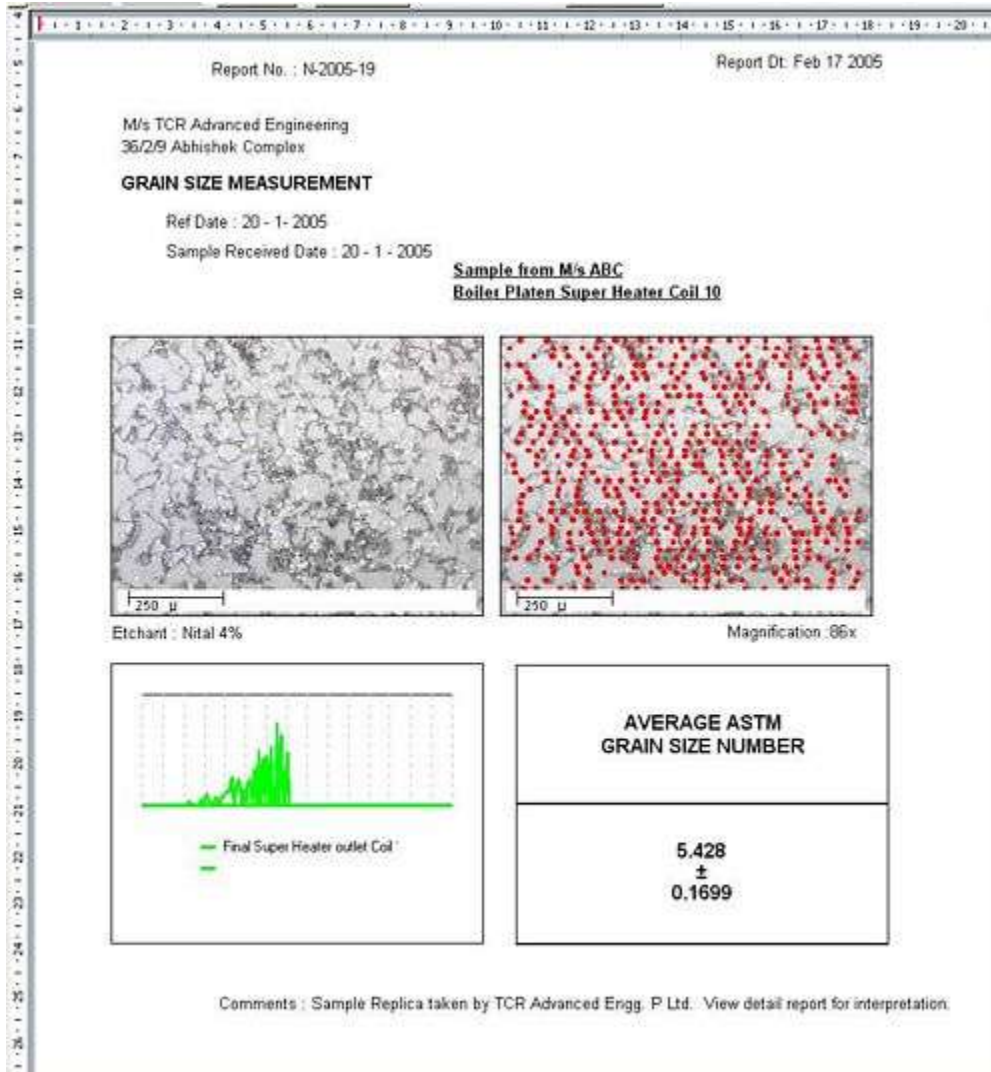
Any strength of customization is possible with MiC, right from new detection logic concept or image resolution or simultaneous image processing or with regard to reporting. What ever wished by the customer can be fulfilled with highest accuracy and repeatability algorithms.

MiC has two built in modules for Reporting. Namely, report format in word 'Rich Text Format' that may be opened in standard text formatting editors like MS Word and second, 'Custom Report Format' that ships with MiC. Both of the report modules are easy to understand and does not require user input. On click of a button you can print the report with elegant look and feel. Reporting in word 'RTF' is easy to port between the applications. By clicking option 'Send To Report' shall generate a 'RTF' file, opened in in-built RTF editor of MiC.

