Adaptive Neuro-Fuzzy Inference System (ANFIS) based modelling of incipient steam generator tube rupture diagnosis

Abstract

Steam generators are one of the primary barriers in pressurized water reactors that play a critical safety role in separating the non-radioactive and the radioactive sides of nuclear power plants. The occurrence of primary to secondary leakage as a result of incipient faults on the tubing could cause a through-wall tube rupture which may lead to the release of undesirable levels of radioactive products into the environment. The efficiency of existing monitoring techniques and models in the detection of incipient faults and the diagnosis of steam generator tubes is a key challenge facing the nuclear industry. This paper bridges this gap by applying an Adaptive Neuro-Fuzzy Inference System (ANFIS) approach that not only has a high sensitivity in the detection of incipient faults but also has superior local interpolation capabilities and high prediction of time series. Data-driven ANFIS models were used to predict uncertain critical parameters that were sensitive to the fault signatures as well as to estimate the severity of ruptures. To evaluate the optimized models, steam generator tube rupture (SGTR) scenarios were simulated in Qinshan I NPP (CNP300 PWR) reactor coolant system using a thermal-hydraulic best estimate code, RELAP5/SCDAP Mod4.0. The parameters estimation efficiencies were evaluated statistically using the mean absolute percentage error (MAPE), coefficient of determination (R2), relative standard deviation (RSD) and visually by residual plots.