Experimental Study on the Break Accident for the Negative Pressure Pipe in the Primary Cooling System of a Research Reactor

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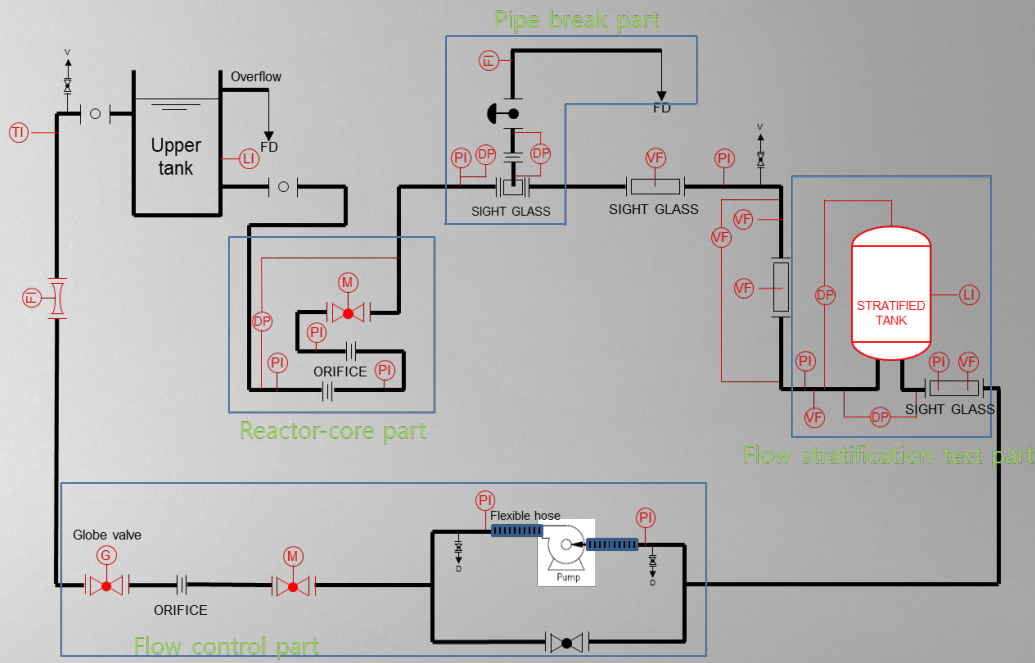
Research Background

- **Negative pressure pipe in the PCS (Primary Cooling System)**
  - Causes
    - Large core pressure drop
    - Piping height for PCS to maintain the pool inventory
  - Maintain a lower pressure than atmospheric pressure in the highest-position pipe
  - Pipe breakage
    - Completely different with LOCA (Loss Of Coolant Accident)
    - The external air inflow is caused by the breakage of the negative pressure pipe, which can lead to the degradation of the performance of the major fluidic devices.
    - Unlike the LOCA accident, there is no accident mitigation devices/systems.
  - Decay tank
    - Used to reduce the N-16 radioactivity in research reactors with its very large volume
    - evaluated whether the air trapping performance of the decay tank is suitable for incident response

Test facility

- **Target facility is the PCS of the medium-powered research reactor designed by this research team.**
- **To implement cooling system experimentally, a three-level scaling method presented by Ishii and Kataoka has been utilized.**
- **Consisted by four parts**
  - Reactor core : two orifices and a flow control valve to impose the core pressure drop
  - Pipe break : an orifice indicating the size of the pipe break, an air operating valve for break operation, and an air flow meter
  - Flow stratification test : decay tank and related measuring instruments to check the behavior of the air-water mixture introduced into the tank and whether air is leaked for a certain period of time
  - Flow control : to form a system flow rate with a pump and a flow control valve



