Modeling engine spray ignition with igniting flamelets

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Modeling Engine Spray Ignition with Igniting Flamelets

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Introduction

Auto-ignition is an important process in Diesel engines. This process is instationary and the ability to numerically predict it becomes more and more important due to:

- New combustion concepts (HCCI/PCCI)
- Future Fuel developments (bio-fuels)

Therefore ignition models that switch on a combustion model at a certain time may not suffice. Instead, auto-ignition may be predicted with tabulated igniting flamelets (FGM).

Objectives

Investigate the influence/sensitivity to tabulation approach:

- This study aims to investigate strain rate (a) dependency of ignition delay

Spray Ignition Modeling

- Approach based on the flamelet concept using a presumed PDF method

Manifold created using:

- Classical stationary counter-flow flames
- Extended by igniting non-premixed flamelets

An example result for an auto-igniting heptane spray is shown in Figure 1. This is a full 3D simulation result of FGM implemented in Fluent.

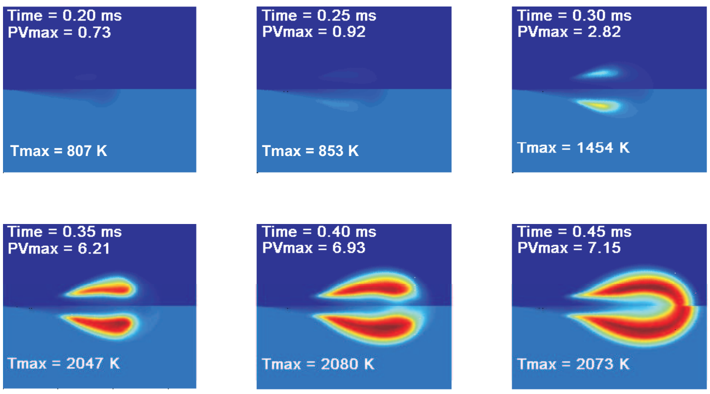

Figure 1: Temporal sequence of progress variable and temperature contours showing the auto-ignition process resulting in total combustion. FGM filled with $a = 500$ solutions.

Manifolds

Flamelet Generated Manifolds are parameterized with:

- Mixture fraction Z
- Reaction progress variable PV (CO_2, CO, CH_2O)

Strain rate choice of the igniting flamelet is arbitrary, possibly giving rise to:

- Shifts of source term position in Z,PV-space
- Different magnitudes of PV source

Results

- Tops more or less stay at same positions
- Magnitudes tend to increase with increasing strain rate

See Figure 2 ($a = 100$) and 3 ($a = 3000$).

- However, increasing strain rate results in higher auto-ignition times (Figure 4)

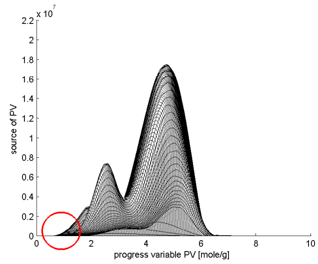

Figure 2: Source of progress variable during ignition with $a = 100$

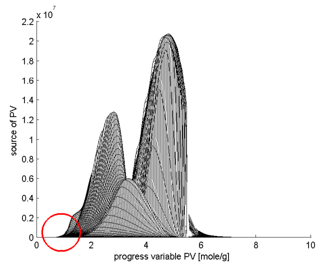

Figure 3: Source of progress variable during ignition with $a = 3000$

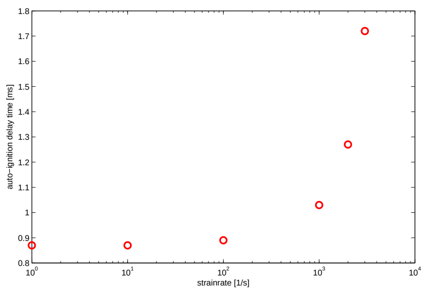

Figure 4: Auto-ignition delay time as function of strain rate. Auto-ignition is defined at 5% increase of the progress variable.

Outlook

- Consequence of different manifolds for 3D spray simulation
- Investigation of the PV choice influence on ignition and combustion behavior
- More detailed validation with ignition delay times and flame lift-off lengths

Acknowledgements

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