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CHF enhancement of a large heated surface by a honeycomb porous plate and a gridded metal structure in a saturated pool boiling of nanofluid

(Article)

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Abstract

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The enhancement of the critical heat flux (CHF) in saturated pool boiling of water-based nanofluid (containing TiO_2 nanoparticles) by the attachment of a honeycomb porous plate (HPP) and a gridded metal structure (GMS) on a horizontal heated surface have been investigated experimentally. The honeycomb porous plate attached to the heated surface enhances the liquid supply due to capillary action to the heated surface and the release of vapor through the vapor escape channel. The deposition of nanoparticles on the heated surface during the boiling of the nanofluid enhances the spread of liquid along the heated surface due to the capillary action. The preceding papers by the present authors revealed that the CHF could be significantly enhanced by 2.2 times that of water boiling by the attachment of the HPP on the heated surface with the nanoparticle deposition layer. According to the hydrodynamic theory by Lienhard et al. (1973), the installation of a gridded structure on the heated surface could also enhance the CHF because the number of the escaping vapor jets each of which allows the liquid flow to the heated surface near the CHF conditions increases with the increment in the number of grid. The present paper describes the results directed toward the further enhancement of the pool boiling CHF of nanofluid by the installation of the GMS onto the HPP on a large heated surface. The tested surface has a diameter of ϕ50 mm, which is 20 times the capillary length, $\lambda_C(=\sigma/g(\rho_l-\rho_v)$. For plain surfaces being larger than 20 times the length λ_C, the CHF can be regarded as being equivalent to that of an infinite large surface. Based on the Lienhard model, grid size of the GMS is chosen so that the CHF of water boiling is increased most effectively. As a result, for simultaneous existence of three factors (the HPP, the GMS and deposition layer of nanoparticles), the CHF has been enhanced to 3.1 MW/m^2, which is the higher than either of the HPP in water, the HPP in water-based nanofluid and the GMS in water. High-speed-movie visualization of water boiling revealed that the attachment of the gridded metal structure shortens the hovering period of the coalesced bubble compared to the plain surface. Shortened period causes the more frequent liquid supply to the heated surface. These results illustrate the potential for increasing the safety margin in the IVR (In-Vessel Retention) systems as a heat removal technology. © 2017 Elsevier Ltd

Author keywords

Capillary action; Critical heat flux enhancement; Gridded metal structure; Honeycomb porous plate attachment; IVR; Nanofluid

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Effects of heater orientation on critical heat flux for nanoparticle-deposited surface with honeycomb porous plate attachment in saturated pool boiling of water

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