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Prediction of Quenching of Hot Solid Sphere under Uniform Flow with STAR-CCM+

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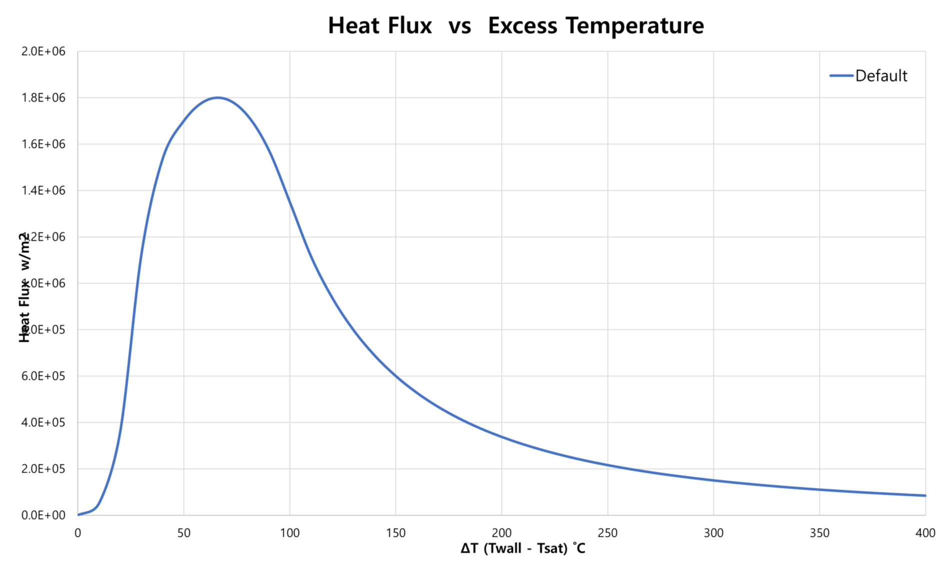
Introduction

- The fuel-coolant interaction (FCI) affects the formation of the corium debris generated in the lower cavity, and the temperature distribution of the debris is determined according to the cooling property.
- Quenching is a phenomena in which unstable vapor film collapses and heat transfer occurs through direct contact between liquid coolant and particles, resulting in a sharp decrease in particle surface temperature.
- In order to simulate the phenomena more accurately, it is very significant to model the heat transfer process in detail.
- As a result, it is necessary to refine the overall heat transfer coefficients, including nucleate boiling, transition boiling, and film boiling.

Physical Modeling

- Volume of Fluid multiphase
- K-ε turbulence
- Two-layer all y+ wall treatment
- Transition boiling model
- Segregated Flow and Multiphase Temperature
- Fig. 1 Boiling curve of STAR-CCM+ built-in transition boiling model provides a correlation including nucleate and transition boiling region.

