Fundamental Experiment to Investigate the Effect of Steam Spike on Ex-vessel Debris Bed Shape

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1. Introduction

- **SAG-04 in SAMG of Korean PWRs**
  The fourth strategy (SAG-04; Injection into the containment) leads to fill a reactor cavity with water ex-vessel corium falls into the pre-flooded cavity. By the interaction with water, the falling corium would become a lot of solidified particles and then form a debris bed on the bottom of the cavity.
- **Study Topic :** Early phase of the debris bed formation affected by steam spike which spread falling debris far away
- **Purpose :** To Introduce the fundamental experiment for investigating the effect of steam spike on the debris bed shape

2. Experimental Facility

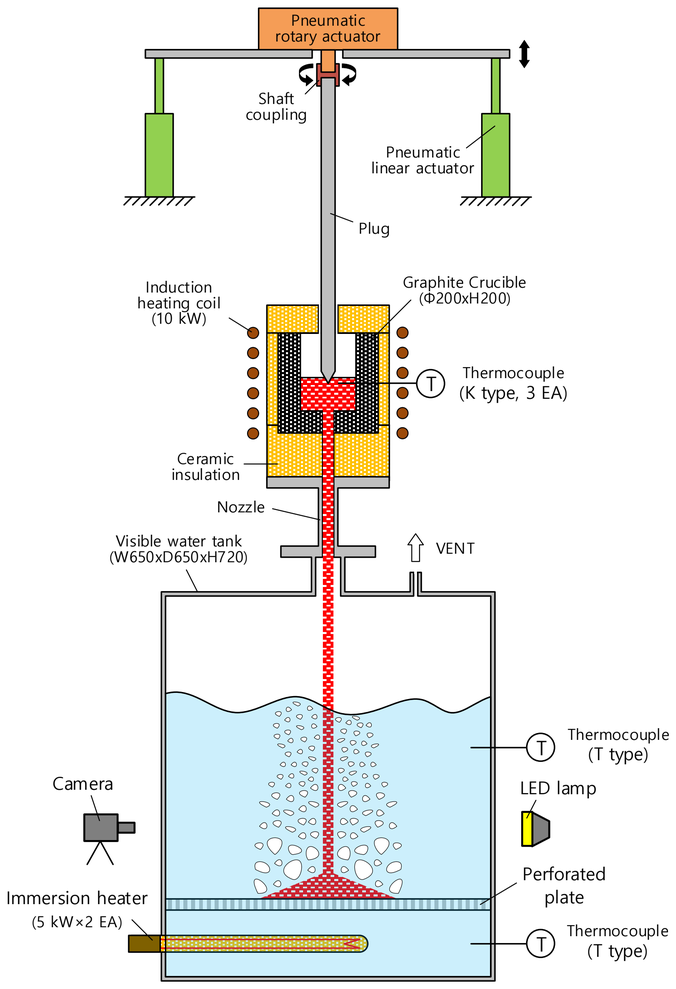

Fig. 1. A schematic design of DEFCON-S

- Fig. 1 shows a schematic design of the experimental facility, so called 'DEFCON-S'
- It was constructed for experiments using about 5 kg stainless-steel simulant particles.
- The graphite crucible which is filled with the particles is heated by induction heating, and heat is transferred from the crucible to the particles by thermal conduction.

Fig. 2. Installation of thermocouples for measuring the temperature of the particles

- In order to confirm the uniformity of temperature in the radial direction, thermocouples are installed in the middle of particle filling such as Fig. 2.
- At each tip of the thermocouples, the particle is welded.
- The pneumatic rotary actuator rotates repeatedly the stainless-steel plug with cogwheel cross section clockwise and counterclockwise to prevent the particles from sintering.
- Operating pneumatic linear actuators upwards, the particles heated up to a certain temperature fall free into the visible water tank through the nozzle which has φ20 mm hole.
- The cuboid tank with polycarbonate windows has the size of 650 mm × 650 mm × 720 mm.
- Stainless-steel perforated plate with a lot of φ0.8 mm holes is installed inside the tank and the falling particles are piled up on the plate.
- Under the plate, there are two immersion heaters to heat water.
- Experiment process is recorded by using camera and LED lamp.