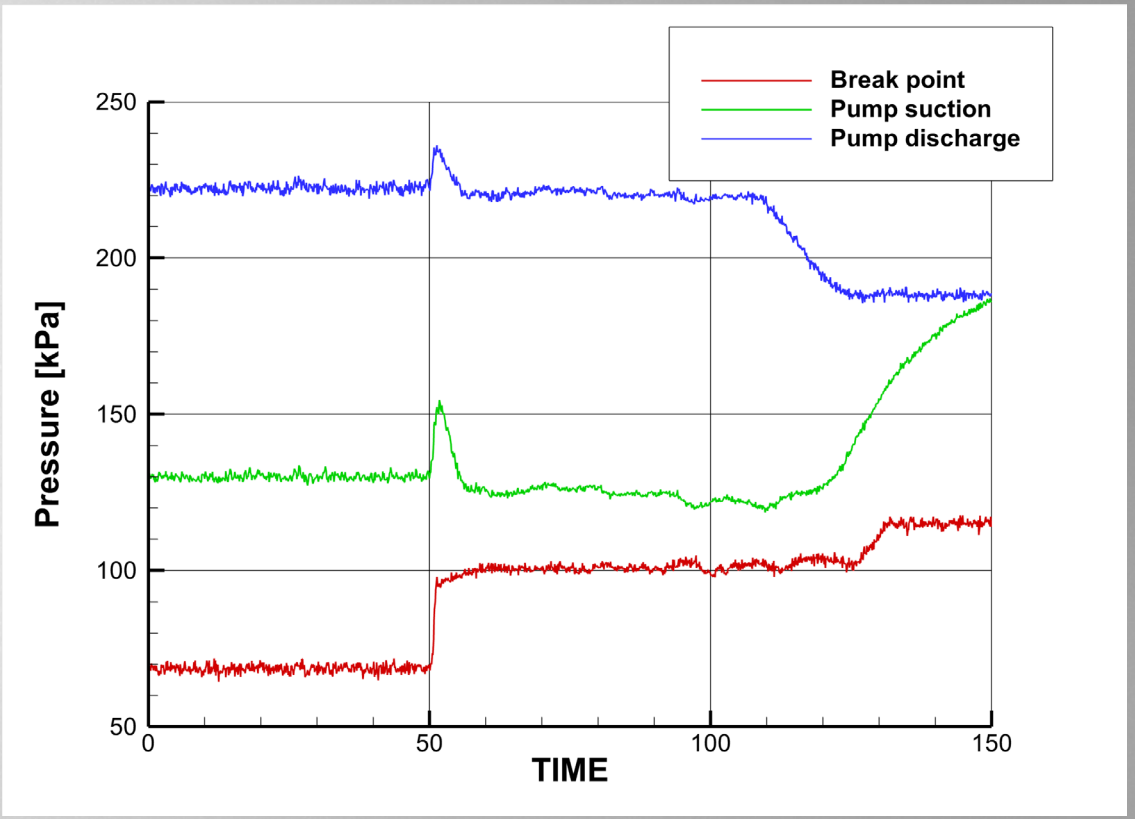
Test Overview

- **Test condition**
  - System flow rate : 40 kg/s
  - Absolute pressure for break point : 70 kPa
  - Break size : ¾ inch based on Dt/4 break criteria

- **Contents to be checked in this study**
  - Check the air inflow rate due to the negative pressure pipe breakage and the air-water mixture behavior in the pipe
  - Observation of air-water stratification in the decay tank
  - Check whether air is leaking through the decay tank outlet

