Direct Numerical Simulation of Heat Transfer in Fluidized Bed for Thermal Energy Storage

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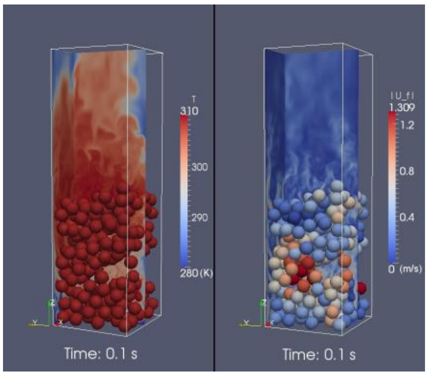
ABSTRACT:

Climate change concerns, the will to reduce dependence on fossil fuels and greenhouse gas emissions, are resulting in increased deployments of renewable energy technologies. But the intermittency of renewable power sources such as wind and photovoltaic presents a major obstacle to their extensive penetration into the grid. Electricity storage is a potential solution to address this intermittency problem by compensating for wind and sunshine's variability. Among the many technologies available, Advanced Adiabatic Compressed Air Energy Storage (AA-CAES) is a promising technology since it is a zero-emission storage system with a potential round-trip efficiency close to 70%. AA-CAES stores not only the compressed air, but also the heat which is released upon compression of the air, in a separate heat storage tank. In order to generate electricity, the heat is returned to the compressed air which flows to the turbine. The Thermal Energy Storage (TES) system plays a prevailing role in the global efficiency of AA-CAES process. At IFP Energies nouvelles, we develop an innovative technology for TES system, based on fluidized beds to store heat in particles of phase change material.

The objective of this work is to investigate how thermal homogenization would occur in such a TES system, and how the energy transfers would be distributed among the particles. In order to gain a precise insight on thermal transfers, we focus on Direct Numerical Simulations (DNS) of a representative portion of fluidized bed with heat transfers using the home-made code PeliGRIFF (http://www.peligriff.com). In PeliGRIFF, the solution of the fluid conservation equations relies on a Finite Volume discretization and an operator splitting time integration scheme. The solid/solid interactions are handled by a Discrete Element Method (DEM) that enables us to consider true contacts, and a Fictitious Domain method for the hydrodynamic and thermal interactions between the fluid and the particles.

In the present study, representative portions of fluidized beds embedded with a few hundreds of particles are simulated at moderate particulate Reynolds number (Re_p). Results regarding thermal transfers in fluidized beds will be presented. In particular, the influence of the air injection velocity and the initial bed height on heat transfers and energy distribution among the particles is investigated.



Temperature (left) and velocity (right) fields in a 250 particles fluidized bed (Re_p = 440)

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