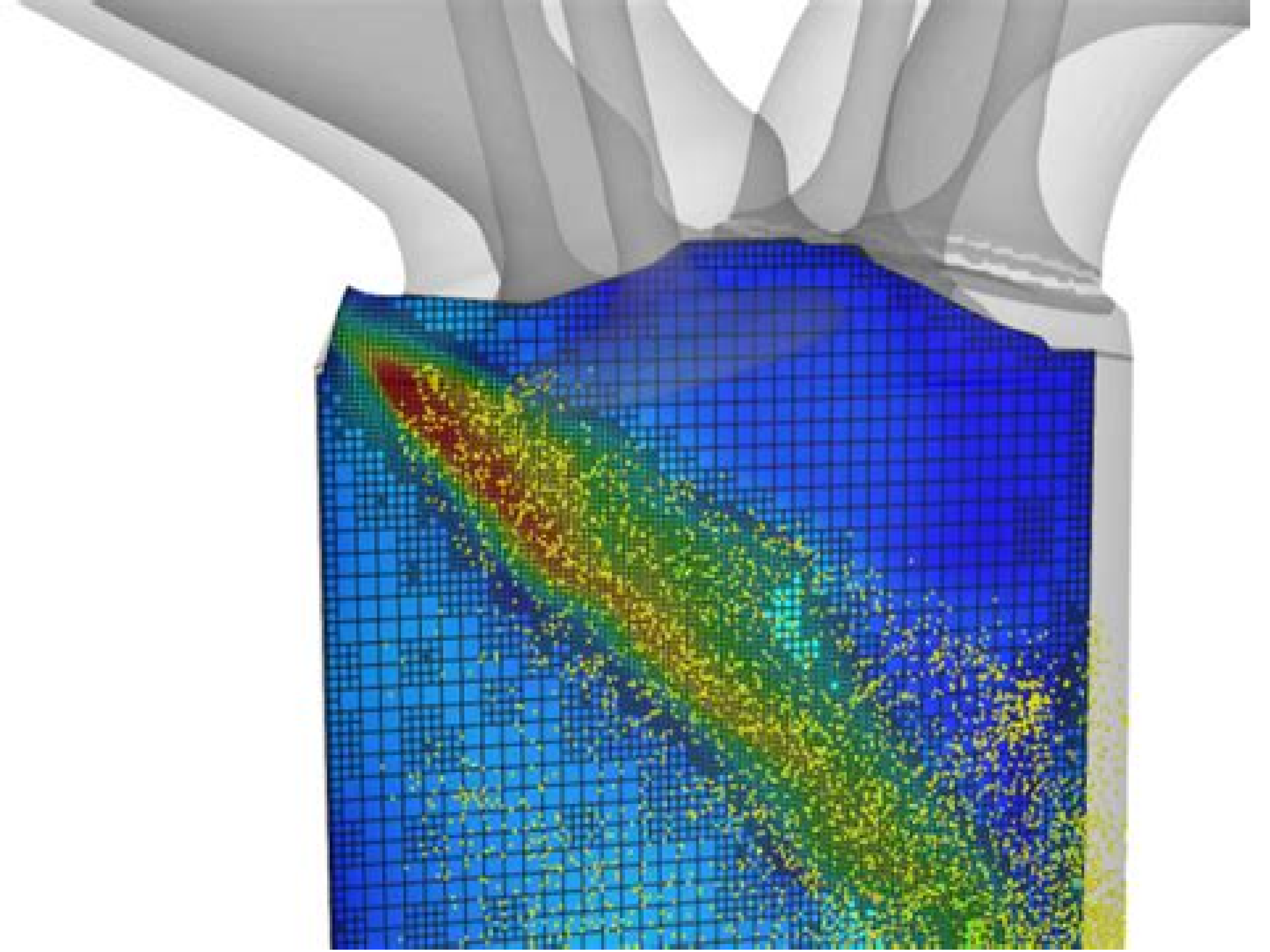

Mesh For Internal Combustion Engine Simulation

Yu Shi,Hai-Wen Ge,Rolf D. Reitz

Mesh For Internal Combustion Engine Simulation

Simulating Combustion Günter P. Merker,Christian Schwarz,Gunnar Stiesch,Frank Otto,2005-12-17 The numerical simulation of combustion processes in internal combustion engines including also the formation of pollutants has become increasingly important in the recent years and today the simulation of those processes has already become an indispensable tool when veloping new combustion concepts While pure thermodynamic models are well established tools that are in use for the simulation of the transient behavior of complex systems for a long time the phenomenological models have become more important in the recent years and have also been implemented in these simulation programs In contrast to this the thr dimensional simulation of in cylinder combustion i e the detailed integrated and continuous simulation of the process chain injection mixture formation ignition heat release due to combustion and formation of pollutants has been significantly improved but there is still a number of challenging problems to solve regarding for example the exact description of s processes like the structure of turbulence during combustion as well as the appropriate choice of the numerical grid While chapter 2 includes a short introduction of functionality and operating modes of internal combustion engines the basics of kinetic reactions are presented in chapter 3 In chapter 4 the physical and chemical processes taking place in the combustion chamber are described Ch ter 5 is about phenomenological multi zone models and in chapter 6 the formation of poll ants is described

1D and Multi-D Modeling Techniques for IC Engine Simulation Angelo Onorati,Gianluca Montenegro,2020-04-06 1D and Multi D Modeling Techniques for IC Engine Simulation provides a description of the most significant and recent achievements in the field of 1D engine simulation models and coupled 1D 3D modeling techniques including 0D combustion models quasi 3D methods and some 3D model applications

Combustion Engines Development Günter P. Merker,Christian Schwarz,Rüdiger Teichmann,2011-09-24 Combustion Engines Development nowadays is based on simulation not only of the transient reaction of vehicles or of the complete driveshaft but also of the highly unsteady processes in the carburation process and the combustion chamber of an engine Different physical and chemical approaches are described to show the potentials and limits of the models used for simulation

