Rewetting temperature during reflood of a single heated rod in a PWR simulated channel : A comparison of experiment, correlation, and simulation

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Introduction

- ❖ The **rewetting** is a key phenomenon for predicting the cooling behavior of heated fuel rods during reflood in flow channels.
- ❖ Most prior studies attempted to **correlate the rewetting temperature** using **inlet flow condition**.
  - However**, measured rewetting temperature** in Kyung Hee University (KHU) reflood test was **considerably different from the predicted by correlation** in SPACE code.

Objective

- ❖ To clarify the **reason of the disagreement** between the **measured rewetting temperature data** and the **prediction value**
  - **Development and validation** of correlation in the SPACE **were reviewed**.
  - **Numerical simulation** of the KHU reflood test using SPACE code **was conducted**.
  - **Obtained results were compared**.

Literature review and SPACE simulation method

- ❖ In the SPACE code, the **rewetting temperature** is calculated using the correlation developed by **Carbajo (1985)**.
  - Carbajo correlation was **validated using quenching experiments**.
- ❖ The considerable **difference** between the quenching and the reflood experiment is **continuous heating during cooling process**.
  - During reflood test, **vapor is generated** by nucleate boiling **below the quench front**.
- ❖ **Test section was nodalized** including heater rod, flow channel, and Pyrex glass for housing as Fig. 2.
- ❖ Three combination of reflood tests with **different inlet coolant subcooling** and **reflood rate** were simulated and listed at Table. 1.

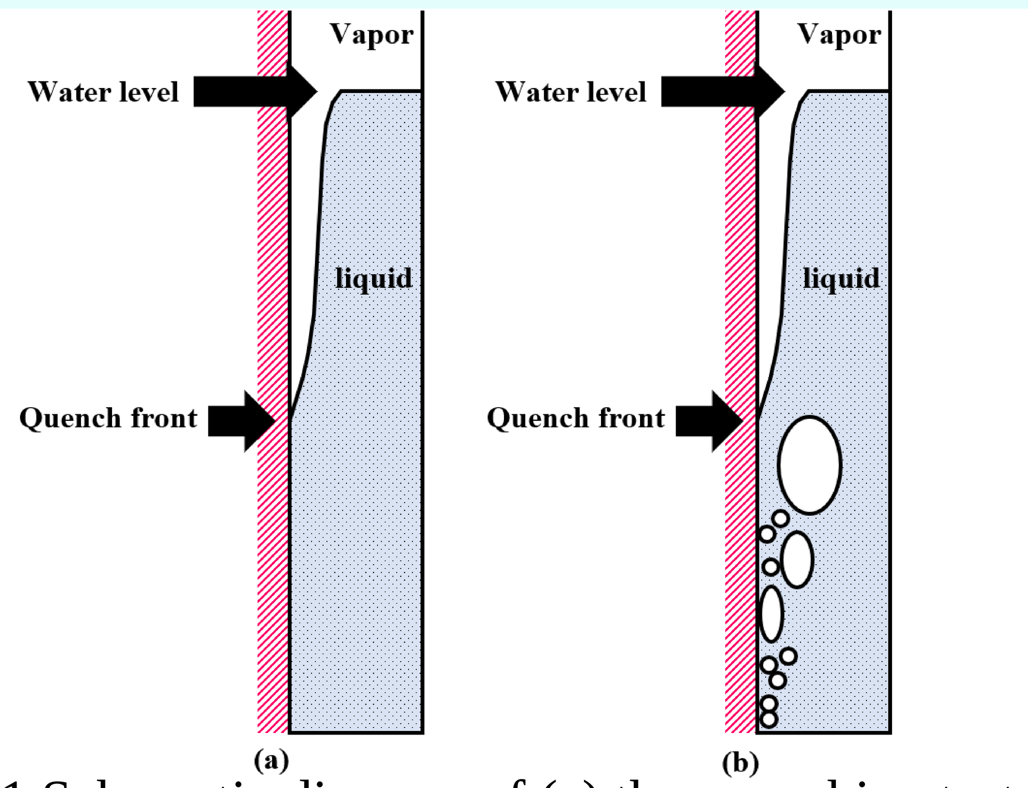

Fig. 1 Schematic diagram of (a) the quenching test and (b) reflood test in cooling period.

Table. 1 Conditions of simulation set corresponding to the flow conditions in the KHU experiments

	Inlet liquid subcooling (°C)	Inlet liquid velocity (mm/s)
V25_S10	10	25
V50_S10	10	50
V50_S30	30	50