3. Experiment Result

3.1 Experiment Conditions

Table. 1. Experiment conditions

Exp. #	Particle				Water	
	Shape	Size (mm)	Mass (kg)	Temp. (°C)	Level (mm)	Temp. (°C)
#1	Sphere	3	5	12	300	10
#2	Sphere	3	5	700	300	100

- For the base case, Exp. #1 was performed at the unheated condition.
- Water level was based on the perforated plate.

3.2 Heating Process

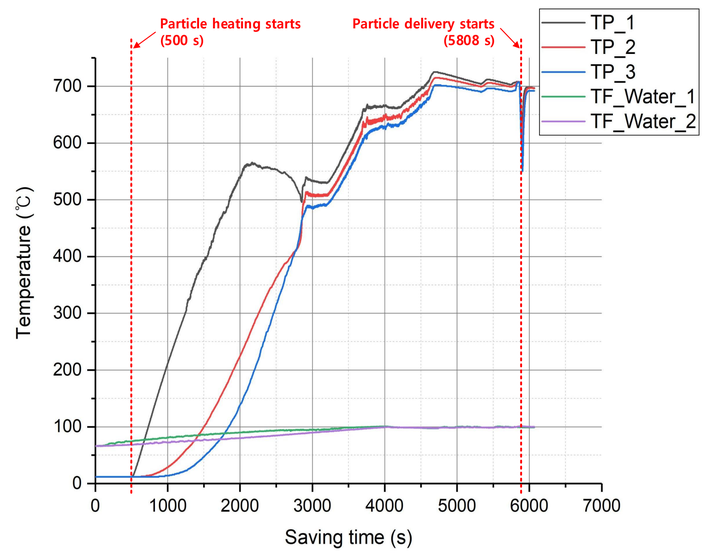

Fig. 3. Water & particles temperature of Exp. #2

- Since heat was transferred from the crucible to the particles, TP_1 was heated first.
- Since the thermocouples remained in the crucible after particles' delivery, the temperature change of the particles by the interaction with water was not measured.

3.3 Delivery Process of Particles

- Fig. 4 shows the delivery process of particles.
- At Exp. #1, the time taken for 5 kg of the particles to be delivered completely was 20 seconds.
- The particles fell into water with air and a few of bubbles were generated.
- At Exp. #2, it was hard to determine the delivery time exactly because a lot of steam bubbles screened the falling particles.
- It took more than about 10 seconds for all the particles to fall on the plate as compared with Exp. #1.
- It was seen that some particles stayed in the water for a while because of a lot of steam bubbles.
- It was also seen that the particles which were pushed away due to the bubbles and fell on the side of perforated plate rolled towards the center due to convection flow of water.

