Strain Measurement on Water Intake Coarse Grid of Nuclear Power Plant in Ice-covered Region of China: FBG Sensor

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ABSTRACT

Sea ice is the dominant environmental factor to nuclear power plants in ice-covered region, especially for the cold source water intake. In order to monitor the sea ice risk of water intake to the only nuclear power plants in ice-covered region of China, Fiber Bragg Grating (FBG) strain sensors were used to directly measure the water intake coarse grids strain during May 2014 and Feb. 2015. Effective coarse grid strain data was obtained in and out of ice period. Analysis results show that, the impact by submerged floe ice was not measured. This method could be used to monitor the sea ice risk condition of water intake by submerged floe ice, and then contribute to ensure the cold resource safety of nuclear power plant of cold regions during ice period.

KEY WORDS: Nuclear power plant in ice covered region; water intake coarse grid; sea ice risk; strain measurement, Fiber Bragg Grating strain sensor.

INTRODUCTION

Sea ice is the dominant environmental condition in the Bohai Sea of China (Yue and Bi, 1998). For the traditional business, such as oil exploration, harbor and navigation, sea ice action will induce the physical damage on ocean engineering structural (Zhang, et al., 2015), which is the main sea ice risk mode. For the purpose of the safety production during winters, research on sea ice risk mechanics and reduction method, management during ice period had been conducted since 1990’s (Qu, Y., et al, 2006; Yue, Q.J., et al, 2009; Huang, Y. 2010, Zhang, D.Y., et al., 2006; Xu, N. and Yue, QJ, 2011). Nuclear power plant is one of the new kinds of industry in Bohai Rim Economic Circle; therefore the sea ice risk is a new challenge issue. Based on the accident of nuclear power plant (WIKIPEDIA, 2015), the possible influence to cold resource should be the primary issue effect when considering the sea ice risk.

Hong Yan He Nuclear Power Plant (LHNP) is the first nuclear power plant in ice covered region of china, which was under operation on June 2013. While the mechanics for sea ice risk to cold source water intake is not clear. Either there is no recommendation on design or production to prevent sea ice. Water intake is the first position for water supply of cold resource in nuclear power plant. Since water intake is exposed to the natural sea water with low temperature, the sea ice floe or ice accumulation will reduce the effective area of water intake channels. Under distinct low tide level and serious wave, the appearance of submerge floe ice would act on the coarse grid. In one case, the coarse grid will be destroyed by significant ice impact, or the underwater ice block could be formed in the front of coarse impact, and then risk the safety of water intake.

In this case, some field sea ice measurements for ensuring LHNP safety have been conducted since 2012. As direct measurement from submerged floe ice influence to coarse grids, the FBG strain sensors were adopted. Considering the ice condition and structural parameter, the coarse grid strain measurement system was exhibited. The operational transform factor of FBG strain sensor was obtained base on field calibration. Equivalent load on sensor point was calculated based on field measured strain data in and out of ice period, which could be directly used to demonstrate the sea ice risk to LHNP.

MEASURING METHODS FOR SUBMERGED FLOE ICE IMPACT TO WATER INTAKE

There are mainly two kinds of sea ice hazard to water intake channel of nuclear power plant. First, if the submerge floe ice badly impacting on grids plates, the grids will be destroyed and then loss the function of preventing external blockage, such as sea creatures. Second, if the submerge floe ice stayed in the front of the coarse grids, the effective flow area of water intake will decreased significant, which is the most serious risk to cooling water safety.

Based the operational technology about sea ice observation, object tracking and data inversion, there are mainly two methods to measure submerge ice floe action or accumulation of underwater coarse grid: (1) Video by optical measurement. The submerge ice floe accumulation would be measured directly. While the following disadvantage should be considered: limitation and difficulty of construction, stability of optical facility, and the sharpness and accuracy of video, which could be significantly influenced by suspended solids (sediment) and large-scale impurity underwater. (2) Structural response measurement. With high level of technology maturity and of facility miniaturization, this method would be carried out in conveniently.