TRANSPORT CHARACTERISTICS OF REPRESENTATIVE DEBRIS IN A OPEN CHANNEL

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1. Introduction

During LOCA(Loss of Coolant Accident), emergency core coolant supplements form a recirculation sump and cooled core and containment. When the double ended guillotine Break (DEGB) at the hot leg near steam generator, due to the jet impingement discharge flow, the debris could be potentially generated at pipe or wall nearby steam generator and be transported to the recirculation sump. Therefore, the debris could be accumulated and be clogged in the recirculation sump screen. If debris blocked the sump screen, the pressure drop increased at the screen so as to increase the pressure loss of ECCS (Emergency Core Cooling System) pump NPSH (Net positive suction head). It is potentially influenced to decrease the long-term cooling capability of the recirculation sump. The recirculation sump screen clogging accident has happened in BWR at 1990. Considering the important of safety, US NRC published Regulatory Guide 1.82 Rev.3 incorporating the R&D findings and experiences in 2003. NEI introduced the methodology procedure to solve this safety issue in the NEI 04-07 report. In the meanwhile, US NRC also published individually the regulatory guidelines as a SER (Safety Evaluation Report) report for PWR plant. However, the current available technical information including the reports is applicable to the generic PWR plants not the plant specific plant. Therefore, the additional research reflecting characteristics of plant specific plant is necessary to develop the methodology and technical guides on the recirculation sump clogging issue. The objective of this study explores the characteristics of debris tumbling velocity during LOCA.

2. Flume Test Apparatus

This research was referred to test apparatus of GSI-191; it was designed considering minimum depth which exists during LOCA.

2.1 Flume Construction

A flume was constructed and placed on a steel table 5.1m x 0.7m x 1m. Flume consists of a transparency PVC, a open top box 5m x 0.5m x 1.5m. The water falls down in the first 0.8m of the flume. The water entering a flume passes through 0.15mm wire mesh and straighterner. The dimension of the straighterner is 0.3m long, 0.5m wide and 1.5m high, mesh size is 50mm square lattice cells. A screen of 0.15mm wire mesh is placed at the 1m from the near end of the flume.

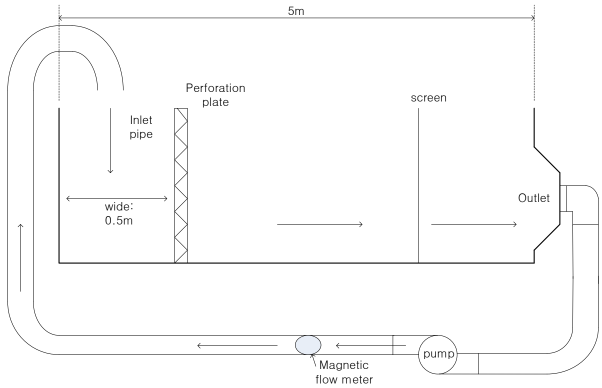

Fig. 1. Schematic of Flume Assembly

Test section is about 2.8m long. On the floor of test section, a coated paper of gradation was attached. The dimension of the gradation was 10mm in width and length. Water is inlets in the flume from front side and outlets at the rear side. From outlet to inlet, water circulates using a centrifugal pump. The capacity of the pump is 6000 L/min. An inverter is used to control the speed of pump. An elector magnetic flow meter is used to measure the inlet water velocity.

2.2 Test procedure

The test tracers were of acrylic and glass. The dimensions of the acrylic and glass were 12mm and 16mm. The specific gravities of the acrylic and glass were 1.12 and 2.3. These tests were done with 1m water height and water height was kept constant. The tests were explored tumbling velocity of tracers on test section. Flow 3d calculate opr1000 Floor for 120 sec. Fig.2 is Comparison of tumbling velocity and turbulence kinetic energy(TKE) on OPR1000 floor. The high TKE was found at the high tumbling velocity zone and at low tumbling velocity zone. The tests were classified in three cases. Case 1 was no obstacle in the test section. The tracers were placed at the left side of the screen. The distance was 1m and between two tracers was 10cm. Case 2 used obstacle (a) only, tracers placed at the line 1 to line 3 on the floor of the test section. Distance between the adjacent lines of tracers was 10cm. It was observed that tracers of the line influence the other lines. So, for each line tests were performed individually and it was repeated 10 times for every time. Case 3 used obstacle (b) only, tracers placed at the line 2 to line 4 on the floor of the test section.

