Comparison of optical particle counter and cascade impactor gravimetric measurement methods for the evaluation of separators used in blow-by applications

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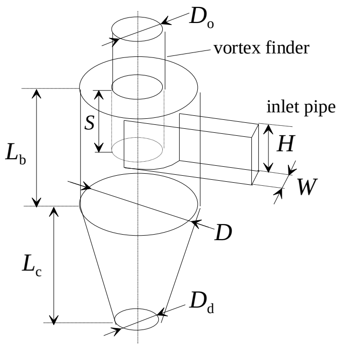
Oil separators are used in the automotive industry for the separation of oil mist from blow-by gases in internal combustion engines. These so-called "blow-by gases" result from leakages between the combustion chamber and the crankcase. The resulting oil mist has to be cleaned up, for pollution control, oil consumption reduction and also to avoid oil deposit in the intake line, mainly turbo-charger and intake valves.

In laboratory conditions, the separation performances evaluation of different devices is usually based on the measurements of the fractional efficiency and associated pressure losses. In this study, the oil mist is produced by an aerosol generator (PALAS PLG 2010), and fractional efficiency curves are determined from measurements of the aerosol particle concentrations upstream and downstream of the tested device with a WELAS OPC (optical particle counter).

However, when running bench engine testing, the amount of carry away oil depends on both the collection efficiency of the separator, and on the upstream particle size distribution generated by the engine. For these reasons, engine car manufacturer mainly use gravimetric measurements, to evaluate the amount of oil carried away.

The aim of this study is to provide a consistent comparison between these two measurement techniques, in laboratory conditions. For this evaluation, a standard cyclone separator configuration was chosen, with the following dimensions:



Dimensionless ratios
$(L_b + L_c)/D = 2$,
$L_b/D = 1$, $S/D = 0.62$,
$W/D = 0.22$,
$H/D = 0.48$,
$D/D_o = 2.23$

Cyclone size
$D = 35$ mm

For this cyclone configuration, measurements of collection efficiency curves were carried out with the WELAS OPC on a wide range of flow rate (20 to 120 Nl.min^{-1}). Cutoff size diameters d_{50} and pressure losses were found to be in good agreement with Muschelknautz's model (Muschelknautz, 2010). For an intermediate flow rate value of 84 Nl.min^{-1}, measurements with both OPC and Andersen cascade impactor were carried out. Optical and Stokes diameters were converted to geometrical diameters for these spherical particles.

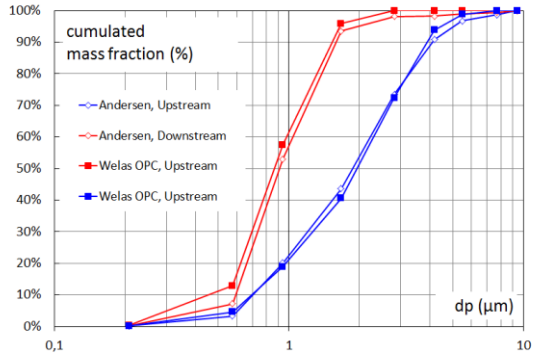


Figure 1. Comparison of OPC and Andersen cascade impactor results.

As illustrated in figure 1, cumulated mass distributions measured with both Welas OPC and Andersen are in good agreement. Fractional efficiency curves are presented in figure 2.

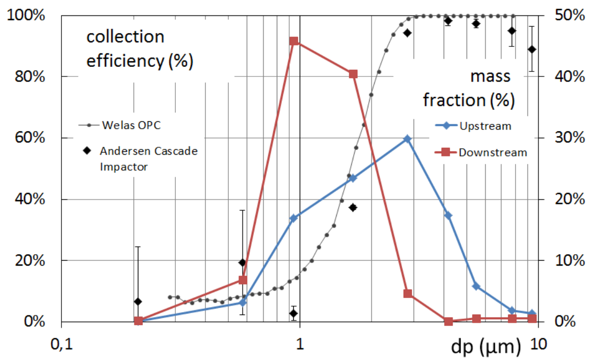


Figure 2. Comparison of OPC and Andersen cascade impactor results.

Measurements error bars based on three determinations are quite wide for both small and large diameter particles, due to insufficient loading of the impactor collection plates. However, a good confrontation is obtained for the main parameter which is the cutoff size diameters d_{50}.

Muschelknautz, U. (2010) *L3.4 Cyclones for the Precipitation of Solid Particles.* 1226-1237, VDI Verlag GmbH Heat Atlas, 2ème. ed, Ed Springer, Düsseldorf