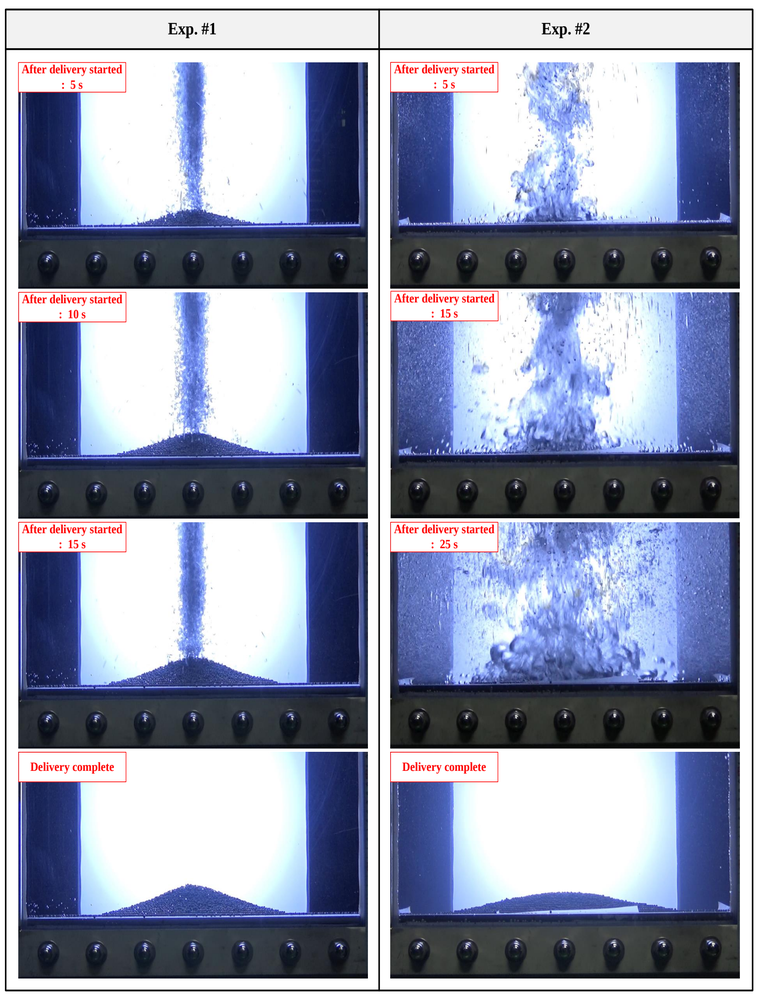

Fig. 4. Delivery process of each experiment

3.4 The Shape of Particle Bed

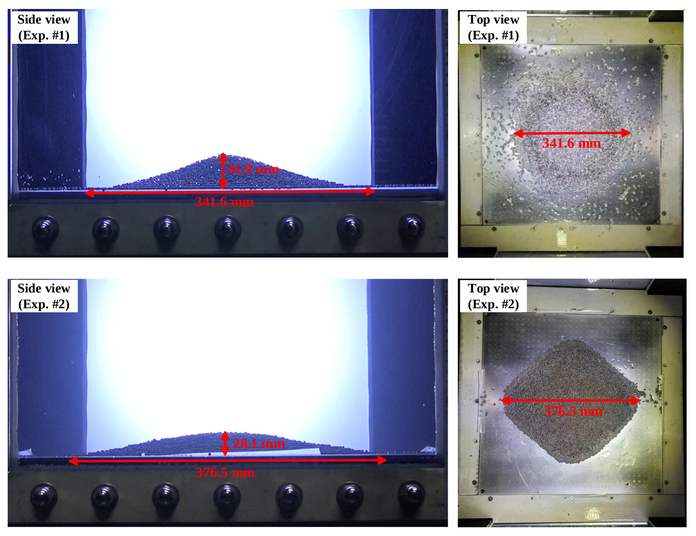

Fig. 5. Particle bed of each experiment

- Both beds looked like a hill, however, that of Exp. #2 had a lower height and a gentle slope.
- That was because steam bubbles pushed falling particles far away.
- Comparing top views, Exp. #1 had a circular shape, while Exp. #2 had a diamond shape.
- It seemed that the regions close to the tank wall had more strong convection flow and thus particles accumulated much more than other regions.
- Also, since the particles rolled towards the center due to the convection flow, there were few particles around the bed of Exp. #2.

4. Conclusions

- DEFCON-S facility was constructed to investigate the effect of a sudden steam generation on the shape of fragmented debris bed and the fundamental experiments using 5 kg of 3 mm stainless-steel ball were conducted.
- An explosive steam generation by the interaction between heated particles and saturated water pushed falling particles far away. As a result, the particle bed spread more widely.
- The coolability of debris bed is related to its shape and early phase of it primarily affected by a sudden steam generation.
- It is expected that performing experiments under various conditions by using DEFCON-S facility will contribute to COLAS (COrium cooLability of Analysis Simulator) code development.