CHF Experiments under Realistic Severe Accident Condition for IVR-ERVC Strategy

Tae Il Kim[1*], Hae Min Park[1], Sun Heo[2], Soon Heung Chang[1]
[1] *Nuclear and Quantum Eng., Korea Advanced Institute of Science and Technology*
335 Gwahak-ro, Yuseong-gu, Daejeon, Republic of Korea, 305-701:
+82-42-350-3826: jeongyh@kaist.ac.kr:
[2] *Nuclear Engineering and Technology Institute, Korea Hydro & Nuclear Power Co.*
25-1, Jang-dong, Yuseong-gu, Daejeon, Republic of Korea, 305-701:
hs@khnp.co.kr:

1. Introduction

In vessel retention of molten corium through external reactor vessel cooling (IVR-ERVC) is a strategy to manage severe accident of nuclear power plant. This IVR-ERVC strategy is adopted by some operating nuclear power plants and proposed for some advanced LWR such as AP600 and AP1000. It gives sufficient thermal margin for AP600. However it is not sure that the IVR-ERVC provides sufficient thermal margin for large power reactors (more than 1000MWe) without additional enhancements [1]. In this study, CHF experiments were conducted using 2-D silce under realistic severe accident condition such as additives of coolant and material of heater to find additional thermal margin of IVR-ERVC.

2. Experimental Apparatus

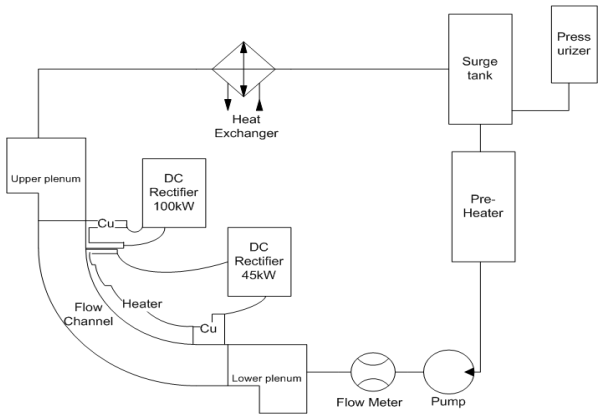

Fig. 1. Schmatic diagram of the experimental loop

CHF experiments were conducted in IVR-ERVC CHF experimental loop which is shown in Fig. 1. The experimental water loop used in this study consisted of test section, heat exchanger, surge tank, preheater, pump, flow meter, lower plenum, test section and upper plenum.

The test section was divided in two parts. One part (inclination angle 0~82°) was the pre-heated region by DC heating. This part was divided in three parts (thickness 2~6 mm) to simulate the actual heat load of the APR1400 design during severe accident. Another part of test section was main heated section. The main heated section was vertical plate of which the width was 3 cm and the length was 2~3 cm. The heater thickness was 2 mm for SUS304 and 1 mm for SA508. The dimensions of the test section and the experimental conditions are listed in Table 1.

Table 1. Test matrix of CHF experiments

Test matrix		
Pressure		1 bar
Mass flux		100, 200, 300 kg/m^{2}s
Inlet subcooling		2, 10 K
Dimension of test section	**Radius**	150, 250, 500 mm
	Gap	30, 60 mm
	Material	SA508, SS304
Working fluid		DI water, TSP, Boric acid.

3. Results and Discussion

In this study, it is investigated the effects of additives (TSP : $Na_3PO_4 \cdot 12H_2O$, boric acid : H_3BO_3). In case of radius of 150mm test section heater, The CHFs of boric acid were decreased at all mass flux while the CHFs of TSP and TSP+BA were enhanced up to ~35% (Fig. 2). In case of radius of 250mm test section heater, The CHFs of TSP+BA were enhanced up to 20% (Fig. 3). In case of radius of 500mm test section heater, The CHFs of BA were enhanced up to 26% and The CHFs of TSP were enhanced up to 35% (Fig. 4). These enhancements can give more margins for the IVR-ERVC strategy under severe accident conditions.

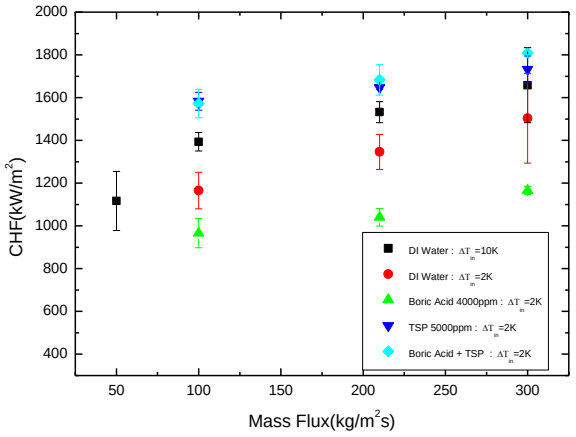

Fig. 2. CHF results of 150mm radius

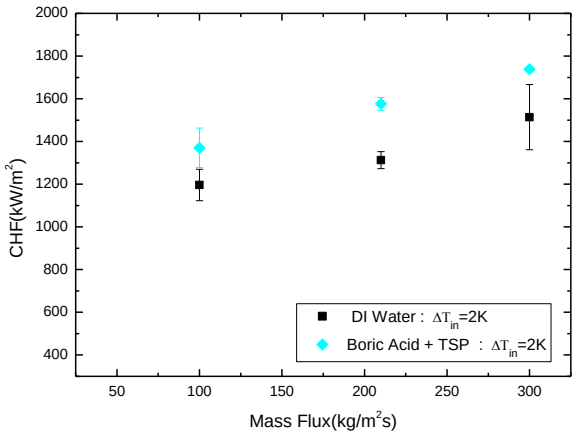

Fig. 3. CHF results of 250mm radius

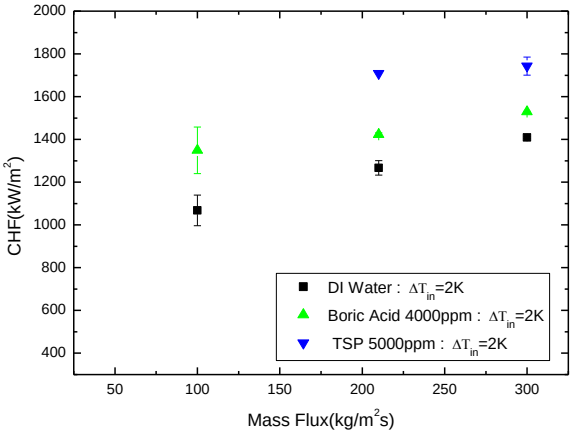

Fig. 4. CHF results of 500mm radius

4. Conclusions

Through this study, CHF experiments for IVR-ERVC using a small scale two-dimensional slice test section were conducted. Basically, the effect of additives and heated material on CHF was investigated. Through the experiments, we found that the CHFs of BA, TSP and BA+TSP were all enhanced except the CHFs of BA at radius of 150mm. These enhancements can give more margins for the IVR-ERVC strategy under severe accident conditions.

Acknowledgements

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