Stand-alone containment analysis of the Phébus FPT-0 test with the ASTEC V2.1 and the MELCOR v2.2 codes

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Abstract

During the last 40 years, several efforts have been carried out to investigate the different phenomena occurring during a Severe Accident (SA) in a Nuclear Power Plant (NPP). Within this framework, the execution of different experimental campaigns, investigating only specific phenomena or the coupling among two or more phenomena, has been one of the main activity and the integral Phébus FP tests were probably the most important experiences in this field. In these tests, the degradation of a PWR fuel bundle and the related phenomena in the primary circuit and in the containment system were investigated, employing different control rod materials and fuel burn-up levels, in strongly or weakly oxidizing conditions. Such Phébus integral tests were of fundamental importance to understand the key aspects of different phenomena and to develop numerical codes capable to simulate the evolution of a SA in a real NPP.

Two of the main codes international employed (ASTEC and MELCOR) for SA analysis were intensively benchmarked against the experimental data of the different Phébus FP tests. In the latest years, these two codes were furthermore improved, to implement the more recent research findings after the termination of the Phébus experimental campaign, as the several results obtained during the two SARNET projects. Therefore, a continuous verification and validation work is still needed for these codes, to check that the new improvements introduced really allow a better prediction of the different expects of the Phébus tests and of the other tests forming the validation test matrix. The aim of the work presented in this poster is to summarize the activities at the University of Pisa on up-dating the Phébus FPT-0 input decks utilized with the former ASTEC (v2.0) and MELCOR (v2.1) codes to the latter released versions (respectively rev2.1 for ASTEC and v2.2 for MELCOR). This update was performed trying to suppress all the warnings and the non-critical errors that may occur during a calculation. At the same time, these two input-decks were modified to benefit the model advancements introduced in the latest code versions, as the improved film tracking model of MELCOR, and the new ASTEC module to treat the Fission Products (FPs) behavior in the containment. The successive analysis focus on the thermal-hydraulics /aerosol coupling, and only the stand-alone containment aspects of the FPT-0 test have been investigated.

In the former analysis with the precedent code versions, three different spatial nodalizations were employed. The aim was to show that the subdivision of the containment vessel into 15/20 Control Volumes (CVs) is necessary to satisfactorily predict the thermal-hydraulics of the test and the aerosol behavior. In these new analyses, the focus is only on two nodalizations: the simplest one (6 CVs) and the most complex one (21 CVs). The first results obtained show small regressions in both codes, and some strategies to solve/avoid them have been implemented. A comparison with the experimental data on the aerosol behavior in the containment vessel is also performed, to stress the different behavior shown by the two different code versions. As a matter of fact, ASTEC v.2.1 introduces a new module (SOPHAEROS) to treat the aerosol behavior in containment, thus a comparison with the former v.2.0 is of utmost importance to check the differences.

The comparison among the different code versions shows that the newly released ASTEC version (v2.1) pushes forward the capabilities of this SA code. On the contrary, the MELCOR code presents only few advancements, and the main limitations affecting the latest versions are all still in place, as the poor iodine behavior modeling. Nevertheless, the initial choice to update the old input-decks, instead of creating of new input decks, was found to be an opportune choice. With this approach, it was possible to retrace the choices did employing the previous code versions, and to newly evaluate them in the light of the new modelling improvements.

Keywords: ASTEC, MELCOR, Aerosol behavior, containment, Phébus

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