System Modeling of Multi-parameter Measurement by Magnetostrictive Sensors to Analyze into In-vessel Phenomenon

Kil Mo Koo[1], Seong Hwan Park[2], Kwang Sik Yoon[3], Soo Min Park[4]

[1]Technical research institute, Technical commissioner, Monitoring & Inspection, Inc. , Republic of Korea, [1]Technical research institute, Universal Monitoring & Inspection, Inc., Republic of Korea, [1]Equipment inspection group, Universal Monitoring & Inspection, Inc. , Republic of Korea, [1]Advanced reactor technology development division, KAERI (Korea Atomic Research Institute), Republic of Korea

For the Fukushima No. 1 nuclear power plants, in order to identify the phenomena associated with the nuclear severe accidents, the demonstration experiments conducted by the KAERI (Korea Atomic Energy Research Institute), according to definition of damage of the reactor pressure vessel, that could be classified into the In -vessel phenomenon to be called TMI accident and the Ex-vessel phenomenon to be called Fukushima accidents. As the EVP (Ex-vessel phenomenon), the melt through is defined as the melt-down in the process of relocation of the melting material when the cooling water in contact with the fuel rod in the reactor leaks, and then the fuel rod is exposed to outside air in this phenomenon. As the first concern in the above simulation experiment, it is needed to analyze for the In-vessel phenomenon before the Ex-vessel phenomenon stage, at that time the experimental hemisphere in the chamber appear specially not only various measurement parameters for the temperature condition, vessel thickness change but also physical integrity of the lower subsurface In this paper, it was possible to analyze the internal phenomenon of the reactor pressure vessel before the external vessel phenomenon under severe accident conditions (SAC) of a nuclear power plant (NPP) using only the magnetostrictive ultrasonic method. Here, the magnetostrictive ultrasound method includes various measurement parameters such as high temperature measurement that is called Ultrasonic Thermometer(UT), thickness measurement, and material integrity of the lower subsurface of the test hemisphere as a reactor vessel model in the chamber. As a result, specifically instead of each measurement of the three physical parameters, in this case as a single sensor function, that is possible a multi-parameter measurement system for temperature (T), hemisphere thickness change (Vt), and material integrity (Mi) of the lower subsurface hemisphere, that additionally can be analyzed into ultrasonic signal patterns by material stress like a method of NDT. In that case, the stress change of the torque-induced target causes the magnetization change of the magnetostrictive element in the sensor-test/target system. These changes in magnetization can be measured directly or passively as changes in magnetic permeability μ measured at active excitation/transmission in this field.