CHAPTER V
CONCLUSIONS

5.1 Conclusions

Hydrogen permeation tests and surface morphology analysis for carbon steel and Hastelloy tube revealed that:

- The lowest temperature of hydrogen permeation through carbon steel is in the range of $90 \leq T \leq 150$°C and $200 \leq T \leq 250$°C for Hastelloy.
- The desorption rate of hydrogen from carbon steel can be significantly impeded by the presence of an air-formed oxide film on the surface of the steel.
- A palladium coating on the exterior surface of carbon steel gives a higher hydrogen permeation rate.
- A palladium plating on the Hastelloy outside surface has no noticeable effect on hydrogen permeation rate.
- Hastelloy exhibits a lower diffusivity than carbon steel for hydrogen at a comparable temperature of 250°C.
- Hydrogen transport inside metals with palladium coating on the outside surface of carbon steel may be fast enough to provide high hydrogen desorption rates to prevent oversaturated hydrogen concentration which may result in a variety of failures
- The oxide films on carbon steel can be removed by exposure to hydrogen gas at temperature of 325°C for a period of 120 hours.

5.2 Recommendations

Laboratory experiments should be performed to:

- Determine behavior the diffusion of hydrogen through other metal membrane containing different compositions, particularly chromium. The different in composition may be the large effect to hydrogen diffusion. For example,

chromium is a typical additive to form a protective oxide film. The chromium oxide may significantly hinder desorption of hydrogen through a metal.

- Develop coating techniques to provide a good quality film and easily applied. The thickness of coating may be important. The coated layer may act as the barrier layer if it is thick.
- Determine the surface effect of an oxide film by systematically growing films on one or both sides of the metal to better understand the mechanism of hydrogen permeation with the surface barrier.
- Determine the solubility of hydrogen in the steels studied. The more accurate diffusivity is needed the solubility data.
- Demonstrate the ability to determine hydrogen transport through various metals when a gas mixture is present in the system e.g. H_2-H_2S, H_2-HF and H_2-Cl_2.
- Investigate the performance of palladium coating on different metals.
- Determine the diffusivity of deuterium through carbon steel at various temperatures.