Ultra-fast calculation of conductive heat transfer in a moving granular medium

1. Introduction

- Particle-fluid systems can be found:
  - industries (fluidized beds, rotary kilns, …)
  - natural phenomena (avalanches, pyroclastic flows, …)
- Numerically: Discrete Element Method (DEM) for particles
  - Microscopic level: Contact Forces, Transfers
  - Obstacle: CPU time
  - Industrial level: Zillions of particles

2. Scientific challenge

How to accelerate the simulations of the processes at an industrial time scale?

3. Objectives

- Develop models for pseudo-periodic systems to extrapolate DEM results from one period of time over a longer period
- Application to conductive heat transfer in rotary drum
- Extrapolation of results from a coupled CFD
- Moving rotation speed of drum ω = 5 s⁻¹
- Setting up experiments on the constructed rotary kiln for validation purpose

4. Proposed numerical method

Step 1: DEM simulation for one period


Output:
- Red: Temperature profile over time
- Orange: Extrapolated temperature of the particles

5. Results/temperature field

Simulation properties
- 100 000 particles
- Half cold/ hot
- Adiabatic wall
- Biol < 1
- Restitution coefficient= 0.2
- Rotation speed of drum ω = 5 s⁻¹
- t₀ = 10 s = 2 ω

DEM: CPU time = 3900 s / Extrapolated: CPU time = 6 s

Temperature profiles are in agreement.
Error is less than 2% with a gain factor of 650.

6. Conclusions

Work Done/Novelty
- DEM simulation for rotary kiln
  - Standard DEM and extrapolated DEM simulation with pairing algorithm
- Ultra-fast simulation for conductive heat transfer
  - Extrapolation of the heat transport in granular media (massive reduction of CPU time)

Perspectives
- Adaptation of the algorithm for fluid (convective heat transfer)
- Extrapolation of results from a coupled CFD-DEM simulation
- Validation of numerical results with experimental setup
- Setting up experiments on the constructed rotary kiln for validation purpose

7. References


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