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Analysis of Two Phase Natural Circulation Flow in the Reactor Cavity under External Vessel Cooling

Rae-Joon Park, Kwang-Soon Ha, Sang-Baik Kim and Hee-Dong Kim

Key Words : Two Phase Flow(), Natural Circulation(), Reactor Cavity (), External Vessel Cooling()

Abstract

As part of study on thermal hydraulic behavior in the reactor cavity under external vessel cooling in the APR (Advanced Power Reactor) 1400, one dimensional two phase flow of steady state in the reactor cavity have been analyzed to investigate a coolant circulation mass flow rate in the annulus region between the reactor vessel and the insulation material using the RELAP5/MOD3 computer code. The RELAP5/MOD3 results have shown that a two phase natural circulation flow of 300 – 600 kg/s is generated in the annulus region between the reactor vessel and the insulation material when the external vessel cooling has been applied in the APR 1400. An increase in the heat flux of the inner vessel leads to an increase of the coolant mass flow rate. An increase in the coolant outlet area leads to an increase in the coolant circulation mass flow rate, but the coolant inlet area does not effective on the coolant circulation mass flow rate. The change of the lower coolant outlet to a lower position affects the coolant circulation mass flow rate, but the variation trend is not consistent.

1. 가

가 가
(external vessel cooling)
가

(IVR: In-Vessel corium Retention)

(4, 5)

(1)
Loviisa
(2)

(Critical Heat Flux: CHF)
가 (6)

AP 600

APR(Advanced Power Reactor) 1400
(3)

가

(7)

가

가

†

E-mail : rjpark@kaeri.re.kr
TEL : (042)868-8937 FAX : (042)861-2574

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shear key 가

가

가

가

가

가

APR 1400

가

가

APR1400

가

가

APR 1400

가

APR 1400

RELAP5/MOD3

(two

1

(8)

phase)

(natural circulation)

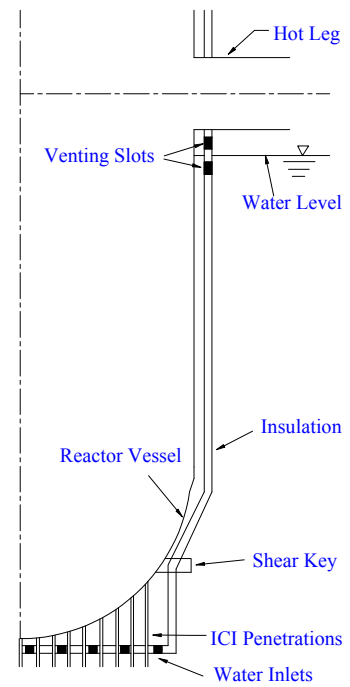


Fig. 1 Schematic diagram of the outer part of the reactor vessel in the APR 1400.

가

가

가

가

2.

1 APR 1400

100 mm

300 □

3. RELAP5

APR 1400

ICI(In-Core Instrumentation)

61

RELAP5/MOD3
 RELAP5
 Nuclear Regulatory Commission
 INEEL (Idaho National Engineering and Environmental Laboratory)

