The Development of Computer Code for Safety Injection Tank (SIT) with Fluidic Device(FD) Blowdown Test

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1. Introduction

Safety Injection Tanks (SITs) with the Fluidic Device (FD) of APR1400 provides a means of rapid reflooding of the core following a large break Loss Of Coolant Accident (LOCA), and keeping it covered until flow from the Safety Injection Pump (SIP) becomes available.

A passive FD can provide two operation stages of a safety water injection into the RCS and allow more effective use of borated water in case of LOCA. Once a large break LOCA occurs, the system will deliver a high flow rate of cooling water for a certain period of time, and thereafter, the flow rate is reduced to a lower flow rate.

The conventional computer code “TURTLE” used to simulate the blowdown of OPR1000 SIT can not be directly applied to simulate a blowdown process of the SIT with FD. A new computer code is needed to be developed for the blowdown test evaluation of the APR1400 SIT with FD.

Korea Power Engineering Company (KOPEC) has developed a new computer code to analyze the characteristics of the SIT with FD and validated the code through the comparison of the calculation results with the test results obtained by Ulchin 5 and 6 units pre-operational test and VAlve Performance Evaluation Rig (VAPER) tests [1,2,3] performed by The Korea Atomic Energy Research Institute (KAERI).

2. Methods and Results

In this section, the basis and algorithm of newly developed computer code are presented. The validation results are also provided.

2.1 Basis and algorithm

The fluidic device in the tank consists of the stand pipe, vortex chamber, main (supply) ports, control ports and exit port. The high and low flow rate is determined in totally a passive manner by making the flow take two different flow paths. For the high flow rate the water enters into the fluidic device through the main ports and control ports and leaves it through the exit port. In this case the flow passage is almost straight and flow resistance is minimized. On the other hand, for the low flow rate, the water enters into the fluidic device through the control ports only and the flow experiences a high swirl before leaving the vortex chamber, which is the major reason for the high flow resistance and low flow.

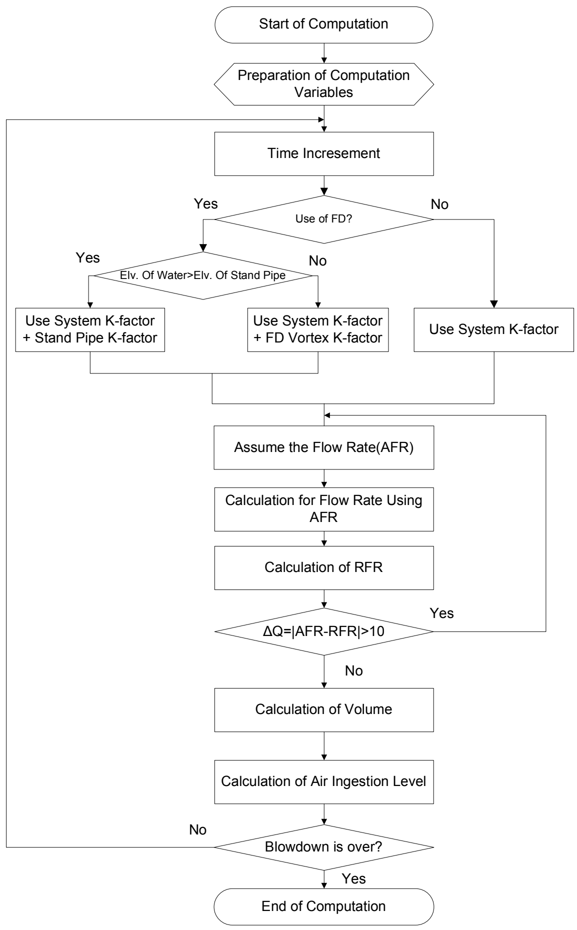

Figure 1. Flowchart of SIT-BD

For APR1400 pre-operational test, two different acceptance criteria are established: i) the case of high flow rate by low K-factor, ii) the case of low flow rate by high K-factor.

As shown in Fig. 1, with an Assumed Flow Rate (AFR) from previous Real Flow Rate (RFR), calculation of some parameters such as velocity head loss and elevation head loss for RFR is performed. Using those parameters and K-factor of the SIT, RFR can be calculated. If the difference between AFR and RFR is small enough, then RFR is finally determined.

