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The Accident Analysis for TMI-2 using MELCOR

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1. Introduction

The object of this study is to perform the analysis of large break loss of coolant accident for Three Mile Island Unit 2 (TMI-2) using MELCOR. To do this, the input was to be made for the Accident Analysis for TMI-2, the analysis of severe accident with inactive ECCS was to be performed. Core Flood Tank (CFT) was only working ECCS, which is similar to Safety Injection Tank (SIT) of SKN 3&4. The delay effect of CFT capacity to the failure time of reactor vessel was evaluated. .

2. Methods and Results

2.1 modeling

TMI-2 was a pressurized water reactor with thermal output of 2772 MWt. The core contained 177 fuel assemblies arranged in a square lattice to approximate the shape of a cylinder. A basic fuel assembly consisted of 208 fuel rods, 16 control rod guide tubes, one instrumentation tube assembly, eight spacer grids, and two end fittings. In this study, the reactor core was modeled radially as 6 rings and divided axially as 20 cells. The reactor coolant system (RCS) consisted of the reactor vessel, two vertical once-through steam generators, four shaft-sealed reactor coolant pumps, an electrically heated pressurizer, and interconnecting piping. The system was arranged with two heat transport loops, each with two pumps and one steam generators. Pumps were simulated using a homologous model built with control function. The pressurizer is represented with a single control volume that in turn connects to the containment volume through the Pilot Operated Relief Valve(PORV) drain line. The PORV is operated by control functions to open at the design set pressure. The core flood system is a passive safety system designed to provide continuity of cooling following a large pipe break. The core flood system is comprised of tanks with are connected via piping to their own nozzles near the top of the reactor. Figure 1 shows the nodalization of MELCOR for the analysis of TMI-2 accident. TMI-2 nodalization was composed of 54 control volumes and 66 flow paths.

2.2 Scenario of Accident

The LBLOCA with the break area of 0.37 ft^2 was assumed to be occurred at hotleg which was located in loop and connected with pressurizer. After LBLOCA, reactor coolant pump, main feedwater pump and auxiliary feedwater pump simultaneously stopped. After 47 seconds since accident occurred, the reactor stopped and decay heat was generated in the reactor core. Active safety injection system such as High Pressure Safety Injection (HPSI) and Low Pressure Safety Injection (LPSI) were assumed to be not working. But Core Flood Tank (CFT), Passive Safety Injection System, would work passively if the pressure of RCS decreased below 600 psig.

