Automatized determination of the primary particles size of soot aggregates by TEM image analysis

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The needs for reference methods to analyse the physico-chemical properties of combustion aerosol have been of rising concern of the scientific community over the last three decades. The morphological characterization of soot aggregate is possible by analysing images obtained by Transmission Electron Microscopy (TEM). Indeed, it is shown that maximum projected length is related to the gyration radius size parameter. The 3D number of primary spheres in the aggregate can also be determined from the measurement of the particle projected area. Finally, these parameters are linked by a power law that permits to determine the soot fractal dimension (Brasil, et al., 1999; Köylü, et al., 1995). These measurements can be achieved automatically over a set of numerous TEM images in order to determine statistically the fractal dimension. However, the size of the primary particles is also needed and the classical method for determine it from TEM pictures is manual, time consuming and tedious.
Recently, an automatized method based on the Hough transform has been proposed in order to determine the primary particle size (Bradski and Kaehler, 2008). Here, we present another approach based on the Euclidian Distance Mapping (EDM) method which is robust, rapid and easy to implement. Indeed, EDM is often used to characterize the morphology of complexes objects as human cells (Ballerini and Franzen, 2001) or atomizing liquid flows (Grout, et al., 2007). In addition to its ability to determine the size of primary spherules, this method is promising to inform us of the fractal dimension of the particles.

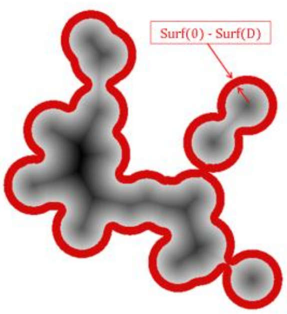

Figure 1. Illustration of the EDM method

The EDM analysis permits to determine, for each position in the image, the smallest distance to the border of the particle. This distance is represented in gray levels in figure 1. The more the Euclidian distance is, the more the gray level is dark. From this EDM map, we define a surface $S(D)$ corresponding to the part of the aggregate whose distance to the border is less than D, a scaling parameter. This surface is illustrated in red in figure 1. A dimensionless function ranging from 0 to 1 is finally defined:

$$S(D) = 1 - Surf(D)/Surf(0)$$

This function is established over a set of images of virtual aggregates generated by a DLCA (Diffusion Limited Cluster Aggregation) code (Meakin, 1999). The interest of this numerical investigation is to control the primary particle size (mode and standard deviation).
The Figure 2 presents the $S(D)$ functions determined for aggregates made of different sizes of primary particles. For each case, 200 aggregates whose number of primary spheres ranges from 10 to 60 are considered. In case of monodisperse primary particles, the representation of $S(D)$ as a function of D is shown to indicate that primary particle size can be determined easily from EDM analysis.
Based on different sets of DLCA aggregates, the way to determine simultaneously the primary spheres mean diameter and standard deviation is discussed.
After all, the EDM method is applied to TEM pictures coming from thermophoretic sampling of real soot aggregates of ethylene diffusion flame and CAST5201© generator.

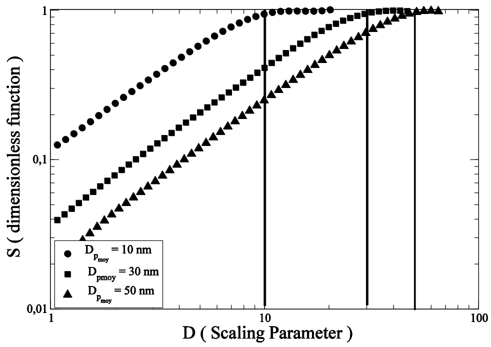

Figure 2. Representation of normalized surface function S

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