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Investigation of Characteristics of Impinging Jet for 1/5-Scale ECC injection

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1. Introduction

In ECCS of SMART reactor, safety injection pump discharges cooling water into the core to maintain the water level by filling the amount of loss of coolant under emergency situation such as SBLOCA. Once the ECCS starts to operate, the injected water will be impinged to the upper wall of core support barrel (CBS). And the water will fall along the wall forming liquid film or droplets as shown in Fig. 1(b) due to high Reynolds number. The breakup and film flow will be bypassed by high temperature and pressure steam-water mixture cross flow from RCP discharge into the atmosphere through broken injection nozzle. Then, the flow phenomena in the downcomer is very complex situation with including jet impingement, jet breakup, liquid entrainment, steam condensation, counter-current flow and etc.

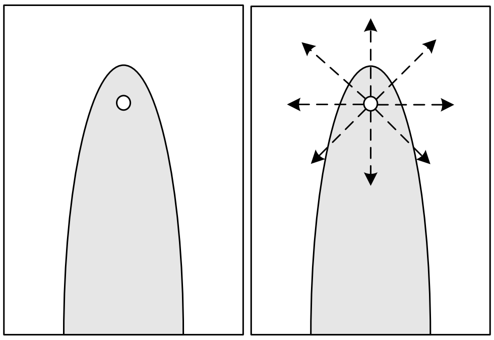


Fig. 1 Type of impinging jet (a) Liquid Film (b) Film + Droplets

In this study, the hydraulic features of impinging jet were investigated through visualization for full scale test for simulation of SMART ECC jet and SWAT test of 1/5 simulated test for ECCS of SMART reactor and measurement of the film width. And the scaling method for SWAT test was discussed considering jet break up and other phenomena.

2. Experiments

The loop simulates a part of the wall of CSB at which ECC water impinge and the jet nozzle of the SMART and scaled down ECCS with two different sets of nozzle and wall. One has the same size of SMART reactor and the other's geometry has 1/5-scale ratio. Fig. 2 shows the schematic diagram of jet test loop.

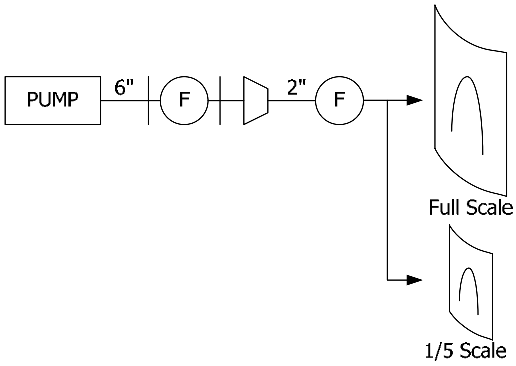
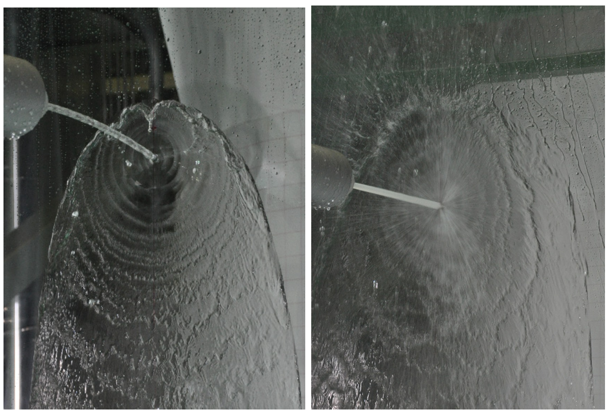


Fig. 2 schematic diagram for test loop

3. Results and Discussions

3.1 Visualization of Impinging Jet

When the impinging jet was observed, the flow pattern was changed as the velocity increased. Fig. 3 shows two typical different kinds of flow pattern. At relatively slow velocity, the jet flow dropped down along the curvature wall forming the liquid film after impinging. Since the flow velocity became faster, liquid droplets started to splash in radial direction from stagnated liquid zone. And the amount of liquid droplets was more growing. That is, the jet flow was divided into liquid film and droplets. At this time, the starting point to break up the bulk flow, which is called as break-up point, exists between 2 m/s and 4m/s for full scaled test and between 6 m/s and 8m/s for scaled down test respectively.



