ECN

Energy research Centre of the Netherlands

HYSEP®

Hydrogen Separation Modules

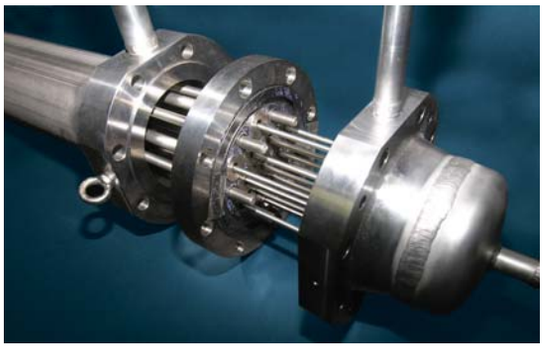
Module Type 1308

Introduction

ECN, a leading research centre in the field of energy innovations introduces a line of thin-film palladium membrane assemblies (or modules) for purposes of evaluation. The modules have been specifically engineered to optimize the extraction of hydrogen from a reformate stream.

ECN delivers these palladium membrane assemblies as complete modules in order to make optimal use of the experience ECN has acquired in handling and sealing of membranes, and in design and construction of the units. The modules can be used to gain experience using thin film hydrogen separation membranes, to verify the performance of the membranes in your specific application, and enable you to benchmark ECN's membranes against alternative methods of hydrogen separation.

The Hysep® 1308 module is the largest module currently offered in the Hysep® product line, and consists of a 13 tube membrane unit with a total area of ~0.5 m^2. It is especially suited for to verify both ECN's thin-film palladium membrane performance and module designs at larger hydrogen fluxes.



Applications

The hydrogen separation module can be used to extract hydrogen from any reformed fuel. This can be an effective means to deliver high quality hydrogen for industrial process gas, for hydrogen fuelling stations or for PEM fuel cells.

Benefits

Quality
- High hydrogen selectivity, high hydrogen recovery possible

Reliability
- No moving parts and therefore reliable (passive operation)

Cost efficient
- Lower Capital Costs. Thin film palladium composite membranes are relatively low cost and allow high hydrogen separation rate per unit membrane area
- Lower operating cost; dramatic reduction in energy use

Flexibility
- Expansion of capacity is straightforward; more membrane modules are added.
- Additional future capacity can easily and cheaply be "designed in" during the first phase of a project
- Small size

Principle of operation

The hydrogen separation module, type 1308, consists of a 316L stainless steel construction, incorporating tubular palladium composite membranes that act as the catalytic/diffusion element. In order to effectively utilize the membranes the hydrogen is brought into contact with the outer surface of the palladium coated ceramic support tube. The thin palladium film acts as a selective barrier, passing only atomic hydrogen through the layer, while excluding other gasses. Molecular hydrogen is adsorbed onto the surface where it is dissociated to become atomic hydrogen. The

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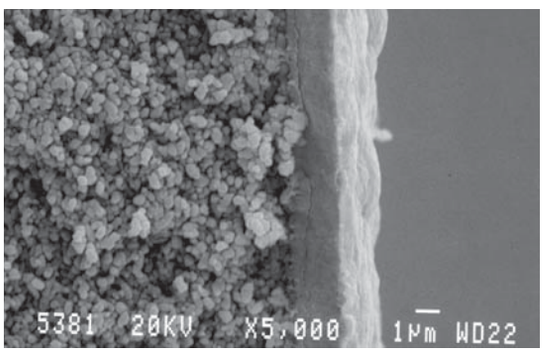
hydrogen diffuses through the layer in a direction determined by the pressure gradient. The hydrogen atom recombines on he low pressure side of the membrane with another hydrogen atom and is desorbed as a hydrogen molecule.

In addition to the separation of hydrogen, the palladium membranes can drive reactions beyond traditional equilibrium levels because the palladium acts as a catalyst. As an example, the membranes can further drive water gas shift reactions for reformats. This membrane configuration may be operated to maximize hydrogen recovery to extremely high levels (>95%).



The Hysep® Technology

ECN has developed the Hysep® technology to enable low cost and reliable hydrogen separation based on thin-film palladium membrane technology. The supported palladium membrane layer in the Hysep® module has a thickness as low as 3-9 microns, a substantial improvement over current commercially available palladium membranes which are based on self-supporting metals foils with a thicknesses of 20-100 µm.

To create these membranes ECN has developed the technology to apply a very thin layer of palladium on a ceramic support tube. The assembly combines the excellent hydrogen selectivity of the palladium layer with the robustness of a ceramic support tube. Focus in all aspects of membrane development is on a low-cost end-product. Using thin layers reduces the amount of palladium on a membrane to a minimum. But because these membranes perform better, at the same time less membrane area will be required which will reduce the amount of palladium even further. Cost is crucial in the selection of the support system and manufacturing steps as well. Although the support tube is a high-tech product requiring unique expertise to manufacture, it is based on low-cost ceramic tubes. In producing membranes based on these tubes only production methods are used which enable scale-up to cost-effective high-volume industrial fabrication.

Key characteristics of the membranes are the hydrogen flux, selectivity and lifetime. These will depend on the specific process, most importantly on the pressure at which the hydrogen containing mixture is available, gas composition and presence of contaminants. Lifetimes of several thousands of hours have been shown under different conditions and purities which can be reached range from 99.5% to 99.995% depending on the initial composition.
The thin palladium layer, combined with the ceramic support tubes on which the Hysep® technology is based, creates a cost-effective and reliable solution to deliver high quality hydrogen.

Specifications

Process specifications[I]
- Reformate feed gas inlet pressure: 2-25 bar
- Operating temperatures: 300°C - 450/480°C

[I] process specifications can be adapted to client demands

Mechanical specifications
- Tubing/cell material: SS 316 (L) and 316Ti
- Outlet connections: Swagelok SS316 flexible tubing or flanges

Capacity
- Standard size[II]: 3.5 - 6 kW
- Hydrogen flow[II]: 3.5 - 6 Nm^3/h

[II] nominal capacity based on reformate with 33% H_2, an inlet pressure of 25 bar and H_2 outlet pressure of 4 bar

Design features
- Both vacuum and sweep gas (N_2 or steam) at H_2 outlet possible

Safety features
- Designed and manufactured according to PED
- Lifetime pressure vessel 10.000 hours of use

Dimensions
- Length: 1 to 1.4m
- Maximum outer diameter: 0.35m

Quality of hydrogen
- 99.5% to 99.995%

Typical utility specifications
- Additional heating required to at least 300°C
- Nitrogen for start-up and cooling down
- Preheated feed
- T-measurement at H_2 outlet for T-control

Further technical benefits

- Easy installation and connections
- English language standard

Additional options available

- Heating and temperature measurement
- Onsite integration
- Service & support agreements
- Training

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