

RELAP5/MOD3/CANDU+ CANDU

**Large Break LOCA Analysis for CANDU reactor using
RELAP5/MOD3/CANDU+**

150

19

RELAP5/MOD3/CANDU+ CANDU
 . RELAP5/MOD3/CANDU+
 RELAP5/MOD3/CANDU+ LOCA 가
 가 LOCA
 Moody ,
 가 , Moody Henry-
 Fauske , 가
 , CANDU

Abstract

Large Break LOCA analysis is performed for CANDU reactor using RELAP5/MOD3/CANDU+ under development at KAERI/KINS. RELAP5/MOD3/CANDU+ with models for LOCA analysis were developed based on RELAP5/MOD3/CANDU and some of the code changes based on RELAP5/MOD3 gamma version, with an intention of applying as an auditing tool for CANDU-type reactor licensing. The major interest in this study includes investigating the effects of Moody critical flow model, horizontal stratification flow regime model, and fuel heatup model. The code prediction shows slightly reduced break flow rate with Moody model when compared with Henry-Fauske model. Also, the importance of adequate horizontal stratification flow regime model is demonstrated when fuel heatup model is applied with flow regime model of RELAP5/MOD3 gamma vs. newly developed stratification regime model of RELAP5/MOD3/CANDU+.

1.

NRC

RELAP5/MOD3

가

RELAP5/MOD3/CANDU

[1],

LOCA

LOCA

가

RELAP5/MOD3.2.2

gamma

가

RELAP5/MOD3/CANDU+

[2].

LOCA

가

LOCA

가

가

RELAP5/MOD3

가

2. LOCA

LOCA

RELAP5/MOD3/CANDU+

가

Moody

가

가

2.1 Moody

Moody

RETRAN-3

가

$$G_c^2 = H \{ 2(h_o - h_{ls} - X_e h_{fg}) / [H(1 - X_e) v_1 + X_e v_g]^2 [(H^2 - 1) X_e + 1] \}$$

G_c = Critical Mass Flux ,

h_o = Stagnation enthalpy,

X_e = Exit equilibrium quality

v = Phase specific volume

H = Velocity slip ratio (v_g/v_f)

2.2 CANDU

(Flow Regime)

RELAP5/MOD3

Taitel &

CANDU

[3]. RELAP5/MOD3/CANDU+

1984 Hana 가

CATHENA [4]

$$V_{crit} = [g \rho^* / \rho_g \rho_f \{ \rho_f (F_f / \alpha_f - F_f^*) - \rho_g (F_g / \alpha_g - F_g^*) \}]^{1/2}$$

$$F_k = [y_i - (-1)^k / A \alpha_k \int_{y^k}^{y^i} y f(y) dy]$$

$$F_k^* = \partial F_k / \partial \alpha_k$$

$$\rho^* = \alpha_g \rho_f + (1 - \alpha_g) \rho_g$$

y_i = -
 $f(y)$ = y
 k = identification (g f)

, RELAP5/MOD3.2. gamma

가 가

AECL 1981 MR-2[5]

liquid superficial velocity (j_l)

j_f 가 0.085 m/sec

mixed flow

10 m/sec

가

component CANCHAN 가

2.3 가

RELAP5/MOD3/CANDU+

가

dry rod wetted rod

dry rod

(static quality)

1.0

, wet rod

0.0

가

3.

RELAP5/MOD3/CANDU+ LOCA

2/3/4

가

35%

[6, 7].

가

가 RELAP/MOD3/CANDU+

table

가

가

-

가

- 가

-

-

가

-

(2.96m)

-

(I, II, III IV

) 가

-

1

-

2/3/4

95

2

가

,

,

,

.

Nodalization

1

,

가

가

37

18

19

Heat Structure

4.

Moody

가

가

Case 1 :

RELAP5/MOD3.2.2

Henry-Fauske

Case 2 : Henry-Fauske

Moody

(Option 54)

Case 3 : Fuel Heat Model

. 37

18

19

Heat structure

Heat structure .(2)

Case 4 : Case3 가 CANDU 가 RELAP5/MOD3/CANDU+ component 'canchan' component . Case 1 3

'Critical Path' 'Non-Critical Path' 4 .

Moody Case 2 (Case1) 5 20 Moody Henry-Fausek , critical path 5 .

