

## *Image Analysis of Ceramic Powder Catalyst*

Petroleum is a naturally occurring, flammable liquid found in rock formations in the earth, consisting of organic compounds and complex hydrocarbons. These hydrocarbons consist of long chains of carbon and hydrogen molecules which, once refined, break down into a variety of products such as gasoline, diesel, kerosene, and fuel oil, but also solvents, fertilizers, pesticides, and plastics. Other products, such as asphalt, can also be “cracked” by modern refineries into more valuable products.

Cracking is a process whereby complex organic molecules are broken down into simpler molecules by the shattering of carbon-carbon bonds. In Fluid catalytic cracking the long-chain molecules of high-boiling hydrocarbon liquids are turned into much shorter molecular chains at elevated temperature by means of a fluidized powdered catalyst. This powdered catalyst usually consists of small ceramic balls, or beads, about 1 to 2 microns in diameter. These beads, packed in columns, draw out impurities from crude oil as it passes through.

During this process, the beads wear down, and by doing so, lose their properties as catalysts due to a reduction of surface area. Clemex was provided with four vials containing ceramic beads. The purpose of the analysis was to see if the software could classify a group of beads by degree of wear. The vials were numbered: vial #1 containing pristine beads; vial #2 containing slightly worn beads; vial #3 containing worn beads; and vial #4 containing fragmented beads.

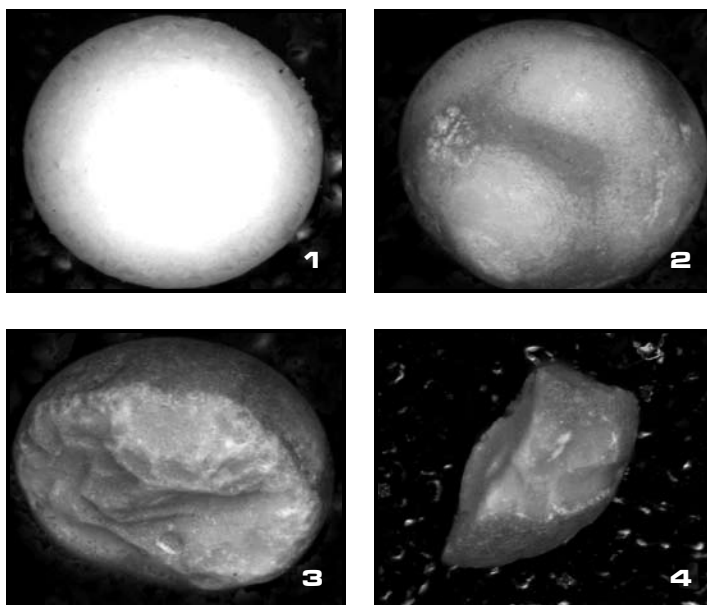
### Analysis

The beads were randomly placed onto a sticky surface in order to prevent them from moving around. If a large number of samples were to be analyzed, the use of a grid to hold the samples in place should be considered. The motorized stage’s movement would thus always be the same.

Given the size of the beads ( $\pm 2\text{mm}$ ), a low-power objective must be used to keep them entirely within the visible area (as much as possible). Nevertheless,



Oil refinery



From left to right: vial #1 pristine beads, vial #2 slightly worn beads, vial #3 worn beads, and vial #4 containing fragmented beads.

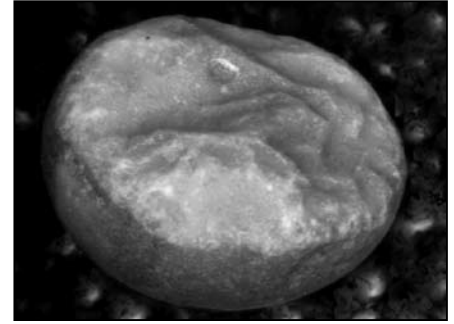
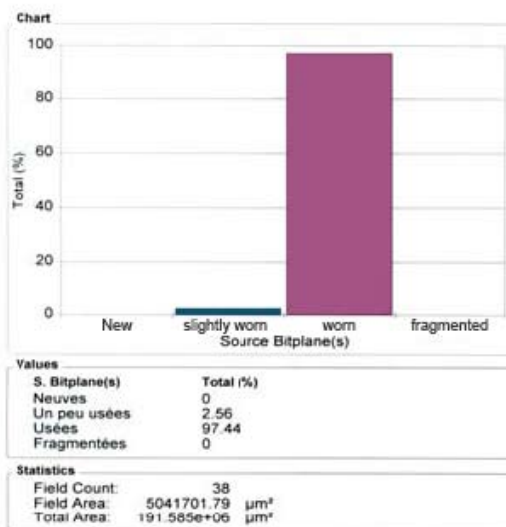
the magnification must be sufficiently high to resolve the texture of the ball's surface. A magnification of 50X was found to be the best compromise for this analysis.

Considering the shape of the beads and the magnification used, it is only possible to focus on small sections of an object at the same time. The Multi-Layer Grab instruction is thus vital in reconstructing the complete image from the several images taken at different Z positions, each containing only a small area in focus. The Z displacement of the motorized stage was doubled in order to increase the speed of the Multi-Layer Grab instruction.

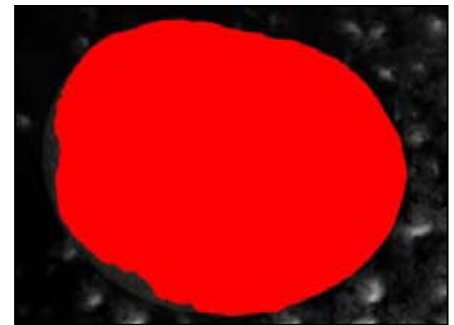
It was found that reflected light and a black background are the conditions which allow for the best contrast of surface details, and thus to obtain the greatest variation in gray levels from one category to another.

Using the analyzer, a number of different factors were measured on beads belonging to each of the four categories. The results obtained were compared using graphs, and those which showed a clear-cut variation between categories were retained for use. These factors are size, gray intensity, and texture. Although none of these three factors alone are enough to categorize the beads according to the four wear levels, their combined use makes classification possible.

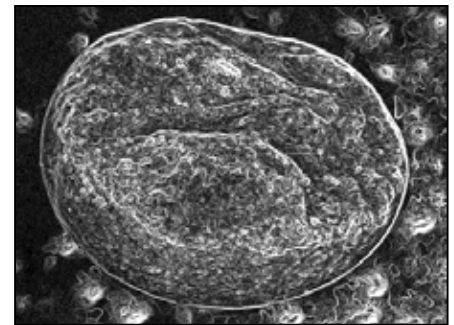
For a group of beads, the Clemex Vision PE image analysis system can automatically calculate the percentage of each of the four categories to which they belong. From there, the final classification is easily done.



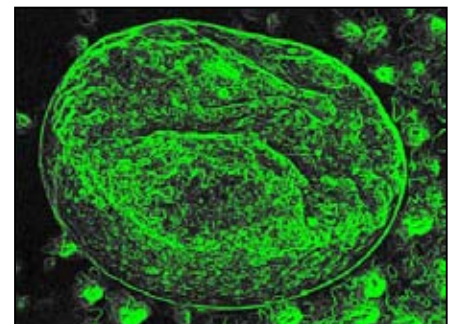
Reconstructed image of the worn bead using the Multi-Layer Grab instruction.



Red Thresholding of the worn bead.



Kirsh Transformation of the original image to make the bead's texture visible.



Green Thresholding of the textured areas which correspond to wear.

