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Describing polydisperse particle population using a global three equation model

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Turbulent flame synthesis via flame spray pyrolysis technology has emerged as a promising technique for the production of metal-oxides (MO) with well-defined characteristics since they determine the final material performance. However, controlling flame-synthesized MO characteristics is a scientific challenge since it requires understanding how multi-physics flame-turbulence-nanoparticle interactions at the continuum scale affect particle characteristics at the nanoscale. For this, computational fluid dynamics (CFD) simulations represent an essential tool for the rational design of MO flame synthesis systems [1]. Among the different characteristics of interest, the particle size distribution (PSD) has to be as narrow as possible to guarantee the homogeneity of the final powder, i.e., a population of particles with almost identical size [2].
To simulate the evolution of particle population characteristics, Eulerian methods can be considered. They rely on the population balance equation to treat particles as a continuum. Different models with increasing accuracy and CPU cost are available [3]. Among them, global models are developed by considering the simplest moment method, which relies on transport equations for a few global quantities [4]. These methods are the least expensive and are classically derived by assuming a mono-disperse population, i.e., that all particles have identical characteristics for a given time and spatial location.
In this work, a new global model based on the transport of three equations and a lognormal PSD closure to account for the population polydispersion when closing the aggregation and sintering source terms.
The performances of the developed model are evaluated in 0-D configurations by comparing the results to data obtained using bi-variate sectional methods. A satisfactory agreement is observed, so the new model can account for particle distribution in volume and surface in CFD simulation of realistic configurations for an affordable CPU cost.

References

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