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THE OXY-COMBUSTION MODELLING IN CFB USING MULTIPHASE APPROACHE

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Circulating Fluidized Bed (CFB) combustors, due to their robustness and insensibility to the quality of the fuel became a popular alternative to traditional Pulverized Coal Boilers. The simulations of such devices requires the solution of complex multiphase transport phenomena in gas-particulates mixtures with high solid phase load. The latter results in a significant influence of the mutual interactions of particles, excluding their simple Lagrangian tracing. The alternative Euler-Euler schemes are cumbersome when applied to reacting flows. The published models of CFB boilers are still in their infancy as they base on plug flow in 2 zones: near wall and core. This approach require many empirical data and cannot account for the complex mixing of polydisperse granular flows.

The technique used in this study is a hybrid Euler-Legrange and Euler-Euler approach known as Dense Discrete Particle Method.. The technique is dedicated to handle multiphase flow of high solid volume (larger than 10%). The basic concept of DDPM is that the particles are treated simultaneously as a disperse phase (DPM) while their mutual interaction is handled by resorting to the extension of the kinetic theory for granular flow (KTGF) (Gidaspow, 1994). The DDPM accounts for four-way coupling to take into account the relationship between continuum and disperse phases in mass, momentum, pressure and energy transfer. The influence of the particle movement and energy transfer on the fluid is accounted for by source terms in the conservation equations for the continuous phase. The interaction between the particles is included in the model by simulation of the collisions of particles. The transfer of information between cells and particles is accomplished by resorting to interpolation operators (Andrews, O'Rourke, 1996). All simulations were performed using commercial ANSYS/FLUENT code extended by original User Defined Functions (UDFs)

Numerical simulations have been performed and validated using the 3D models of a pilot scale CFB installation form Częstochowa University of Technology (see Fig. 1 left). The pilot-scale installation of maximum thermal load is around 0.1MW.

The geometry of the CFB installation includes cyclone, loop seal, recirculation zone and drain part which together form a closed loop. A complete model of the installation would require modeling of several complex flow phenomena e.g. complex swirl flow in cyclone. At the present stage of the development of the modeling tools, this would lead to prohibitive execution time. Thus, the computational domain has been limited to the raiser with a small part of recirculation zone including the solid injection port (see Fig 1 right). In simplified geometry the mass leaving the end of the riser is returned to its bottom which is implemented by a set of appropriate UDFs. Additionally, due to scale problem, at this stage of the model development, the gas flow in the distributor is greatly simplified by modeling it as a pressure drop zone.

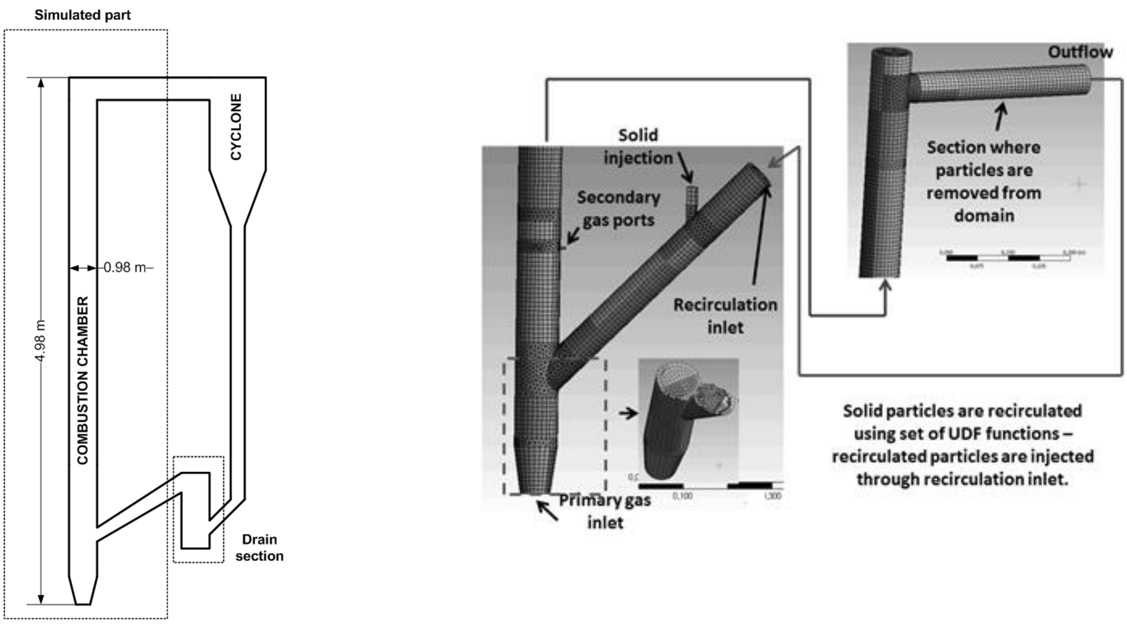

Fig. 1: Geometry of small pilot-scale installation (left), numerical geometry with mesh (right)

The set of simulations were performed for four kinds of O_2/CO_2 mixtures. The fraction of the oxygen in the delivered gas was 21, 25, 30 and 35 percent with the remaining fraction being the CO2. Based on set of calculations the temperature profile in the CFB riser has been compared with experimental data (see Fig. 2).

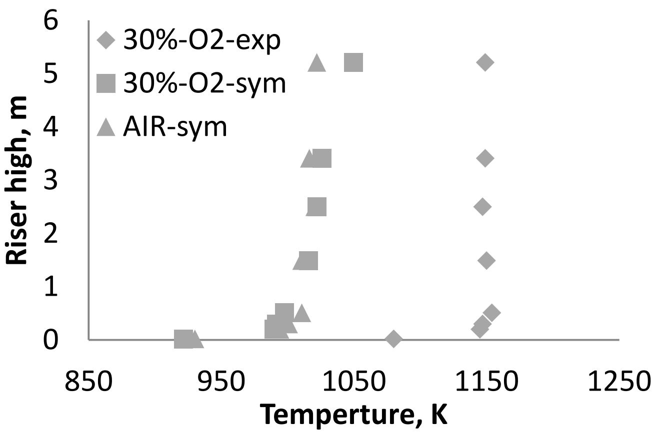

Fig. 2: Temperature profile in the CFB riser

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