Assessment of Molten Pool Cooling Characteristics During LBLOCA for Advanced Passive PWR

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ABSTRACT

Molten pool cooling by external reactor vessel cooling (ERVC) strategy, which is designed as a severe accident mitigation strategy for advanced passive pressurized water reactor (PWR), can prevent reactor vessel failure and decreases the containment failure possibility. Previous studies about ERVC strategy mostly focus on the heat transfer behavior of molten pool and lower head after the molten pool is already exists. Therefore, it's necessary to analyze the formation process of the molten pool coupled with the ERVC strategy. Cavity natural circulation cooling capability is analyzed by SCDAP/RELAP5 code, which is validated with the KOREA experiment for APR1400. The reactor coolant system (RCS) model combined with engineering features systems of the advanced passive PWR for molten pool cooling capability assessment is built coupled with ERVC structure. The major portions of the model include the reactor core, primary system, secondary system and passive core cooling system. The lower head of reactor vessel is modeled by COUPLE module. One severe accident sequence induced by large break loss of coolant accident (LBLOCA) at cold leg with failure of internal refueling water storage tank is chosen to analyze molten pool cooling characteristics during core damage progression and heat remove capability by the natural circulation after cavity injection strategy is implemented. The key events of the accident shows good agreement with the probabilistic risk assessment (PRA) report, and the wall temperature distribution of the lower head is obtained. The results indicate that molten pool in the lower head can be effectively cooled by cavity flooding after core exit temperature exceeds 923K during LBLOCA accident, and the integrity of reactor pressure vessel (RPV) can be maintained.

KEYWORDS

Molten pool cooling, EVRC strategy, LBLOCA, Advanced passive PWR;

1. INTRODUCTION

Molten pool cooling by ERVC strategy can prevent reactor vessel failure and decreases the containment failure possibility, which is designed as a severe accident mitigation strategy for advanced passive PWR. Molten pool cooling capacity during direct vessel line break was analyzed for AP1000 [1]. However, the detail structure of the cavity was not taken into account in the analyses. SCDAP/RELAP5 code can analyze reactor vessel wall temperature distribution with accident progression [2], and it can simulate two phase flow instability at a more detail level when external cooling is considered [3]. Flow analyses using the RELAP5/MOD3 were performed for OPR1000 [4]. The value of corium mass and decay heat were quoted from the SCDAP/RELAP5/MOD3.3 simulation results [5]. Previous studies about ERVC strategy