A PRIORI ANALYSIS OF LEAN TURBULENT PREMIXED HYDROGEN COMBUSTION DNS SIMULATION - ASSESSMENT OF THE POTENTIAL OF FGM AND SUB-GRID SCALE ANALYSIS

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The numerical modeling of combustion systems is a very challenging task. The interaction of turbulence, chemical reactions and thermodynamics in reacting flows is of exceptional complexity. This problem indeed asks for special treatments in the modeling of flames. We developed the Flamelet Generated Manifold (FGM) technique, which combines advantages of chemistry reduction and flamelet models. The idea is that the most important aspects of the internal structure of the flame fronts should be taken into account. In the FGM technique the progress of the flame is generally described by one (or at most a few) progress variable(s), for which a transport equation is solved during run-time. In the solver, only equations for the progress variables are evaluated, using the data-base to retrieve all necessary information to update the solution. The chemical source term in the transport equation is derived from the flamelet system. The data-base is called a manifold. We successfully combined this approach with both Direct Numerical Simulation (DNS) and Large Eddie Simulation for turbulent methane combustion. However combustion of hydrogen rich fuels has become a very important research item. Therefore, in the present contribution we describe the analysis for a future extension of FGM for the modeling of premixed flames with DNS including non-unit Lewis numbers to predict preferential diffusion effects. With this purpose we analyzed the data of a DNS of lean premixed hydrogen combustion with detailed chemistry, investigating the probability density distributions of the hydrogen consumption rate and comparing them with a set of perturbed one-dimensional flamelet solutions. It is shown the one-dimensional results with increasing stretch rate or equivalence ratio can mimic in the correct way most of the DNS data. The essential extinguishing behavior at negative stretch in cusp regions has to be studied further.