**MINERVE an innovative Power-to-Gas pilot unit in Nantes, France: presentation and energy performances.**

Freddy Durán-Martínez1,2\*, Mylène Marin-Gallego1, Khaled Loubar1, Mohand Tazerout1, Bernard Lemoult1,2

*1 GEPEA-CNRS UMR 6144, IMT Atlantique, Nantes, 44300. France; 2 AFUL Chantrerie, IMT Atlantique, Nantes, 44300*

*\*Corresponding author: freddy-libardo.duran-martinez@imt-atlantique.fr*

**Highlights**

* An experimental Power-to-gas pilot unit has been built in Nantes, France
* PEM electrolyzer is used to produce H2, methanation is processed in 2 fixed bed reactors
* Renewable synthetic natural gas (SNG) is produced to provide fuel at a Green-gas station

**1. Introduction**

Storing renewable electricity surplus in a natural gas grid is an attractive concept. Hydrogen storage via chemical conversion with carbon dioxide into methane (also referred as CO2 methanation or *Power-to-Gas* (PtG), see equation (1)) allows the storage, distribution and reconversion to power, benefitting from the readily available natural gas infrastructure [1-3].

CO2 + 4 H2 ↔ CH4 + 2 H2O (1) HR° = - 165 kJ mol-1

Up to now, a reduced number of PtG “demo plants” have been appeared in an effort to scale up lab pilots. MINERVE project aims to show the PtG process feasibility via the first French Methanation demo plant. Experiments are carried out to understand the impact of operating parameters such as reactants volumetric flow rate, H2:CO2 ratio, pressure or temperature among others and to find out the optimal condition operation.

**2. Material and Methods**

This study focused in two main parts of the PtG pilot unit (see figure 1). In one hand, the hydrogen production is carried out by a 20kW PEM electrolysis reactor capable of generating up to 2.4 Nm3/h of hydrogen and in the other hand, the catalytic reaction section which converts hydrogen into methane using 2 fixed bed reactors (FBR) functioning in series and a commercial Ni/Al2O3 catalyst. In order to determine reaction performance, an online infrared methane sensor BCP-CH4 is used as well as an on-line multi-component (CH4, CO2, CO, H2 and O2) analyzer. Gas samples are also taken at each reactor outlet and analyzed with an Agilent Technologies 3000A Micro GC.

**3. Results and discussion**

Methanation experiments were carried out at different pressure, temperature, H2 excess and flow rate, and CO2 ratio between the reactors FBR1 and FBR2 (see table 1).

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| Pressure (bar) | Temperature (°C) | Excess of CO2 in  FBR1 and FBR2 (%) | H2 flow rate (NL/min) | CO2 ratio between  FBR1 and FBR2 (%) |
| [1-10] | [280-380] | [0-100] | [10-30] | [0-100] |

**Table 1.** Methanation operating conditions.

Figure 2 illustrates a typical monitoring of methanation. Four steps are identified in the reactor:

* Step 1: Rise of temperature. In this step, the temperature in the reactors reaches the set point. A constant value of H2 flow rate is imposed.
* Step 2: Rise of H2 flow rate. The H2 flow rate reaches the set point with a constant slot equal to 36 (NL/min). The production of methane starts and the temperature increases. The temperature is maintained as constant as possible by playing with the CO2 ratio between both reactors.
* Step 3: Steady State. The H2 flow rate is constant and the production of methane is stable.
* Step 4: End of the reaction.

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| **Figure 1.** Schematic representation of MINERVE PtG pilot unit installed at AFUL Chantrerie, Nantes (France). | **Figure 2.** Methanation monitoring: = 36 (NL/min), P = 5 bar, TR1 = 350°C, TR2 = 380°C, stoichiometric conditions, CO2 ratio = 60%. |

**4. Conclusions and perspectives.**

A CO2 conversion of 90% and a purity of methane equal to 86%vol were achieved in the current conditions. A parametrical study of the pilot unit is in progress to optimize it. The challenging part of the monitoring of the reactor is the control of the exothermicity of the reaction.

**References [Calibri 10]**

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