(KSNP: Korean Standard Nuclear Power Plant) geometry APR 1400

RELAP5

가

61 62 APR 1400 가 62

6

RELAP5/MOD3

2 APR 1400

1.3 가 가
 0 가 가

RELAP5/MOD3

가

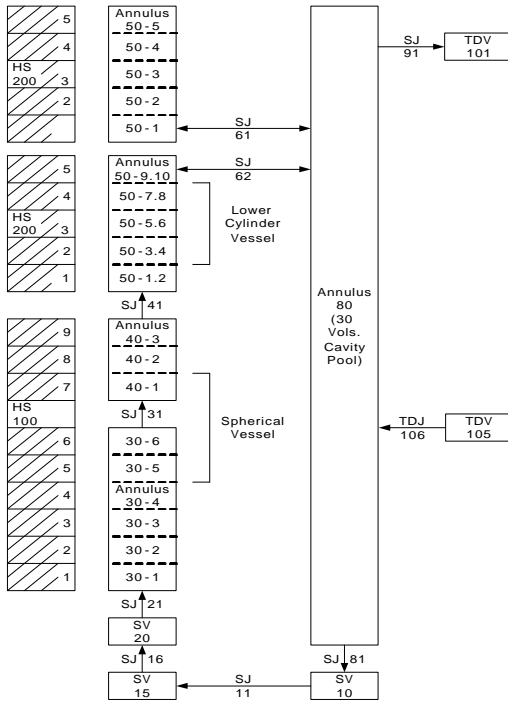


Fig. 2 RELAP5 input model for APR 1400.

(Annulus 30, 40) 가
 (Annulus 50)
 Vessel
 Heat Structure 100 200
 Annulus 30, 40, 50
 Volume 80
 APR 1400
 geometry , APR 1400

가 가
 가
 가
 0.25 - 1.25
 0.1 - 0.5 m²,
 0.05 - 0.5 m²,
 4.
 3 0.5 m²,
 0.5 m²,
 0.5 MW/m²,
 RELAP5/MOD3
 0.8 가

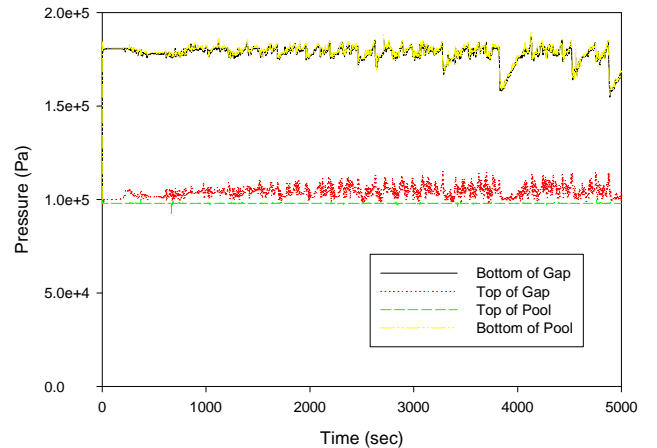


Fig. 3 RELAP5 results on local pressure.

가

4
 0.5 m^2 ,
 0.5
 m^2 ,
 RELAP5/MOD3
 가
 가
 가
 1.0 MW/m^2
 가
 가
 가

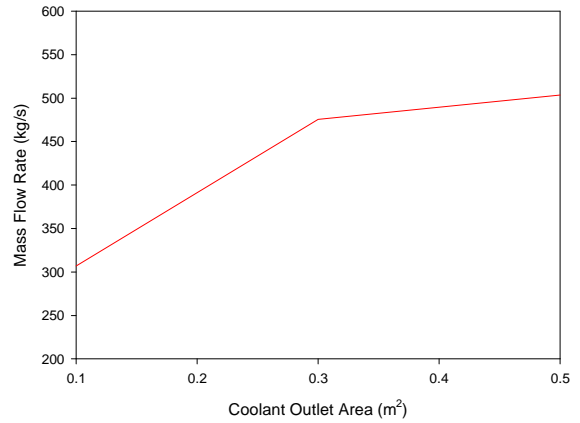


Fig. 5 RELAP5 results on coolant circulation mass flow rate as function of coolant outlet area.

