Calculations of Core Concrete Interaction Using MELCOR 1.8.5

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1. Introduction

OECD/MCCI project is scheduled for 4 years from 2002. 1 to 2005. 12 to perform a series of tests through which the data for cooling the molten core spread out at the reactor cavity and for the long-term CCI (Core Concrete Interaction) are secured.

This paper deals with the transient calculations of the 2-D CCI tests performed under the OECD/MCCI project by using a well-known severe accident analysis code, MELCOR 1.8.5[1]. The CCI test was performed at the rectangular geometry with one ablative bottom wall and two ablative and two non-ablative side walls. Since the MELCOR 1.8.5 can only accommodate a cylindrical geometry, an appropriate scaling methodology was applied to adjust the geometrical difference between the CCI test and the MELCOR calculations.

The default heat transfer models contained in the CORCON-Mod3[2] module of MELCOR 1.8.5 were used for the base case calculation. The key parameters of the CCI phenomena such as the melt temperature, concrete ablation, cavity shape, gas generation, heat transfer rate, etc. were calculated and compared with the test results. In addition, sensitivity studies with the change of the inputs and character variables of MELCOR were also included.

2. CCI Simulations

2.1 Brief Description of CCI Test

As shown in Figure 1, the CCI test facility consists of a test section, a power supply for Direct Electrical Heating (DEH) of the corium, a water supply system, two steam condensation (quench) tanks, a ventilation system to complete filtration and exhaust the off-gases, and a data acquisition system. The test section is about 3.4 m tall with a square internal cross-section of 50 cm x 50 cm. The concrete crucible is located at the bottom of the test section. The test facility can accommodate an axial and radial ablation up to 35 cm.

Temperatures of both the basemat and sidewalls of the test section are measured with multi-junction Type K thermocouple assemblies to determine the 2-D ablation profile as a function of time. Melt generation is achieved through an exothermic chemical reaction and DEH is supplied to the melt to simulate a decay. When 5.5 hrs of operation with DEH continues or the ablation reaches 30 cm, the cavity is flooded using an instrumented water supply system.

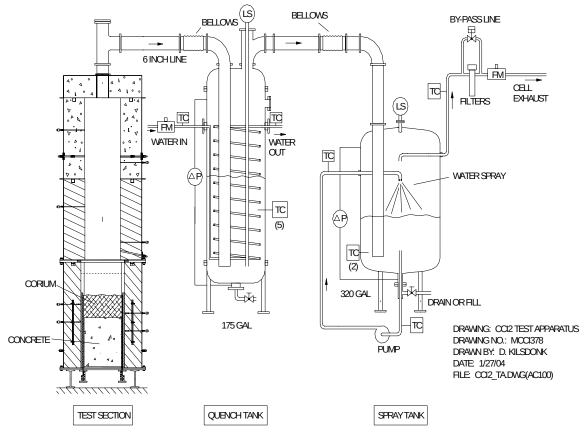

Fig. 1 Schematic of CCI test facility

2.2 Scaling Methodology

Three scaling criteria are applied to determine the equivalent cylindrical geometry for the calculations. The same initial heat flux, the same area ratio of the bottom wall and side wall and the same volume ratio of molten concrete and melt during time dt should be maintained between the test and the calculation. For satisfying the three criteria, the power supplied to the test section and the initial mass are increased π times larger than the test values and the equivalent radius is determined at 0.5m.

2.3 Base Case Calculation

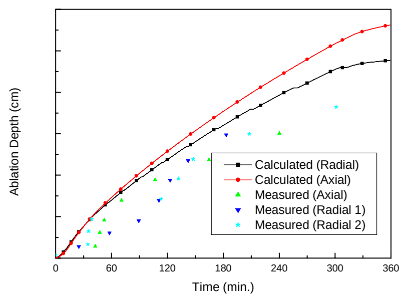

Fig. 2 Comparison of Ablation Depth

Figure 2 shows the ablation depths in the radial and axial directions. The calculated ablation depths generally overestimate the measured values.

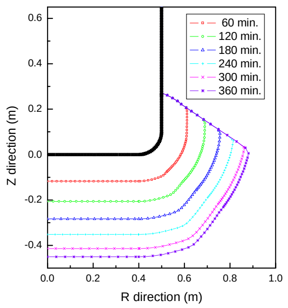

Fig. 3 Concrete Ablation Profile

Figure 3 shows the concrete ablation profiles with a specific time. Initially, the melt is maintained at about 25 cm of the test section. The concrete at the bottom wall is more ablated than the side wall.

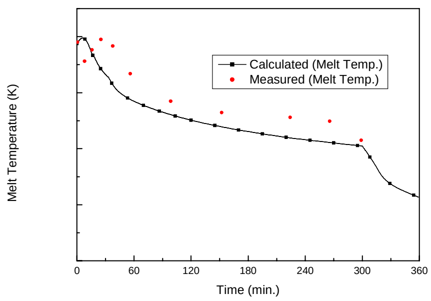

Fig. 4 Comparison of Melt Temperature

Figure 4 shows the melt temperature with time. When the water injection starts, the melt temperature sharply decreases because of a very large heat transfer to the upper coolant. It is generally shown that the calculated melt temperatures underestimate the measured values except for the first few minutes. The reason for the initial decrease of the measured melt temperature is due to the transient heat loss to the crucible.

2.4 Sensitivity Study

In the base case calculation, both the radial and axial ablation depths generally overestimate the measured values. Sensitivity studies were performed to reproduce the CCI test results by adjusting the input parameters and the character variables of the MELCOR code. Efforts were mainly focused on the reproduction of the ablation depths of the concrete.

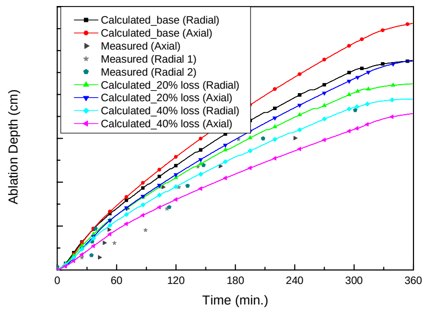

Fig. 5 Ablation Depth with Changing Heat Loss

Figure 5 shows the ablation depths with a change of heat loss. The ablation depth decreases with the increase of heat loss and the axial ablation depth is larger than the radial one. For the reproduction of the test result, an adjustment of the ablations at the beginning stage is still necessary. Various sensitivity studies were performed and compared with the test results.

3. Conclusion

MELCOR calculations of the CCI phenomena were performed and compared with the test results being performed under the OECD/MCCI project. In the base case calculation, both the axial and radial ablation depths overestimate the measured values. On the other hand, the melt temperatures generally underestimate the measured ones. The reproduction calculations for the ablation depths are successful except for the beginning stage where the calculation results overestimate the measured ones. It seems that the probable cause is the less heat transfer from the debris to the atmosphere.

ACKNOWLEDGEMENT

This study was supported by Korea Institute of Science & Technology Evaluation and Planning (KISTEP) and Ministry of Science & Technology (MOST), Korean government, through its National Nuclear Technology Program.

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[2] Bradley, D. R., Gardner, D. R., Brockmann, J. E., and Griffith, R. O., "CORCON-MOD3 User's Manual: An Integrated Computer Model for Analysis of Molten Core-Concrete Interactions", *NUREG/CR-5843, SAND92-0167,* Oct. (1993).