Determination of degree of carbonization in cokes by image analysis

A majority of the industrial processes for metal production is based on reducing the metal oxide to pure metal using carbon under high temperatures and/or electrolysis. Coke is the most common raw material for such carbon-based processes. These processes require a lot of energy and cause CO_2 emission into the atmosphere. The efficiency of the processes is often highly dependent on the properties of the carbon. Examples of such properties are element impurity content and the atomic structure of the carbon.

Traditional methods to characterize a material's atomic structure such as scanning electron microscopy (TEM, SEM) and X-ray diffractometry (XRD) are often not sufficient to characterize carbon materials. This is because many of the important properties are on a millimetre- or micrometer-scale rather than in the nano-scale realm these advanced instruments operate in. Traditional optical microscopy is therefore very useful for examining properties of the carbon materials. Examples of such properties are porosity and degree of crystallization.

In order to be able to reduce the CO_2-emissions and energy consumption of carbon-based metal production, the relationship between carbon consumption and the carbon properties must be studied. A method to determine the degree of carbonization of coke using automatized optical microscopy and image analysis has therefore been developed. The degree of carbonization in a coke grain is determined by examining the interference colours in reflected cross polarized light. Optically anisotropic areas have different colours than the isotropic areas. The degree of carbonization is given as the fraction of optical anisotropic area to the total coke area, excluding porosity.

The microscope is equipped with automatic stage movement and auto-focus. This enables a non-biased fully automatic analysis: Several hundred images at random positions are automatically acquired and analyzed, and statistical values can be calculated. The results show a large variation, and these data is compared to the reactivity data for the different cokes. The cokes characterized in this work are used for manganese and silicon production.

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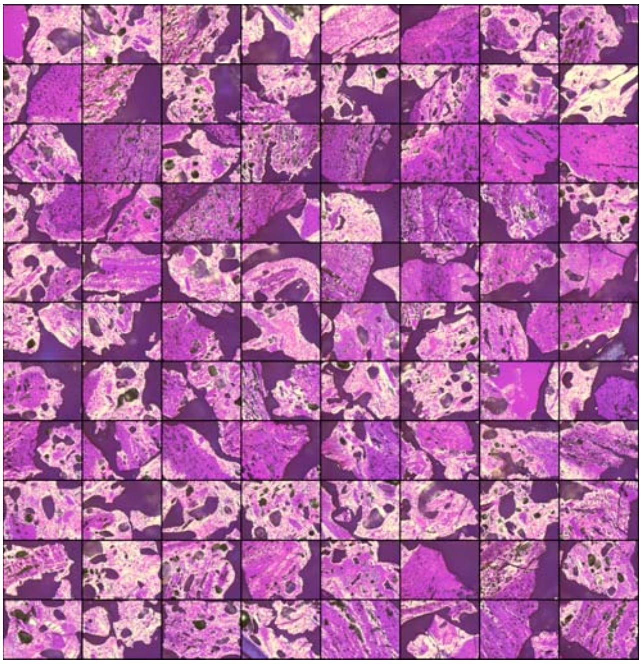

Photo: Stein Rørvik

A composite image of a collection of different coke grains. The areas with purple colour are non-crystalline. The darker areas are pores or at the outside of the grains.

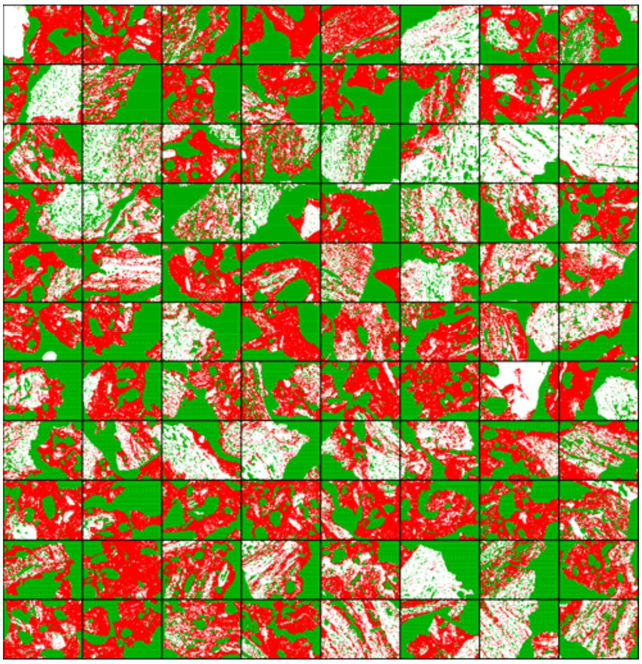

Photo: Stein Rørvik

The result of the image analysis of the same coke grains: A white colour indicates non-crystalline carbon, while a red colour indicates crystallized carbon. Green is pores or areas outside the grains.