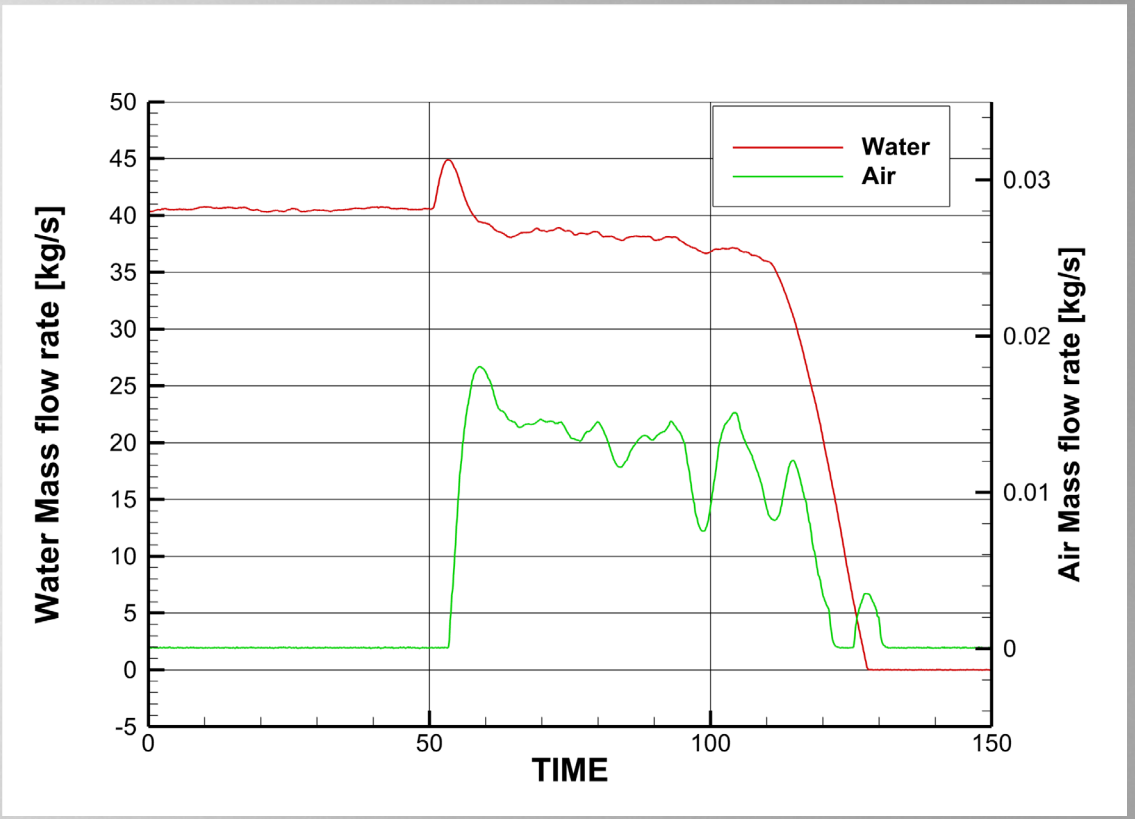
Test Results

- **Pressure change at the break region and the front and rear of the pump**
  - Pressure at the fracture position rapidly rises from negative pressure to about 95 kPa immediately after pipe breakage and then gradually converged to atmospheric pressure.
  - Pressure at the front and rear of the pump tends to decrease again after the initial pressure increase.
  - Differential pressure at the front and rear of the pump decreases after pipe rupture and then gradually increases again.



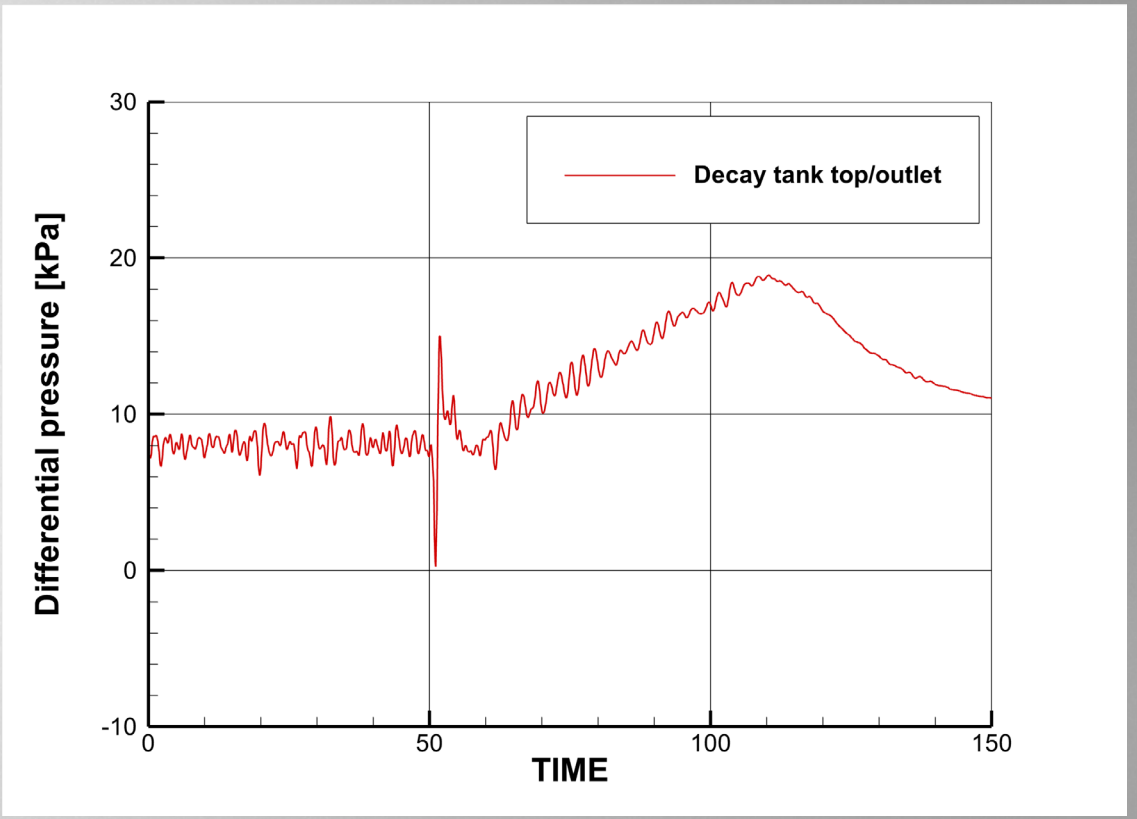
Test Results

- **System flow rate and air inflow rate**
  - Increased to a maximum of 45 kg/s as the differential pressure at the front and rear of the pump decreased after rupture
  - Reduced to about 36 kg/s before the pump stop signal, which can be seen as an effect of the pressure decrease at the front of the pump
  - Air flow rate increased to 0.018 kg/s and then decreased to 0.015 kg/s, and then the flow rate decreased with fluctuations before the pump stop signal.
  - The fluctuation of the air flow rate can be seen as a result of the pressure change due to the fluctuation of the water level in the upper water tank and the air-water interaction at the break position.



