A Thesis for the Degree of Doctor of Philosophy in Engineering

Hydrogen Permeation with Flat Sheet Pd/Ag Membrane for Compact Methanol Steam Reformer

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Graduate School of Science and Technology
Keio University

Mohd Faizal Bin Hasan

Thesis Abstract

No.

Registration Number	☑ "KOU" □ "OTSU" No. *Office use only	Name	MOHD FAIZAL BIN HASAN

Thesis Title:

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Thesis Summary

The performance of a compact methanol steam reformer with a Palladium/Argentum (Pd/Ag) membrane was investigated experimentally. The experiments have been done by changing S/C ratio from 0.8 to 1.6, reference catalyst zone temperature from 589K to 689K and upstream pressure from 0.20MPa to 0.50MPa. The results show that the higher hydrogen permeation rate is obtained when the S/C ratio is around 1 at higher reference temperature and higher pressure. In addition, it is shown that the compact methanol steam reformer with a Pd/Ag membrane is able to produce high purity hydrogen with very low CO contamination, which fulfills the Polymer Electrolyte Fuel Cell (PEFC) requirement (<10ppm). It was found that the experimentally obtained H_2 permeation rate is much lower than the prediction by Sieverts' equation.

The H_2 permeation for flat sheet Pd/Ag membrane was investigated experimentally to make clear the difference between the experimental result and predicted result by Sieverts' equation. H_2:N_2 mixture was used to neglect the surface adsorption effect of non-H_2 species. The results demonstrated that when the feed flow rate is decreased, the H_2 permeation rate decreases, which cannot be predicted by the Sieverts' equation. When the H_2 permeation through the membrane is taken into account for the Sieverts' equation, the variation in the H_2 permeation mole flux as a function of the feed flow rate can be predicted quantitatively. The effect of H_2 permeation is more significant when the feed flow rate is decreased.

The numerical results demonstrate the decrease in H_2 mole fraction towards the membrane surface, that is the concentration polarization occurs, which induces the diffusion of H_2 towards the membrane. It was found that the diffusive effect is more significant when the upstream pressure is increased or binary mixture with higher diffusivity is used.