The impact of diesel fuel quality on the reforming process in auxiliary power units

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Introduction

Increased fuel cost and the introduction of stricter environmental legislation has in recent years created a focus in the transportation industry to introduce innovative energy saving solutions that reduce fuel consumption while maintaining the standards and comforts that the end-users expect from their products. Heavy-duty trucks operate the engine for more than 50% of the operating time at idle – only for supporting the comfort functions in the vehicle. Engine idling is both fuel inefficient as well as a significant contributor of exhaust emissions. Replacing the engine idling with a small auxiliary power unit is today considered by the automotive industry as the most viable alternative for idle reduction. There are today several technical alternatives that are being developed for APU use, including fuel cells, small combustion engines and large battery storage units. Fuel cell-based APU's that can be operated on a commercial fuel like diesel has today the highest potential of eliminating idle emissions while at the same time providing the end-user with significant fuel savings.

This study focuses on the impact of fuel quality on the diesel reformer, as the ability to successfully convert the available commercial fuels to clean hydrogen is a primary requirement for introducing a fuel cell APU in the automotive market. The impact of sulphur on the reforming process will also be investigated as the study includes in addition to the commercial fuels both low sulphur diesel as well as Fisher-Tropsch fuels.

Materials and Methods

For this study an internally developed diesel reformer was used in all experiments. The reformer has been developed for use with a PEM-Fuel Cell APU system (figure 1) and has been shown [1] to produce fuel cell grade hydrogen from US07 diesel fuel.

Parameter studies were performed to determine both the optimal operating conditions for the diesel reformer as well as to determine the potential influence of the fuel mixture on the reformate quality and the optimal operating conditions. The parameter study focused primarily on the influence on the oxygen-to-carbon ratio (O_2/C) and the steam-to-carbon ratio (H_2O/C) in the reformer.

In this study both a gas chromatograph and a gas-phase FTIR was used to determine the gas composition in the reformate mixture – enabling the study of both hydrocarbon slip and hydrogen selectivity in the reformer. The diesel fuels set to be used were Swedish Environmental Class 1, US07, DIN590EN, Fischer-Tropsch-fuel and biodiesel.

Figure 1. A picture of a fuel cell auxiliary power unit (APU) prototype

Results and Discussion

The diesel reformer was shown to successfully convert all of the diesel fuel mixtures tested into a "fuel cell grade" hydrogen containing gas. The experimental data from the study, however, showed that both the fuel quality and sulphur content affect both hydrogen selectivity and optimal operating conditions for the reformer. Sulphur had a detrimental effect on the hydrogen selectivity, but the effect was however shown to be reversible. Generally the higher aromatic content in the fuel, the higher air-to-fuel ratio is required for complete conversion of the diesel fuel, yielding lower reforming efficiencies for high aromatic diesel fuels. The reformer has been successfully operated with a PEM fuel cell without any degradation in performance, compared to synthetic reformate, when operated using commercial diesel fuels.

Significance

To introduce fuel cells in vehicle industry fuels, which are available in the open market, must be able to be handled. This study proves that it is technically feasible and we have successfully operated a fuel cell-based auxiliary power unit on commercial diesel fuels.

References

1. Nilsson, M., Karatzas, X., Lindström, B., and Pettersson, L.J. *Chem. Eng. J.* 142, 309 (2008).