

Laminar combustion CFD of iron particle suspensions using an Eulerian sectional approach

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As interest in iron as an energy carrier increases, progress is being made in modelling its combustion. Single particle combustion is becoming well-documented in the literature, with various groups successfully leveraging CFD to gain key insights into the combustion process. Particle suspensions, by contrast, have proven to be more stubborn in this regard. Theoretical models exist, but their implementation is hampered by the capabilities of current simulation hardware. This is especially the case with the traditional treatment of particles as Lagrangian objects, where the governing equations of each particle are computed individually.

In this contribution, we will present initial results on the simulation of iron particle suspension combustion using an Eulerian sectional approach. This approach has two key characteristics. The first is that particles of similar chemical composition are not treated individually, but rather as Eulerian fields. This reduces the computational load of the simulation significantly. The second key characteristic is that particles of similar chemical composition are split into *multiple* Eulerian fields, with the discriminatory parameter here being the particle diameter. The advantages of this lie in the accurate treatment of, for example, combustion kinetics, which are a function of the particle diameter.

After presenting a brief overview of the sectional approach, we will discuss its application to the combustion of iron particle suspensions. The flames that we will present are based on an experimental laminar iron Bunsen burner [1], against which we will validate our results. We will present single-phase, “dusty gas” simulations carried out in OpenFOAM v11 [2], and discuss the strengths and limitations of this model. Next, we will pivot to multiphase simulations carried out using MFIX [3], an open-source CFD software specialized in the simulation of granular objects. We will compare and contrast MFIX results with OpenFOAM results, and discuss the differences between the two models, as well as between simulation and experiment. Finally, we will provide a brief outlook on the future of iron particle suspension combustion, and discuss the improvements to our model planned to help achieve our final goal: simulating the combustion of iron particle suspensions in industrial furnaces.

[1] Fedoryk M et al. Experimental investigation of the laminar burning velocity of iron-air flames in a tube burner. *Applications in Energy and Combustion Science*. 2023;13:10011.

[2] Weller HG et al. A tensorial approach to computational continuum mechanics using object-oriented techniques. *Computers in Physics*. 1998;6:620-631.

[3] Syamlal M et al. MFIX documentation theory guide, 1993, <https://dx.doi.org/10.2172/10145548>.