Health and Safety Executive

Evaluation of an exposure control cabinet designed to prevent inhalation exposures associated with FFF desktop 3D printers

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Introduction

An increasing number of industries, and the education sector are considering using 3D printing technologies[1]. Existing studies suggest that nanoparticles are likely to be emitted due to the fused filament fabrication (FFF) process[2,3,4,5]. Inhaled nanomaterials have the potential to initiate inflammatory responses[6]. This project evaluated an exposure control cabinet (ECC) (Figure 1).

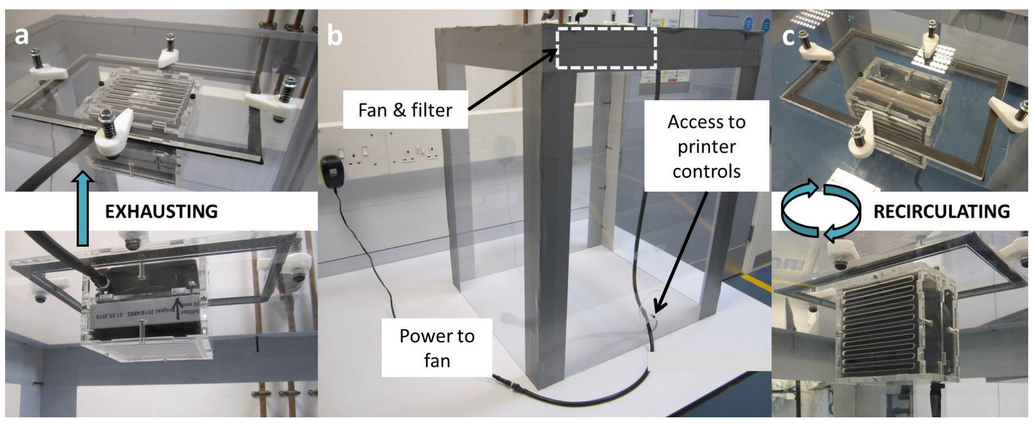


Figure 1-Photographs of the ECC a) fan orientation in 'exhausting' mode, b) key features, c) fan orientation in 'recirculating' mode

Methods

Measuring emission rates

The 3D printer printed with acrylonitrile butadiene styrene (ABS) at 250 °C (nozzle) and 78 °C (print bed). The emission rate of the system was determined with: i) no exposure control, ii) the ECC as in Figure 1a and iii) the ECC as in Figure 1c.

Measuring particle concentrations inside the ECC

The 3D printer printed in the laboratory with the ECC using another common filament, Polylactic Acid (PLA) at 220 °C (nozzle) and 50 °C (print bed). The particle concentration inside and outside the ECC was measured simultaneously.

Determining the clearance time

Smoke visualisation was used to qualitatively assess the clearance time of the ECC (Figure 2).

