6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11 – 15 June 2018, Glasgow, UK

Efficient CFD Simulation of Combustion and Emission Processes by Applying a Tabulated Chemistry Approach

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Key Words: *Combustion, Tabulated Chemistry, Diesel Engine, Gasoline Engine.*

Within the development process of modern combustion engines and gas turbines, the number of parameters is increasing continuously. Not only the reduction of fuel consumption, but also the continuous improvement of the emission behaviour are drivers for the ongoing research and development. In this context it is necessary to apply tools like optical diagnostics and computational fluid dynamics (CFD) to improve the combustion itself as well as related processes like formation of pollutants. It is generally acknowledged that more details of the chemical reactions occurring during ignition and in the flame front should be accounted for in the CFD simulations to achieve a higher level of accuracy. On the other hand, the associated CPU cost grows quickly beyond practical engineering time limits with increasing the number of species and reactions involved. Therefore it has been a common approach in the past to apply turbulent combustion models in a RANS (Reynolds Averaged Navier Stokes) as well as in a LES (Large Eddy Simulation) context. Such models, of which many exist in literature [1], always face the challenge of closing the chemical reaction rate on a sub-grid level. The two main ingredients are the sources from the chemical reactions and the so-called turbulence-chemistry interaction (TCI). The various combustion models then differ mainly by how the chemistry is calculated (level of detail, canonical flame model) and on the other hand how turbulence is assumed to affect the reaction rate on the sub-grid level.
In this work, an advanced combustion model based on tabulated chemistry is applied for 3D CFD calculations of Diesel and Gasoline engine cases as well as a gas turbine combustion chamber. This model, which has been implemented in the AVL FIRE™ CFD software, is based on the Flamelet Generated Manifold (FGM) chemistry reduction technique [2,3]. The underlying pre-processing and tabulation technique allows including skeletal reaction mechanisms as well as large state-of-the-art mechanisms in CFD simulations at very practical CPU costs. The advantage mainly originates in the fact, that the chemical mechanism only has to be calculated in the beginning of the simulation process and later during the costly CFD calculation only table look-up and interpolation operations are necessary.
The TCI modelling is based on a presumed PDF approach. The look-up tables have up to 7 dimensions: pressure, temperature, mixture fraction, mixture fraction variance, progress variable, progress variable variance and EGR.

REFERENCES

[1] Poinsot, T., and Veynante, D., Theoretical and numerical combustion. R. T. Edwards, 2001.
[2] 1. van Oijen, J.A., Lammers, F.A., de Goey, L.P.H., Combust. Flame 127(3), 2124–2134, 2001.
[3] 2. Tap, F., and Schapotschnikow, P., SAE Technical Paper 2012-01-0152, 2012.