Key Messages from AMF Research

Annex 52

April 2018

Fuels for Efficiency

PTT Public Company Limited

Major Conclusion

The analysis of five different concepts for improving fuel efficiency revealed that the use of ethanol blended fuels and paraffinic fuels as well as the use of a methanol steam reformer all allow for better fuel efficiency if operated with modern engines and eventually adapting the engines regarding ignition timing or fuel injection duration. Modern engines should be flexible for a wide range of fuels.

Background

Annex 52, Fuels for Efficiency, was initiated in compliance with the global requirement of improving fuel efficiency for road transport fuel application.Generally, automotive original equipment manufacturers (OEMs) try to improve their engines` efficiency while controlling the exhaust emission with regard to the country's requirement. The implication for advanced motor fuels, or the method for optimizing the fuels in order to maximize engine efficiency, has rarely been discussed worldwide. Annex 52 demonstrated how to optimize fuels with specific engines in terms of thermal efficiency gain.

Research Protocol

Annex 52 comprised a range of different experimental setups on various subtopics of improving fuel efficiency. The five major research topics were:

- WP I: Survey on Advanced Fuels for Advanced Engines (Information Exchange with IEA Bioenergy Task 39),
- WP II: Performance Evaluation of Chemical Friction Modifiers for Diesel and Gasoline Fuels (Teknologisk Institut-Denmark),
- WP III: Fuel reforming by Thermo-chemical Recuperation (Technion – Israel),
- WP IV: Performance Assessment of Various Paraffinic Diesel Fuels (VTT-Finland),
- WP V: Opportunity for Enhancing Fuels Efficiency by Ethanol Blended Gasoline Fuels (PTT-Thailand).

Key Findings

Key findings from the project can be summarized as follows:

- WP I: The **survey on advanced fuels for advanced engines** finds that the diversity of fuels will further increase. Next to user friendly drop-in fuels that can be implemented using the existing infrastructure, advanced fuels like synthetic fuels will be researched or introduced in the market. These fuels can be produced based on biomass (so called biomass-to-x-fuels), but also on renewable electricity together with a carbon source (so called power-to-x-fuels). Furthermore, to achieve the mutual benefit of engine – fuel interaction, **new engine techniques should be flexible for a wide range of fuels fulfilling the requirements with regard to minimum $CO_{2\text{-eq.}}$ emissions as well as limited and unlimited local emissions like NO_x, particles etc**.
- WP II: Experiments were undertaken to evaluate the **performance of chemical friction modifier additives** for gasoline and diesel fuels to prove the effect of fuel economy improvement. The results show that the effect of **chemical friction modifier in gasoline was in the range of 1-2% improvement and the cetane improver in diesel fuel was not the promising solution for fuel efficiency improvement,** at least for conventional engine technology.
- WP III: Experiments showed that the **methanol steam reformer improved fuel efficiency by 18 to 39%** when running under the low-to-medium load condition. The major improvement comes from the wide flammability limit of hydrogen-rich fuel, which allows the engine to operate unthrottled, especially at low-load conditions, and leads to reduction of heat transfer losses and maximal cycle temperatures. The extremely high burning velocity of hydrogen-rich reformate enables getting closer to the theoretical most efficient Otto cycle. In addition, the waste heat recovery from exhaust gas helps to maintain the endothermic reactions of methanol steam reforming (MSR). Thus, **MSR is one of the major technologies for fuel efficiency improvement for a modified stationary gasoline engine**.
- WP IV: The aim of this project was to **optimize non-road diesel engines for one paraffinic diesel fuel** and compare the results with typical European grade diesel fuel measured with OEM engine parameters. The experiment was undertaken with a fully controllable diesel engine. The key deliverable is that paraffinic diesel fuels allow engines to be calibrated for better thermal efficiency with the same engine out emission levels as with fossil diesel fuel, mainly due to the lower engine out soot levels. **With optimized injection parameters it was possible to improve the average thermal efficiency by 2%, and in optimal load conditions by 4%.**
- WP V: **Ethanol blended fuel has significantly improved fuel octane number** which results in the possibility of higher engine output, if operated with the advance ignition timing feature. Since advanced ignition timing is a strategy used in modern Gasoline Direct Injection (GDI) engines, it can be concluded that ethanol blended fuels have high potential for thermal efficiency improvement compared to pure gasoline. Therefore, **fuel efficiency improvement in modern gasoline GDI engines can be achieved by using ethanol blended fuel.**