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Experimental Study on the Turbulent Steam Jet from Four Different Nozzle Exit Geometries Using PDPA System

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Extended Abstract

When a coolant loss accident occurs due to the fracture of a pipe undergoing wall thinning, the coolant can be discharged into the building through an orifice hole on the surface of a pipe in the form of a turbulent steam jet. At the time, a large amount of hydrogen gas is generated by nuclear reaction and combined with oxygen in the containment building. Water vapor level inside the containment building may influence the hydrogen concentration inside it. When the hydrogen concentration exceeds a certain limit, it can result in a severe hydrogen explosion accident. Therefore, it is worthwhile to investigate the distribution and behaviour of the water vapor discharged from the orifice pipe nozzle.

Pipe can have an orifice hole on its surface undergoing local wall thinning. The orifice hole is more likely to have non-circular shape, not circular. Previously, the steam jet discharged from a circular pipe nozzle was investigated numerically and experimentally [1]. In the present study, we investigated the velocity distribution, temperature distribution and condensation characteristics of steam jet sprayed from four different orifice nozzles (circle, square, triangle, and cross shape) in axial and radial directions using the PDPA system. In our experiments, the Reynolds number of steam jet was in the range of 80,000 to 85,000.

Similar to the steam jet flow discharged from a circular pipe nozzle, velocity and temperature distributions of all orifice nozzles exhibit self-similarity in the far-field. Since the aspect ratio of non-circular orifices was 1, differences between the circular orifices and the non-circular orifices were not significant. However, the difference between the orifice nozzle and the pipe nozzle was clearly observed. While the velocity of the steam jet issued from the pipe nozzle has the maximum velocity at the nozzle exit (z/d=0), that from the orifice nozzle increased from the outlet and then decreased after reaching the maximum speed at z/d=4~5. Similar to the pipe nozzle, the temperature of the steam jet generated by the orifice nozzle reached the maximum at the exit and gradually decreased as the z/d increased. As z/d increased, the steam jet started to be condensed, and the droplet size was measured to be below 1 μm.

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