Analysis of Injection Processes in an Innovative 3D-CFD Tool for the Simulation of Internal Combustion Engines Marlene Wentsch,2018-05-16 Due to the large number of influencing parameters and interactions the fuel injection and therewith fuel propagation and distribution are among the most complex processes in an internal combustion engine For this reason injection is usually the subject to highly detailed numerical modeling which leads to unacceptably high computing times in the 3D CFD simulation of a full engine domain Marlene Wentsch presents a critical analysis optimization and extension of injection modeling in an innovative fast response 3D CFD tool that is exclusively dedicated to the virtual development of internal combustion engines About the Author Marlene Wentsch works as research associate in the field of 3D CFD simulations of injection processes at the Institute of Internal Combustion Engines and Automotive Engineering IVK University of Stuttgart Germany

Turbocharger Integration into Multidimensional Engine Simulations to Enable Transient Load Cases Andreas Kächele,2019-11-29 Despite the increasing interest in multidimensional combustion engine simulation from researchers and industry the field of application has been restricted to stationary operating points for turbocharged engines Andreas K chele presents a 3D CFD approach to extend the simulation into the transient regime enabling the detailed analysis of phenomena during changes in engine operating point The approach is validated by means of a virtual hot gas test bench and experiments on a two cylinder engine

An Innovative 3D-CFD-Approach towards Virtual Development of Internal Combustion Engines Marco Chiodi,2011-03-07 In the engine development process simulation and predictive programs have continuously gained in reliance Due to the complexity of future internal combustion engines the application of simulation programs towards a reliable virtual engine development is a need that represents one of the greatest challenges Marco Chiodi presents an innovative 3D CFD tool exclusively dedicated and optimized for the simulation of internal combustion engines Thanks to improved or newly developed 3D CFD models for the description of engine processes this tool ensures an efficient and reliable calculation also by using coarse 3D CFD meshes Based on this approach the CPU time can be reduced up to a factor 100 in comparison to traditional 3D CFD simulations In addition an integrated and automatic evaluation tool establishes a comprehensive analysis of the relevant engine parameters Due to the capability of a reliable virtual development of full engines this fast response 3D CFD tool makes a major contribution to the engine development process S dwestmetall F rderpreis 2010

