Representative Interactive Linear Eddy Model II

I. Background

In order to improve combustion engines for a clean and efficient use, new computational tools need to be developed to simulate processes in non standard conditions such as low temperature combustion.

Most of combustion models that currently exist are developed for limited applications. RILEM however, is a recently developed combustion model that is mode and regime independent, that can simulate both premixed and non premixed combustion, with fast and non fast chemistry at low temperature conditions. RILEM is resolving all scales similarly to DNS and uses LEM [1] (Linear Eddy Model) which simulates turbulence on a one dimensional line that represents the entire combustion chamber.

II. Method

The original model is currently coupled to a CFD solver (OpenFOAM 2.2.5), it is able to run on multiple LEM lines to increase the statistical fidelity. The project is aiming for the development of a new, general purpose combustion model for engine simulations with the following features:

- Predictive for non-premixed, premixed and mixed-mode combustion under low temperature combustion conditions.
- Natural handling of dual-fuel combustion
- Evaluated with non-academic test cases relevant to CERC partners

III. Results

The results [2] were found applying the extended version of RILEM based on the progress variable simulating a Volvo heavy-duty truck engine for both full and partial load.

The study was done to investigate the influence of unresolved fluctuations on global combustion properties such as pressure development. The results from RILEM were then compared to the experimental results and to the WSR (Well Stired Reactor) which was tuned in this case.

The pressure development and the AHRR calculated from RILEM show good agreement with the experimental data and the tuned WSR model for both the FL the PL cases. However, a peek is noticed at the start of the combustion in the PL case. Since RILEM did not go threw any calibrating procedure in this case, it possible to solve this problem by tuning the model to match with the experimental data.

IV. Conclusion and future work

A first evaluation of the extended progress variable version of RILEM lead to very promising agreement with experimental data for a heavy-duty truck engine under full and part load conditions without tuning. However, further improvements need to be realized.

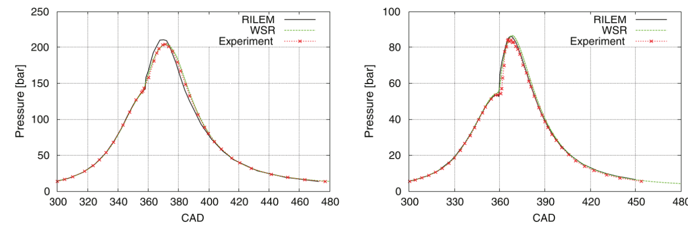

Figure 1: Cylinder pressure for RILEM compared to the WSR model and experimental data for the full load case (left) and the part load case (right)

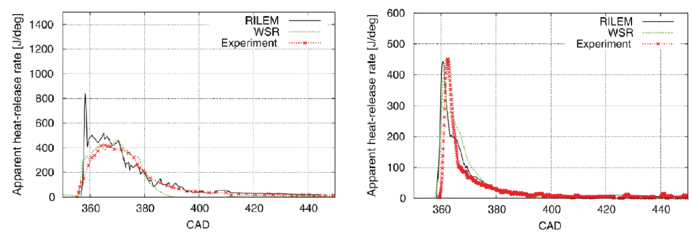

Figure 2: Apparent heat release rate for RILEM compared to the WSR model and experimental data for the full load case (left) and the part load case (right)

The volume-based coupling between the CFD solver and the LEMs will be replaced with a pressure based formulation, this enables a better and more natural treatment of wall heat losses in the LEMs. The approximation of the progress variable PDF with a simple delta peak will also be replaced with more realistic shapes. Many realizations of the LEMs will be required to achieve statistical fidelity with RILEM. To achieve this with good computational efficiency, full MPI parallelization for shared memory machines will be implemented. Finally, the method will be used to simulate more realistic engine cases, preferably based on experimental results available in the division and CERC.

References

[1] T. Lackmann, A. R. Kerstein, and M. Oevermann. A representative linear eddy model for simulating spray combustion in engines. *Combustion and Flame*, 193:1–15, 2018.

[2] T. Lackmann, A. Nygren, A. Karlsson, and M. Oevermann. Investigation of turbulence–chemistry interactions in a heavy-duty diesel engine with a representative interactive linear eddy model. *International Journal of Engine Research*, 2018.