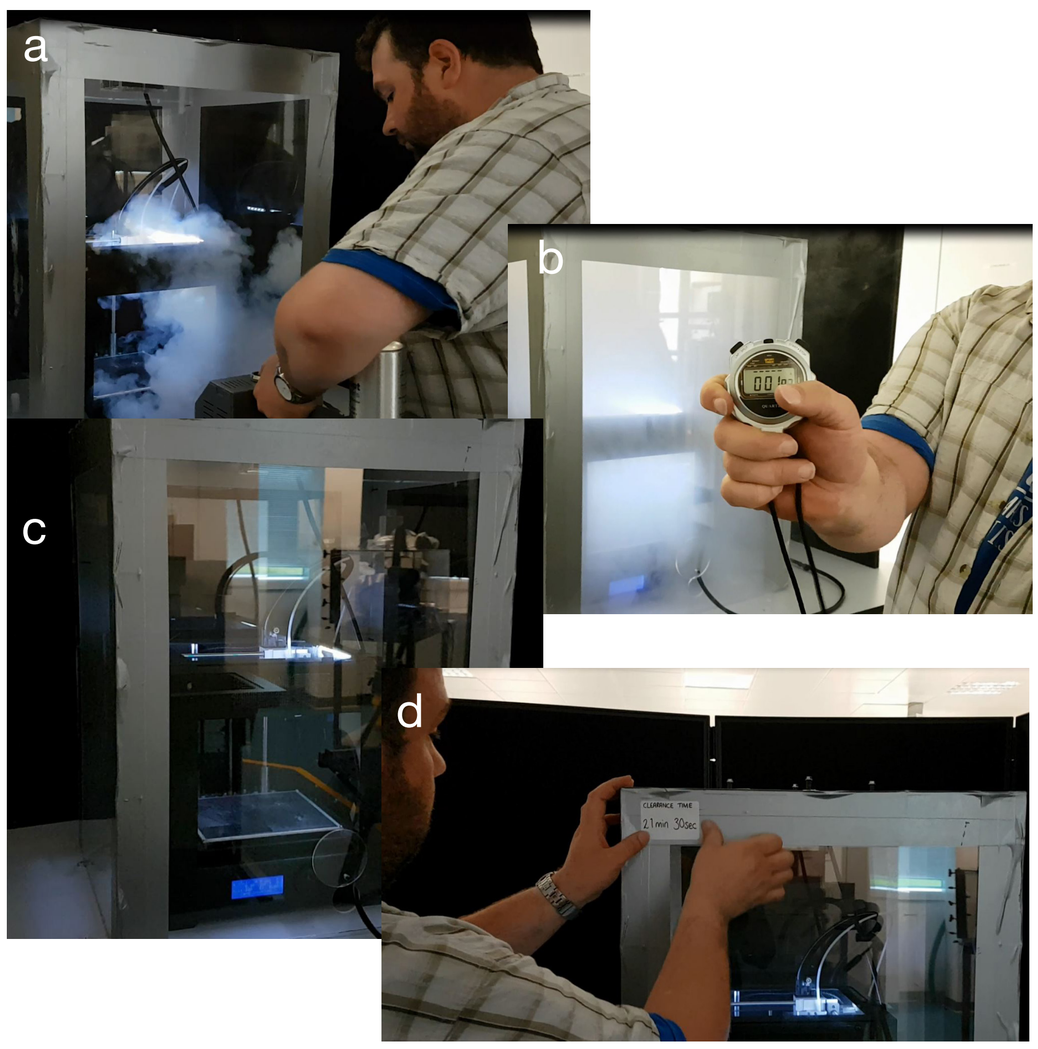


Figure 2- a) Filling the ECC with smoke b) Starting the stopwatch & switching on the ECC fan c) Observing until the smoke has cleared and noting the time d) Labelling the ECC with the clearance time

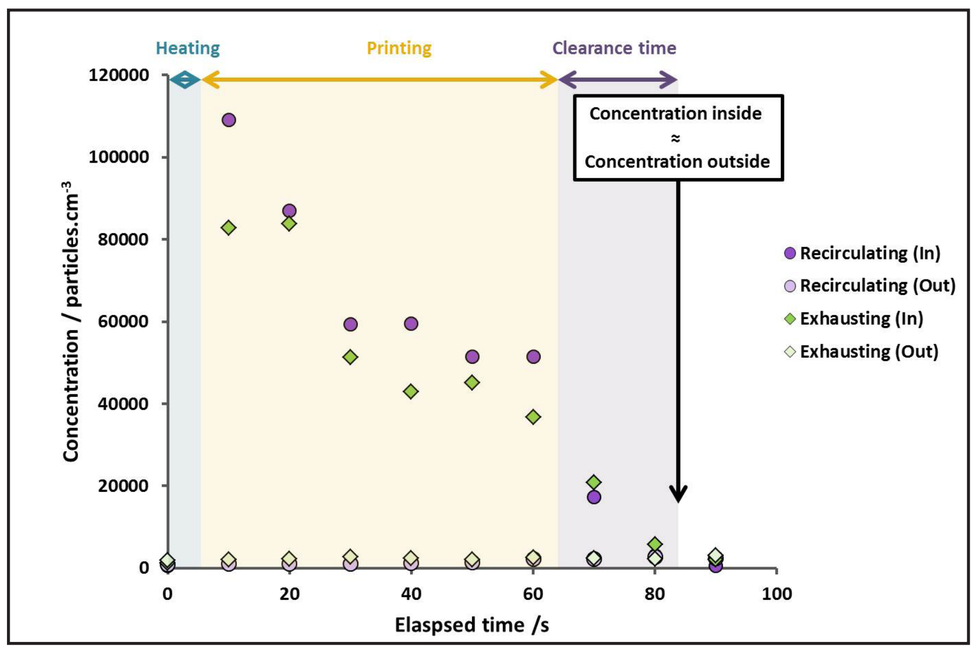
Results

The ECC reduced particle emission rates by up to 99% (Table 1).

Table 1-Emission rates i) no control, ii) ECC exhausting mode and iii) ECC recirculating mode

Exposure control	Emission rate / particles.min^{-1}	Reduction in emission rate compared with no control / %
No control	4.90×10^{11}	N/A
Exhausting	1.48×10^{10}	97.0
Recirculating	2.73×10^{9}	99.4

The clearance time was approximately 20 minutes (Figure 4) and the smoke visualisation tests supported this finding.



Conclusions

- Exposure controls, such as this ECC, can reduce the rate at which particles are released into the workplace from desktop 3D FFF printers by up to 99%.
- Particle emissions can accumulate inside an enclosure so it is important to be aware of the clearance time, i.e. the time it takes for the filter to remove the particles and the concentration inside the enclosure to return to background levels.
- Smoke visualisation is a quick and simple way to qualitatively assess the clearance time of an ECC.

References

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