(a) liquid film only (b) liquid film and droplets

Fig. 3 Flow pattern of impinging jet

3.2 Measurement of Liquid Film Width

The liquid film formed by impinging jet flows downward along the wall surface with wavy liquid surface balancing among the inertia force, friction force, gravity force and surface tension force as shown in Fig. 4

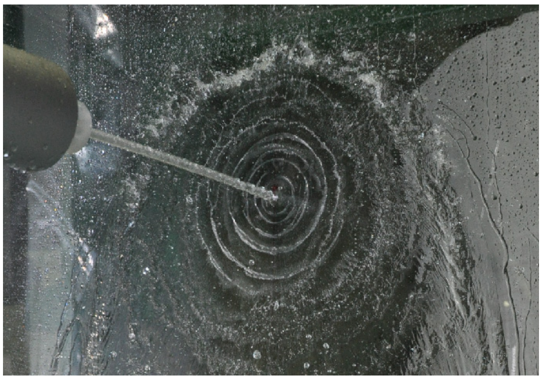


Fig. 4 Liquid film without liquid droplets

On the quantitative comparison, the variation of film width with velocities was drawn at Fig. 5. From the figure, the relationships of film width seemed to be classified into three different regions with the velocity depending on the existence of breakup phenomena. One is non-breakup region. Another one is a breakup region and the other is restricted film region.

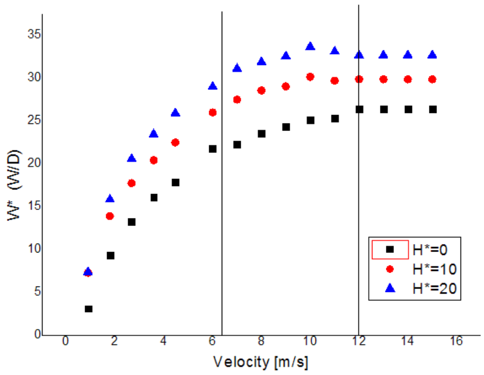


Fig. 5 Variations of film width with velocities at some level (y*=0, 10, 20)

To investigate the scaling effect on impinging jet, jet tests were performed at full scale and 1/5 scaled test section. For the full scale test with 5 times nozzle diameter, the breakup of jet flow occurred at relatively low velocity. In viewpoint of scaling methodology about liquid film width, the linear scaling method and the modified linear scaling method was compared in Fig. 6 When the non-dimensional velocity was low, modified linear scaling method seemed to be more appropriate. And this result agreed with previous works (Yun et. al., (2004)). However, at the jet velocity of ECC of SMART, the scaling law did not coincide with scaling parameter of prototype with the other. According to the figure, jet velocity (about 8m/s) for ECC of SMART reactor put into the transient region for scaling method. Therefore, a new scaling approach for jet breakup flow was needed.

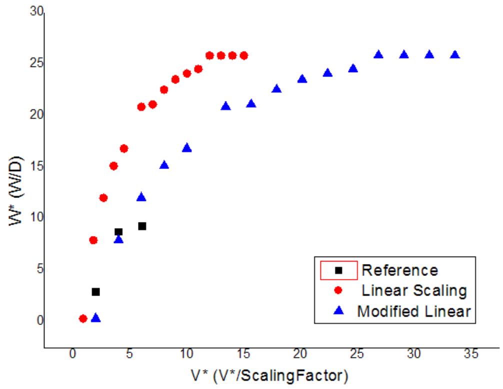


Fig. 6 Comparison between linear scaling and modified scaling methodology (H* = -2)

4. Conclusions

This study investigated hydraulic features of impinging jet anticipated when the ECC water was injected into the downcomer of the SMART330 reactor. And the applicability of scaling methods to the breakup flow was also examined. From this study, the flow patterns of impinging jet were divided into three different types: film region, film and breakup region, and limited-film region. The modified linear scaling law showed a good agreement for the liquid film region. However, a new scaling law should be developed for the jet breakup flow.

REFERENCES

[1] Ishii, M., Kataoka, I., Similarity analysis and scaling criteria for LWR's under single-phase and two-phase natural circulation, NUREG/CR-3267 ANL-83-32, 1983

[2] Ishii, M., Kataoka, I., Similarity analysis and scaling criteria for LWR's under single-phase and two-phase natural circulation, NUREG/CR-3267 ANL-83-32, 1983

[3] B. J. Yun, H. K. Cho, D. J. Euh, C. H. Song and G. C. Park, "Scaling for the ECC Bypass Phenomena During the LBLOCA REflood Phase", Nucl. Eng. Des. Vol. 31, 315, 2004