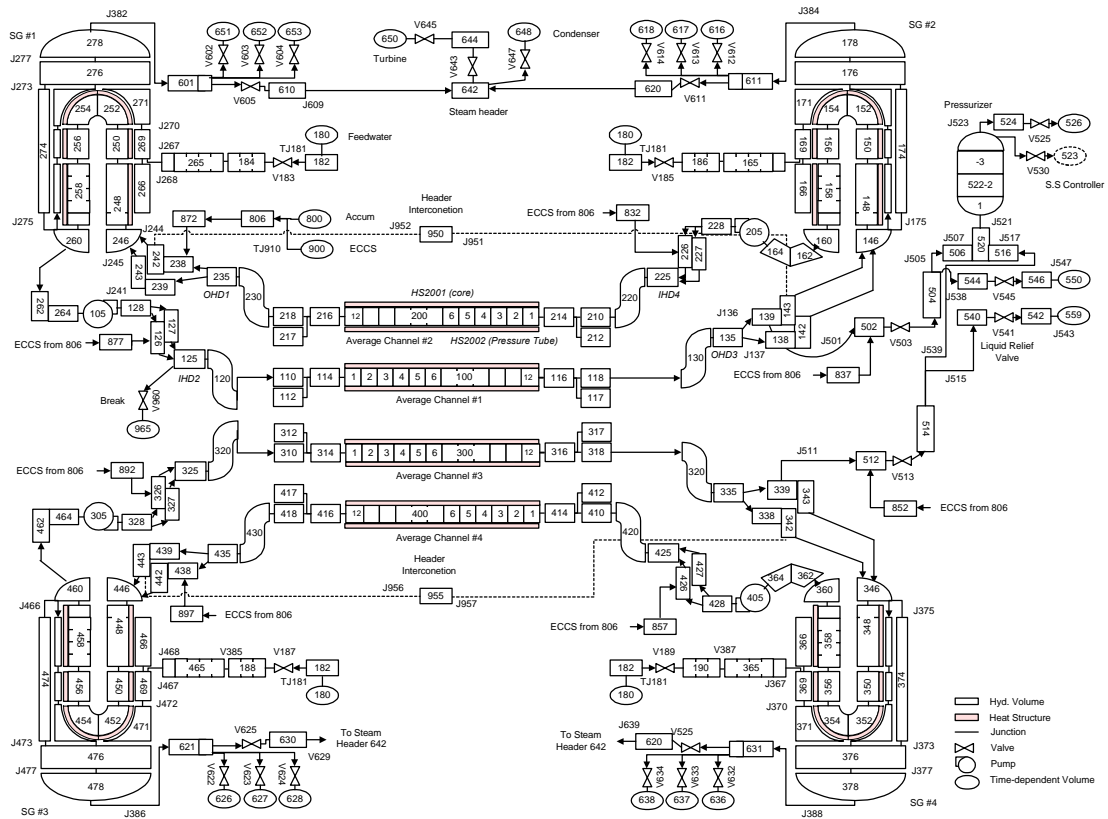
가 , 6 Non-Critical Path 25 가 가 Critical Path RELAP5/MOD3.2.2 가 가 7 .

Case4 Case3 가 가 CANDU CANCHAN component RELAP5/MOD3 가 . 8 Critical Path Case3 Case4 가 CANDU 5 1228 K RELAP5/MOD3.2.2 gamma 1122 K 106 K , Non-Critical Path 9 CANDU , 5 7 가 CANDU

5.

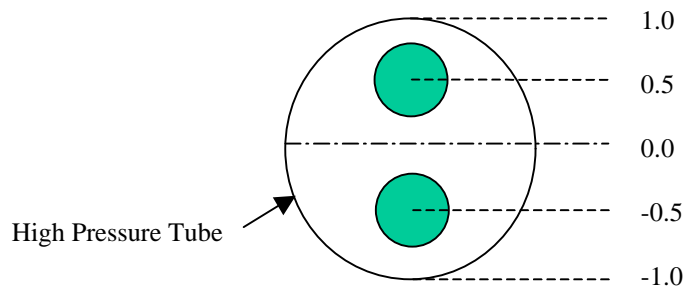
CANDU LOCA RELAP5/MOD/CANDU+
35% Moody
, 가 CANDU , Moody
, 가
CANDU RELAP5/MOD3.2.2
가 100K CANDU
가 .
LOCA . , 가
37 Lumping

- [1] B.D.Chung, W.J.Lee, H.S.Lim, “Development of Best Estimate Auditing Code for CANDU Thermal Hydraulic Safety Analysis”, KINS/HR-248, KAERI/CR-67/99 (1999)
- [2] B.D.Chung, W.J.Lee, H.S.Lim, “Development of Best Estimate Auditing Code for CANDU Thermal Hydraulic Safety Analysis”, KINS/HR-293, KAERI/CR-89/00 (2000)
- [3] Thermal Hydraulics Group “RELAP5/MOD3 Code Manual Volume 4 : Models and Correlations”, page 3-9, Scientech, Inc. , NUREG/CR-5535 (1998)
- [4] B.N. Hanna “ CATHENA MOD-3.5/Rev 0 ; Theoretical Manual”, page 3-5, RC-982-3, COG-93-140 Rev 0.0, AECL, Whiteshell Lab.(1995)
- [5] A.M.M.Aly, “Flow Regime Boundaries for an Interior Subchannel of a Horizontal 37-Element Bundle”, The Canadian Journal of Chemical Engineering, Vol. 59, pp. 158, April (1981)
- [6] 2,3,4 (1995)
- [7] , CANDU 가, KINS/GR-111 (1996)