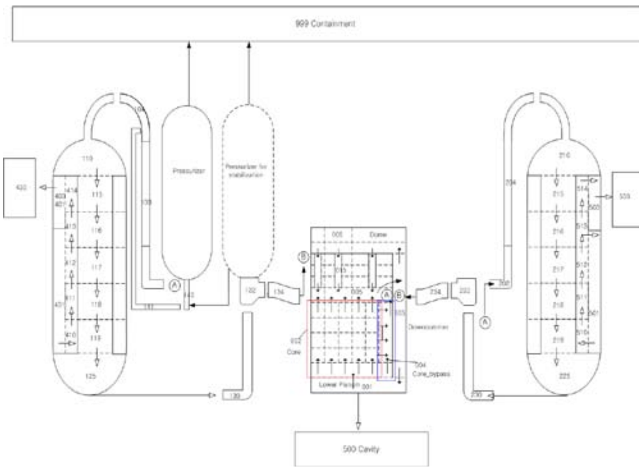

Figure 1. Nodalization for the analysis of TMI-2 accident

2.3 Result

The failure of reactor vessel and late phenomena of core melt are mainly focused in this paper. In MELCOR, the failure of the lower head will occur if the temperature of a penetration (or the temperature of the innermost node of the lower head) reaches a failure temperature specified by the user. 2. In this study, the failure temperature was 1273.15 K, MELCOR default value[1],[4]. Also, the lower head fail can be occurred by overpressure condition or creep rupture due to the mechanical loading in MELCOR, but only the fail by temperature was considered in this study. Figure 2~5 show the temperature profile of lower head and penetration with different CFT cooling water capacities. TMI-2 had two CFTs having cooling water capacity of 29.4m^3. First, this original CFT capacity was tested in figure 2 and 3. A penetration failed at 2,408 seconds since LBLOCA had occurred, but lower head didn't reach the fail temperature yet as shown in Fig. 2 and 3. The cooling water remaining in the lower head prevent the lower head to fail, while the penetration surrounded by the relocated molten corium had not the effect of cooling water in the lower head. Therefore, the temperature of penetration reached the fail temperature faster than that of lower head. Secondly, the CFT capacity of 210m^3 which is similar to SIT capacity of SKN 3&4 was tested in Figure 4 and 5[3]. As shown in Fig. 4 and 5, the penetration 1 failed at 4690 seconds, but lower head didn't fail until 5.000 seconds. The original CFT capacity was very small to earn sufficient operator action time. The CFT capacity similar to SIT capacity of SKN 3&4 could delay the failure time of reactor vessel by about 1,700 seconds.

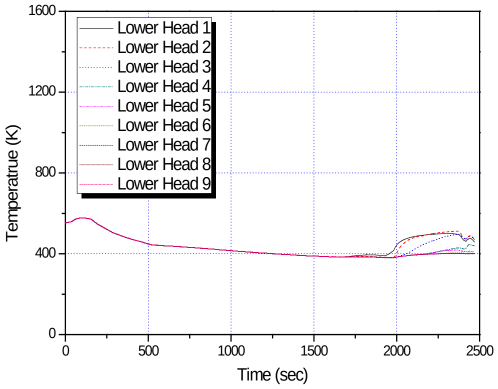

Figure 2. Temperature profile of lower head (CFT cooling water capacity 58.8m^3)

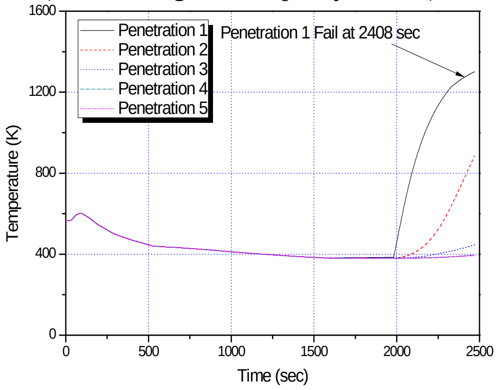

Figure 3. Temperature profile of penetrations (CFT cooling water capacity 58.8m^3)

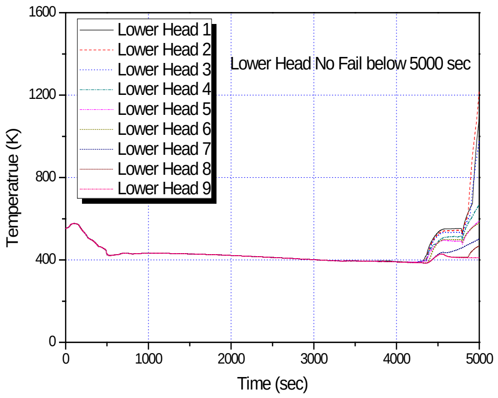

Figure 4. Temperature profile of lower head (CFT cooling water capacity 210m^3)

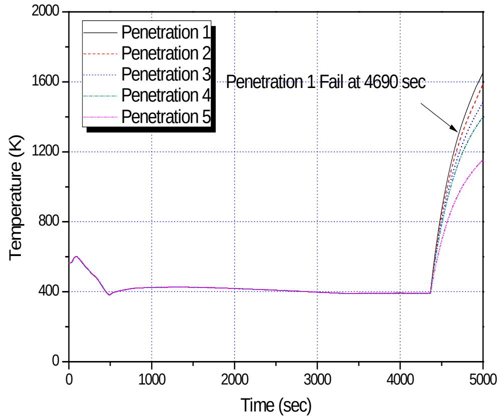

Figure 5. Temperature profile of penetrations (CFT cooling water capacity 210m^3)

3. Conclusion

Using MELCOR, the analysis of LBLOCA with the break area of 0.37m^2 and inactive ECCS was performed. Also, the core damage phenomena and the flooding effect to delay the rupture time of reactor vessel were evaluated. The penetration surrounded by molten corium failed faster than lower head. The CFT capacity similar to SIT capacity of SKN 3&4 compared to the original CFT capacity delayed the failure time of reactor vessel by about 1,700 seconds

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