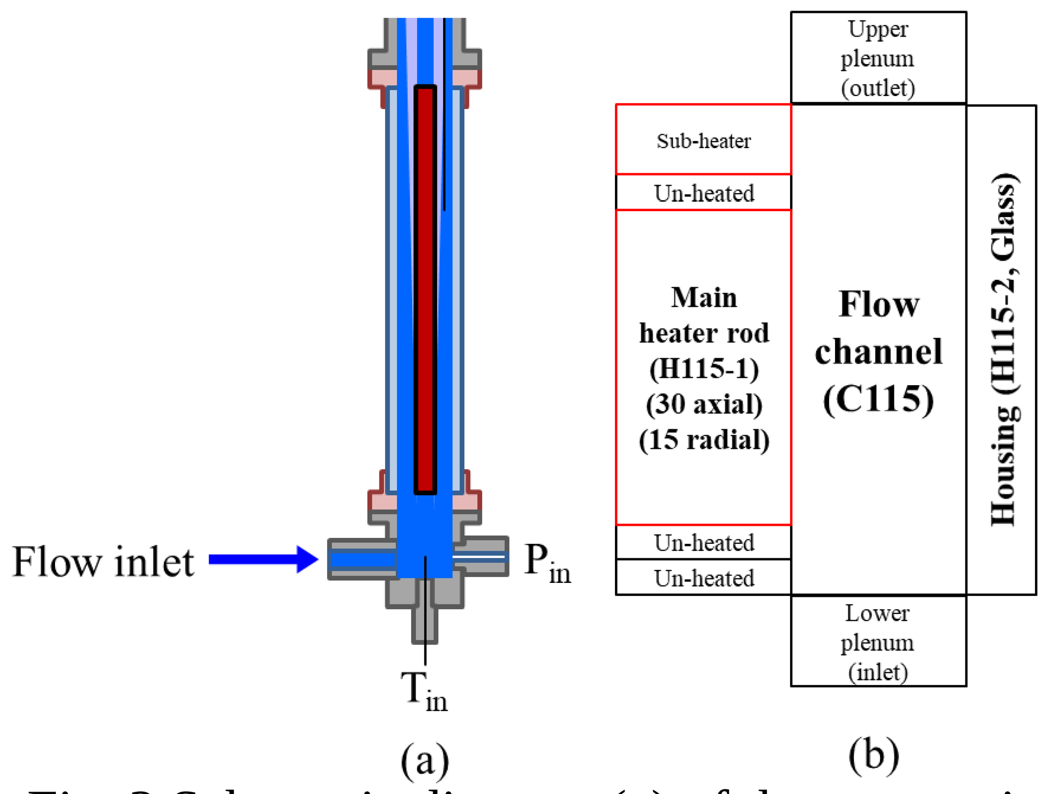

Fig. 2 Schematic diagram (a) of the test section and its nodalization (b) for the SPACE code simulation

Results

- ❖ The **experimental results** were **matched to the simulation results within ±10%** in contrast with predicted **results from Carbajo correlation with inlet flow condition** which were **not matched well**.

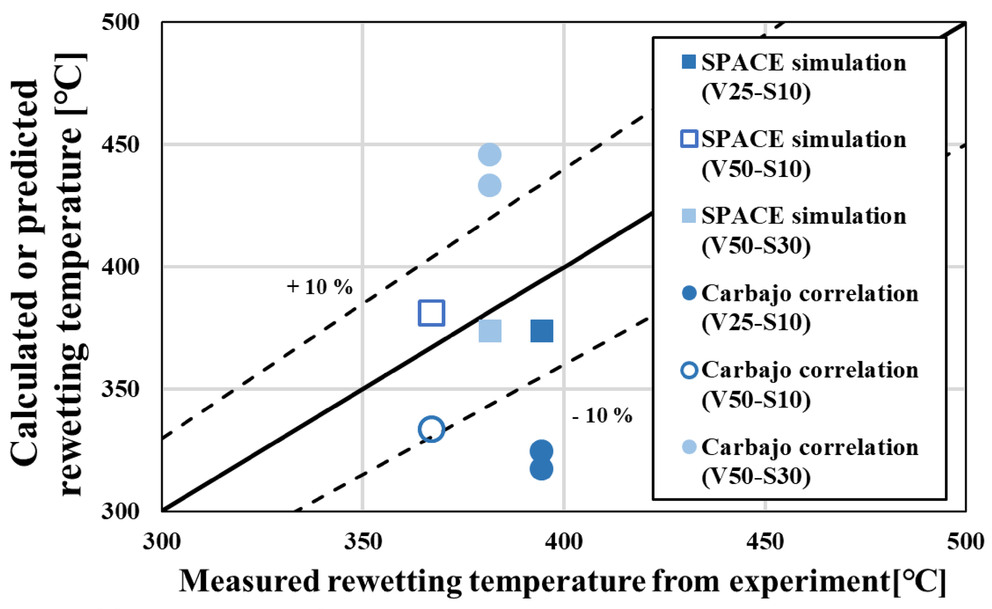

Fig. 3 Difference of rewetting temperature between SPACE simulation and Carbajo correlation from experiments

- ❖ The **flow conditions near the quench front** were **significantly differed** from the **inlet flow condition at reflood test** unlike **quenching test**.

