Filtration Efficiency of Bubble Scrubbers

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Wet scrubbers and bubble chambers have been used for cleaning carrier gasses, and are receiving attention as possible collection devices for sampling atmospheric dust particles. Fibrous filters are also used, but have a defect in that the pressure drop across the filter increases as the deposits of filtered particles build up. Eventually the filter fibres need to be cleaned or replaced. As noted by Charvet et al (2011) "..there is still a lack of models able to predict the time evolution of the pressure drop and the life time of such filters..". One advantage of bubble processes and bubble chambers is that they operate at constant pressure drop, and ".. do not require particle unloading.." Charvet et al (2011).

The passing of air through a column of water results in streams of bubbles rising through the chamber. Such a device has been used in science and industry, as a filtration mechanism to remove pollution particulates and gases from exhaust streams. Models of the individual processes inherent in the device have been developed over time. However there are problems when attempting to match these theoretical results with the observations from experimental work, which measures the efficiency of removal of the pollutants.

We use input-output analysis to model the bubble chamber as a complete system and incorporate existing individual process models as parts of the whole. The independent variables in the model are the water volume and the pollutant mass inside the scrubber chamber Figure 1. The ensuing model is a set of two ordinary differential equations whose complexity depends on which individual process models are selected. The output processes include the "film" and "jet" droplets which are formed when the air bubble bursts at the water surface in the bubble chamber. Some of these droplets can be entrained and exit the chamber with the cleaned gases.

The equation for the water volume becomes redundant when the water volume in the chamber is held constant. Using the results from Fuchs, for particle absorption with in the column, and typical models for the generation of jet and film drops, the equation for the pollutant mass simplifies to a single linear ordinary differential equation. The outcomes are the existence of an equilibrium point and time varying exponential expressions for the efficiency of the chamber.

Measuring the efficiency of the scrubber is also compounded by the effects of measuring points and lengths and curvature of piping, and the expulsion of water droplets from the outlets. Some measurements of the deposition of particles in lengths of piping were made. Results show that the deposition depends on pipe length, curvature and flow rate. This effect needs to be accounted for in both the inlet and outlet piping and measurement points. Outgoing water droplets will also influence the size distribution and particle count at the outlet measuring point. The model suggests that the best way of measuring efficiency is to monitor the particle count in the water column, possibly by sampling and then taking a particle count in the sample. The sampling point should not be too close to the water surface.

The results provide guidance for operating the scrubber so that desired efficiency is met including estimating time for maintenance. Monitoring the particle mass in the water is a better option than monitoring the input and outputs. Timing of the measurements is also important when performing experimental work and comparing with theoretical results, due to the time varying nature of the efficiency.

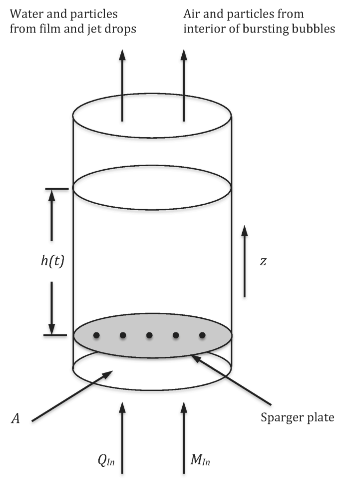

Figure 1. Bubble chamber used in experiments. *A* is the cross-sectional area of the bubble chamber, *h(t)* is the height of water in the chamber, *z* is the vertical dimension, Q_{In} is the flux of air in and M_{In} is the mass of particles in the air in.

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