Radiation Heat Transfer within the Discrete Element Method
- Relevance, Implementation and Examples -

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ABSTRACT

The theoretical description of fuel conversion processes and the numerical simulation of the equipment employed has gained considerable industrial application throughout the last two decades. Starting from the combustion of gaseous fuel in homogeneous turbulent flows, a basically continuous, Eulerian fluid, the further development lead to the Lagrangian description of droplets or pulverized solid fuel particles by independently tracking there movement and conversion within the fluid and neglecting collisions.

Current developments in the energy sector require the consideration of much larger particles which can no longer be considered as non-colliding material points. Municipal waste incineration on grates [1], directly or indirectly heated rotary kilns [2] or wood pellet combustion in domestic boilers are such examples, where the Discrete Element Method (DEM) extends the Lagrangian description to a mechanically and thermally fully interacting flow of reacting granular material. In some situations with sufficiently large scale differences distinctive interfaces can be identified between the conventional CFD-description and the solid bed, thus allowing a separate and different treatment of radiation in both regions. In other applications like in shaft kilns, the radiative transfer within the moving bed enhances the effective conductivity of the porous medium.

Available commercial CFD-Codes provide several different radiation models suitable for grey or non-grey media enclosed by walls. They range from approaches fully neglecting interaction with the enclosed gas phase (S2S), models describing the radiative transfer solely as a diffusive process (P-1), directionally discretised radiative transport equations as in the Discrete Ordinates (DO) method up to techniques explicitly relying on rays passing through the participating media (Discrete Transfer, DTRM). The integration of any of these radiation models into a coupled CFD-DEM code represents a challenge and is even more complex if a distinctive separating surface does not exist.

In the work presented, the significance of using adequate modelling of the radiative fluxes onto the surface of reacting granular media will be discussed in the context of two technical relevant examples, the waste conversion on reciprocating grates in municipal waste incinerators and heat the exchange with the moving material surface in rotating kilns. The restrictions and pitfalls in modifications of the boundary conditions for the different radiation models will be discussed and compared with each other.

REFERENCES

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