Coolant Leak Monitoring using Tunable Diode Laser Absorption Spectroscopy

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1. Introduction

During recent years, leak detection for the coolant leakage monitoring has been constantly developed to achieve an improved sensitivity and a more accuracy. At present, radiation detection, acoustic emission detection, Fourier Transform infrared (FT-IR) spectroscopy, humidity sensor, etc has been used for the detection of a nuclear reactor coolant leakage. Radiation detection has been widely used to provide the more sensitive quantitative detection of heavy water. However, it needs high operation cost and it gives rise to a serious problem of nuclear waste disposal. FT-IR spectroscopy is an excellent analytical method to measure heavy water and is also a non-invasive and non-destructive technique without using any chemical reagents. But its sensitivity is somewhat poor. Acoustic emission detection is possible to continuously detect the leakage of coolant, but it is undetectable the small leak. Therefore, it is strongly required to develop a new additional and analytical method that can measure the leakage of heavy water as a manner with improved sensitivity, more accuracy, no reagent and waste, and minimal operation cost.

Heavy water (D_2O) and light water (H_2O) are essentially utilized as a neutron moderator and coolant in a pressurized heavy water reactor (PHWR) and a pressurized light water reactor (PWR). The laser leak sensor is useful method to continuously monitor the leakage of D_2O in H_2O. Tunable diode laser absorption spectroscopy has a great potential for detection and monitoring of constituents in gas phase. The laser leak sensor using tunable diode laser absorption spectroscopy has a number of important properties, e. g. a high sensitivity and a high selectivity with non-intrusive and remote sensing capabilities. In this presentation the laser leak sensor using tunable diode laser spectroscopy is introduced and some of the representative results of the coolant leakage monitoring experiment are described.

2. Methods and Results

Laser leak senor consists of a delivery pump part, vacuum pump part, multi-pass absorption cell part using tunable diode laser, and detector part. In the

atmosphere the heavy water (D_2O) was completely converted to semi-heavy water (HDO) with a water vapor (H_2O) by isotope exchange reaction. Therefore, it has better monitor a concentration of semi-heavy water instead of a concentration of heavy water in coolant leakage monitoring. The semi-heavy water sample was analyzed by the laser leak sensor with the Tunable Diode Laser Absorption Spectroscopy (TDLAS). The Littman external cavity tunable diode laser (Sacher, Model TEC500-1380) producing wavelengths centered at 1.392 μm with a power of ~ 3mW was used. [5] Figure 1 shows the differential absorption signals of the water vapor measured in the oscilloscope. A monitoring of semi-heavy water in the water vapor was determined by comparing the peak-to-peak ratio of each isotope assigned in the differential signals as shown Figure 1.

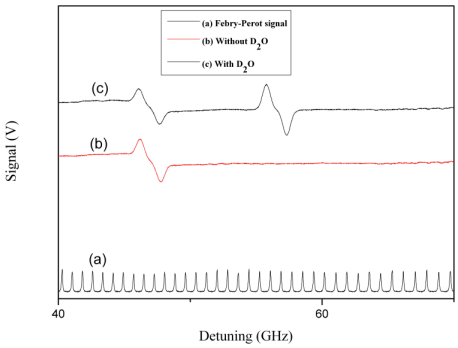

Figure 1. Differential absorption signals of the water vapor. (a) Fabry-Perot signal, (b) with D_2O, (c) without D_2O.

3. Conclusions

The laser leakage sensor for the leak monitoring of D_2O (heavy water) for the nuclear reactor coolant system has been studied. The coolant leakage monitoring using laser leakage sensor has been proved to be an excellent analytical technique to quickly and non-invasively determine a D_2O concentration in H_2O without using any chemical treatments. Since the coolant leak monitoring using laser leakage sensor is possible to finding a location of leak region, it will be possible to repair the coolant leakage in its early stages.

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