Simulation of a Hydrogen Internal Combustion Engine with Cryogenic Mixture Formation Simon Ellgas,2008-02-25 It is generally accepted that the worldwide change of the climate is caused by the manmade emissions of the greenhouse gas CO2 For this reason the development of new technologies for propulsion aims at the reduction of the CO2 emissions Using hydrogen as an energy carrier offers the possibility to produce the fuel for vehicles from renewable energy sources thus avoiding the emission of CO2 completely The on board storage of liquid hydrogen at very low cryogenic temperatures offers currently the best basis to achieve acceptable cruising ranges of hydrogen vehicles The consistent utilisation of the cold hydrogen using cryogenic mixture formation offers unique opportunities for the optimisation of a combustion engine with regard to power and efficiency To fully exploit the potential of this promising mixture formation strategy the usage of modern simulation techniques is necessary In the course of this thesis 1D and 3D computational fluid dynamic simulation tools were brought to a serviceable state ready for the optimisation of a hydrogen engine with cryogenic mixture formation The simulation of the mixing and the combustion with novel models adapted for hydrogen engine simulations was verified by comparison to engine test bench results and optical experiments Careful model and mesh studies have been performed The ability of a Turbulent Flame Speed Closure TFC combustion model to predict the combustion process for a large part of the engine operating map could be demonstrated This is a significant progress compared to results achieved until now regarding hydrogen engine simulations A crucial point of the cryogenic mixture formation is the formation of frost inside the intake port due to the low mixture temperature For the simulation of this phenomenon a novel approach to compute frost formation in combination with a 3D CFD simulation has been developed The validity of the model could be demonstrated on the basis of experimental results reported in literature and by comparison to preexisting cryogenic hydrogen injection experiments The innovative simulation tool could be applied developing suggestions how to avoid the undesired formation of frost A simple but robust solution for the frosting issue was elaborated whose functionality could be demonstrated during engine operation at the test bench which is regarded as an essential step towards the realisation of a hydrogen engine with cryogenic mixture formation The presented thesis was conducted at BMW Group Research and Technology in the course of the European funded project HyICE Optimisation of a Hydrogen Powered Internal Combustion Engine

Simulation of Internal Combustion Engines with High-Performance Computing Tools ,2015 Traditional Lagrangian spray modeling approaches for internal combustion engines are highly griddependent due to insufficient resolution in the near nozzle region This is primarily because of inherent restrictions of volume fraction with the Lagrangian assumption together with high computational costs associated with small grid sizes A state of the art grid convergent spray modeling approach was developed and implemented by Senecal et al ASME ICEF2012 92043 in the CONVERGE software The key features of the methodology include Adaptive Mesh Refinement AMR advanced liquid gas momentum coupling and improved distribution of the liquid phase which enables use of cell sizes smaller than the nozzle diameter This modeling approach was rigorously validated against nonevaporating evaporating and reacting data from the literature The current numerical study focusses on further demonstration of the grid convergent modeling approach for simulating a single cylinder Cat compression ignition engine The simulated injector is characterized with a nominal nozzle exit diameter of 259 mu m Simulations using various minimum grid sizes ranging from 125 mu m to 1000 mu m are compared for engine performance and emissions parameters of interest such as pressure heat release rate ignition delay NOx HC and soot emissions The peak cell count for the highest resolution simulation was on the order of 34 million These computationally expensive simulations were facilitated at a high performance computing facility at Argonne National Laboratory METIS load balancing algorithm was developed and implemented in Converge code for the simulations Scaling studies were also performed The validity of previously recommended grid settings ASME ICEF2012 92043 for accuracy runtime trade off is further assessed Efficacy of a simplified combustion model is also compared against a detailed chemical kinetics based combustion model
Simulation and Optimization of Internal Combustion Engines Zhiyu Han,2021-12-28 Simulation and Optimization of Internal Combustion Engines provides the fundamentals and up to date progress in multidimensional simulation and optimization of internal combustion engines While it is impossible to include all the models in a single book this book intends to introduce the pioneer and or the often used models and the physics behind them providing readers with ready to use knowledge Key issues useful modeling methodology and techniques as well as instructive results are discussed through examples Readers will understand the fundamentals of these examples and be inspired to explore new ideas and means for better solutions in their studies and work Topics include combustion basis of IC engines mathematical descriptions of reactive flow with sprays engine in cylinder turbulence fuel sprays combustions and pollutant emissions optimization of direct injection gasoline engines and optimization of diesel and alternative fuel engines
Simulation of a Hydrogen Internal Combustion Engine with Cryogenic Mixture Formation Simon Ellgas,2008