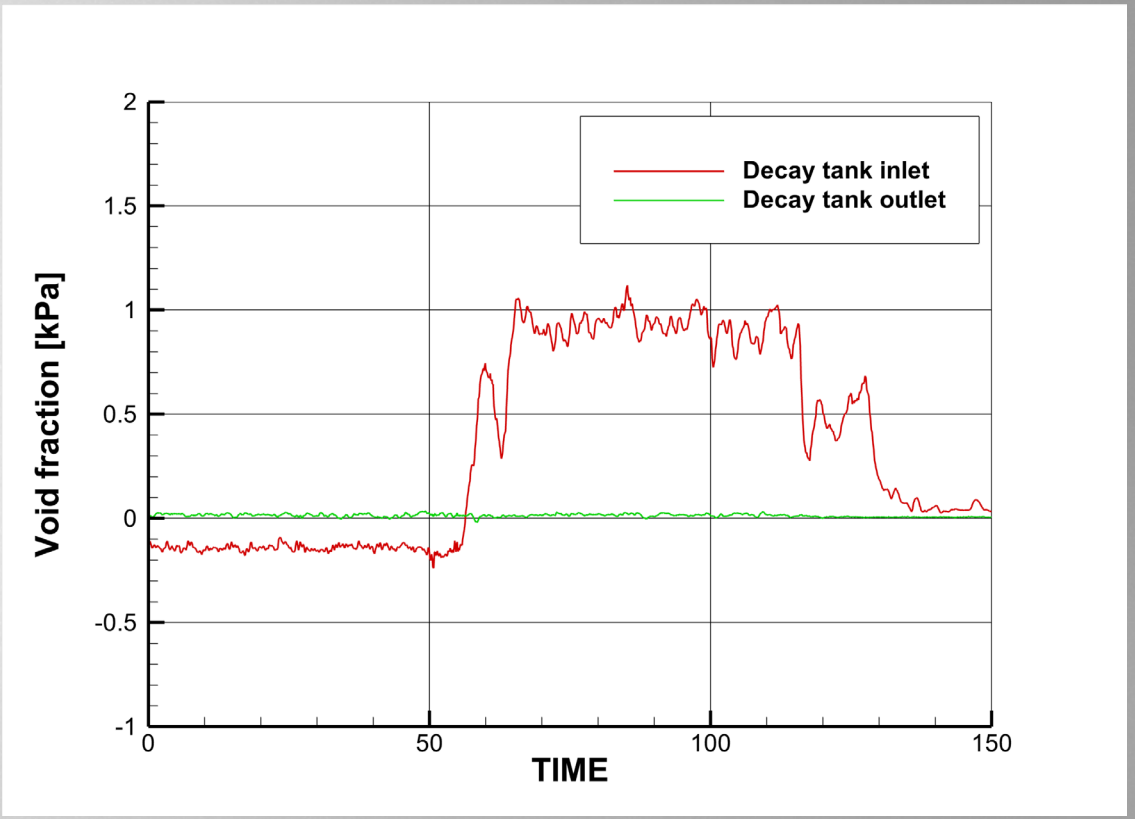
Test Results

- **Differential pressure for decay tank**
  - to observe the differential pressure change of the decay tank due to air inflow
  - maintains about 8 kPa in a steady state, and then vibrates greatly after breakage
  - Air accumulates in the decay tank, the differential pressure of the tank increases.
  - In an air inlet accident, the differential pressure at the top/outlet of the damping tank is evaluated as applicable as a variable for reactor trip.



Test Results

- **Air leakage test at the decay tank outlet**
  - Observation through the visualization window and air fraction measurement using the pipe head were performed.
  - A large differential pressure increases with the air inflow at the decay tank inlet.
  - A significant differential pressure change does not appear at the rear.
  - It can be determined that there is no significant level of air leakage.



Conclusions

- Negative pressure pipe breakage accident was experimentally implemented, and the system behavior according to the accident, the air-water stratification phenomenon in the decay tank, and air leakage to the decay tank outlet was evaluated.
- Air inflow from the break point accumulates due to the air-water stratification in the decay tank, and no significant air leakage was observed.
- Based on the present results, experiments on various experimental variables, such as negative pressure magnitude and fracture area size, will be conducted.

THANK YOU!