Experimental study of negative pressure pipe breakage accidents according to the breakage size

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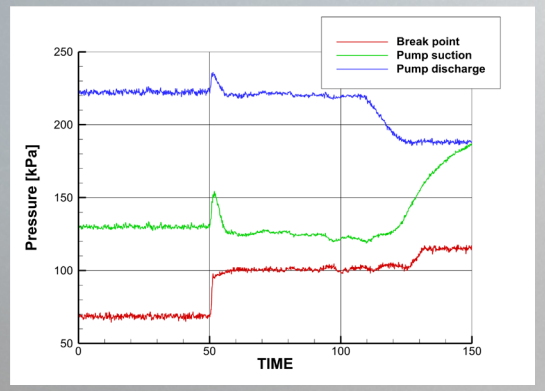
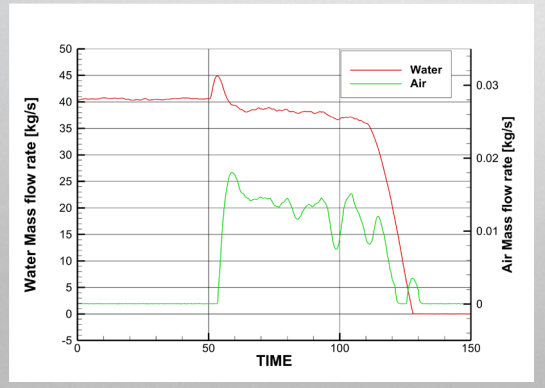
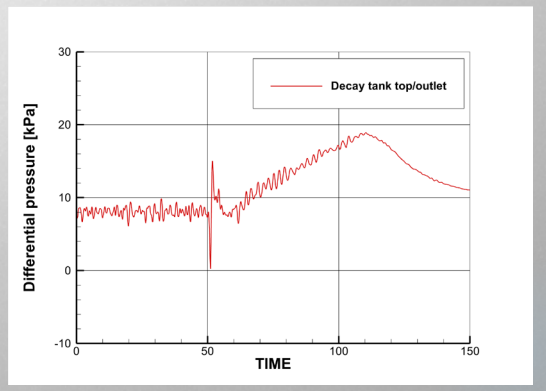
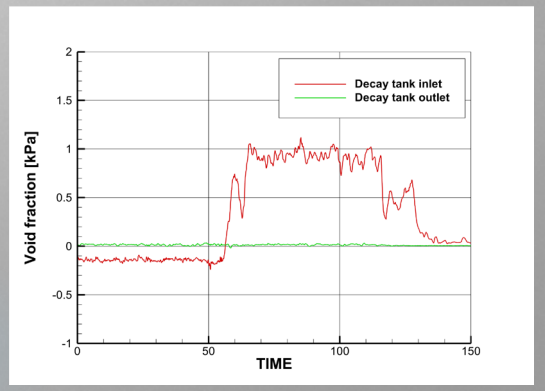
Research Background

- **Previous study**
  - Test condition : 70 kPa @ 40 kg/s with ¾ inch break size
  - 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.
  - 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.
  - Air accumulates in the decay tank, the differential pressure of the tank increases.
  - A significant differential pressure change does not appear at the rear.