Modelling Diesel Combustion P. A. Lakshminarayanan,Yogesh V. Aghav,2022-01-21 This book comprehensively discusses diesel combustion phenomena like ignition delay fuel air mixing rate of heat release and emissions of smoke particulate and nitric oxide It enables quantitative evaluation of these important phenomena and parameters Most importantly it attempts to model them with constants that are independent of engine types and hence they could be applied by the engineers and researchers for a general engine This book emphasizes the importance of the spray at the wall in precisely describing the heat release and emissions for most of the engines on and off road It gives models for heat release and emissions Every model is thoroughly validated by detailed experiments using a broad range of engines The book describes an elegant quasi one dimensional model for heat release in diesel engines with single as well as multiple injections The book describes how the two aspects namely fuel injection rate and the diameter of the combustion bowl in the piston have enabled meeting advanced emission noise and performance standards The book also discusses the topics of computational fluid dynamics encompassing RANS and LES models of turbulence Given the contents this book will be useful for students researchers and professionals working in the area of vehicle engineering and engine technology This book will also be a good professional book for practising engineers in the field of combustion engines and automotive engineering

Technical Progress Report for Application of Numerical Simulation Methodology to Automotive Combustion ,1981 This report represents the third quarterly technical progress report for a program entitled Application of Numerical Simulation Methodology to Automotive Combustion The goal of the program is to develop validate demonstrate and apply a numerical simulation methodology for incylinder reactive flows in internal combustion engines Previous work on this contract involved the initial development and validation of a finite difference based simulation model for time dependent axisymmetric flows which includes a generalized coordinate system for arbitrary mesh design and treatment of complex and time dependent boundaries multiple and interacting chemical species coupled swirl flow velocity component and two equation turbulence closure In its various stages of development the model has been used to simulate numerous engine related problems for validation and demonstration purposes The technical effort during the current reporting period has concentrated on reactive flow model development test and parametric study calculations engine simulation code clean up restructuring and documentation and fuel injection droplet model development Results of these studies are discussed

A Probability Density Function Time-scale Model for Combustion Using Large Eddy Simulation Shrikanth Rao,2001

Design and Simulation of Four-Stroke Engines Gordon Blair,1999-08-15 This book provides design assistance with the actual mechanical design of an engine in which the gas dynamics fluid mechanics thermodynamics and combustion have been optimized so as to provide the required performance characteristics such as power torque fuel consumption or noise emission

Design and Simulation of Four-Stroke Engines Gordon Blair,1999-08-15 This book provides design assistance with the actual mechanical design of an engine in which the gas dynamics fluid mechanics thermodynamics and combustion have been optimized so as to provide the required performance characteristics such as power torque fuel consumption or noise emission

