Experimental validation of TASS/SMR-S critical flow model for the integral reactor SMART

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1. Introduction

An advanced integral PWR, SMART (System-Integrated Modular Advanced ReacTor) is being developed in KAERI [1]. It has a compact size and a relatively small power rating (330MWt) compared to a conventional reactor.

Because new concepts are applied to SMART, an experimental and analytical validation is necessary for the safety evaluation of SMART. The analytical safety validation is being accomplished by a safety analysis code for an integral reactor, TASS/SMR-S developed by KAERI [2]. TASS/SMR-S uses a lumped parameter one dimensional node and path modeling for the thermal hydraulic calculation and it uses point kinetics for the reactor power calculation. It has models for a general usage such as a core heat transfer model, a wall heat structure model, a critical flow model, component models, and it also has many SMART specific models such as an once through helical coiled steam generator model, and a condensate heat transfer model. To ensure that the TASS/SMR-S code has the calculation capability for the safety evaluation of SMART, the code should be validated for the specific models with the separate effect test experimental results.

In this study, TASS/SMR-S critical flow model is evaluated as compared with SMD (Super Moby Dick) experiment [3,4].

2. SMD Experiment

This experimental apparatus is designed to study a steady state critical flow in various thermal hydraulic conditions. When this experiment is performing, Flow is discharged to environment through two types SMD nozzle. And discharged flow rate at each condition is measured.

Fig. 1 Configuration of SMD nozzle

A configuration of long SMD nozzles is shown in Fig. 1. l and d in the Fig. 1 represent length and diameter of nozzle respectively.Length and diameter of long SDM nozzle is 100mm and 66.7mm. Experiment conditions with long SDM nozzle is summarized in Table 1.

Table 1. SMD long nozzle experiment condition

Press. (MPa)	ΔT	Temp. (K)	Quality	State
2	25.294	459.925	0.00	Subcooled
	19.509	465.710	0.00	
	14.068	471.151	0.00	
	8.039	477.180	0.00	
	2.107	483.112	0.00	
	0.98	484.239	0.00	
	0.147	485.072	0.00	
	0.0	485.22	0.033	Saturated
	0.0	485.22	0.148	
	0.0	485.22	0.198	
	0.0	485.22	2.557	
	0.0	485.22	3.382	
	0.0	485.22	4.801	
6	28.792	519.987	0.00	Subcooled
	20.579	528.2	0.00	
	14.299	534.48	0.00	
	8.695	540.084	0.00	
	2.657	546.123	0.00	
	0.048	548.731	0.00	
	0.0	548.78	0.00	Saturated
	0.0	548.78	0.26	
	0.0	548.78	0.796	
	0.0	548.78	1.674	
	0.0	548.78	3.869	
	0.0	548.78	4.796	
12	18.447	579.352	0.00	Subcooled
	15.605	582.194	0.00	
	12.204	585.595	0.00	
	4.798	593.001	0.00	
	0.046	597.753	0.00	
	0.0	597.80	0	Saturated
	0.0	597.80	0.077	
	0.0	597.80	3.23	

3. Validation of the critical flow model

The critical flow model of TASS/SMR-S is verified. The Nodalization of the SMD nozzle for the two cases; one is a SMD short nozzle, the other is a SMD long nozzle is shown in Fig. 2.

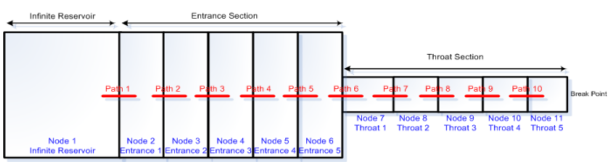

Fig. 2 Nodalizatoin of SMD long nozzle for the critical flow model validation

First node (Node 1) is setting up infinite reservoir to supply constant temperature and pressure for nozzle. A break path on a node 11 is assumed using the

TASS/SMR-S break option to simulate critical flow. And two critical flow models, H-F (Henry Fauske model) and Moody model, are applied to this calculation.

From the simulation of the SMD test with the given conditions, the flow rate at outlet of nozzle is obtained. These values are compared with experimental data. The comparison results are summarized in Figs. 3-5.

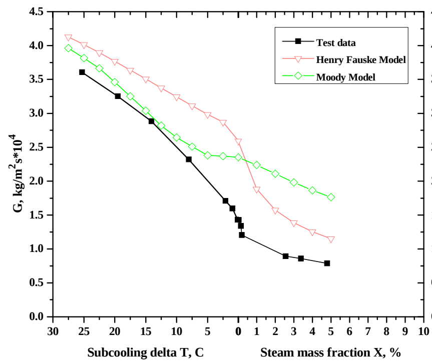

Fig. 3 SMD long nozzle for 2MPa

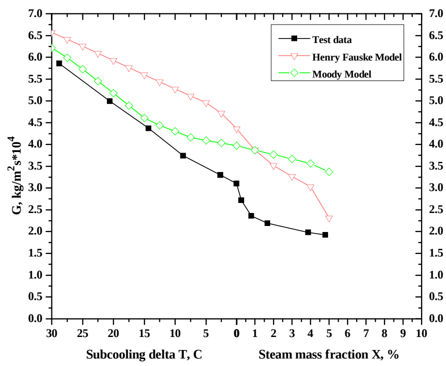

Fig. 4 SMDlong nozzle for 6MPa

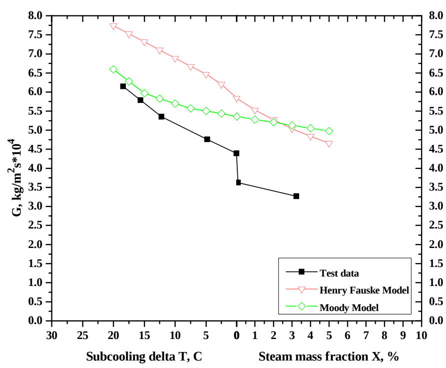

Fig. 5 SMDlong nozzle for12MPa

Square line represents the experimental data. And an inverted triangle and diamond line represent the result of the Henry-Fauske model and the Moody model, respectively.

In the case of the subcooled region of Fig. 3, the result of the Henry-Fauske model is more conservative than the result of the Moody model from the aspect of the safety. On the other hand the result of the Moody model is more conservative than the result of the Henry-Fauske model in saturated region of Fig. 3. And it is confirmed that these two critical flow models of TASS/SMR-S are over estimate compare with the experimental data in the subcooled and saturated region.As ΔT increases in subcooled region, calculated result roughly agrees with the experimental data. Similar trend is observed in the case of the Fig. 4 and 5 without discrimination.

These calculated results show that TASS/SMR-S can predict the critical flow rate value conservatively from the aspect of the safety.

4. Conclusions

The critical flow model of the TASS/SMR-S code has been developed for the safety analysis of the SAMRT. Therefore an experimental and analytical validation is necessary for the safety evaluation of SMART.

For the verification of the critical flow model, the flow rate was calculated according to various thermal hydraulic conditions. And these results are compared with SMD experimental results.

The result of the calculation with Henry-Fauske model is bigger than the result of the Moody model in subcooled region. But the result of the calculation with Moody model is bigger than the one of the Henry-Fauske model. It is also confirmed that two critical flow models are over estimate compare with the experimental data in whole region. It means that the critical flow model of TASS/SMR-S can predict critical flow rate conservatively from the aspect of the safety.

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