Modelling of the thermochemical processes in the gasifier reactor using XDEM method

<u>Izabela Wardach-Święcicka</u>*, Dariusz Kardaś* and Bernhard Peters†

* Renewable Energy Department
Institute of Fluid-Flow Machinery Polish Academy of Sciences
PL-80231 Gdańsk, Poland
e-mail: izabela.wardach@imp.gda.pl, dariusz.kardas@imp.gda.pl, web page: http://www.imp.gda.pl

† Faculty of Science, Technology and Communication
University of Luxembourg
L-1359 Luxembourg, Luxembourg
e-mail: bernhard.peters@uni.lu, web page: http://www.uni.lu

ABSTRACT

The goal of this work was to investigate the possibility of the XDEM (eXtended Discrete Element Method) program to simulate the behavior of wood particles during the gasification process [1] that was performed in the Institute of Fluid-Flow Machinery PASci (IMP PAN) INKA gasifier. The program is based on the Lagrangian approach for simulation of heat and mass transfer during thermal decomposition of the solid fuel particles. The main assumption of numerical modelling is that each particle undergoes a sequence of thermodynamic processes that are described by a set of one-dimensional and transient conservation equations for mass, momentum and energy using Discrete Particle Method (DPM). The coupling CFD (openFOAM) with XDEM is realized by the mass, momentum and heat transfer between fluid and particle part. The fluid flow is computed as a flow of gas in a porous zone, consisted of biomass particles and the gas phase filling empty spaces. The sum of all particle processes represents the overall behavior, including heating, drying, pyrolysis and gasification.

The INKA reactor consists of one tube with 3 inlets at the top and one outlet at the bottom [2]. The height of the reactor is 850 mm and its diameter is 206 mm. In the real case, the reactor is filled by the cuboid shape biomass particles with three different sizes: small ones 10 mm x 5mm x 10mm (length x width x height), medium ones 20 mm x 6 mm x 7.5mm and large ones 34.5 mm x 15 mm x 18 mm. The mass fraction of each type is equal to 44%, 28%, 28%, respectively.

For computations of the test case the simplified geometry was used. It was decided to consider reactor with height of 280 mm and diameter of 206 mm. First the XDEM method was adopted for filling the container with the particles. The cylinder was filled approximately with 300 of biomass cuboid shape particles. In the next step coupled CFD and XDEM calculations were performed to simulate the drying process. The numerical results show propagation of the heating front and change of the moisture content in each particle.

Additionally, for comparison the numerical analysis of single wood particle heating obtained from ANSYS FLUENT code and in-house 1D [3] code, were presented.

REFERENCES

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