Computational Optimization of Internal Combustion Engines Yu Shi,Hai-Wen Ge,Rolf D. Reitz,2011-06-22 Computational Optimization of Internal Combustion Engines presents the state of the art of computational models and optimization methods for internal combustion engine development using multi dimensional computational fluid dynamics CFD tools and genetic algorithms Strategies to reduce computational cost and mesh dependency are discussed as well as regression analysis methods Several case studies are presented in a section devoted to applications including assessments of spark ignition engines dual fuel engines heavy duty and light duty diesel engines Through regression analysis optimization results are used to explain complex interactions between engine design parameters such as nozzle design injection timing swirl exhaust gas recirculation bore size and piston bowl shape Computational Optimization of Internal Combustion Engines demonstrates that the current multi dimensional CFD tools are mature enough for practical development of internal combustion engines It is written for researchers and designers in mechanical engineering and the automotive industry
Modeling for SI & Diesel Engines ,2004

Numerical Simulation of Non-reactive Aerodynamics in Internal Combustion Engines Using a Hybrid RANS/LES Approach Al Hassan Afailal,2020 Internal aerodynamics is a key element for improving the combustion efficiency in Spark Ignition SI engines Within this context CFD tools are increasingly used to investigate in cylinder flows and to support the design of fuel efficient engines The present research aimed at extending and validating a non zonal hybrid Reynolds Averaged Navier Stokes Temporal Large Eddy Simulation HTLES approach initially formulated for stationary flows to cyclic SI engine flows with moving walls The aim was to model the near wall regions and coarse mesh regions in RANS while solving the turbulent scales in core regions with sufficient mesh resolution using temporal LES in a seamless approach with no a priori user input HTLES was retained as it proposed a consistent hybridization combining time averaging in RANS regions with temporal filtering in TLES A first development consisted in implementing a smooth shielding function that enforces the RANS mode in near wall regions regardless of the local temporal and spatial resolution The extension of HTLES to cyclic flows was then achieved via the formulation of a method allowing approximating the phase averages of resolved flow quantities based on an Exponentially Weighted Average EWA A dynamic expression for the width of the weighted average was proposed in order to ensure that the high frequency turbulent fluctuations be filtered out from the resolved quantities while keeping the low frequency cyclic components of the flow variables The resulting EWA HTLES model was implemented in the commercial CONVERGE CFD code The developed EWA HTLES model was first applied to the simulation of two steady flow configurations a minimal turbulent channel and a steady flow rig Predictions were confronted with reference data as well as with those from RANS and LES All simulations relied on the use of standard wall laws and coarse grids at walls Imposing the RANS mode at walls yielded EWA HTLES predictions of pressure losses much closer to DNS and experimental findings than with LES At the same time it allowed yielding results in terms of mean and RMS velocities s in the core regions of the same quality than LES and superior to RANS Finally EWA HTLES was applied to the simulation of two cyclic flows representative of SI engines the compressed tumble and the Darmstadt single cylinder pentroof 4valve engine For each configuration a total number of 40 consecutive cycles were simulated The results were confronted to PIV data and to RANS and LES predictions obtained using the same numerical set up It was shown that EWA HTLES successfully drives the RANS to LES transition in such complex configurations exhibiting unsteady flow features and important cyclic geometrical deformations It switched from the RANS mode at the walls to LES in the core region of the cylinder allowing a better prediction of unsteady phenomena including the evolution of the overall tumble characteristics and phenomena associated to cyclic variability The EWA HTLES results were shown to be comparable to those predicted by LES and superior to RANS The performed developments and obtained results open encouraging perspectives for the application of this hybrid RANS LES method in industrial configurations involving non stationary conditions and in particular moving boundaries