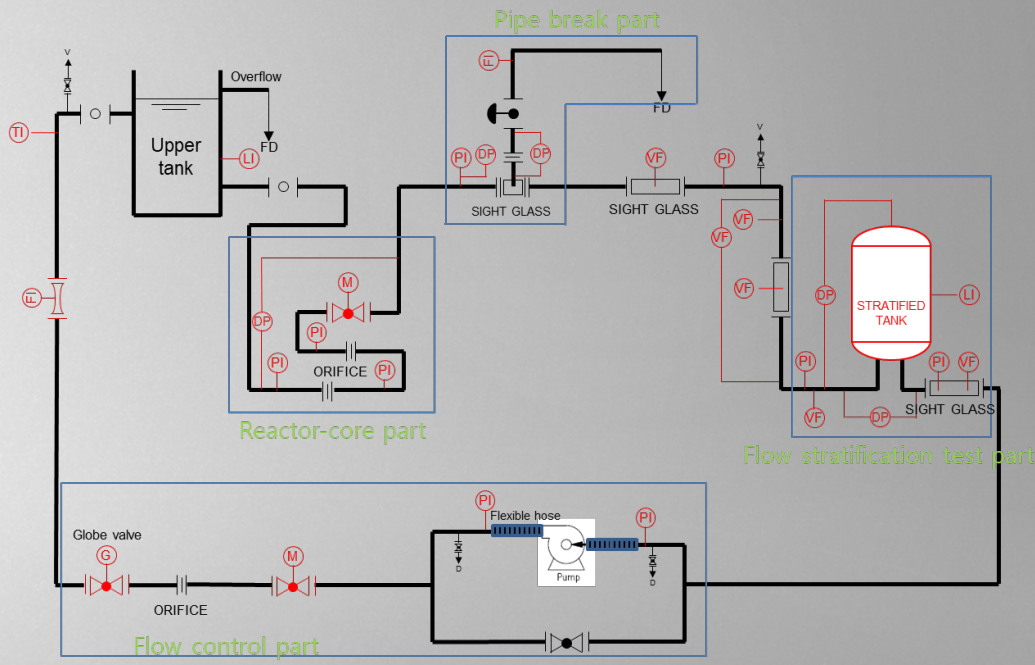


Research Background

- **Experimental major factors**
  - Pipe pressure at the break point
    - Determined by the coolant flow rate and water height between reactor pool top and break point
    - Coolant flow rate has a certain range based on the minimum core cooling flow rate TDF (Thermal Design Flow)
    - As the coolant flow rate increases, the core pressure drop increases, and accordingly, the pipe pressure decreases.
  - Breakage size
    - Determined by the core power, reactor shape, and purpose of the reactor
    - Dt/4 is applied as the breakage size in many research reactors.
    - In the present study, total three (3) cases of 3/4 inch based on Dt/4 and other 1/5 inch and two (2) inch cases were applied.

