A Comprehensive Implementation of the Eddy-Dissipation Model for Turbulent Combustion Simulation

Bjørn Lilleberg, bjorn.lilleberg@ntnu.no **Prof. Ivar S. Ertesvåg**, Ivar.S.Ertesvag@ntnu.no	Norwegian University of Science and Technology (NTNU) NO-7491, Trondheim, Norway
Dominik Christ, christ@wsa.rwth-aachen.de **Dr. Dobrin Toporov**, toporov@wsa.rwth-aachen.de **Prof. Reinhold Kneer**, kneer@wsa.rwth-aachen.de	Rheinisch Westfälische Technische Hochschule (RWTH) Aachen Unversity D-52062, Aachen, Germany
Dr. Kjell Erik Rian, kjell.e.rian@computit.no	ComputIT Pirsenteret, NO-7462, Trondheim, Norway

Abstract

The Eddy Dissipation Concept (EDC) [1] is a widely applied model for prediction of premixed and non-premixed flames. Various model approaches for turbulence/chemistry interaction in the frame of the EDC model were implemented and validated against experimental data:

I. Perfectly Stirred Reactor (PSR)

II. Homogeneous Reactor (HomRea)

III. Fast Chemistry (FastChem)

IV. Local Extinction (LE)

The PSR approach was previously implemented in OpenFOAM, however using external libraries for thermodynamic data and applying the CVODE solver for internal integrations. The presented new implementation of the PSR approach is based on the internal OpenFOAM thermodynamic functions and utilizes the RADAU5 solver which the authors have found to be faster and more robust. Furthermore, the computationally expensive EDC/PSR model is accelerated by several orders of magnitude using binary tree tabulation. This tabulation had been implemented previously into OpenFOAM 1.3 by T. Lucchini and has been now ported to OpenFOAM 1.6.

The HomRea is a modification of the PSR approach with the aim of performing unsteady calculations.

The FastChem represents the "mixed is burned" approach thus avoiding chemical kinetic details.

The LE is based on pre-determined characteristic reaction time scales providing very fast and robust calculations while still considering detailed chemistry data. These data may be acquired by experiment or calculation. The method how to pre-calculate the chemical kinetic data from any detailed reaction mechanism is presented as well.

For the sake of completeness a previous version of the EDC model, namely the Eddy Dissipation Model (EDM) [3] has been included as well together with the option of explicit coupling with chemical kinetics.

Validation with experimental data from literature for both a diffusion flame (Flame D) and premixed combustion (Piloted Premixed Jet Burner and A Pilot Stabilized Premixed Flame) is presented. The validated cases are calculated using the GRI-3.0 chemical mechanism with 325 reactions and 53 species and include NOx-chemistry.

Keywords: Combustion, turbulence/chemistry interaction, eddy dissipation concept, EDC

References

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