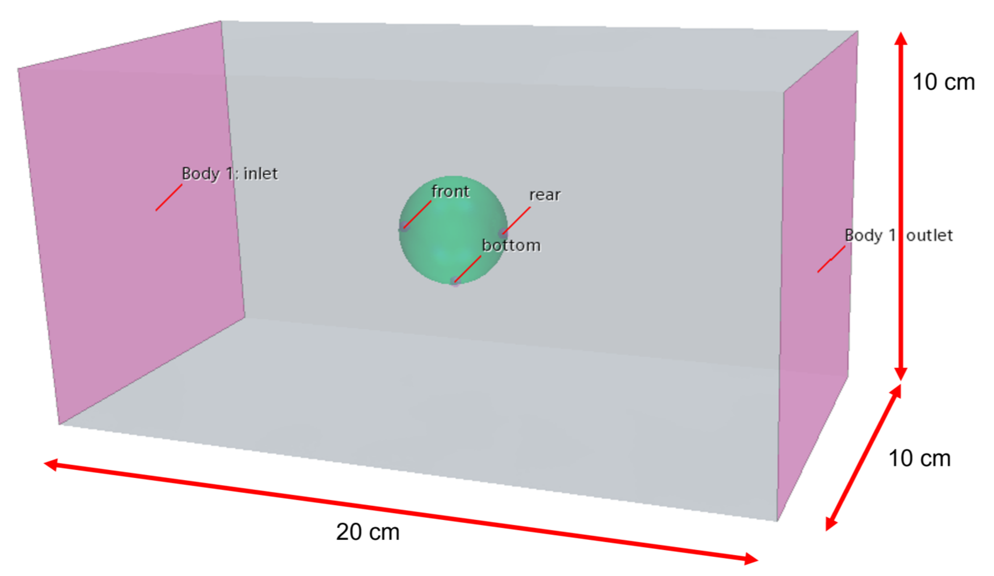


Simulation Methodology

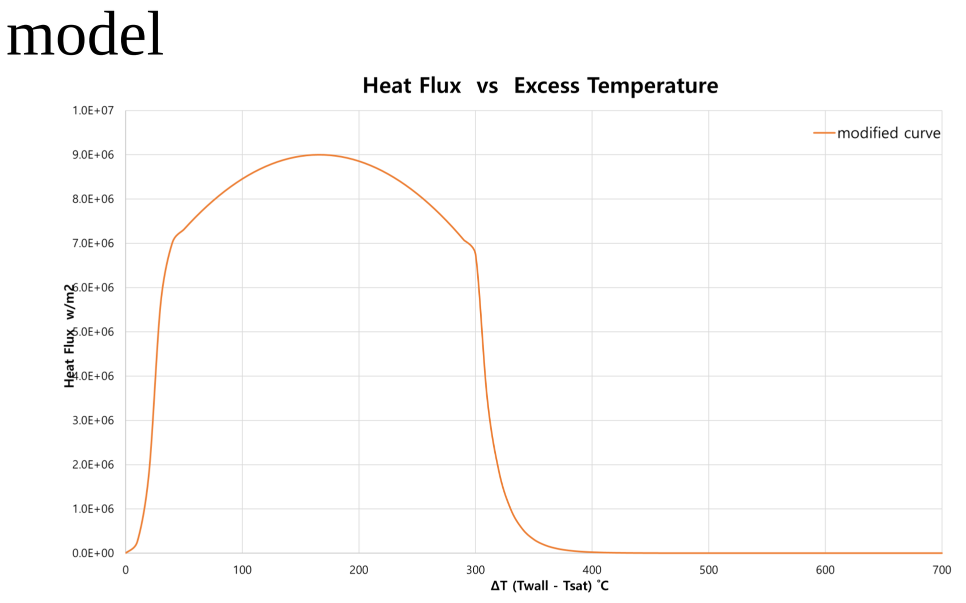
- Table. 1 Initial condition of quenching experiments

Sphere material	Stainless steel
Sphere diameter	3 cm
Initial sphere temp.	800 ℃
Subcooled temp.	35.6 ℃
Flow velocity	0.035 m/s

