Influence of the inlet particle diameter distribution on the experimental determination of cyclone collection efficiency

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The aim of this experimental study is to investigate the influence on a cyclone collection efficiency determination of the inlet particle diameter distribution. The internal diameter of the cyclone has been fixed to a given value of 30 mm, which is a typical size of these devices when they are used for the separation of oil mist from blow-by gases, in internal combustion engines. To reproduce the flow rates and temperature operating conditions (80°C) of combustion engines, we developed a temperature controlled flow bench, with a polydisperse aerosol generator producing engine oil droplets with diameter in a 0.3-10 µm range.

Measurements of the aerosol particle concentrations upstream and downstream of the cyclone permitted the determination of the particle collection efficiency, with flow rates ranging from 56 to 262 Nl/min which are typical operating conditions. During this study, we observed classically that for any given value of the flow rate, the collection efficiency increases with the particle diameter, to reach a value close to 100%. While in most of the practical applications, this grade-efficiency curve takes a smooth "S" shape, with low values of the collection efficiency for small particle diameters, we observed however that a minimum in the grade-efficiency curve exists for high values of the flow rate, with an increase of the collection efficiency for low values of the particle diameter. Such experimental results have already been observed by Abrahamson and Allen (1986), and the shape of the curve is described as a "tail" by Hoffmann & Stein (2002). The aim of this experimental study is to investigate the influence of the particle load on the grade efficiency curve, and particularly on the intensity of the "tail" for small diameter particles.

As an illustration, for a fixed flow rate with a given value of 100 Nl/min, and a fixed particle mass load of 125 mg/m³, we changed the oil in the aerosol generator, and the corresponding measurements of the collection efficiency are reported in figure 1, together with the dimensionless particle number distribution dN/N. As observed, the aerosol generated with engine oil is composed with a fraction of large particles significantly higher than for DEHS, and measurements obtained with DEHS demonstrate a high reduction of the "tail" in the collection efficiency curve observed for small particles with diameter below 1 µm.

These measurements seem to confirm the explanation proposed by Cortés & Gil (2007) who suggested that this tail could be attributed to a swept of the small particles by the larger particles inside the vortex: when we modify the particle number distribution with an increase in the fraction of small particles, the collection efficiency of the fine particles reduces, suggesting that the entrainment mechanism has been reduced.

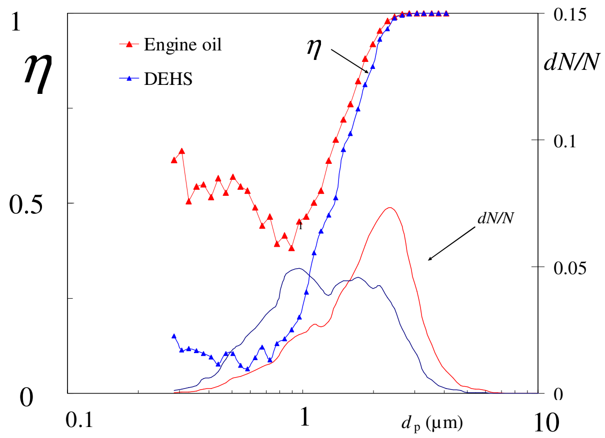

Figure 1. Collection efficiency measurements, for a fixed flow rate of 100 Nl/min..

To further investigate the influence of the inlet particle diameter distribution on the collection efficiency, we used different cyclones, associated in series, to cut the large diameter particles from the inlet distribution.

We observed a significant reduction in the "tail", by removing from the distribution the large particles. These measurement results will be detailed in the submitted paper. This result suggests that the collection efficiency of cyclones should be carried out with polydisperse aerosols, and with particle-size distributions that correspond to real-life conditions of use of the cyclone.

Abrahansen, J. and Allen, R. W. K. (1986) The efficiency of conventional return-flow cyclones at high temperatures. *American Institute of Chemical Engineers Journal* **99**, 31-43.

Cortés, C. and Gil, A. (2007) Modeling the gas and particle flow inside cyclone separators. *Progress in Energy and Combustion Science* **33**, 409-452.

Hoffmann, A. C. and Stein, L. E. (2002) *Gas Cyclones and Swirl Tubes. Principles, Design and Operation*, Springer, New York.