Hessisches Kompetenzzentrum für Hochleistungsrechnen

LES of Coal Combustion in the Context of FGM Tabulated Chemistry

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Project Areas
Heat Energy Technology, Thermal Machines, Fluid Mechanics

Clusters
Lichtenberg Cluster Darmstadt

Software
FASTEST

Institute
Energy and Power Plant Technology

University
Technische Universität Darmstadt

Introduction

The objective to reduce the emission of the greenhouse gas CO_2 has a high priority in today's energy supply. However, in order to meet demands a considerable proportion of energy still comes from fossil primary energy sources. In the context of this project, a deepened understanding for the processes in coal combustion will be obtained by means of numerical simulations. Furthermore, a modeling approach will be developed that will help to design more efficient, i.e., CO_2-reducing, or even CO_2-avoiding (Oxyfuel-technology) coal powerplants.

Methods

The simulation of combustion processes in general and coal combustion in particular comes along with large computational costs due to the complex chemistry and the wide scale separation. In this project the Large Eddy Simulation (LES) method will be applied for an adequate transient description of the reactive flow. The main goal of this project is the development of a flamelet based method. This method originates from pure gas phase combustion but shows great potential when enhanced to coal combustion. In the so called FGM model the chemical complexity gets drastically reduced by projecting it onto a manifold, which is controlled by only a few variables. These variables unambiguously describe the thermo-chemical state and its progress. By solving transport equations for them, one avoids the solution of a detailed chemical reaction mechanism and the corresponding transport of all involved species. Furthermore, the spatial (and accordingly the temporal) resolution requirements for the FGM controlling variables are much lower than for detailed kinetics. The challenge is to apply this approach to the complex fuel coal. Since the coal structure and hence, the fuel composition changes in the course of the combustion process, one has to develop a distinct chemistry reduction technique, which covers all physical aspects of coal combustion.

Discussion

Good progress has been made in the last three years in terms of the model development. Simulations of a realistic coal combustion chamber were carried out. The investigation of specific operating points in the context of oxyfuel and a further refinement of the model are the goals for the upcoming granting period. Although effort is made to reduce computational costs by means of modeling, the simulation of realistic coal combustion chambers still requires tenthousands of CPU-hours, where the Lichtenberg cluster provides a valuable service.

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