Particle Size and Shape Analysis of Activated Carbon using Dynamic Image Analysis

AN167

Activated carbon is a type of carbonaceous material that is made extremely porous through processing. The very large surface area of activated carbon makes the material useful for chemical adsorption or reaction. Particle characterization of activated carbon often includes size, shape, and surface area measurements. Dynamic image analysis has proven useful for the size and shape analysis of many forms and grades of activated carbon and has successfully replaced older techniques such as sieving at factory plants around the world.

Introduction

Activated Carbon is pure carbon (i.e. carbon content > 90%), either in the form of microcrystalline graphite or amorphous carbon. The inner structure of the material is highly porous with a specific surface area of about 500 - 1500 m^2/g (which means only 3g of activated carbon will have the surface area of a football field). The material is able to adsorb a large number of (mainly organic) molecules. It is therefore used as a filter material for many applications such as water purifiers, tobacco smoke filters, or the automobile industry to prevent (via hydrocarbon adsorption) the evaporation of gasoline fumes into the environment.

Three types of activated carbon are available:

- **Powdered Activated Carbon (PAC)**
  - Particle size < 0.18 mm
  - Used for cleaning and de-coloration of liquids as well as for flue gas

- **Granular Activated Carbon (GAC)**
  - Particle size 0.2 – 5 mm
  - Rough, edgy particle shape
  - Commonly used for water treatment and deodorization

- **Extruded Activated Carbon (EAC)**
  - Particle size (diameter) about 0.8 – 5 mm
  - Short, cylindrical granular particle shape
  - Used for gas purification owing to high mechanical strength, favorable dust generation, and manageable pressure drop

Production Process

Activated carbon can be produced either from plant material like wood, peat or nutshells, or from fossil fuels. Raw material processing into activated carbon occurs through chemical and/or physical action to remove non-carbon components. Physical activation involves the pyrolysis of raw material in an airtight environment[1]. This process is also known as *dry distillation*. Chemical activation commonly uses acids (e.g. phosphoric acid), bases (e.g. potassium hydroxide), or salts (e.g. zinc (II) chloride) to impregnate the carbon during carbonization at temperatures between 450-900°C. Finally the pores are enlarged by the processing with hot steam (700 – 1000°C). Within this process the organic matter is transformed into amorphous carbon or microcrystalline graphite.

Quality assurance

The size distribution and the shape of the carbon particles determines the efficiency and throughput of the filter. Especially the amount of fine particles, which may be created by abrasion, is a critical parameter, as the fines might block the filter. Sieve analysis is the historical technique used for particle sizing of activated carbon. Dynamic image analysis can correlate very closely with sieve results owing to shape analysis of the particles and how they would slip through the square sieve mesh.

Extruded Carbon Rods

Besides the opportunity to independently measure the length and width distributions of extruded "carbon rods", very small quantities of fine particles on the order of below 0.1% can be reliably detected.

[1] This dry distillation process occurs in the absence of air to generate tight pores. The same method is used for the production of coke.

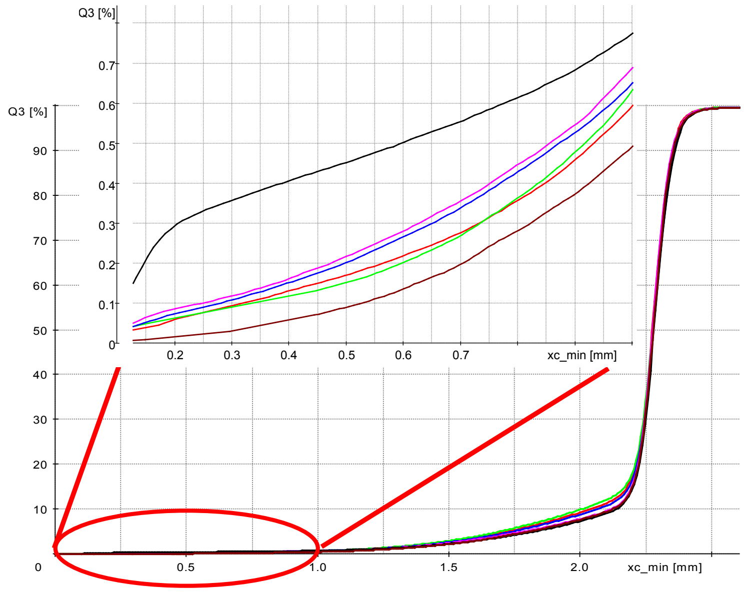

Figure 1

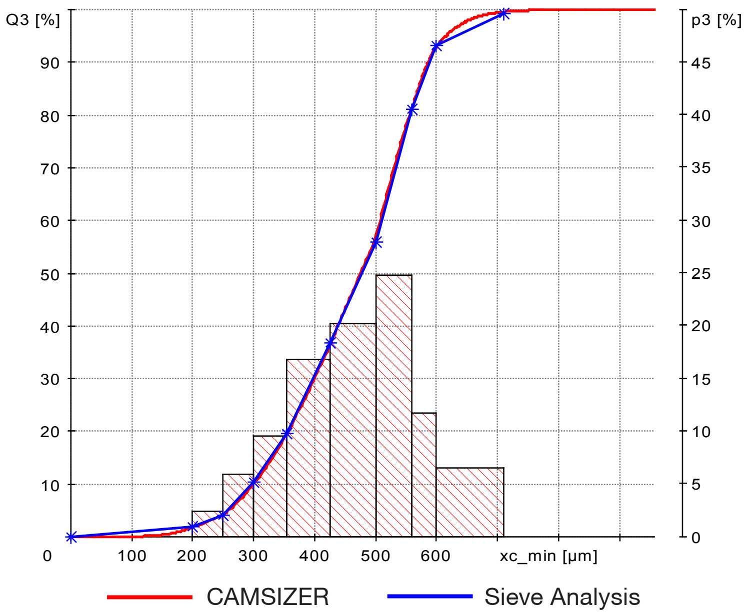

Figure 2

In the example shown in Figure 1, the contents of six 1 liter cartridges of extruded activated carbon have been measured with the CAMSIZER Dynamic Image Analysis System. These cartridges are used to adsorb gasoline fumes. One of the samples had a higher amount of fines (black curve) than the others (0.4% for the black and 0.1% for the rest). This is only a slight, but very important difference, because small amounts of dust can clog the filter material. The CAMSIZER has been thoroughly evaluated for this application, as the quality management in many industries (e.g. the automotive industry) is extremely strict.

Granular Activated Carbon

As for all other edgy bulk material, there are systematic differences between sieving and CAMSIZER results. Since the particle shape of granular activated carbon is quite uniform, elementary fitting can easily be established. Customers who wish to replace their sieve analysis with the CAMSIZER benefit from the powerful fitting algorithms giving a very good comparability between the two methods.

Figure 2 shows an example of elementary fitting for a sample of granulated activated carbon:

Conclusions

Dynamic image analysis provides many benefits over historic techniques such as sieves for analyzing activated carbon. The advantages of dynamic image analysis include:

- Gentle measurement without breaking the particles; minimizes dust generation.
- Results directly comparable to sieving.
- Higher resolution size distribution information.
- Accurate determination of fine particle (dust) amount.
- Particle shape information: length and width measurement for extruded rods.
- Analysis of a complete filter without sample splitting.
- High speed and objectivity benefits of digital image processing as opposed to slower, subjective sieve use.