Mathematical Modelling of Ignition processes

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Detailed numerical simulations of ignition processes using the complete set of time-dependent governing equations and complex chemistry have become an important research tool in the recent years. Whereas in most cases such simulations are used to optimize practical combustion systems like internal combustion engines, these simulations are also of tremendous value to explain the multiple-parameter dependence of ignition hazards.

A major problem of mathematical models is the multi-physics character of such ignition processes. Processes that have to be accounted for are: multi-phase processes (e.g., ignition of droplets), formation of ions, interaction with electrical fields (e.g., spark ignition, streamer discharges), heterogeneous reactions (e.g., ignition at hot walls or by hot particles), and very detailed chemical kinetics (e.g. auto-ignition at low temperatures). In addition interaction of the ignition process with turbulent flow conditions has to be accounted for.

In the talk we discuss the principle of these modelling strategies and their application to generic ignition scenarios like auto ignition, ignition by sparks or by hot particles. Although these "generic" scenarios already allow a good insight into the governing processes, it is important for practical applications to characterize the overall ignition process. Therefore, we shall discuss in the second part of this work how the detailed information can be used to devise models for the overall ignition process. The problem in modelling these (typically turbulent) processes is that the description of chemically reacting systems leads to scaling problems in space and time. In particular, an oversimplification of the coupling processes between chemical reaction and turbulent flow should be avoided by all means to allow a predictive character. In the presentation it is shown how hierarchical concepts can be used to solve this problem.