Thermalhydraulic and Containment Analysis for Small Main Steam Line Break In CANDU6 Plant

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1. Introduction

Main Steam line break(MSLB) inside the containment is the Design Based Accident which raises the temperature and pressure of containment. Unlike large MSLB, small MSLB do not have process trips which adequately lead the reactor to be in a safe shutdown state beside the reactor building high pressure trip(RBHP). This study concentrate on the influences of reactor building high pressure trip in CANDU6 (specially Wolsong 1 loaded with ACNFLEX-NU fuel). In addition to that, the effect of the ECCS to the integrity maintenance will be shown.

2. Methods and Models

The thermalhydraulic analysis of the primary and secondary circuit behaviour is performed using the CATHENA thermalydraulic code and the CATHENA models developed to represent the Wolsong 1 plants. CATHENA is used to model the primary and secondary heat transport systems, the emergency coolant injection system including associated controlsystems. CATHENA is a two-fluid thermalhydraulic model which is capable of predicting mechanical and thermal non-equilibrium effects in two-phase flow.

And the analysis of containment response (temperature and pressure) to the mass and energy discharged from the break is performed using the containment thermalhydraullic code PRESCON2. And the threshold pressure for through wall cracking is set to be 200 kPa(g) in ECCS available case and 400 kPa(g) in ECCS unavailable case.

Break is assumed to occur in the steam line which is between steam generator and reactor building wall. And the break sizes is assumed to be three kinds; 14.2%, 5.78% and 2.81% of steam line cross section which discharges initially 500kg/s, 200kg/s and 100kg/s of steam respectively. In this summary only 5.78% break analysis results will be shown.

Discharged mass/enthalpy from the break and containment behaviours will be shown comparatively about the availability of RBHP trip and ECCS respectively.

3. Results

3.1 The effects of RBHP trip

When the break size is relatively large, there is appropriate trip parameter such as steam generator low level trip and steam generator low feedline pressure trip. But for small break, there is no appropriate process trip parameter because the primary and secondary circuit transient behavior is no so severe as to reach the trip set point. Therefore discharged mass flow from the break is maintaining even though the rate is small, which raise the containment pressure above the threshold value of 200kPa/400kPa. But when RBHP trip is applied, the reactor trips around 3seconds after the break initiated. So the primary coolant pressure reduces and discharged mass flow also decreases, while discharged enthalpy does not decrease. Due to this decrease of discharged flow, the containment pressure does not exceed the threshold value. (Fig1, Fig2, Fig3)

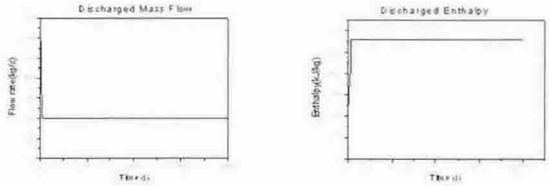

Fig1. RBHP trip not applied

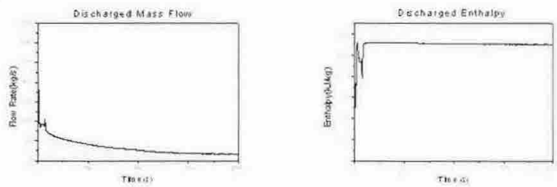

Fig2. RBHP trip applied

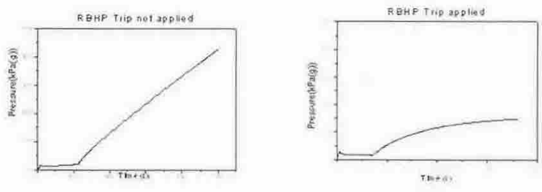

Fig3. Containment Pressure

3.2 The effects of ECCS

In the small break above the 5%, the primary heat transport system pressure decreases enough to result in steam generator crash cooling and ECI injection. But the ECI injection rarely influences the discharged mass flow and enthalpy. So failure of ECCS is not thought to be a big concern to the integrity of containment. (Fig4, Fig5) When RBHP trip is not applied, ECI can not injected into the loop even though ECCS is available, because without reactor trip resulting from RBHP trip, primary system pressure does not decrease to the set points of LOCA signal and steam generator crash cooldown.

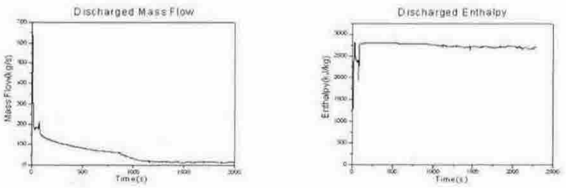

Fig4. ECCS Available

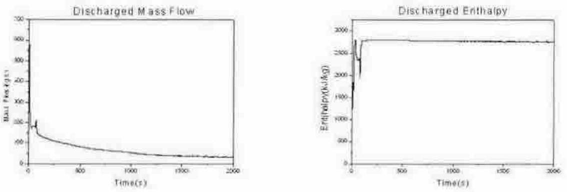

Fig5. ECCS Unavailable

3. Conclusion

When small MSLB occurs inside the containment of CANDU6 plant, there is no appropriate process trip parameter which can prevent secondary steam discharge to the extent that impair the containment integrity, besides the reactor building high pressure(RBHP) trip. When RBHP is applied, the steam discharge rate out of the break decreases right after the accident, which restraints the containment pressure increasing. So the containment integrity can be maintained. Therefore the availability of RBHP trip must be secured. And the availability of ECCS does not influence the discharge rate of mass and enthalpy out of the break.

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