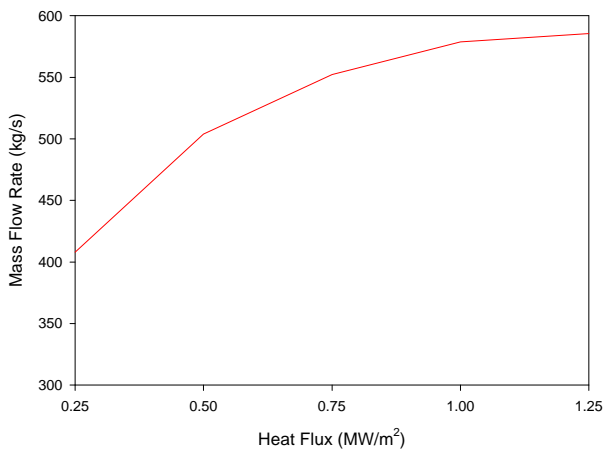


Fig. 4 RELAP5 results on coolant circulation mass flow rate as function of internal heat flux in the reactor vessel.

5
 0.5 MW/m^2 ,
 0.5 m^2 ,
 RELAP5/MOD3
 가
 가
 가
 가

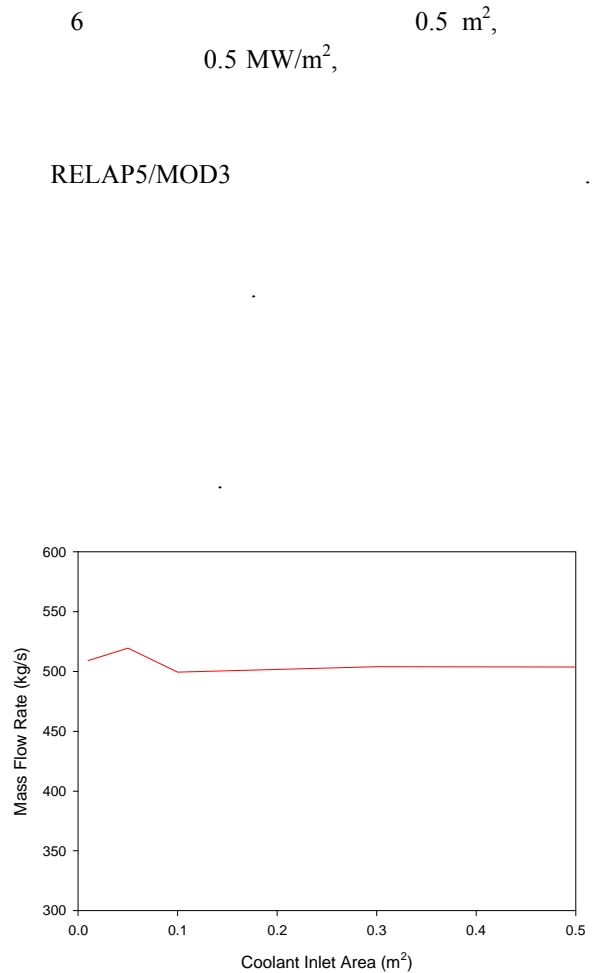


Fig. 6 RELAP5 results on coolant circulation mass flow rate as function of coolant inlet area.

7
 0.5 MW/m^2 ,
 0.5 m^2 ,
 0.5 MW/m^2

RELAP5/MOD3

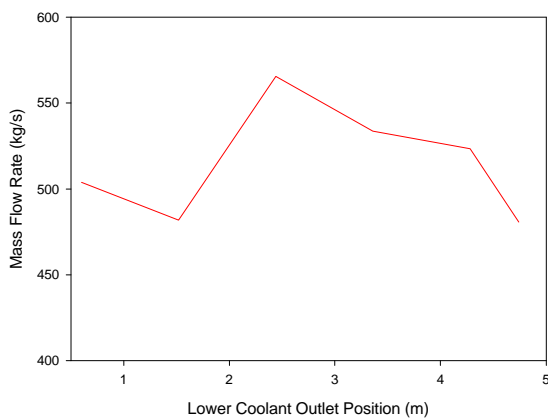


Fig. 7 RELAP5 results on coolant circulation mass flow rate as function of coolant inlet area.

APR 1400

RELAP5/MOD3

300- 600 kg/s

1.0 MW/m²

가
가
1
ICI shear key
3 가
APR 1400
3

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