Theoretical study of Diesel fuel reforming by a non-thermal arc discharge

Alexandre Lebouvier, Guillaume Petitpas, José Gonzalez-Aguilar, Adeline Darmon, Laurent Fulcheri

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A. Lebouvier[1,2], G. Petitpas[1], J. Gonzalez-Aguilar[1], A. Darmon[2], L. Fulcheri[1]

[1] *Center for Energy and Processes, MINES ParisTech, 06690 Sophia Antipolis, France*

[2] *Technocentre Renault, DREAM/DTAA - Service 68240, 78288 Guyancourt Cedex, France*

1. Introduction

Nitrogen oxides are in the center of future EURO VI norm, the European anti-pollution norm namely for Diesel powered vehicles. NO_x (NO, NO_2,...) are very irritant pollutants for people and are considered as tropospherical ozone precursors. Their effect is observed when ozone peak pollution is noticed during rush hours.

A promising post-treatment technology is to add a NO_x trap in exhaust line to store NO_x under nitrate form. An alternative to fuel-air ratio increase and catalytic technologies purge is the use of non-thermal plasma.

Plasma reforming of diesel fuel and exhaust gas mixture creates reducing chemical species like hydrogen and carbon monoxide, which are able to purge the NO_x trap.

2. Model presentation

Two approaches have been considered: thermodynamic and kinetic.

The thermodynamic model is based on Gibbs free energy minimization. Calculations have been realized by the free software T&TWinner [1].

The kinetic model is a 1D model implemented with commercial software CHEMKIN II [2]. The kinetic mechanism employed is the Lawrence Livermore National Laboratory for n-heptane, containing 160 species and 1540 reactions [3]. Charged species and NO_x chemistry are not taken into account. Plasma is considered as a heating source. A part of the gas goes through the plasma and the other part is not affected by the plasma. Then, these two phases are perfectly mixed and injected in a Plug Flow Reactor (PFR).

3. Results and Discussion

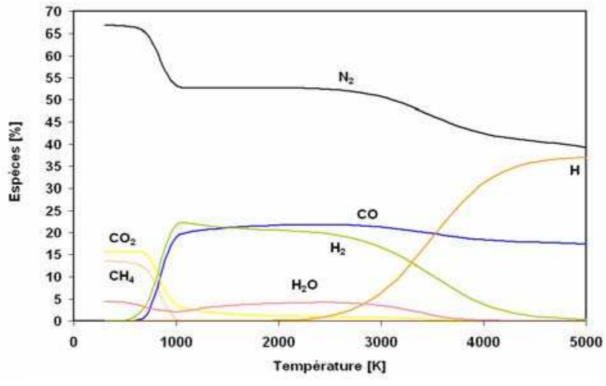

Fig.1 Gas composition in function of temperature. Thermodynamic calculations.

A sensibility study over O/C ratio, injected electric power and reaction volume has been carried out. We chose two typical operating points of Diesel powered vehicle, represented by their mean effective pressure of 1.01 and 7.06 bars respectively.

From thermodynamic modeling (cf. Fig. 1), it is noticed that the maximum rate of syngas is 42 % corresponding to the ideal case. Over 3000 K, diatomic hydrogen (H_2) is dissociated in atomic hydrogen (H).

1D modeling provides an indication on the reactor length necessary to reach good syngas rate (cf. Fig. 2). For the most oxygen-rich case (MEP = 1.01 bars), 30 % syngas production can be obtained with a 10 cm long reactor and 1 kW of injected electric power.

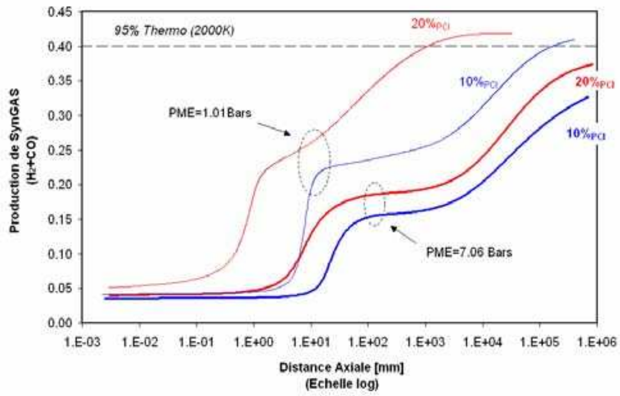

Fig. 2 Syngas rate in function of axial distance. 1D model calculations.

4. Conclusions and perspectives

This modeling work shows the potential of this application. The following work will concern computational fluid dynamics (CFD) modeling of our plasma torch. These results will be then compared to experimental results.

Acknowledgements

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