Assessment of a Wolsong 1 PHTS Thermalhdyraulic Model based upon Site Data

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Abstract

The heat transport system (HTS) of a CANDU 6 nuclear power plant requires monitoring throughout the plant life for efficient operation of the station. Successful monitoring of a station can identify the timing of preventative maintenance and proper assessment of safety parameters due to changes that have occurred from operation. One of the key components of successful monitoring is the development of a thermalhydraulic plant model of each component in the primary heat transport system. Once this is done, the model can then be assessed and appropriate actions taken.

The first step in developing a plant model is the collection of site data, in particular process measurements, and assessing their accuracy. Quite often, the process of assessing the data and developing the model will indicate potential calibration errors which help staff at the stations to verify the performance of their instrumentation. The next step is the development of the model, in particular the configuration of each component: steam generator, pump, header, feeder, end fitting, and channel.

In this work, the main objective is to assess the current HTS conditions for the Wolsong 1 generating station. This assessment is used to develop a current NUCIRC model for determination of critical channel power calculations and ROP system updates.

The NUCIRC code is a one-dimensional steady state code used to predict flow rates, pressure, temperature, and quality throughout the HTS. Some code features allow the calculation of critical channel powers (channel power at dryout), of channel flow conditions during refuelling operations, and of HTS auxiliary system flows such as purification flows.

Although the NUCIRC code predictions agree fairly well with site data during commissioning of a new plant, use of a commissioning NUCIRC model for an operating plant becomes inappropriate for site date of increasing effective full power days (EFPD). Several phenomena affect the characteristics of the components of the HTS, for example magnetite transport, pressure tube diametral creep, and orifice rounding. These are the effects that need to be considered in developing a current NUCIRC model.

Due to the complexity of developing a model that captures each of these coupled phenomena explicitly, a new methodology was employed to characterize the core. An iterative process between a suite of codes is used in the new methodology to define the HTS model within a prescribed set of aging criteria, thus minimizing the impact of ad-hoc human bias.

For the current Wolsong 1 model, the analysis results indicate that magnetite transport has fouled the steam generators to a significant degree despite the low temperatures observed. The station flow has decreased from the original value by approximately 5%. In spite of pressure tube diametral creep which increases channel flows over time, consideration of the phenomena indicate that the bulk core flow has reduced due to the magnetite and deposition behaviour.