摘 要

本研究利用 RELAP5-3D 模擬馬鞍山核電廠大破口冷卻水流失事故 (Large Break Loss of Coolant Accident ,LBLOCA)，將壓力槽降流區及爐心做多維度模擬分析，觀察與傳統一維模式模擬結果的差異。

研究發現降流區多維度的模擬，造成降流區的反向極限流限制(Counter Current Flow Limitation)提早 5 到 10 秒解除，使緊急爐心冷卻水提早接觸爐心底部，進入再泛水期 (Reflood)。使燃料護套溫度較一維模式提早下降，造成燃料護套尖峰溫度降低約 10°F。且暫態過程中降流區橫向流動情形更為平順，減少了大幅度的來回震盪。

爐心多維度模擬則發現暫態開始不久後的爐心回吸水流能力減弱，以及再泛水後蒸汽挾帶液態水向上離開爐心的能力減弱，無法像一維爐心般讓冷卻水流重複通過爐心形成強烈的自體循環，冷卻爐心上部燃料；並且發現爐心入口水流集中往功率最高的流體通道流入冷卻的效果減弱，使得爐心多維度模擬的燃料護套尖峰溫度高於傳統一維模式，約 240 °F 到 500°F，隨通道數增多而上升但有收斂的趨勢。

同時結合多維度爐心與降流區模擬時，研究發現結果除同時保有上述結果的特性外，並看到降流區多維度模式使再泛水階段提早外，提高爐心多維度模式的液態水挾帶能力，但仍不及一維模式的爐心自體循環能力，因此燃料護套溫度仍較一維模式來得高 30 °F 到 120 °F，但比起單純只有爐心多維度模式而言已降低許多。

Abstract

In present Study, RELAP5-3D code is used to simulate the large break loss of coolant accident (LBLOCA) of Maanshan Nuclear Power Plant. The Plant employs a Westinghouse designed three-loop Presssurized Water Reactor (PWR). In the simulation, the multi-dimensional components of RELAP5-3D code are used to simulate the downcomer and core regions within the reactor pressure vessel (RPV). The Results of the simulation are compared with RELAP5-3D results obtained from the traditional one-dimensional modeling of these regions.

In the multi-dimensional simulation of downcomer, the limits of counter current flow (CCFL) in downcomer ends earlier by five to ten seconds than that in the 1D simulation. It makes core reflood starting early and lowers the peak cladding temperature (PCT) by 10^{o}F. The oscillations of cross flow between the downcomer regions connected to intact and broken loops are less violent than these observed in the 1D simulations.

In the multi-dimensional simulations of core, the predicted PCTs are between 240 and 500 ^{o}F higher than that in the 1D simulation. It is observed that the capability of core sucking back the coolant is less during the early period of transient. But the major phenomenon that affects the predicted PCT is the core self circulation that caused by liquid entrainment in core region during the reflood period. The entrained Liquid falls back to lower plenum through the core bypass region. Heat transfer in the upper part of the core is improved significantly improved due to the liquid flow through the bypass region. In the 1D simulation, larger amount of liquid is predicted to be entrained by the steam. The amount of liquid entrained is higher when the core is modeled by finer meshes in the X-Y plan.

When both downcomer and core are modeled multi-dimensionally, the earlier termination of CCFL and enhancement of self circulation in the 3D simulation of downcomer have a tendency to lower the predicted PCTs. The predicted PCT is still about 30 ^{o}F to 120 ^{o}F higher than that of 1D model.