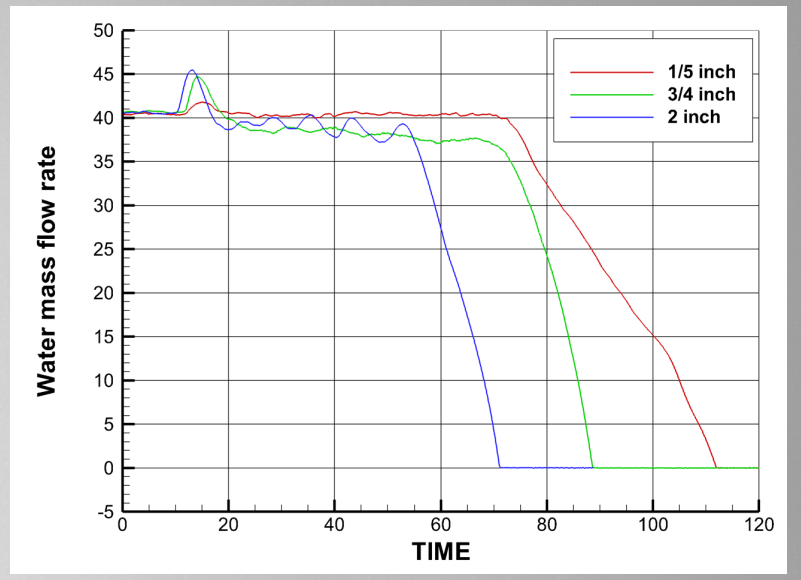
Test facility

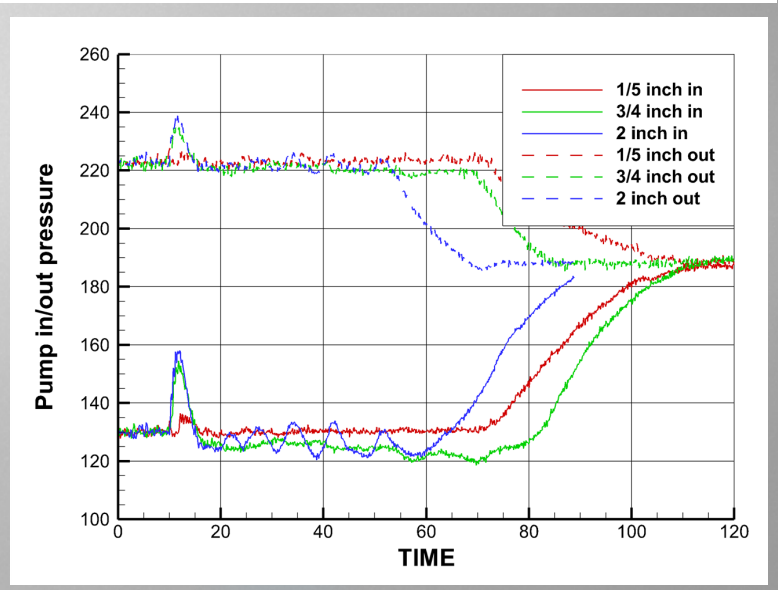
- **Target facility is the PCS of the medium-powered research reactor designed by this research team.**
- **To implement cooling system experimentally, a three-level scaling method presented by Ishii and Kataoka has been utilized.**
- **Consisted by four parts**
  - Reactor core : two orifices and a 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 Results

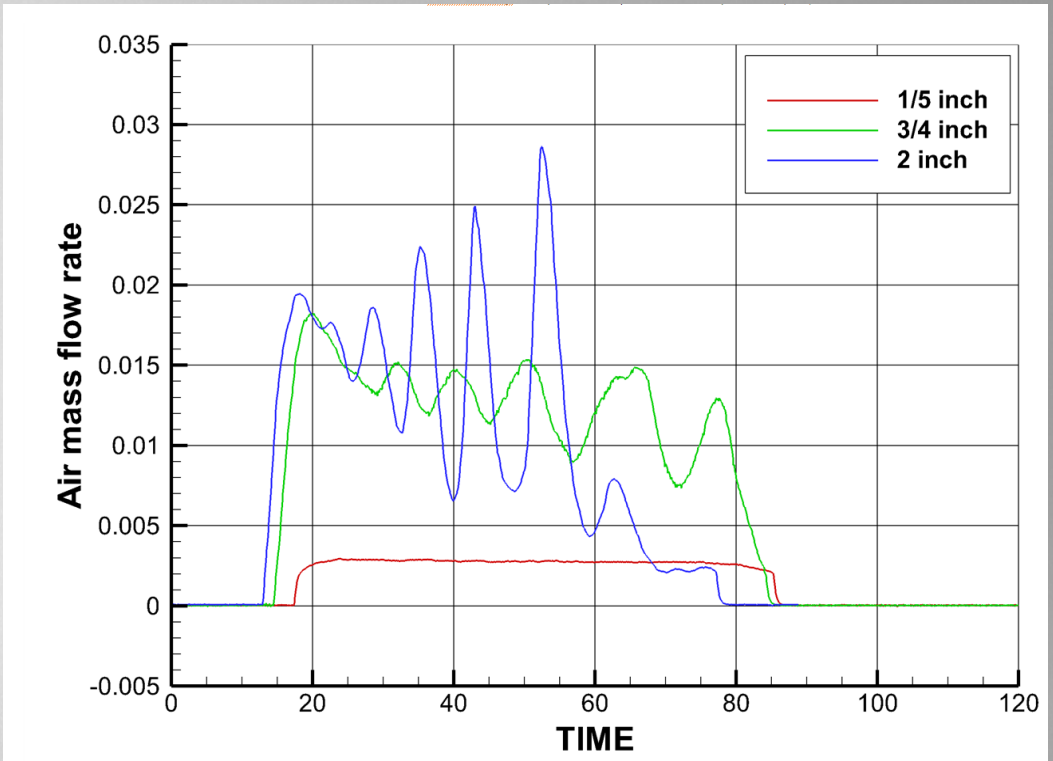
- **Coolant flow rate**
  - In the case of a small breakage size of 1/5 inch, the system pressure change is not large, so the pressure and system flow rate change at the front and rear ends of the pump hardly appear.
  - In 3/4 inch and two (2) inch, the pressure in front of the pump is lowered according to the inflow of air, and accordingly, the system flow rate is reduced.
  - At two (2) inch break, the system flow rate greatly vibrates as the pressure fluctuation in front of the pump is large.





