Analysis of the LOFT L2-5 Experiment
Using the 3D Module of the MARS-KS Code

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Introduction

❖ Background

- Thermal-hydraulic system analysis code, MARS-KS has been widely used in nuclear safety analysis.
- Three-dimensional simulation is required for the safety assessment of some components like reactor vessel due to complex multi-dimensional phenomena in those.

❖ MARS-KS 1.5

- MARS-KS has been used as a one-dimensional analysis tool.
- 3D modeling can be performed using "multi-d" component of MARS-KS.

❖ TECPLOT 360

- CFD visualization and analysis tool that can handle large data sets

❖ Scope of the study

Experimental data → TECPLOT 360 → Analysis
(Post processing)

Three-dimensional RV model → MARS → Comparison with experimental data
(Simulation)

Description of LOFT L2-5 Experiment

❖ Loss of Fluid Test (LOFT) L2-5 Experiment

- The LOFT facility is a 50 MWt pressurized water reactor with instrumentation to measure and provide data on the thermal-hydraulic and nuclear conditions throughout the system.
- Experiment L2-5 objectives
  - To determine if early rewet occurs following 200% double-ended cold leg break with immediate RCP trip
  - To determine system and core response during normal ECC reflood following double-ended cold leg break transient
  - To provide data on three-dimensional core thermal response which can be used to evaluate computer code predictions

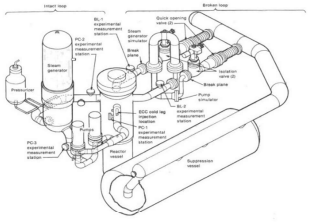

Fig. 1. LOFT system configuration for Experiment L2-5

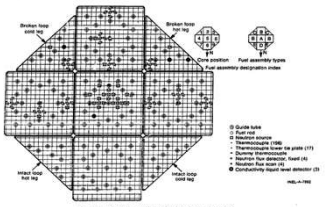

Fig. 2. LOFT core configuration and instrumentation

Analysis of experimental data using TECPLOT 360

❖ Top down quenching phenomena during blowdown period

- The flow in the intact loop hot leg was generally towards the steam generator until 5 seconds. Then the flow reversed, going towards the reactor vessel due to the pump trip and the corresponding flow coastdown..
- The draining of the pressurizer also contributed to the flow from the hot leg to the reactor vessel.
- The cladding temperature at the top of the core began to decrease after LOCA because the water in the intact loop enters the reactor vessel through the hot leg and the heat generation at the top of the fuel rods is relatively small.

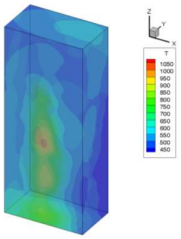

Fig. 3. Temperature distribution at 13 seconds after LOCA

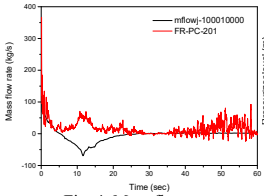

Fig. 4. Mass flow rates in the intact loop hot leg

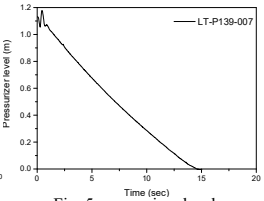

Fig. 5. pressurizer level

❖ Comparison of temperature at top of the core between the broken loop hot leg side and cold leg side during reflood period

- During reflood period, the cladding at the bottom of the core was already quenched by reflooding water. Meanwhile, non-uniform temperature distribution appears at the top of the core.
- The temperature at the broken loop cold leg side is lower and decrease earlier than the temperature at the broken loop hot leg side.
- The time of the rewet at intact loop hot leg side is consistent with the flow reversal in the intact loop hot leg as shown in Fig. 6. The flow reversal caused liquid to drain back into the vessel, rewetting the rods underneath the intact loop hot leg first.

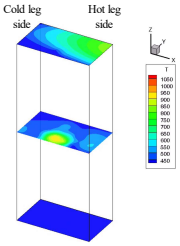

Fig. 5. Temperature distribution at 40 seconds after LOCA

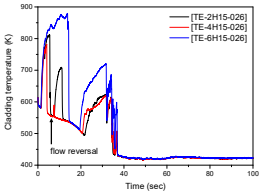

Fig. 6. Measured cladding temperature showing azimuthal effect

Simulation of LOFT L2-5 Experiment using MARS-KS 1.5

❖ Nodalization

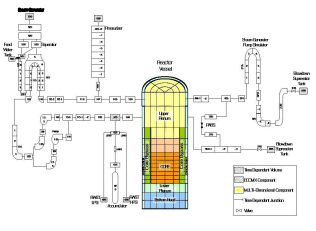

Fig. 7. MARS-KS nodalizations for LOFT

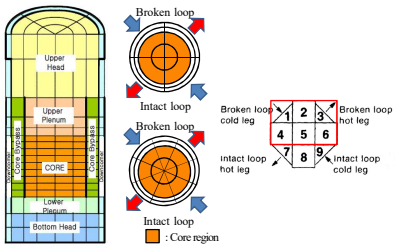

Fig. 8. 3D Modeling for LOFT reactor vessel

❖ Simulation results

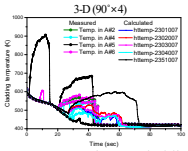

Fig. 9. Cladding temperature - 1.14 m above the bottom of the core

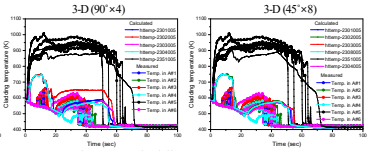

Fig. 10. Cladding temperature - 0.79 m above the bottom of the core

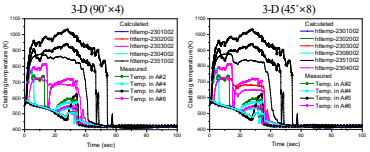

Fig. 11. Cladding temperature – 0.28 m above the bottom of the core

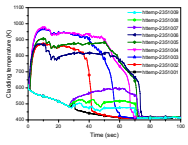

Fig. 12. Cladding temperature according to the axial level

- 3D simulation results show that the temperature of the middle assembly is under-predicted, but the azimuthal non-uniform temperature distribution is well predicted.
- Simulation results show that the temperature at the top of the core begins to decrease without heat up. Also, simulation captures the axial effect that the cladding at the bottom of the core was quenched by reflooding water before the cladding temperature at the top of the core decrease during reflood period.

Conclusion

❖ In this study, multi-dimensional thermal-hydraulic phenomena in the LOFT reactor vessel during the L2-5 experiment are analyzed using TECPLOT 360 and simulated using MARS-KS 1.5.

❖ From these results, it can be said that the "multi-d" component of the MARS-KS code has the capability to analyze the thermal response in the core under the LBLOCA well.