Turbulent Combustion Modeling Tarek Echekki,Epaminondas Mastorakos,2010-12-25 Turbulent combustion sits at the interface of two important nonlinear multiscale phenomena chemistry and turbulence Its study is extremely timely in view of the need to develop new combustion technologies in order to address challenges associated with climate change energy source uncertainty and air pollution Despite the fact that modeling of turbulent combustion is a subject that has been researched for a number of years its complexity implies that key issues are still eluding and a theoretical description that is accurate enough to make turbulent combustion models rigorous and quantitative for industrial use is still lacking In this book prominent experts review most of the available approaches in modeling turbulent combustion with particular focus on the exploding increase in computational resources that has allowed the simulation of increasingly detailed phenomena The relevant algorithms are presented the theoretical methods are explained and various application examples are given The book is intended for a relatively broad audience including seasoned researchers and graduate students in engineering applied mathematics and computational science engine designers and computational fluid dynamics CFD practitioners scientists at funding agencies and anyone wishing to understand the state of the art and the future directions of this scientifically challenging and practically important field

Optimization Methods for the Mixture Formation and Combustion Process in Diesel Engines Jost Weber,2008-09-02 The optimization of the combustion and mixture formation process in Diesel engines by CFD simulations requires a reliable model approach as a pre requisite in order to predict combustion and emissions A general and commonly used model for the liquid spray is the discrete droplet model Sub models for droplet breakup collision and coalescence and evaporation are available in the CFD code With regard to combustion the flamelet model approach is interactively coupled with the CFD code known as RIF model It benefits from a one dimensional description of the thin reaction zone in the flame By this approach a detailed reaction mechanism for the model fuel can be used Sub mechanisms for NOx formation and a soot model are included The reaction mechanism has been modified in this work to account for a correct ignition delay and heat release at low temperature conditions e g in the PCCI combustion The modeling of the mixture formation in a spray contains uncertainties in the model constants and initial conditions Spray data is required to calibrate the spray model At least the spray penetration has to be measured under engine like conditions as performed in a spray chamber The spray penetration is interpreted as a criterion for the mass and momentum exchange between the spray and the surrounding gas on a macroscopic level Finding a good agreement for the spray penetration between simulation and experiment defines an optimization problem That agreement is expressed in an Euclidean norm as a merit function The objective is to minimize this merit function The search for an appropriate set of spray model parameters and initial conditions is denoted here as calibration of the spray model Six parameters have been identified spanning a six dimensional parameter space A manual search is not feasible anymore but the implemented Genetic Algorithm is suitable to find a global optimum where a good agreement between measured and simulated spray penetration is obtained If the same spray parameters are applied to a virtual engine case a similar good agreement is achieved although the mesh resolution is much finer and the mesh topology is different than for the spray chamber simulation From this result spray data for engine simulations should be provided and be used for sake of calibration before the engine simulation is conducted Additionally data is obtained by PDA measurements at discrete points in the spray That measurement technique is however limited to less dense areas Nevertheless it shows that also local data is in agreement with the simulation data Agreement with spray penetration is thus a relatively good choice and accounts also for the physics on a local or microscopic level That hypothesis is well supported by the data from the ethanol spray calibration The excellent agreement with regard to the global spray penetration is reflected by the 2D comparison of liquid and vapor fuel concentrations and temperature respectively Furthermore a similar good agreement in spray penetration is obtained if the breakup and collision model is not used In that case the spray penetration is only controlled by the evaporation process The Genetic Algorithm finds a point in the parameter space with an initial SMR that is of the order of size of the outcome of the secondary droplet breakup However in engine simulations spray data is not always available In that case the spray parameters have to be adjusted That adjustment is carried out following a methodology that is presented in this work Mainly SOI and EGR variations have to be used to calibrated the spray and combustion model That approach has been investigated for three different engine data sets for conventional and PCCI combustion mode On the Cummins QSX engine a conventional combustion has been studied Spray parameters are subject of adjustment On the Duramax 6600 Diesel engine a conventional and PCCI combustion mode are investigated For the PCCI combustion mode the reaction mechanism is modified in order to account for a correct ignition delay in the low temperature combustion regime The comparison between engine data and results from the simulation indicates a good agreement for the combustion and engineout emissions On the Duramax full load case most uncertainties are addressed to the spray wall interaction Uncertainties from physical not well based models will always occur in the engine simulation Therefore calibration of these models is a mean to quantify its influence and minimize the discrepancies

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