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The Effect of Particles Surface Temperature Distribution in Numerical Modelling Of High Scale Combustion and Gasification Chambers

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Extended Abstract

Solid fuels are common source of energy in global primary energy and electricity production. Numerical modelling of combustion and gasification chambers is an important stage of a design and optimisation of existing facilities. To better reproduce real conditions, it is essential to improve numerical models. In the presented work the influence of a char particle surface temperature distribution on the particles dispersion has been analyzed. The flow of species between the particle surface and surrounding gas, so called Stefan flow, is uniform for the entire particle surface when uniform particle reactivity is assumed. However, a structure of real char particles in non-uniform due to the distribution of pores and ash. Previous research [1, 2] have shown that temperature distribution on the particle surface is non-uniform with standard deviation of temperature up to 400K. This can lead to additional force resulting from varied Stefan flow around the particle.

Based on measured surface temperature distributions, numerical model has been developed and described in [3]. It has been shown that a non-negligible force can occur especially in high temperature regions where reactivity and surface temperature variances are high. The purpose of this work is to examine the influence of non-uniform Stefan flow around particles in real scale combustion and gasification systems.

A real scale boiler OP-430 has been simulated using the developed numerical model in order to examine the influence of surface temperature variances in combustion conditions. OP-430 is a tangential, middle-sized boiler producing 430 t/h of steam at 532^{o}C and 12,7 MPa. A detailed description of the boiler geometry and operating conditions can be found in [4]. The gasification chamber considered in the paper was Shell Coal Gasification Process (SCGP) gasifier which is a one-stage, entrained-bed facility with nominal power of 300 MW. All details including geometry and work conditions can be found in [5].

All simulations were performed using commercial software Ansys Fluent. The 3-dimensional steady state, Reynolds-averaged Navier–Stokes (RANS) model has been used. The model included momentum, energy and species transport equations. The realizable k-ε model was used for turbulence. Solid particles were treated as a discrete phase using Lagrangian reference frame, and stochastic tracking was employed to account for the influence of turbulence on the particles dispersion. The additional force resulting from non-uniform reactivity and Stefan flow was calculated and included in the particle force balance equations using User Defined Function (UDF). Heterogeneous reactions were analyzed using kinetic-diffusion model.

Based on performed simulations it can be concluded that the influence of additional particle force on global parameters such as temperature and gas species profiles is insignificant. Differences are local and can be found mainly in high temperature regions where reactions reach the diffusion regime. However, slightly higher dispersion of particles can be observed in the reaction zone. This effect is less noticeable in the case of the gasification reactor due to the lower temperature of the process.

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