Water flow velocity was changed by using the inverter. These water flow velocities are used to calculate tumbling velocity of the areas.

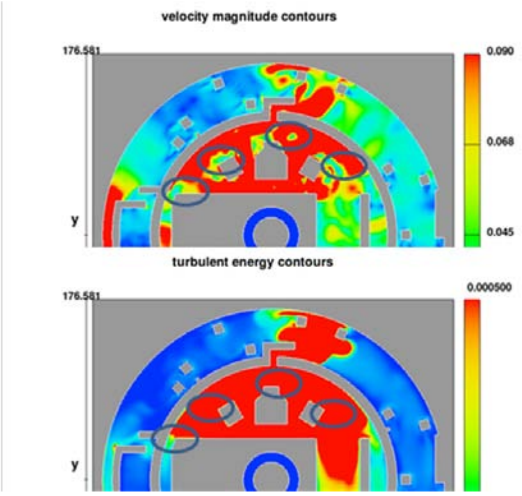

Fig. 2. Compare of tumbling velocity and turbulence kinetic energy on OPR1000 floor at 26.85m

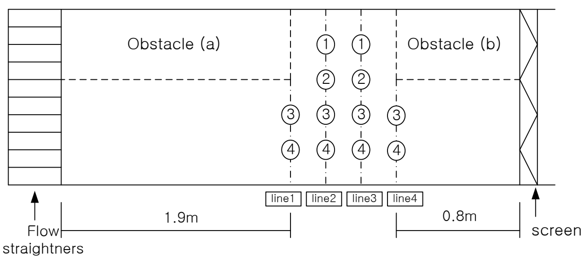

Fig. 3. Schematic of Flume Assembly

2.3 Test results

Case 1, two types of sample are tested, one is of acrylic and another is of glass. Each type is consistent of 4 samples. Both samples include 4 tracers, and each of the samples one set of tracers was tested 10 times. Average tumbling velocities of these data are shown in table 1. Each type of sample is used in case 2. Both sample include 4 tracers, each sample tested 10 times and the tracers one placed on line 1 to line 3. Each tumbling velocities of tracer of these data are shown in table Ⅱ. Sample of case 3, each sample tested 10 times and the tracers one placed on line 2 to line 4. Each tumbling velocities of tracer of these data are shown in table Ⅲ.

Table I: Tumbling velocity of Case 1

Debris type	Tumbling velocity(m/s)
Acrylic	0.026~0.063
Glass	0.076~0.093

Table Ⅱ: Tumbling velocity of Case 2

Debris type	Debris Number	Tumbling velocity(m/s)
Acrylic	1	0.076~0.093
Acrylic	2	0.026~0.063
Acrylic	3	0.023~0.063
Acrylic	4	0.023~0.060
Glass	1	0.085~0.114
Glass	2	0.069~0.103
Glass	3	0.061~0.081
Glass	4	0.061~0.079

Table Ⅲ: Tumbling velocity of Case 3

Debris type	Debris Number	Tumbling velocity(m/s)
Acrylic	1	0.011~0.038
Acrylic	2	0.011~0.038
Acrylic	3	0.011~0.038
Acrylic	4	0.011~0.039
Glass	1	0.038~0.058
Glass	2	0.036~0.057
Glass	3	0.041~0.063
Glass	4	0.045~0.084

3. Conclusions

Tumbling velocity of tracers depends on the presence of obstacle and they are shown in table Ⅱ and table Ⅲ. Tracer 1 and 2 was placed at the obstacle side of flume. For case 2, high velocities were observed for these two tracers. It can be seen in table Ⅱ. For case 2, if pump velocity increases then tracer at the obstacle end moves. This is because, as the pump speed increases the water velocity in the flume increases. Vortex generates at the obstacle end along the flow and it influences tracers 1 and 2. From table Ⅱ, it can be observed if water velocity is more higher, then the tracer 1 and 2 spins, swirls and starts move along the flow path. For case 3, low velocities were observed for these two tracers 1 and 2. The results are shown in table Ⅲ. Vortex generates at the obstacle first along the flow and it influences tracers 1 and 2. In these case tracers 1 and 2 are move faster than tracer 3 and 4.

REFERENCES

[1] USNRC, Regulatory Guide 1.82, Revision 3, "Water Sources for Long-term Recirculation Cooling Following a Loss-of-Coolant Accident", Washington D.C., November 2003.

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