- Fig. 2 The geometric shape of experimental facility

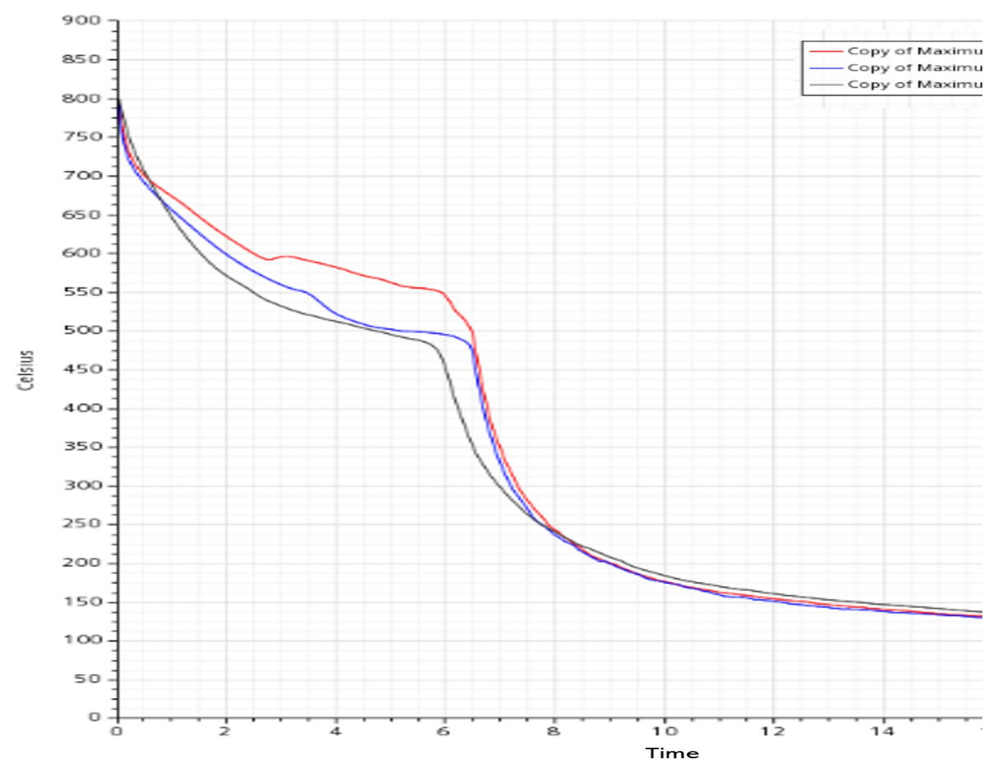


- Fig. 3 Boiling curve of modifying built-in transition boiling model

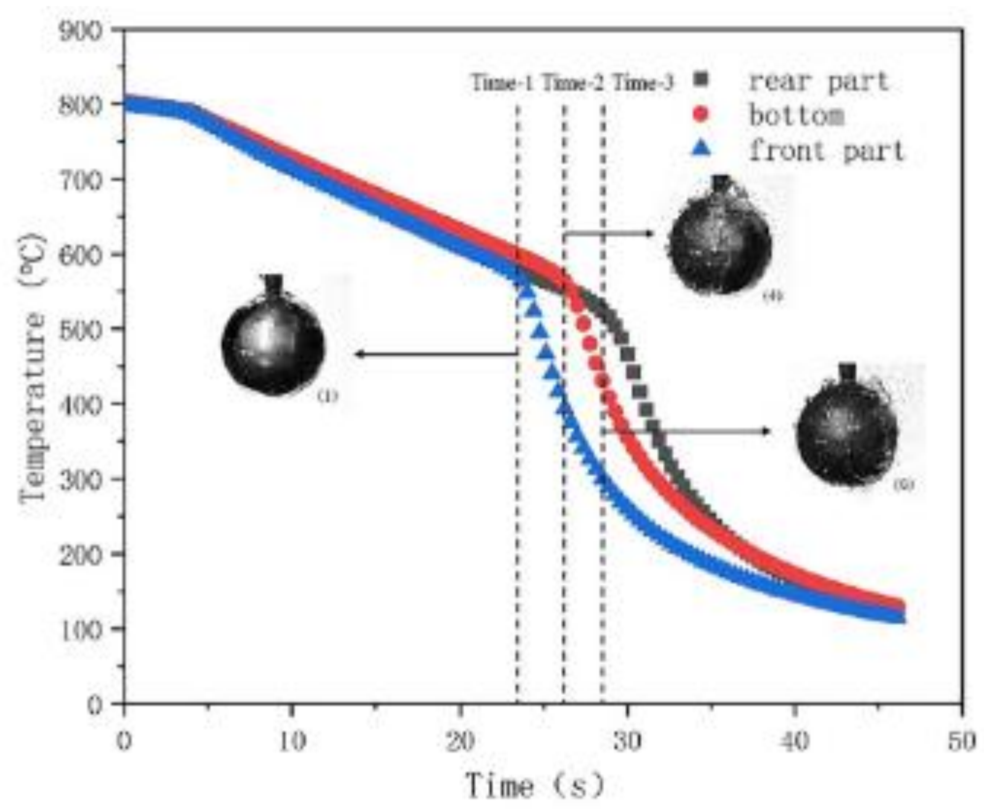


Result

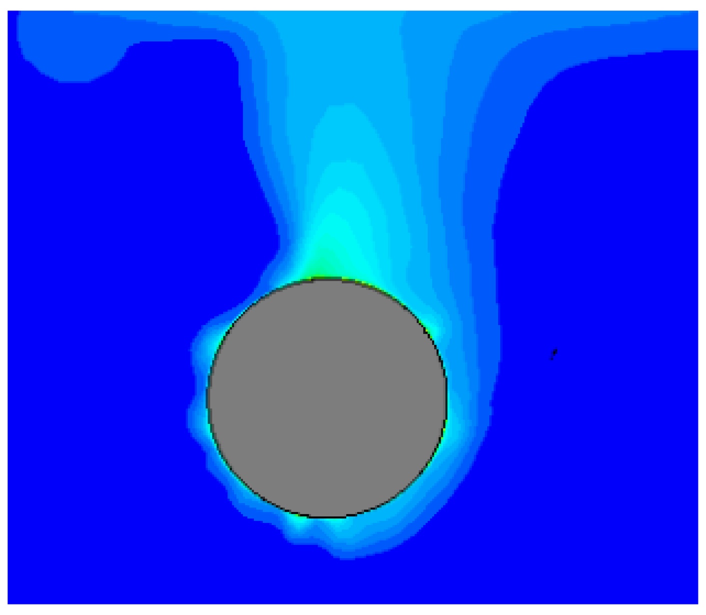
- Fig. 4 Result of simulation graph

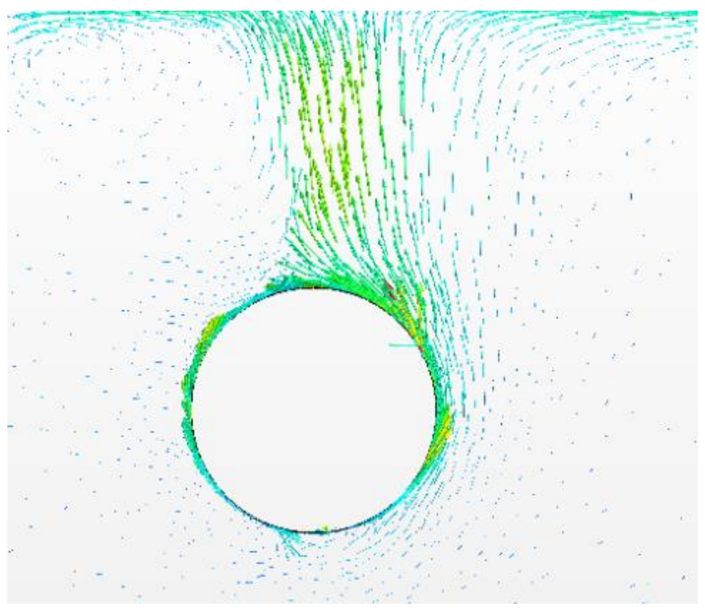


- Fig. 5 Result of quenching experiments



- Fig. 6 Volume fraction of steam scene during the quenching section
- Fig. 7 Velocity vector scene during the quenching section





Conclusion

- Simulations using the modified transition boiling curve show similar results to the experimental results.
- It is very similar to the experiment of vapor film collapse and temperature drop in quenching area.
- Sophisticated overall heat transfer coefficients, including nucleate, transition, and film boiling, will reduce uncertainty in interpreting severe accidents in nuclear power plants.