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Concept Design of Ex-Vessel Cooling System for In-Vessel Retention in Severe Accidents

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1. Introduction

In-Vessel Retention is epoch-making safety concept that can absorb severe accidents result that confine Corium (nuclear fuel and melting mixture of construction) on nuclear reactor Pressure Vessel interior. Therefore this research Installation Floating Gate on Cooling Well lower part, existing obstacle factor improvement, develops a demonstration and prediction model. Also in compliance with severe accidents EVCS the line which will come out falling heat containment vessel suddenly raised the pressure and a temperature of pressure containment vessel. Therefore, wish to design Ultimate Heat Sink for emergency containment integrity preservation and achieve an experiment

2. In-Vessel Retention Basic Concept

In-Vessel Retention (IVR) to maintain the case malleability of severe accidents pressure vessel in order not to flow out this outside of the radioactivity material (Corium) of high-level, is the severe accidents disposal concept.

Ex-Vessel Cooling (EVC) implants the cooling water in the severe accidents pressure vessel lower part department outer wall and the outside is pressure vessel to penetrate in cooling prevention (case malleability maintenance). Consequently the fact that confines Corium on the pressure vessel inside is IVR core concepts

EVC is proposed with the disposal plan for severe accidents IVR and the research is in the process of advancing.

3. Problem of existing EVC concept

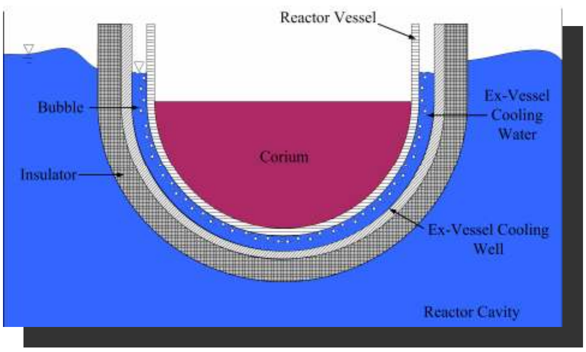

Fig 1. Existing EVC

3.1 Supply early stage & supply long term

Need installation of Ex-Vessel Well of confined capacity on nuclear reactor Pressure Vessel lower part outside for cooling water supply early stage. Long term cooling water supply is impossible by confined Well capacity, intercept that water that accumulates to Cavity touches with Pressure Vessel lower part. Therefore, become obstacle factor of long term supply of cooling water

3.2 Heat insulator problem

Because driving nuclear reactor Pressure Vessel whole is coated by insulation material, cooling water is impossible direction contact on nuclear reactor courage outside by ordinary method. Therefore, Ex-Vessel Cooling Well (EVCW) should be installed between Heat insulator inside and nuclear reactor Pressure Vessel outside

3.3 Establishment space problem

Space between Pressure Vessel of EVCW should be minimized on Establishment space restriction. Must equip depth that cooling corresponds to height of necessary Pressure Vessel. Cooling early stage gets into advantage on this restriction. But Well capacity is limited and is run dry after schedule time.

3.4 Long term cooling problem

Most of water that is supplied at early fills EVCW. The water is full by Reactor Cavity after fill EVCW. The well capacity is limited, pass during schedule time, EVCW is run dry easily in evaporating or boiling. But the water which comes to be put in Reactor Cavity is caused by with Well, Vessel and heat transfers being intercepted. Therefore, necessary water is not supplied on Vessel outside to long term cooling.

3.5 Non Passivity system

Operation opening uses Bimetal, there is driven passivity system using head.

Necessary new EVC System's development that can overcome existing EVC's problem with upside.

4. Passive Floating Gate Concept Development

Floating Gate Operation essential factor development

- Corium creation capture by Bimetal
- Pouring in cooling water.
- Cavity Flooding
- Pouring in cooling water Evaporation exhaustion.

$$(P_C - P_W)A = \rho g(h_C - h_W)A > Mg\ ,\quad M = mA$$

- Floating gate open condition $\rho(h_C - h_W) > m$
- Other consideration item

: Gate Interior and exterior density difference (Temperature)

- Bubble effect (Bubble pump)

△P_{exp} (Boiling)

