Analysis of gaseous and particle number concentration from a binder jetting 3D printer during manufacturing of a mould

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Nowadays the importance of indoor air quality (IAQ) is clear, since people spend more than 80 % of time in indoor environments like, for example, office or laboratory environments. In the last years, the use of laser printers or 3D printers has become widespread. The IAQ in the printers laboratory may be deteriorated by the emission of particulate matter (PM) and volatile organic compounds (VOCs), compromising the health of workers. In this context, inside the chambers of the binder jetting 3D printer, a continuous movement of dry powder occurs. Hence, this process can be a potential source of particles, from the powder, and VOCs, from the binder solution, as observed by Afshar-Mohajer *et al.* (2015).

The main aim of this study is the analysis of particle number concentration (PNC) during the processes of manufacturing 3D printing (3DP) mould, melting and pouring of aluminium. The concentrations of particles by sizes -modes (nucleation: <30 nm; Aitken: 30-100 nm; accumulation:100-310 nm) and gases (NO_2, SO_2, CO and VOCs) have been analyzed.

The casting process using binder jetting technology has been divided into two steps: (1) manufacturing 3DP mould, including printing and post-processing, and (2) melting and pouring. The phases were: 1.1) bed; 1.2) printing the mould; 1.3) drying the mould; 1.4) dust aspiration and extraction of the mould; 1.5) cleaning the mould; 1.6) heating in the oven at 240 °C for 60 min; 1.7) maintenance at 240 °C for 90 min; 1.8) cooling inside the oven; 2.1) heating of aluminium to 750 °C; 2.2) pouring and cooling; 2.3) breaking mould; and 2.4) cooling.

In order to analyse the IAQ in the laboratory during these phases, the following equipments were used: i) a Scanning Mobility Particle Sizer spectrometer (TSI-SMPS Model 3938) to measure the PNC between 8 and 310 nm in 110 channels; ii) an automatic infrared monitor from Gray Wolf (WolfSense IQ-610) to register temperature, relative humidity, CO, CO_2 and VOCs; iii) three portable gas sensors of Aeroqual series 500 to measure O_3, NO_2 and SO_2.

Preliminary results indicate a clear increase in particle number concentration during the phases associated to heating (1.6, 1.7, 1.8 and 2.1) (Figure 1). The gas concentrations during the first five phases presented a slight and constant increment: CO (from 2.17 to 2.64 ppm) and CO_2 (from 480 to 526 ppm). The maximum PNC registered was during the phase 1.7 with a mean N_{total} of 101,797±22,290 cm^{-3} associated with a decrease of VOCs (from 774 to 327 ppb). This fact may indicate that a nucleation process of particles occurred and the growth of particles caused a high concentration of Aitken and accumulation modes. Regarding the median, four phases (1.3, 1.4-1.5 and 2.2) showed values lower than 20 nm, while the highest value, 95 nm, was recorded in the phase 2.4

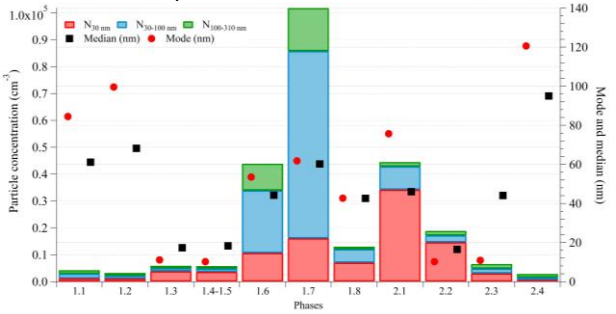

Figure 1. PNC by modes: nucleation, Aitken, and accumulation, median and mode in nm during the different phases.

The study of the evolution of particle number size distribution and gaseous compounds during the processes of manufacturing 3DP mould, melting and pouring will allow to estimate the exposure of working individuals compared with other methodologies.

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