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Development of an HPC Multi-Physics Biomass Furnace Simulation and Integration in a Cloud-based Workflow

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Biomass combustion offers a credible alternative to reduce the consumption of fossil fuels. To optimize the biomass combustion process and improve the design of biomass furnaces numerical simulation is a less expensive and time-effective approach as opposed to the experimental method. However, the combustion in a biomass furnace involves intricate physical phenomena that must be modeled (and validated) carefully, in the fuel bed (with particle motion and shrinking, heat transfer, drying, pyrolysis, gasification) and in the surrounding gas (with turbulence, combustion, radiation). With this level of complexity, and to be conducted in a reasonable time, the simulation of industrial biomass furnaces requires the use of High-Performance Computing (HPC) platforms and expertise, which is usually not affordable for manufacturing SMEs.

To address this issue, we developed a configurable digital twin of a biomass furnace [3] running on HPC and we designed a *cloudified* easy-to-use end-to-end workflow. This fully automated workflow, from user input to results analysis, has been integrated into the digital marketplace of the CloudiFacturing EU project[1] [1] and is now directly available to SMEs via a Cloud portal.

With this presentation, we want to offer a glance at the internal details and enabling technologies used in our parallel coupled application and scientific workflow. Our parallel simulation tool for biomass furnaces combines OpenFOAM (for the gas phase) parallelized with MPI and XDEM [2] (for the solid wood particles) parallelized with OpenMP. The two libraries are coupled in parallel using an original approach based on the co-located partitioning strategy [4] which has been tailored to minimize communications. As for the cloud workflow, it is based on an all-in-one Singularity image containing all the software, scripts, and data required to prepare the simulation input, execute the computation-intensive simulation, and analyze the results. Finally, we present the lessons learned from the development of this complex workflow and highlight the remaining challenges related to HPC multi-physics coupled simulations.

[1] https://www.cloudifacturing.eu/

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