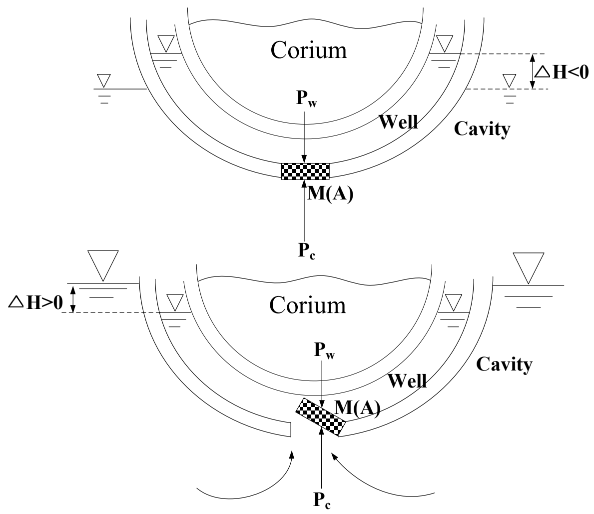

Fig 2. Passive Floating Gate

5. Passive EVC System Concept Development

5.1 Operation scenario

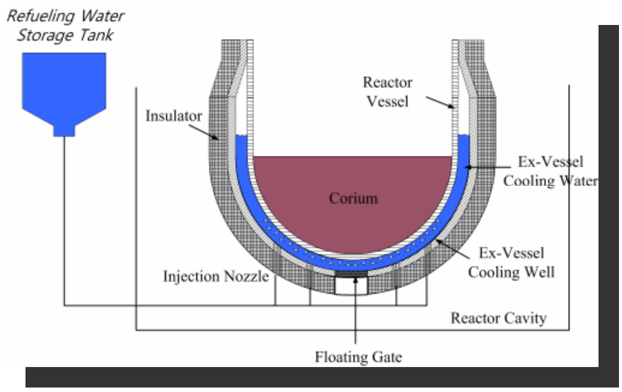

Fig 3. Phase Ⅰ: Safety injection starting.

① Injection starting by Bimetal signal

: Accident opening part, Cooling water pouring in beginning step by EVCW that become low by early cooling

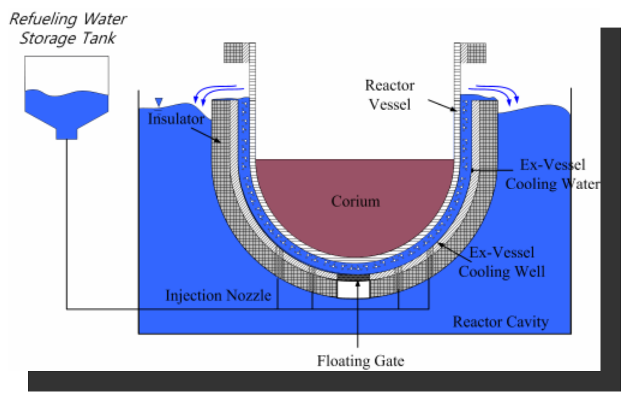

Fig 4.Phase Ⅱ : Rupturing of insulation and overflowing of cooling water

② Cooling water that is driven by heat insulator fracture overflows and water enters to Reactor Cavity

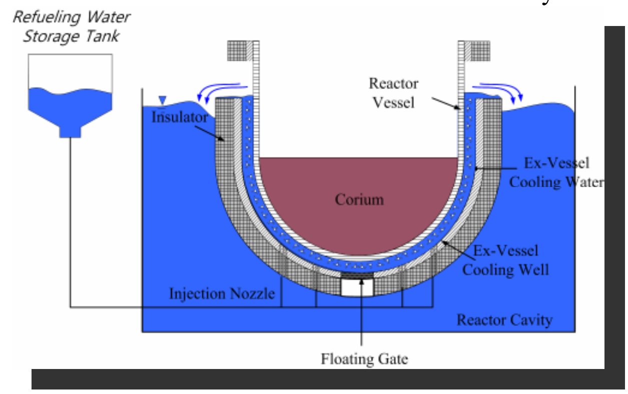

Fig 5. Phase Ⅲ : Flooding to Reactor Cavity

③ Water in injection nozzle.

Outer wall Bubble removal and continuous heat transfer by Flooding.

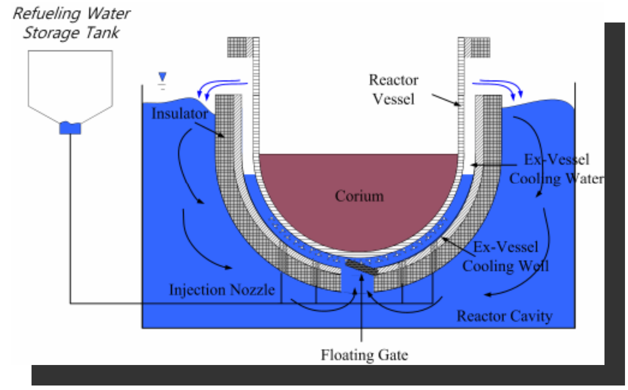

Fig 6. Phase Ⅳ : Opening Floating gate and Natural Convection Mode

④ Storage Tank empty and long term cooling step to natural convection by Passive Floating Gate opening.

가압경수형 원자로의 노심요융방지를 위한 노외 냉각구조' patent application June, 2007 by result of this research.

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