AUTOMATED DIGITAL IMAGE ANALYSIS OF SEMI-COKE TEXTURE

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Introduction

Optical texture of petroleum cokes refers to the appearance of the surface under a polarized-light microscope[1]. The size and shape of isochromatic areas can be used to identify the type of the textures observed. In general, direct characterization of the optical texture is very difficult, since the optical domains in petroleum cokes are often connected and tortuous [2]. Several image analysis techniques have been used to determine the size, shape, and orientation of the optical domains in calcined petroleum cokes [2-5]. In the present study, an image analysis method was developed to characterize the texture of semi-cokes using a different technique from that reported earlier [6]. Optical texture indices were defined to describe the degree of anisotropy according to the shape and orientation of domain boundaries identified by image processing techniques.

Experimental

Thirteen semi-coke samples were prepared by carbonizing eight slurry oils and five thermal tars in a tubing bomb reactor at 500°C for 3h. Before carbonization, 4 g of each sample was weighted in an aluminum foil tube and then put into a stainless tube bomb. The resultant lump coke was mounted in epoxy resin longitudinally. Polished pellets of semi-coke samples were placed on the microscope stage such that the long axis of coke samples was parallel to the x-axis of the stage. Image acquisition from a polarized-light microscope (Nikon, Microphot-FXA) was carried out via a high resolution video camera and an image analysis system (PGT, IMAGIST) [6].

Before image acquisition, contrast and brightness of the image were adjusted in order to obtain a clear gray level image. After the gray level image was acquired, Robert's cross operator was used to find out the boundaries of the image. Since the gray levels of the boundary image only occurred at the dark end of the gray scale, it was necessary to let the gray levels of boundary image to occupy the whole range of gray scale by using the stretching technique [7]. Consequently, a threshold at 67 gray level was set to obtain a binary image. The binary image could be used to analyze the features in the image (e.g., the longest dimension, breadth, and maximum horizontal chord) [8]. Normally, thirty images were analyzed for each pellet. Because a binary image often contained some large boundaries of pores and small noise, we only measured the features in the size range of 50 μm^2 and 1500 μm^2. If the image had some scratches which was in the measured range, they were removed manually.

A manual point counting technique was also used to characterized the semi-coke to compare the results with those obtained by digital image analysis. An automated microscope stage was used to scan the sample by moving a mask of 1mm×1mm for each pellet.

Results and Discussion

Figure 1 shows the different types of the images created by the image processing techniques. The gray level image of petroleum cokes does not have distinct boundaries between texture elements. Interpreting optical domains as objects give, in most cases, complex object shapes. Since each optical domain is not always an enclosed object, instead of analyzing the complex shape of the optical domains directly, we can analyze the boundaries of these optical domains. The boundary image which was shown in Figure 1(b) was created by the Robert's cross operator. Obviously, the boundary image does not reflect exactly the shape and size of the optical domains as seen in the gray level image. However, the boundary image can represent the properties of the optical domains, and can, therefore, be used to characterize the optical texture of petroleum cokes. The binary image shown in Figure 1(c) was created by thresholding technique [7]. Feature analysis can be carried out on the binary image.

For feature analysis, we used three parameters, longest dimension (LD), breadth(B), and maximum horizontal chord (HC). Two feature Indices, Called FRI1 and FRI2, were defined to reflect the shape and orientation of the boundaries of optical domains. The following equations were used to calculate the feature indices for each pellet:

$$FRI1 = (1/n)\Sigma^n((\sum_{j=1}^{m} \frac{LD_j^2}{B_j})/m) \quad (1)$$

$$FRI2 = (1/n)\Sigma^n((\sum_{j=1}^{m} \frac{LD_j}{B_j} \times HC_j)/m) \quad (2)$$

where: m is the number of features in an image; n is the number of images (normally, n=30). Based on these definitions cokes with more anisotropic and well oriented structures ordered structures should have higher values of feature indices.

Using the semi-automated point counting data and the assigned factors for four texture classifications, another optical texture index (OTI) was calculated as described before [7].

Figure 2 shows plots of feature indices (FRI1, FRI2) against optical texture index (OTI) for semi-coke samples. It appears that the boundary analysis of optical domains can represent the characteristics of optical texture of semi-cokes. The boundary analysis method does not require texture identification for each image, as needed for the point counting method. There is also no need to create closed boundaries and analyze the complex shape of optical domains. Instead, the method relies on the boundary properties of the optical domains. This technique can also be used to analyze the optical texture and porosity of calcined cokes [7].

Conclusions

Boundary imaging and analysis can be used to characterize the optical texture of semi-cokes. The principal advantage of this technique is that there is no need to identify the individual texture elements in a given image.

Acknowledgments

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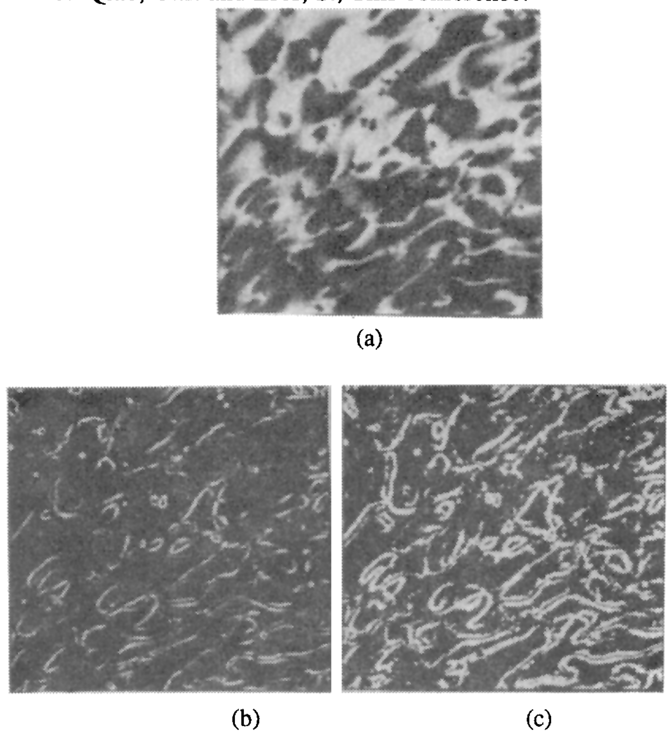

Figure 1. Typical images of domain structure: (a) gray level image; (b). boundary image; (c) binary image.

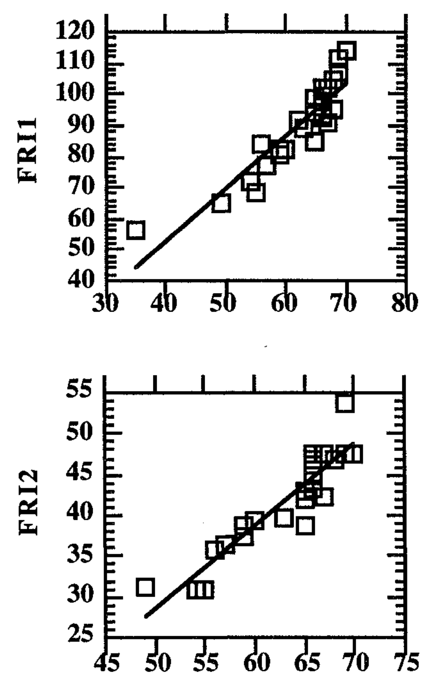

Figure 2. Comparison of optical texture index and feature indices.