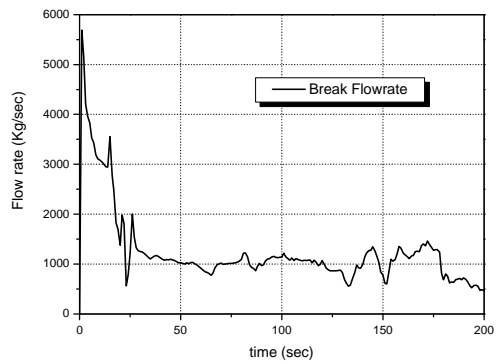
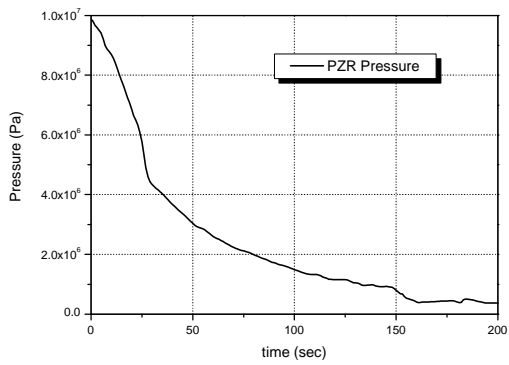
1. CANDU

LBLOCA Noding

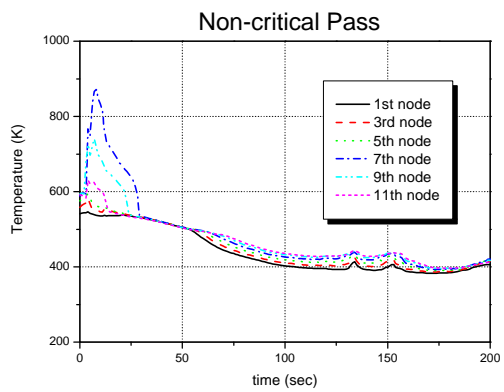
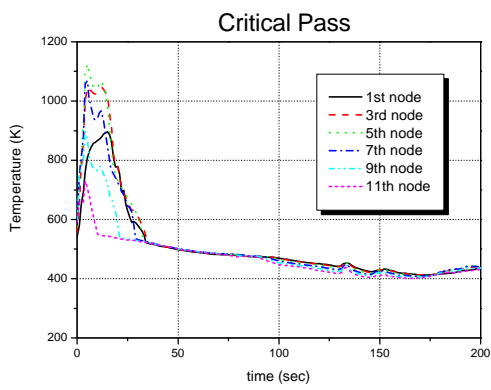


2.

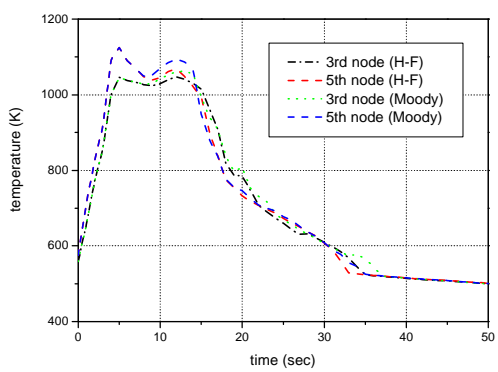
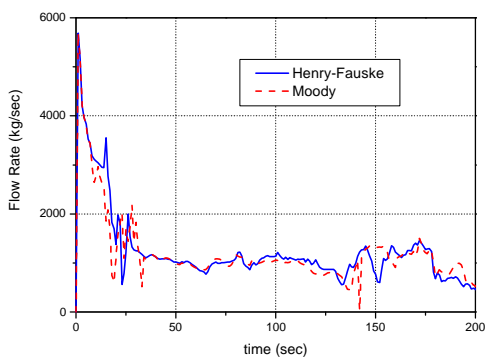
lumping



