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ScienceDirect

Procedia Chemistry 21 (2016) 386 – 393

Procedia Chemistry

5th International ATALANTE Conference on Nuclear Chemistry for Sustainable Fuel Cycles

Thermal Analysis of Spent Nuclear Fuels Repository

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Abstract

In the first part, Pressurized Water Reactor (PWR), Very High-Temperature Reactor (VHTR) and Accelerator-Driven Subcritical Reactor System (ADS) spent fuels (SF) were evaluated to the thermal of the spent fuel pool (SFP) without an external cooling system. The goal is to compare the water boiling time of the pool storing different types of spent nuclear fuels. This study used the software Ansys Workbench 16.2 - student version. For the VHTR, two types of fuel were analyzed: (Th,TRU)O_2 and UO_2. This part of the studies were performed for wet storage condition using a single type of SF and decay heat values at times t=0 and t=10 years after the reactor discharge. The Ansys CFX module was used and the results show that the time that water takes to reach the boiling point varies from 2.4 minutes for the case of VHTR-(Th,TRU)O_2 SF at time t=0 year after reactor discharge until 32.4 hours for the case of PWR SF at time t=10 years after the discharge reactor.

The second part of this work consists of modeling a geological repository. Firstly, the temperature evaluation of the spent fuel from a PWR was analyzed. A PWR canister was simulated using the Ansys transient thermal module. Then the temperature of canister could be computed during the time spent on a portion of a geological repository. The mean temperature on the canister surface increased during the first nine years, reaching a plateau at 35.5°C between the tenth and twentieth years after the geological disposal. The idea is to extend this study for the other systems analyzed in the first part. The idea is to include in the study, the spent fuels from VHTR and ADS and to compare the canister behavior using different spent fuels.

Peer-review under responsibility of the organizing committee of ATALANTE 2016

Keywords: *Thermal analysis; Ansys CFX; Ansys transient thermal; Spent fuels; Spent fuel pool; Geological repository.*

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Peer-review under responsibility of the organizing committee of ATALANTE 2016
doi:10.1016/j.proche.2016.10.054

1. Introduction

Considering the insertion of different fuels obtained from different reprocessed techniques, and used in different systems of nuclear power generation, it is important to verify how these spent fuels will behave in the spent fuel pool. In the same way, it is important to verify the impact in the final repository. The idea is to compare the temperature behaviour of the spent fuel pool and geological repository for three nuclear systems: ADS, PWR, and VHTR.

For the pool, the external cooling system was not considered and for the geological repository, only the PWR spent fuel was simulated.

1.1. Spent Fuels types considerations

The enrichment, the initial and final amount of fissile material, the burnup and the operation reactor time considered in this work are listed below:

- PWR: UO_2 enriched to 3.2%. The burnup was 33GW/tHM during three years. The final amount of fissile material is 1.46% [1].
- VHTR:
  1 - UO_2 - enriched to 15.5%. The burnup was 90.2 GWd/tHM during three years. The final amount of fissile material is 9.2%.
  2 - $(Th,TRU)O_2$ - this fuel consists mainly of transuranic obtained from UREX+ reprocessed technique containing 15% of the fissile material. The burnup was 97.80 GWd/tHM during three years. The final amount of fissile material is 8.05% [2].
- ADS: $(Th,TRU)O_2$ Fuel consists mainly of transuranic obtained from GANEX reprocessed technique containing 12% of the fissile material. The burnup was 237.6 GWd/tHM during 20 years. The final amount of fissile material is 2.04% [3].

The fuel properties listed above determine the decay heat profiles over the time after the reactor discharge. These profiles are essential for specifying the heat sources in thermal analysis, and they are obtained using the ORIGEN2.1 code [4], using the condition specified above. Figure 1 shows the decay heat profile for the SF types considered.

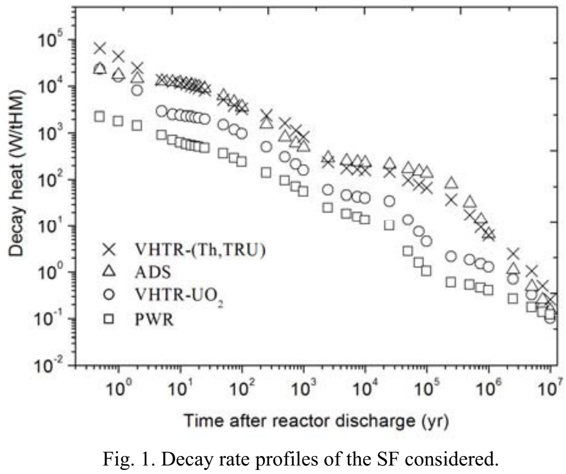

Fig. 1. Decay rate profiles of the SF considered.

2. Description of the models

The Ansys CFX is a fluid dynamics program based on finite elements method [5] and contains powerful geometry tools - the Design Modeler - used to design both SFP and SF. The geometry of SF was performed using the Ansys Cut Material tool, which avoiding SF composition details and their packaging material. This geometrical