Using RFR, we can calculate the volume change of water in the SIT and the height of possible air or N_2 gas ingestion. If the gas in tank is ingested with emergency cooling water, it can lead to reduction of flow rate from the SIT. The blowdown behavior with gas ingestion, it is difficult to predict the actual flow rate and the ingested gas amount exactly. So we introduce a simple algorithm to predict the initiating height of gas ingestion using ANSI/HI standard [4].

All the water in measurable range of SIT is discharged, the computation is completed.

Using these algorithms, we have developed the SIT-BD (Safety Injection Tank BlowDown analysis) module, which is one part of SS-PAC (Safety System Performance Analysis Code).

2.2 Ulchin 5, 6 Units Pre-Operational Test

To validate the newly developed SIT-BD module for SIT without FD, the Ulchin 5 and 6 Units pre-operational test results were used.

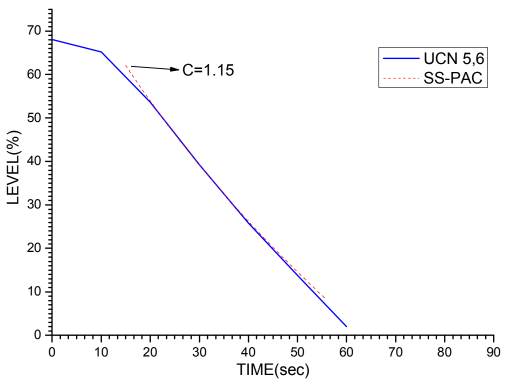

Figure 2. The comparison of Ulchin 5 and 6 units pre-operational test with SIT-BD code calculation

In Fig. 2 the calculation result of SIT-BD for the Ulchin 5 and 6 units pre-operational test condition shows very good agreement with the measured data. In this case, the specific heat ratio of N_2 gas is assumed as 1.15.

2.3 VAPER test result

To validate the newly developed SIT-BD module for SIT with FD, the VAPER test results were employed.

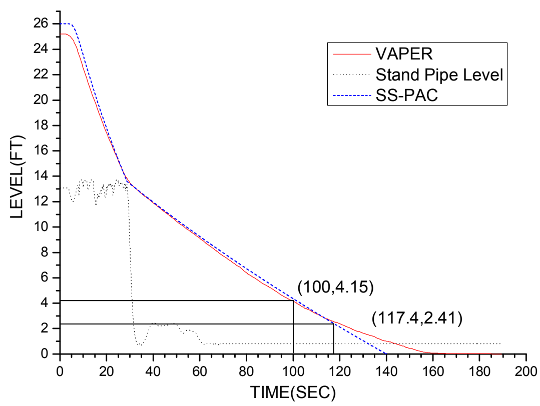

Figure 3. The comparison of VAPER test with the SIT-BD code calculation

In Fig. 3 the calculation result of SIT-BD for the VAPER test condition shows also very good agreement with the measured data. In this case, the specific heat ratio of air is assumed as 1.25. And the initial air ingestion height calculated by SIT-BD is 2.41ft at 117.4 seconds, while the test result is estimated as 4.15ft at 100 seconds. This discrepancy seems to be due to the simple algorithm to predict gas ingestion phenomena.

In general, the gas expansion during SIT blowdown procedure is expected to be done in the range between isothermal (C=1.0) and isentropic (C=1.4). Therefore, the constants of specific heat ratio used to verify the code, C=1.15 for N_2 gas and C=1.25 for air, appear to be reasonable.

3. Conclusion

Reviewing the validation results of SIT-BD module, it can be seen that the blowdown procedures of SIT without FD and SIT with FD are well simulated by SIT-BD module, respectively. It is noteworthy that the initial air ingestion height can be predicted by SIT-BD module, even though the prediction is not enough satisfied.

It can be concluded that SIT-BD module is applicable to generate the acceptance criteria for pre-operational SIT blowdown tests for OPR1000 (SIT without FD) as well as APR1400 (SIT with FD). The initial air ingestion height prediction can be used to determine the valid region of SIT blowdown procedure.

REFERENCES

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