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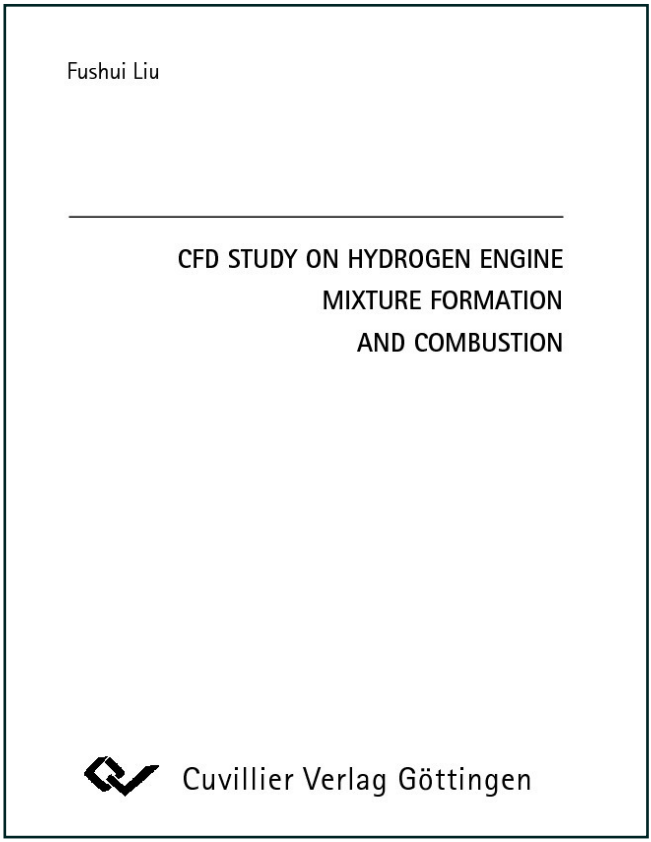
CFD Study on Hydrogen Engine Mixture Formation and Combustion



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Preface

The impending worldwide energy crisis, most importantly the potential crisis of fossil fuels, and the ever increasing environmental impacts caused by automobiles have made it a great necessity to find a clean, regenerative energy form for the future. Hydrogen, the most abundant element in the universe, is being regarded as the most appropriate and promising energy carrier.

From this point of view, the German automaker BMW has chosen hydrogen engine as one of their research objects and has entrusted the author with research work on hydrogen injection and mixture formation in engine conditions.

Based on the BMW project, the author takes an ulterior step and lucubrates the combustion characteristics of hydrogen engine. Instead of the routine laboratory work, the whole process, including hydrogen injection, mixture formation, ignition and combustion, was studied by compute simulations with the help of well-known CFD Code AVL FIRE. In order to ensure the simulation results to be reliable, great effort has been put on verification and validation of the Code.

This six-part thesis focuses on the hydrogen direct injection engine and tries to find some general principles to optimize its performance.

Part I analyzes the present problems related to the traditional internal combustion engine, puts forward the hydrogen economy and shows the necessity to develop hydrogen engine.

Part II deals with the Verification and Validation of Fire Code, and proves that FIRE is capable of simulating the supersonic flow in Hydrogen direct injection engine.

Part III studies the influence of many factors on hydrogen injection and mixture formation, and reveals the detailed behavior of the mixture formation process in Hydrogen engine.

Part IV gives detailed analysis of all the available combustion models in FIRE version 8, and concludes that only TFSC model is capable of calculating hydrogen laminar combustion.

Part V investigates the combustion performance on Hydrogen engine at different conditions and gives the general concepts for optimization of NO emission and thermal efficiency.

Part VI makes a summary of the thesis and gives the main conclusions.