AIRBORNE PARTICLE EXPOSURE ASSESSMENT OF ADDITIVE MANUFACTURING VIA FINITE ELEMENT METHOD ANALYSIS

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ABSTRACT

Additive manufacturing (AM) is gaining increasing attention nowdays due to the manufacturing of complex geometries at low cost using a large variety of materials (plastic, metal and ceramic feedstocks).[1,2] Fused Filament Fabrication (FFF) is the most extensively practiced AM technique, displaying applications in various fields, while also being widely used in non-occupational settings. However, airborne ultrafine particle emissions are commonly encountered during FFF processes,[3] hence it is necessary to develop methods and tools to characterize and mitigate the health-related risks. A novel approach using a finite element method (FEM) model was developed, in order to trace the dispersion of the emitted particles during a FFF printing protocol for different thermoplastic materials. Various parameters were included in the FEM model such as the room dimensions, printing setup and the environmental characteristics (e.g. air flow). Through testing alternative scenarios, i.e. changing the position/orientation of the air filtration unit and air flow velocity, different particle dispersion patterns were identified. These results can lead to optimization of the printing setup in order to subside the particle exposure. A series of on-site measurements have confirmed the emission of large concentrations of micro- and nano-size particles during the AM process, as discussed in literature,[4] while these measurements have shown that particle emission rates are not constant but are correlated to the manufacturing stages of the FFF printing. Therefore, taking into account the particle concentrations and dispersion would allow evaluation of the particle exposure and the necessary engineering and administrative strategies to minimize the health-related operator hazards (i.e. exposure to respirable or inhalable fractions).[5] The outcomes of this study provide a valuable tool and methodology for the assessment of the exposure-related risks during FFF processes and promote the development of an AM-focused Safe-by-Design (SbD) approach.

KEYWORDS:

Ultrafine particles, Safe-by-Design, Additive manufacturing, Nanosafety, Finite element method

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