



## CHAPTER V

### CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Conclusions

The oxide formation on carbon steel (CS A106B), stainless steel (SS 316) and nickel-alloy (alloy 625) was studied. The conclusions based on the present work are as follow.

##### 5.1.1 Carbon Steel (CS A106B)

The kinetics of oxide formation of CS A106B at 400°C in atmospheric air was studied, the result showed that Hematite ( $\text{Fe}_2\text{O}_3$ ) was formed in all cases and the reaction was controlled by diffusion through the oxide layer. The diffusivity of oxygen through the oxide layer was found to be  $D_{O_2} = 7.05545 \times 10^{-14} \text{ m}^2 / \text{s}$  and the parabolic rate,  $k_p$ , was found to be  $1.089 \times 10^{-17} \text{ m}^2 / \text{s}$ .

The case of oxide formation 400°C in reduced  $\text{O}_2$  concentration was separated into two parts;

For the first set of experiment, the oxide formed on the surfaces exposed for 1 day and 7 days are Hematite ( $\text{Fe}_2\text{O}_3$ ). Magnetite ( $\text{Fe}_3\text{O}_4$ ) was found on 14 days exposure. The kinetics of oxide formation is also controlled by diffusion through the oxide layer. The thicknesses of oxide formed are higher than the prediction and there was not enough oxygen in the cavity to form all the oxide. The reason of this should be because the concentration of oxygen inside the cavity is different from that predicted (i.e. leak in the cavity during the exposure and oxidation before the temperature reach 400°C).

The second part result shows that, the oxide formed are Magnetite ( $\text{Fe}_3\text{O}_4$ ) for the exposure time of 5 hours, 1 day and 7 days, however, some Hematite ( $\text{Fe}_2\text{O}_3$ ) was found at the 5 hours exposure. The kinetics of oxide formation is also controlled by diffusion through the oxide layer. The thickness of oxide formed is lower than the prediction due to the lower oxygen concentration in the cavity (i.e. leak out at the beginning and oxidation before the temperature reach 400°C)

Oxidation of CS A106B was not observed for the 90°C exposure for 14 days.

#### 5.1.2 Stainless Steel (SS 316) and Nickel-alloy (Alloy 625)

Oxide formed on SS 316 and alloy 625 surfaces on for the 400°C exposure, but at a much lower rate compared to oxide formation of CS A106B. The oxide film might form on the surfaces, however, very thin, and more data were required to determine the kinetics.

The oxide on SS 316 was iron oxide and chromium oxide. And the oxide formed on alloy 625 was titanium oxide.

Oxidation of SS 316 was not observed for the 90°C exposure.

## 5.2 Recommendations

The longer exposure time of each material and the various temperatures (i.e. 100°C, 200°C and 300°C) of the exposure should be studied.

The study of oxide formation during the heating step (non-isothermal) should be performed in order to explain the pressure inside the cavity at the beginning step.

The diffusion of hydrogen through oxide films will be further study by the Centre for Nuclear Energy Research (CNER).