Heat Transfer Modelling in a Spent-Fuel Dry Storage System

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The purpose of this paper is to present a numerical modelling of heat transfers in a Spent-Fuel horizontal dry storage. The horizontal dry storage is an interesting issue to momentary store spent fuel containers before the final storage. From a thermal point of view, the cooling of spent fuel container by natural convection is a suitable and inexpensive process but it necessitates to well define the dimensions of the concept due to the difficulty to control the thermal environment.

We focus our study on a horizontal dry storage system which is used in the USA. This system was designed by Nutech Engineers and is utilised in spent-fuel storage installations. Before the use in USA, experimental measurements were realised during a demonstration program with electric heaters to prove the correct thermal behaviour of the module. All the experimental results are listed in a report of EPRI.

The first aim of this study is to compare our numerical results with the experimental measurements in normal performance in order to evaluate the accuracy of our numerical approach and identify and well understand the air flows and the heat transfers in the system. The second aim is to assess the thermal performance of such a system in abnormal performance for air inlet blockages. In both cases, the heat level we have chosen is the highest allowed by the constructor. Indeed we want to know if this system can support high burn-up spent fuel.

The numerical tool we have used is composed by two numerical codes developed by the EDF - Research and Development.. The air flowing by natural convection into the concrete module is tackled by the finite element code N3S. The radiation between the container and the walls of the module and conduction through the walls of the module are handled with Syrthes respectively by a radiosity method and a finite element method. A numerical procedure was defined to deal with the problem coupling radiation; conduction and convection.

Our results are compared with experimental data in normal configuration. A good agreement for different temperature spots is obtained. Based on our numerical results, we can observe the flow pattern, recirculating zones and the hottest temperature areas. When the air inlets are blocked, the temperature of the system increases. However, this elevation is relatively weak due to the fact that one of outlet vents began functioning as an inlet.

To conclude, we have simulated all the heat transfers in a horizontal spent fuel dry storage. By coupling a conduction-radiation code (Syrthes-EDF) and a fluid dynamic code (N3S-EDF) we have a powerful tool to study the cool of such a system. From a physical point of view, it is necessary to ensure a circulation of air in the system to well cool the container whatever the performance. Finally, we are able to improve the design of the interim storage by using 3D simulation.