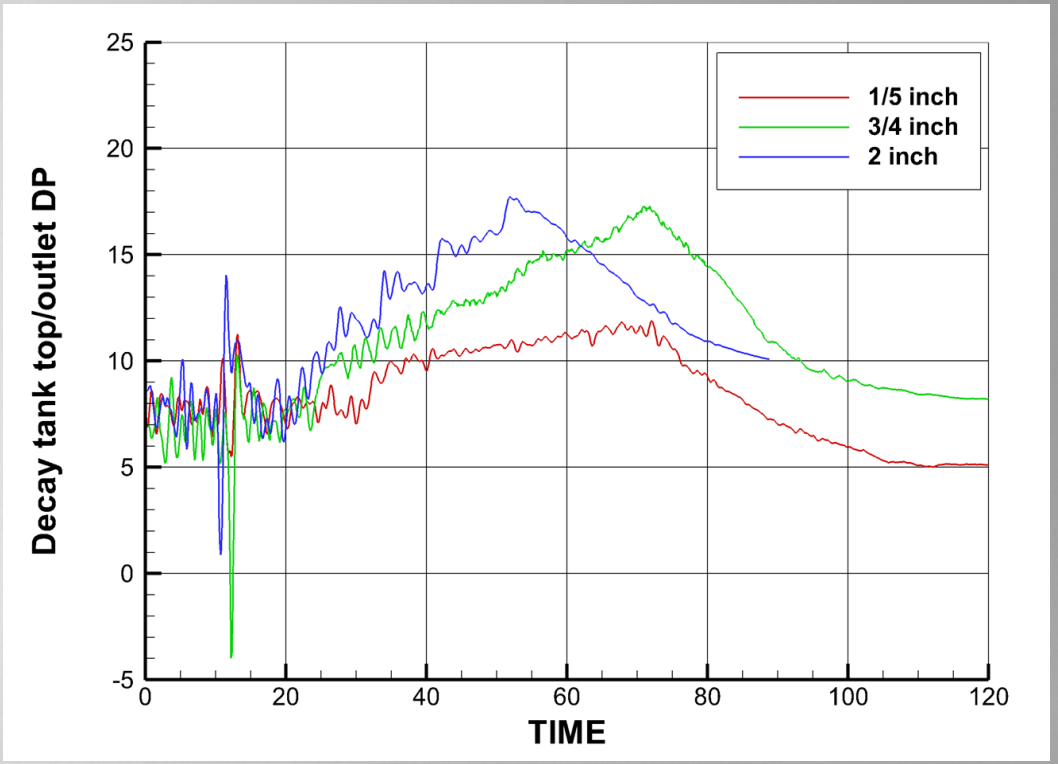
Test Results

- **Air inflow rate**
  - As the breakage size increases, the air inflow increases, but the ascent rate decreases slightly.
  - The average air inflow is estimated to be 0.00046 kg/s at 1/5 inch, 0.00256 kg/s at 3/4 inch, and 0.00288 kg/s at 2 inch.
  - At the break size of two (2) inches, the fluctuation of the air inflows is very large.



