**Minutes of ECN 9 Topics**

**Alternative fuels spray combustion**

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The objective of this topic was to investigate the injection and combustion processes for high-pressure spray flames in the context of compression-ignition combustion systems. To remain in agreement with current research trends, the guidelines for this session suggested alternative fuels, such as methanol and OMEs, along with large nozzles, such as Spray D. The work also relied on comparison to n-dodecane experiments and simulations, to provide a frame of reference to place the alternative fuels in context.

Technically speaking, the session evolved into synthesizing all “diesel” activities, as this was the only session on the topic, compared to four sessions at ECN 8. As such, the presentation had to cover a very large space, from injection processes to combustion and emissions. Experimental and numerical results for liquid and vapor penetration, mixing, ignition and flame stabilization, as well as soot were presented. Molecular decomposition results were also presented applying high-speed planar laser Rayleigh scattering under reacting conditions.

Four groups contributed with CFD simulations: Denmark Technical University, Sandia, Technical University of Eindhoven and Technical University of Darmstadt; while experimental results were mostly compared to Sandia’s methanol and OME dataset, with limited comparisons to CMT’s OME data.

The key take-away message is given below:

* Similar to the last ECN 8, where larger nozzles were a target, this year’s session successfully focused on Spray D and sustainable fuels: OME and methanol.
* Methanol showed longer liquid length compared to OME and n-dodecane (which have near identical liquid penetration), most likely because of the higher latent heat of vaporization.
* Unfortunately, simulations did not capture this behavior, with similar liquid length results predicted for all fuels, but inconsistent liquid length definition likely affected the outcome. We emphasize use of ECN standards for liquid length definition (such as projected liquid volume) for future comparisons.
* While mixing predictions are OK, methanol mixture fraction falls below the other two fuels; there are no direct mixing measurements to confirm, but spray morphology measurements do not support such behavior.
* As anticipated, methanol has longer ignition delay and flame stabilization distance (lift-off length) compared to OME and n-dodecane, due to its much lower reactivity (methanol DCN ~ 5); methanol does not ignite below 1100 K under Spray D injection conditions and time-scales.
* Reasonable agreement for ignition delay, though simulations tend to underestimate ignition delay, particularly at higher temperature (1200 K).
* More scatter on lift-off length in the best scenario, but simulations results may also be way off, due to either data processing or combustion model shortcomings – to be investigated
* Overall, simulations showed improvement since ECN 8, but key aspects of spray and combustion physics are still off; First time for methanol was OK, but it is fair to say that the results were worse than for n-dodecane and OME.
* As anticipated from ECN 8, experiments did not show any measurable soot for OME, as well as for methanol, even at elevated temperatures (1200 K).
* Soot simulations indicate that methanol should produce two orders of magnitude lower C2H2 concentration compared to OME; the absence of C-C bond in the fuel limits the rate of formation of species necessary to form PAHs and soot.

A couple of points follow regarding the gaps that remain and that should be addressed by future work on the topic:

* More work is needed both experimentally and numerically on nearly all processes, from liquid injection to emissions to improve the quality and reliability of the predictions.
* Most pressing experiments aiming at assisting in the validation of alternative fuel spray simulations are mixing measurements for methanol (or other relevant fuels not yet tested).
* Future work should emphasize on other pollutant emissions, besides soot, such as NOx and CO.
* Efforts should also be devoted to understanding the interaction between low temperature and high temperature, and the relationship to kinetics and combustion models to minimize deviation in lift-off length predictions for methanol or other low-reactivity fuels.