CHAPTER I
INTRODUCTION

Due to the increasing of demand in energy consumption, nuclear energy has become one of the important energy sources in many countries. Based on 2002 data from OECD/IEA World Energy Outlook 2004, nuclear energy is the world's third largest source of electricity. Nuclear power generates clean electricity because it does not release greenhouse gases such as SO_2 and NO_X that contribute to global warming other pollutants that cause acid rain.

In the late 1950s, Canada developed the technology for a nuclear generating system, called CANDU (CANada Deuterium Uranium). The CANDU has several unique design features that distinguish it from other nuclear reactors such as using natural uranium as a fuel, high pressure heavy water as a coolant and low pressure heavy water as a moderator. CANDU nuclear reactors have been built to generate a significant part of the electricity energy in Canada and other countries.

Corrosion is a well-known concern for all nuclear plants. Since the feeder pipe cracking and the excessive wall thinning were first discovered in CANDU reactors at Point Lepreau in 1996. Since that time corrosion has become one of the important issues for the continuous operation of CANDU reactors. Subsequent studies have shown that wall thinning occurs in all CANDU outlet feeders.

The wall thinning observed in CANDU reactors has been attributed to "Flow- Accelerated Corrosion (FAC)". FAC is a complex phenomenon that is not fully understood in spite of considerable research by the industry. FAC is most severe in tight bends in carbon steel piping carrying high temperature water at high flow velocities.

Carbon Steel has been the construction material of coolant feeder pipes in CANDU reactors. Under operating conditions, water reacts with the outermost layers of carbon steel, forming an oxide film, mainly magnetite (Fe_3O_4), which reduces the corrosion rate of the steel. Therefore, the stability of this oxide film is important for maintaining the integrity of the feeder pipes.

The operating conditions have an important effect on the magnetite layer formed on the steel surface. Since the temperature rises from 265 °C to 310 °C while flowing through the reactor core resulting in a higher solubility of magnetite. For the outlet feeder pipes an increase of magnetite solubility with temperature leads to under-saturation of the coolant at the reactor outlet. This causes magnetite dissolution into the bulk coolant. The high velocity coolant can also enhance the dissolution of steel by increaseing the mass transfer of iron ions into the coolant and removing the oxide layer by erosion as the coolant velocity increases.

In order to predict the FAC phenomenon, models have been developed. These models are used to predict the thinning rates of outlet feeder pipes at various locations in the reactor. Such models can be used to interpret data from the laboratory and plant and predict the life expectancy of the feeder pipes.

This work characterized the surface properties of the oxide films formed on carbon steel A106Bin high temperature water. The effect of coolant velocity and exposure time on the oxide film properties were studied. There were two sets of experiments – static and flow experiment. The static experiment was used to represent nonflow conditions, 0 m/s coolant velocity, with different exposure times – 15, 20, 30, and 50 days. While the flow condition was for 5-m/s coolant with 15, 38 and 54 days exposure time and high velocity coolant (10 m/s and 20 m/s) sample. Moreover the FAC model developed by researchers at the University of New Brunwick was applied to the experimental conditions of this study.

Visual inspection and surface characterization techniques were used to evaluate the oxide films formed during exposure. The surface image and color were observed by using the first method. The surface and cross-sectional morphology of the oxide films were examined by using Scanning Electron Microscope (SEM). The chemical composition and chemical structure of the oxide films were identified by Energy-Dispersive X-ray Analysis (EDXA) and Raman Spectroscopy, respectively.