The report may be tailored to your choice of look. Video demonstrations of how to alter different setting for custom report are provided with the MiC installation CD. To incorporate your company letterhead, you may open the file named 'letterhead.bmp' located in MiC installation folder, in paintbrush application and carry out necessary changes. To change overall effect and look of the printed report you may change a file 'vf.bmp' located in the same folder, by opening simple image editors like Paint Brush. Changing these files once, makes permanent changes to the look of custom report and does not require alteration at any other time.

A click of a button command 'Send To Custom Report' from any of the MiC Modules prints the report directly on default printer. Prior to print you shall also be provided a preview as shown below for the case of Grain Size measurement module.





### Cost

This software is for sale. Please contact TCR World Inc. in case you are interested in purchasing this tool.

Our software is priced attractively and includes option for on-site training for your metallurgists.

A time limited demo version of the software along with screen cam video's of the different functionality listed above is available at <http://www.tcreng.com/products/laboratory-software/microstructure-characterizer/demo/>

## About TCR Engineering Services

Founded in 1973, TCR Engineering Services (TCR) is India's most reputed and established, NABL and ISO 17025 accredited independent material testing laboratory. The core services TCR provides include Mechanical Testing, Chemical Analysis, Positive Material identification (PMI), Non Destructive Testing, Metallography, Corrosion Testing, Failure Analysis, Raw Material Inspection, Metallurgical Product evaluation, Engineering Research and Consultancy.

### Mechanical and Physical Testing

Comprehensive range of Mechanical Testing with a dedicated machine shop to assist in sample preparation. Capabilities include: Tensile, Impact, Weldability, Bend, Compression, Flaring/Flattening, Hardness, Dynamic Loading, Drop Weight, Proof Load, Fasteners, Hydraulic/Pneumatic, Component Testing, and more.

### Chemical Analysis

State of the art Chemical Analysis laboratory allows our expert chemists to analyze ferrous and non-ferrous metals, ceramics, glass, refractories, mineral and ferro alloys in PPB or PPM level or in percentage. Our capabilities include: Wet Chemistry, Optical Emission Spectroscopy (OES), Inductively Coupled Plasma (ICP) Spectrometer, Automatic Combustion based Carbon and Sulfur determination, Glow Discharge spectrometer for (GDS) chemical depth profiling, and more.

### Positive Material Identification (PMI)

TCR Engineering's Positive Material Identification service is fast becoming an integral part of process safety management in the petroleum refining, petrochemical and electric power generation industries in India, Middle-East and Asia-Pacific. Our capabilities include: Portable Optical Emission Spectrometer and a number of Portable X-Ray Florescence (XRF) Spectrometers.

### Failure Analysis and Metallography Testing

Our facilities include Optical Microscope with Image Analysis system, Micro Hardness Tester, In-situ Metallography Kits, Stress Analyzer, Dilatometer, and Electronic Polishing and Etching system. TCR can procure on-hire basis, a scanning electron microscope and an elemental analysis by EDAX.

### Corrosion Testing

TCR performs a wide range of Corrosion and Stress Corrosion Tests as part of the AST, NACE or client supplied specifications. Senior staff members are available to help and advise on corrosion problems or materials selection in laboratory or on-site inspection. Routine tests undertaken to evaluate the corrosion resistance of materials to environmental corrosion, pitting corrosion, resistance of materials to stress corrosion and inter-granular attack, including HIC, and SSCC tests.


### Specialized Non Destructive Testing (NDT) Services

Radiography Testing, Ultrasonic Flaw detection, Magnetic Particle and Liquid Dye Penetrant Testing, Portable Hardness detection, Ultrasonic Thickness Gauging survey and Raw Material Inspection. Residual Life Assessment (RLA) of Boilers and pressure vessels.

## Locations

We welcome service and technical inquiry, from simple questions to more involved interpretations of codes and specifications. We are located at:

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