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Successful testing of Pd membranes at a 20 Nm^3/h hydrogen production site

M. Saric*[1], Y-C. van Delft[1], A. Salladini[3], G. Iaquaniello[2]
[1]ECN, The Netherlands, [2]Tecnimont KT, Italy, [3]Processi Innovativi, Italy

The last decade has seen an increase of membrane technology research and development. Carbon capture, hydrogen production related technologies and fuel cells applications have expedited research on various types of hydrogen selective membranes leading to successful steps in bringing membrane technology out of the laboratory.

In the last decade ECN gained wide experience in the area of Pd membranes, membrane modules and membrane reactors. The goal is to develop the thinner and cheaper Pd and Pd-alloy membranes with higher permeation rates and stable long-term performance and to integrate these in modules and membrane reactors.

In addition to the membrane research and development, ECN is involved in commercialization of membrane technology as a part of its strategy to increase availability of the membranes and build experience in design and operation of membrane modules under actual process conditions. In the last year ECN has delivered its Hysep® multi–tubular membrane modules to N-GHY and Tecnimont-KT.

In this work we will present the performance of the multi-tubular Hysep® module in the Tecnimont KT's Chieti test site in Italy. The 0.4 m^2 module was integrated in the steam reforming plant with a capacity of 20 Nm^3/h of hydrogen. This plant was designed to investigate on the industrial scale performance of Pd and Pd-alloy membranes.

The membrane was integrated in to separate hydrogen in between two stages of a two-stage natural gas reforming process. The most important benefit this type of integration of a membrane module in the reforming plant is the shift of the equilibrium of steam reforming reaction and enhancing the final product yield. Due to this shift, the operating reactor temperature can be decreased from 850-880 ºC used in conventional plants to 600-650 ºC. As a result the low-temperature heat source can be used for heating of the reactor. Next to that a high-purity hydrogen stream is obtained from the process.

Recent test results show excellent ECN membrane performance. The membrane behaviour was assessed in a range of operating conditions. During the experiments the two most important performance indicators where closely monitored: the flux (or hydrogen yield per m^2 of membrane surface area) and the purity of the product. Both were shown to be high. More importantly, they remained high during the whole experiment which included 600 hours of operation and more than 50 thermal cycles. The average hydrogen permeance was 30 $Nm^3/m^2 \cdot h \cdot bar^{0.5}$ at 430°C, while CO concentration at the permeate side was only in the range of 20 to 40 ppmvol.

The calculated hydrogen purity was 99.95 dry mol % and higher .

This successful result brings this highly energy-efficient hydrogen production technology one step closer to the industrial application.

Keywords: palladium, Steam reforming, hydrogen, selective hydrogen membrane