A novel approach for modeling of complex granular flows

Because of constantly improving environmental regulations the energy sector need to improve of the fuels conversion process into higher energy forms. Besides of integration of renewable and traditional sources that can be seen as a promising solution for the clean heat and power production also large attention is paid to the diversified usage of biomass or refuse derived fuels. In order to ensure high quality of fuel conversion process a special technique need to be used, which is very important in case of co-combustion of traditional fuel with refuse derived fuels. An example of the technology which can be used for such application is fluidization. It has found various applications in different industries, e.g., power generation, steel, petroleum, chemical, and food processing. Fluidized beds are created by blowing gas from the bottom of a vessel though a granular bed. The moment when the force due to the friction of the gas and the particle (drag) is equal to the gravitation force produces an intensively moving particle bed, behaving as a boiling fluid. Within such a bed, the rate of chemical reactions, heat and mass exchange is very violently. Thanks to the distribution of the solid material over the combustion chamber of the considered unit and intensive heat transfer between phases the uniform temperature is expected. This ensures that defined regulation that needs to be fulfilled in case of burring refuse derived fuels.

Important issue in case of adaptation of existing and building new units is appropriate organization of combustion process. This can be visualized by application of mathematical modelling based on the Computational Fluid Dynamics (CFD) which numerically solves the governing equations of conservation of mass, energy and momentum. The CFD is able to simulate dozens of physical processes occurring in the system under consideration, without running expensive and time consuming experiments. The CFD model of complex phenomena that occur in the fluidized beds is a collection of numerous sub-models of elementary phenomena constituting the total picture of the processes in the beds. Each of these sub-models contains several parameters whose values, for a given case, may change within a certain range.

Due to the complexity of the mathematical models, which are used to model fluidization is seen as an example of physical process which causes engineers sleepless nights. One of the grand challenges in modeling fluidization process is the need of accurate, robust, fast and stable numerical model for predicting the collision between particles in dense systems. Available techniques like Granular Euler-Euler (EE), hybrid Euler-Lagrange (HEL), Discreet Element Model (DEM: Soft or Hard Sphere) suffer from number of

The most accurate option in these collection is the DEM apporach, where the collisions of the particles are directly modelled. The number of involved particles prevents this method from application in realistic industrial scales. The proposed method bases on a multiscale approach, i.e. modelling the phenomenon at the scale of a small volume of the fluidized bed. The obtained results are then approximated by a special statistically based method known as the Proper Orthogonal Decomposition producing a *surrogate model*. This simplified sub-model, able to produce accurate results in a fraction of time needed to solve the full scale one, is embedded in the total fluidized bed model.

The process of building the complex fluidized bed model will be based on the principle of Validation and Uncertainty Quantification principle. The idea behind this technique is to generate a sequence of experiments of increasing complexity in order to calibrate the component sub-models of the entire fluidized bed phenomenon.