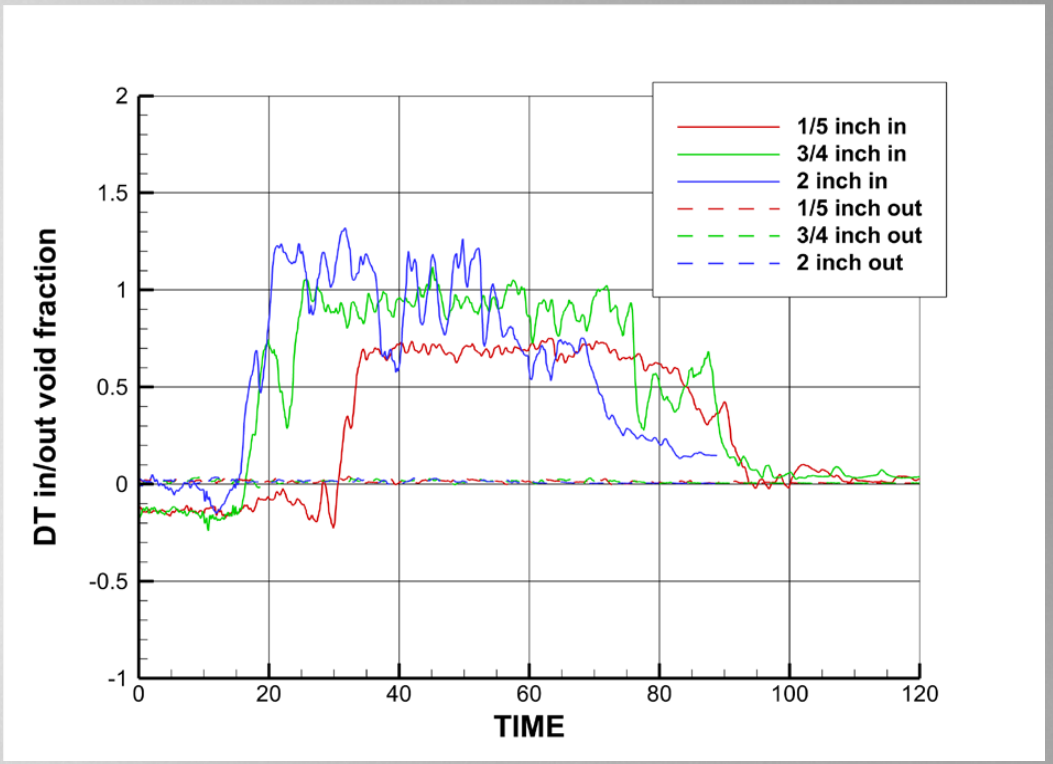
Test Results

- **Differential pressure for decay tank**
  - The larger the breakage size, the larger the gradient of the differential pressure rise.
  - After a pipe breakage accident occurs, the pressure at the break point rises first, then the pressure rise is transmitted to the decay tank and pump. A time difference occurs in the process of transferring the pressure rise, and as s result, it can be seen that the pressure difference of the decay tank fluctuates greatly immediately after the breakage.
  - At the largest 2-inch break, the differential pressure rise appears in the form of a step, which can be seen as a result of the flow of air.



Test Results

- **Air leakage test at the decay tank outlet**
  - shows the air fraction in front and rear of the decay tank to check whether the decay tank outlet air leaks or not
  - The larger the breakage size, the larger the air fraction at the decay tank inlet is confirmed.
  - The result of no air leakage can be seen through the no significant change of air fraction at the rear end of the decay tank, and this was also confirmed through the visualization window.



Conclusions

- The breakage accident of negative pressure pipe according to the breakage size was experimentally studied.
- With a large breakage size, the pressure recovery at the breakage portion is large, and the pump shear pressure rises, and accordingly, the coolant flow rate decreases.
- It was confirmed that as the breakage size increased, the pressure recovery of the breakage size was large, and the air inflow rate also increased.

THANK YOU!