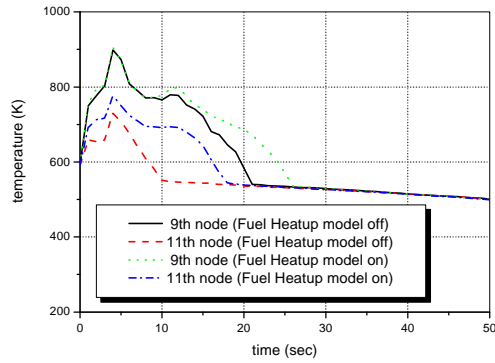
3. Case 1: 1



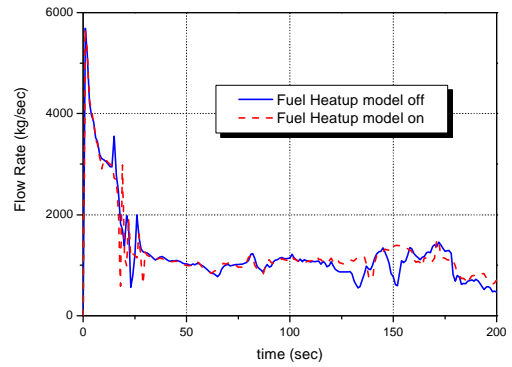
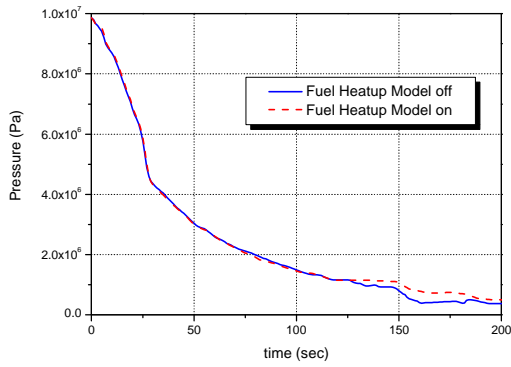
4. Case 1: (Critical Path Non-critical Path)



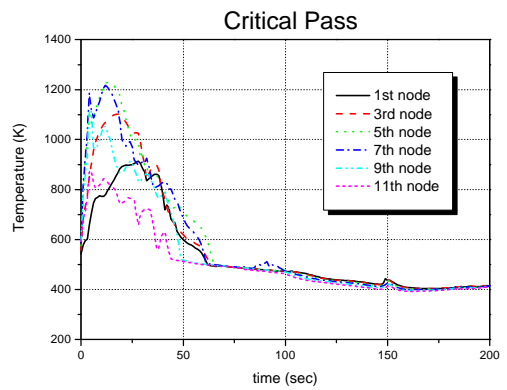
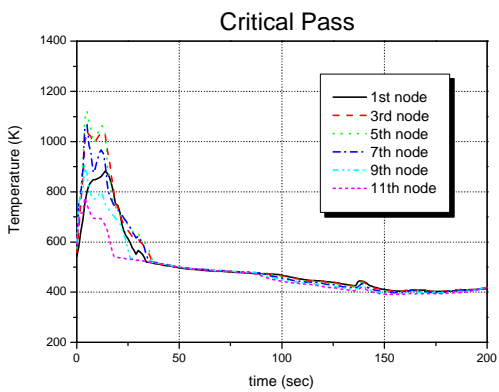
5 Case 2: Critical Path



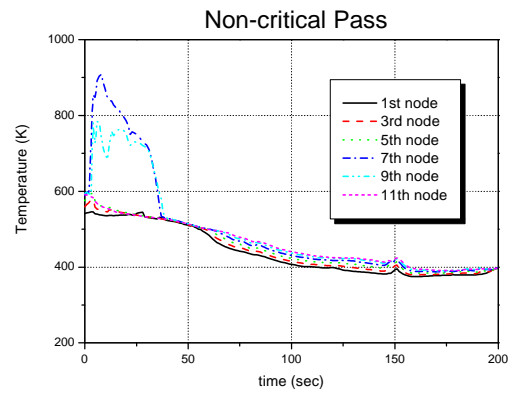
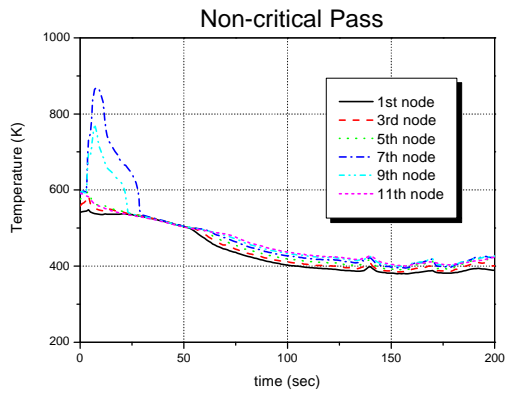
6. Case 3: Non-critical Path



7. Case3: 1



8. Case 3 Case 4: Critical Path



9. Case 3 Case 4 : Non-critical Path