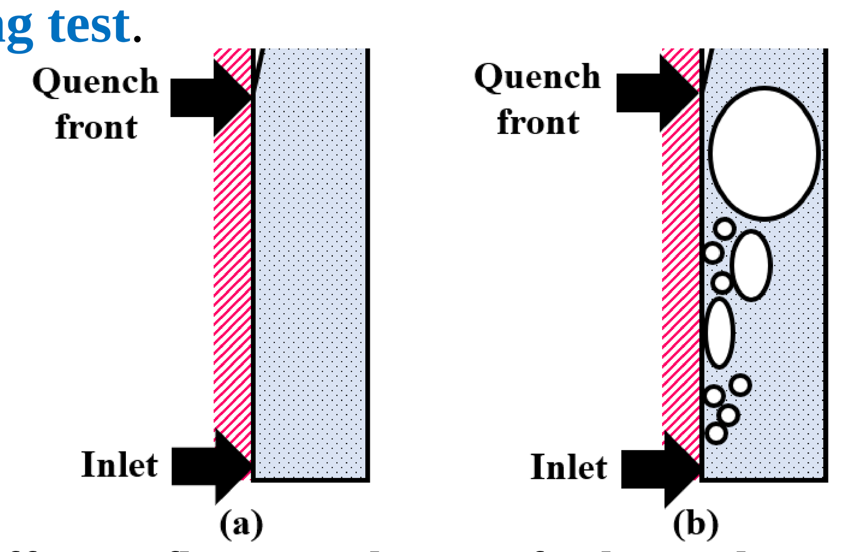

Fig. 4 Different flow condition of inlet and quench front at the (a) quenching test and (b) reflood test

- ❖ A **large increment in the local liquid velocity** was observed by Park (2021) and the **generation of slug bubble was found to be cause** and it was visualized at Fig. 5.

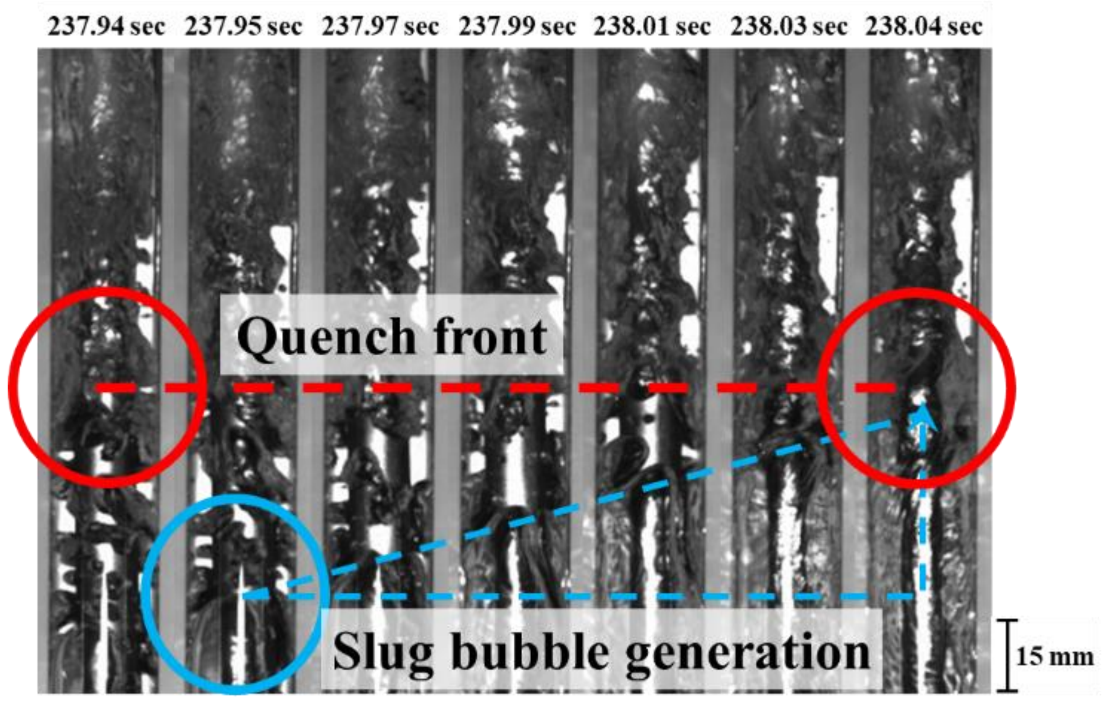

Fig. 5 Visualization of the rapidly rising slug bubble toward the quench front from the bottom of the test heater in the KHU reflood test

- ❖ In the SPACE simulation, **liquid velocity near the quench front is much faster than the inlet velocity in the reflood situation** and it was shown at Table. 2.

Table. 2 Inlet liquid velocity and local liquid velocity at the point of rewetting occurs in H115-1-24-15 node with SPACE simulation

	Inlet liquid velocity (mm/s)	Local liquid velocity at H115-1-24-15 (mm/s)
V25_S10	25	55
V50_S10	50	69
V50_S30	50	62

Conclusion

- ❖ In reflood situation, there are **significant difference of flow conditions** between **quench front and flow inlet**.
- ❖ **Local flow conditions** should be suitably accounted for the **accurate prediction of rewetting temperature using the Carbajo correlation** at the **continuous heating of the heater rod** as reflood situation.

Acknowledgement

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