Improved autothermal reformer design and its experimental evaluation using conventional diesel fuel and electro-fuel

$C_nH_m + n\ H_2O$	$\longleftrightarrow$	$n\ CO + (m/2 + n)\ H_2$	endothermic	(1)
$C_nH_m + n/2\ O_2$	$\longleftrightarrow$	$n\ CO + m/2\ H_2$	exothermic	(2)

For autothermal reforming (ATR) according to reaction equations (1) and (2) given above, long-chain hydrocarbon molecules undergo a catalytic reaction with steam and O_2 generating a gas mixture with CO, CO_2, CH_4, H_2 and traces of higher hydrocarbons such as ethene, propene or benzene. The molar flow of H_2 can be fed into the anode side of a fuel cell for electricity generation, possibly after proper gas cleaning steps based on the selected fuel cell technology. This presentation gives a short overview of the ATR reactor generations developed so far at Jülich and highlights the most recent improvements, which are incorporated into the ATR 14 [1]. Additionally, the experimental evaluation of the ATR 14 using conventional diesel fuel and additionally a blend of diesel fuel with an electro-fuel called polyoxymethylendimethylether (OME) is illustrated. The term electro-fuel describes synthetic fuels from carbon dioxide (separated from the exhaust gas streams of, e.g., steelworks or cement facilities) and hydrogen produced via water electrolysis using renewable electricity. The chemical structure of OME is shown in Figure 1. OMEs consist of two terminal methyl groups with different numbers of interjacent formaldehyde units forming a straight-chain molecule, whose length depends on the number of inserted formaldehyde units. Typically, OME molecules have three, four or five formaldehyde units. OMEs are considered a promising alternative to conventional diesel fuels as it was found in experimental studies that they reduce the emissions of nitrogen oxides (NO_x) and particulates of internal combustion engines working with self-ignition if they are mixed with conventional diesel fuel [2-5]. According to investigations performed by Lautenschütz et al. [6] and Deutsch et al. [7], blends of OME molecules with three, four or five formaldehyde units possess comparable physicochemical and combustion characteristics as conventional diesel fuel. The fundamental idea of this contribution is to compare the operational behavior of ATR 14 when it is fed, on the one hand, with conventional Ultimate diesel fuel and, on the other hand, with a blend of Ultimate diesel fuel and polyoxymethylendimethylether.

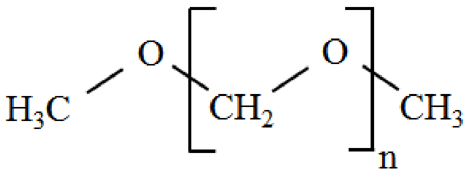

Figure 1 Structural formula of polyoxymethylendimethylether

Figure 2 shows in detail the design of Jülich's autothermal reformer, ATR 14, with its different sections such as fuel evaporation chamber, air mixing area, catalyst and steam generation chamber and the several devices for its proper functioning (nozzles for fuel and water injection, drop-shaped vapor trap, annular air injector, superheater etc.). The interaction of these sections and components will be explained in detail in this contribution.

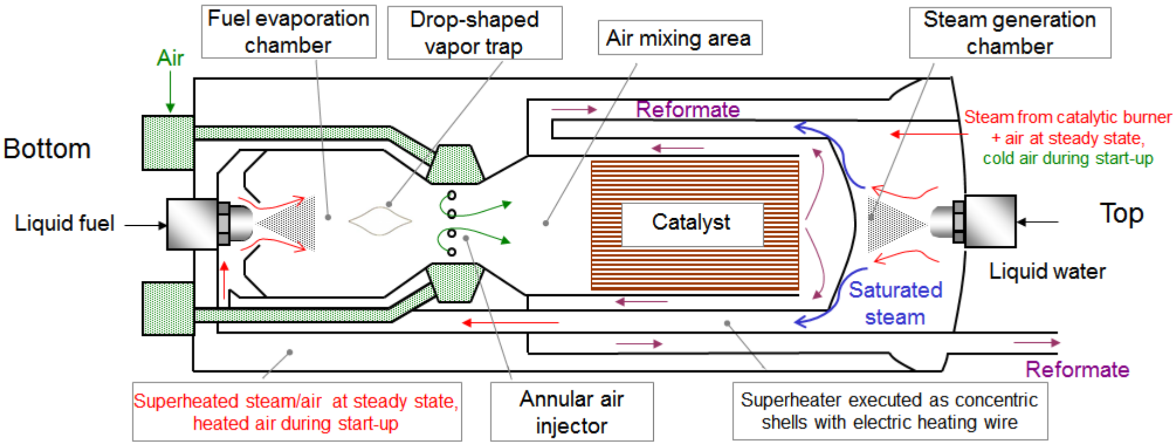

Figure 2 Design of Jülich's autothermal reformer, ATR 14

Figure 3 shows as an example for the experimental evaluation the results of a load change experiment with ATR 14 using conventional diesel fuel. It can be seen that the H_2 concentration remained almost constant at approx. 40%, when the load of the autothermal reformer was varied between 20% and 100%. This contribution will give and explain additional results obtained with ATR 14, when it is operated with conventional diesel fuel and blends of diesel fuel and OME.

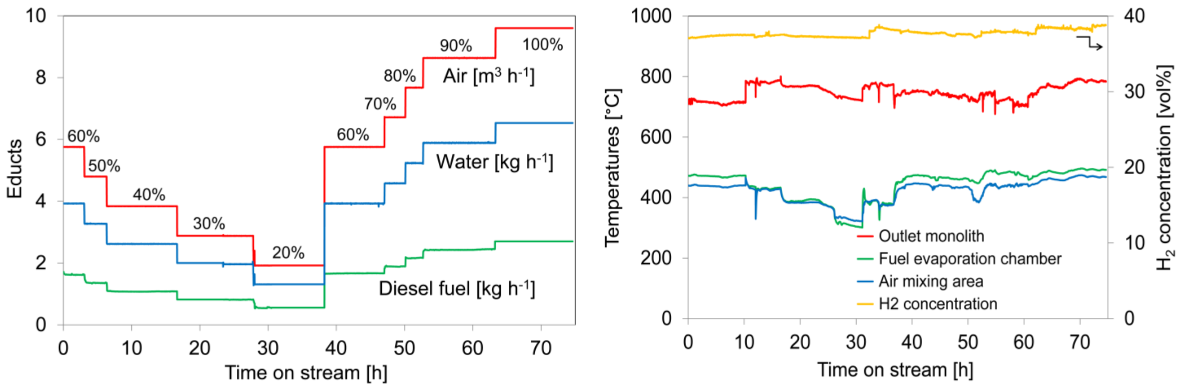

Figure 3 Mass streams and volumetric flow of the educts (on the left) and temperatures and H_2 concentration (on the right) during a load change experiment with ATR 14

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