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Natural safety analysis of the spent fuel residual heat removal in loading and storage process of HTR-10

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Abstract

For the 10 MW High Temperature Gas Cooled Reactor (HTR-10), the residual heat of the spent fuel could be removed by natural ventilation in loading process. The spent fuel storage tank could shield radiation; the outside is covered by an iron sleeve, the spent fuel tank would be stored in atmosphere after fully loaded, and the residual heat could be discharged by natural ventilation in interim storage stage. The calculation showed that, the maximum temperature locates in the middle of the fuel pebble bed in the spent fuel tank in loading process and interim storage stage, and the temperature decrease gradually with radial distance, the temperature in the tank body and sleeve is evenly, it is feasible to remove the residual heat of the spent fuel tank by natural ventilation, and in the natural ventilation condition, the temperature of the spent fuel and the tank is lower than the temperature limit, which provides theoretical evidence for the choice of the residual heat removal method in loading process and interim storage stage.

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Keyword: High Temperature Gas Cooled Reactor; spent fuel; storage tank; loading; interim storage; natural ventilation; numerical calculation

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1. Introduction

After the nuclear accident in Fukushima Japan in March 2011, inherent safety of nuclear power plants has gotten extensively attention worldwide. As a candidate for fourth generation nuclear power reactor, the main feature of High Temperature gas cooled Reactor (HTR) is its inherent safety. For the HTR-10 in China, other than the reactor, the spent fuel storage system also has inherent safety, which is closely related with the nuclear safety.

HTR-10 uses spherical elements as its fuel. The spent fuel elements are transported to the spent fuel storage tank through the fuel handing system after burned out. The spent fuel storage tank is placed on the transport trolley in fuel loading process. There's a steel shielding sleeve on the trolley, which could provide assistant shield to the radiation of the loading tank, so the operators could get close to the tank safely, as shown in figure 1. The residual heat of the spent fuel storage tank could be discharged by forced ventilation driven by blower. Considering the inherent safety of residual heat removal, the residual heat of spent fuel storage tank could be discharged by natural ventilation, which could ensure the safety of residual heat removal during loading process in all conditions. After the spent fuel tank is fully filled with spent fuel, it is transferred to the spent fuel storage area by the transport trolley, and then the tank would be lifted to the ground for interim storage. During interim storage period, the storage tank would be covered by a concrete shielding sleeve, which could provide assistant shield to the radiation of the storage tank, so the operators are able to get close to the tank safely.

Spent fuel elements discharged from the reactor core should be cooled in the discharge tube for about 36 days firstly, and then discharged into the spent fuel loading tank. After fully discharged, the residual heat power of the spent fuel storage tank will decay gradually.

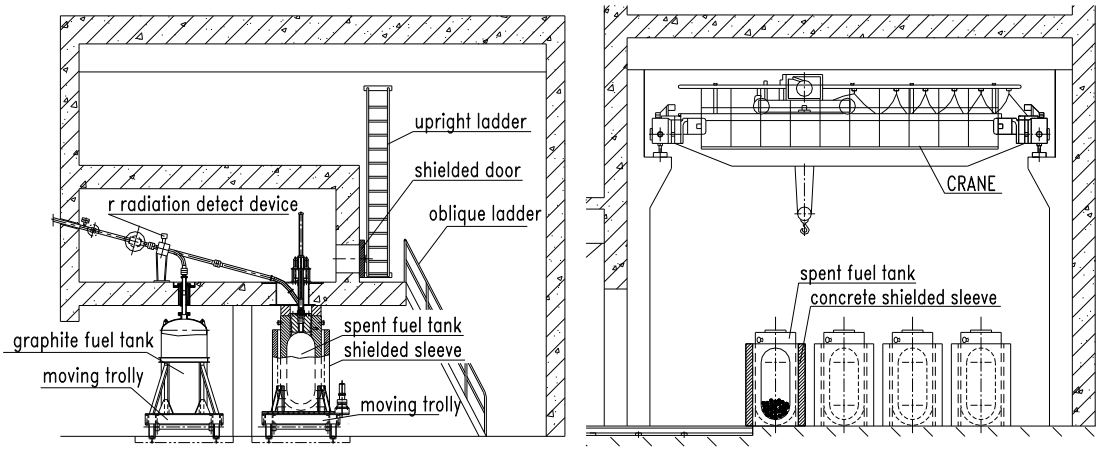

Fig.1. Layout of the spent fuel loading and storage cabin of HTR-10

2. Residual Heat Power of the Spent Fuel Loading Tank

The residual heat power of the spent fuel tank in loading process is shown in Figure 2, which shows that the power increases with the increase of the fuel loaded in the tank. After filled with 2000 spent fuel elements, the maximum residual heat power of the spent fuel storage tank is about 1.9kW.