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著者(和文)	LeTri Dan
Author(English)	Tri Dan Le
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論 文 要 旨

THESIS SUMMARY

専攻： Department of Nuclear Engineering	専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of (Engineering)
学生氏名： Student's Name Le Tri Dan		指導教員（主）： Academic Advisor(main)	高橋　実
		指導教員（副）： Academic Advisor(sub)	竹下　健二

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Thermal neutron reactors such as light water reactors (LWR) have been already commercialized, where nuclear fuel can be partially recycled by reprocessing and Pu burning. Simultaneously, the generation IV fast reactors (FR) have been developed for full fuel recycling for future nuclear sustainability. In addition to Generation IV liquid metal-cooled FRs, LWR, particularly boiling water reactors (BWR), can be expected be FR soon if the reactor core is arranged to be a tight lattice with smaller volume ratio of moderator to fuel. It has been known that wire spacers are more suitable rather than grid spacer if the lattice of the core is tighter. The feasibility of the tight lattice core with the wire spacer depends upon core coolability because of the small flow area, and the coolability can be evaluated by the characteristics of critical heat flux (CHF). In the previous studies, the CHF behavior in the tight lattice core was investigated just for the case of grid spacer.

Therefore, in the present study, the CHF behaviors in tight lattice channel with wire spacer were investigated. The effect of mass flux and geometric parameters on CHF behavior was investigated by means of CHF experiment in the single pin and three-pin bundle with and without wire spacer.

A water test loop consisting of the water tank, the circulation pump, the pre-heater, the orifice flow meter and the CHF test section was set up. The maximum heating power of the electric source is 50kW. Based on the new experimental techniques, two types of simulation tests at atmospheric pressure: the single pin and three-pin bundle CHF experiments could be designed and conducted.

The single pin experiment was conducted to investigate the CHF behavior in boiling two-phase flow. The single pin test section with wire spacer was a simplify geometry channel to investigate the effect of wire spacer on CHF. The flow disturbance as a result of wire spacer could be well simulated by single pin test. According to the experimental results, it was found that the CHF in case of heater pin with circular shape wire was enhanced up to 25% compared with it in case of without wire space under the same flow condition. Therefore, the coolability or heat removability was enhanced by the existence of the wire spacer and spiral flow. On the other hand, with the same flow rate condition, the CHF values can be increased up to 100% with the decrease of gap size. Therefore, the flow channel with smaller gap size a higher coolability compared with the flow channel with larger gap size. Following the results, it also found that the change in a pitch of wire did not have a large influence on the CHF if the mass flux was kept constant. The experiment data was nearly the same value even with two different cases of wire pitch.

On the other hand, the flow condition in practical tight lattice core is affected by multiple wire spacers of the adjacent heater pins. Thus, the CHF behavior in tight lattice core may be different from that in single pin channel. Therefore, the CHF three-pin bundle experiment with and without wire pacer was conducted to investigate the effect of wire spacer on CHF in tight lattice core. According to the experimental results, it was found that the CHF was enhanced by up to 50% with wire spacer compared with it without wire spacer under constant mass flux condition. The enhancement was more significant at

the low quality region. Thus, the coolability in tight lattice core could be optimized by using wire spacer. Besides, under constant flow rate conditions, the CHF values increased by up to 150% when decrease the pitch to diameter ration from 1.18 to 1.10. The new correlation of CHF in bundle pin with wire spacer was created by the fitting method. The correlation was shown as a function of mass flux, quality and gap size value. Following the results, it also found that under the same mass flux condition, the CHF is nearly the same even with difference values of wire pitch. In addition, the new CHF correlation for bundle pin with wire spacer was created. The new correlation can predict the CHF data with the deviation of ± 25% which is good enough in the case of boiling two-phase flow phenomena.

Moreover, in order to have a better understanding of the experimental results, the analytical study on CHF behavior in tight lattice core was also performed. The method of multi-fluid model analysis was used to simulate the CHF phenomenon. In the case of single pin channel, two separated liquid film flows were simulated and in the case of three-pin bundle, a single liquid film flow in a subchannel was simulated. The boundary conditions were inlet enthalpy, inlet mass flux, pressure and heat flux at heater pin surfaces. The parametric studies on the droplet entrainment and deposition rate were performed to clarify the mechanism of the enhancement of CHF in annulus channel in the single pin test and the subchannel in the bundle pin test. According to the results, it can be seen that the CHF can be estimated by the multi-fluid model. Additionally, the parametric study shows CHF may be enhanced by increase of the droplets entrainment rate in outer liquid film in annuli channel. On the other hand, by changing the mass transfer coefficient in the three-pin-bundle subchannel, the CHF was increased.

In summary, the study could found the enhancement of CHF in tight lattice core by using the wire spacers. On the other hand, the CHF in tight lattice core with wire spacer could be increase with the decreasing of gap size or the pitch to diameter ratio under the same mass flow rate condition. In other words, in the tight lattice core, the coolability can be maximized by using the wire spacer.