Hi-Resolution Image Analysis of Void Space in Superconducting Cable-in-Conduit

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Purpose

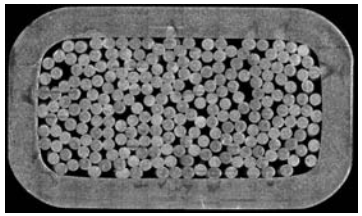
The purpose of my project is to evaluate methods to determine the fraction of liquid helium flow through superconducting cable-in-conduit coils. The use of high resolution micrographs are important in determining the correct void space in superconductive cable. Also, precise methods in sample preparation are needed to produce the optimum surface for observation. Adobe Photoshop Image Analysis Program and Image J Analysis Program were used to determine specific parameters.

A superconductor is an element, inter-metallic alloy, or compound that will conduct electricity without resistance below a certain temperature. Resistance is undesirable because it produced losses in the energy flowing through the material.

Scientist have already determined that high resolution pictures are vital when determining the amount of void space in superconductors. The amount of void space, in each sample, is needed to make sure that the proper amount of liquid helium is flowing through the superconductor at all times. If the flow of the helium is too low, in the superconductor, it will cause the temperature to rise and get above the critical temperature, 4.6° K. When a super conductor's temperature reaches above its critical temperature it becomes too hot and the materials begin to behave as normal materials.

Process

Base Image



Histogram

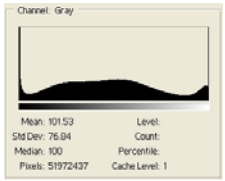
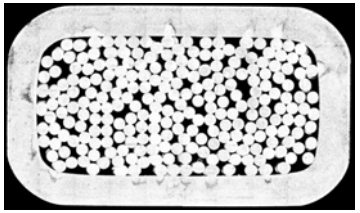


Image taken with a laser confocal microscope and is a composite micrograph of 80 individual images.

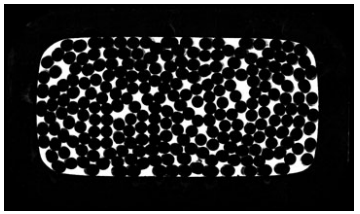
Binary Image



Histogram

The high resolution base composite is converted to a binary image. This forces the individual pixels to be either black (0 value on the Gray Scale) or white (255 value on Gray Scale). (Refer to Histogram)

Paint and Tubing

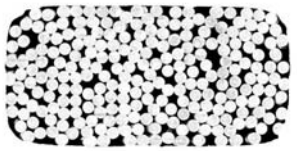


Now the focus shifts to finding the area of the exterior, tubing, filaments and void space.

Each picture has a total value of 51,972,200 pixels.

Using the histogram, I was able to find the total number of black and white pixels.

Conduit Interior

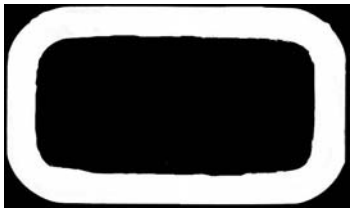


Here we are showing only the interior tubing. White count is 21,768,643 pixels. (superconductive filaments)

Total Conduit Interior

The pixel count on the interior conduit is 27,432,050.

Total Tubing



The total count of the tubing is 19,710,347 pixels. The pixels can be converted to area.

Results

The void space inside the conduit is 23%.

The following pictures depict the process of preparation and polishing necessary to create the samples for the experiment.

Here I am observing the sample using the Leica Inverted Microscope in order to establish the process that will be followed in preparing said sample.

In this picture the sample is being polished. This process is repeated several times with successively smaller polishing compound until the desire results are achieved.

The sample must be checked periodically in the microscope to assure correct polishing.

Conclusions

In conclusion, this is a program with too many variables to be uniformly set for every micrograph with differing preparation and illumination. The experiment should be repeated to accurately determine variability. High resolution may give better precision but does not necessarily give better accuracy.