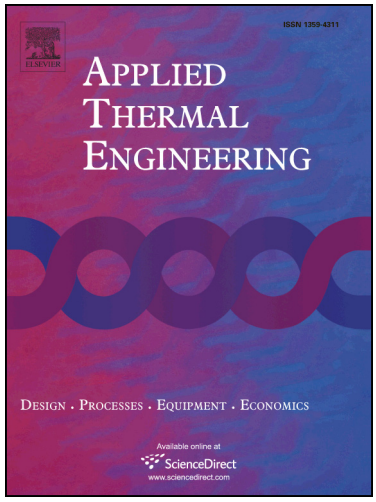

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Computer Modeling of Droplets Impact on Heat Transfer during Spray Cooling under Vibration Environment

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Abstract

The heat transfer process among droplet, film and bubble is selected as the local characteristic process of spray cooling to build a multiphase flow model. Volume of fluid (VOF) method is employed to simulate the transient process, in which single or multiple droplets impact on a liquid film with a vapor bubble growing, considering the effects of surface tension, gravity and vapor-liquid phase transition. The effect of vibration environment is analyzed by setting vibration boundary condition, and a far broader range of vibration condition is calculated in light spray and dense spray to identify the effect. Heat is mainly removed by strong convection due to the droplet impact. It is significant to form stabilized and intact film during spray cooling. Heat transfer process can be mainly separated into four stages: 1.before the impact; 2.droplet impacts on the surface and forms thinner film on the surface; 3.film extends outwards; 4.film breakage. In dense spray cases, the third stage is barely observed due to continuous impacting of droplets, and mainly all the cases show that vibration has invigorating effect on heat transfer.

Key words: spray cooling; Volume of Fluid; droplets impact; vibration

1. Introduction

Spray cooling is regarded as the solution of high heat flux removal problem [1] and has been proved to be able to remove over 1000W/cm^2 heat flux when using water as coolant [2]. Especially under the condition of the rapid development of electronic devices and laser weapons, the application of spray cooling has been paid more and more attention to. In spray cooling, coolant is pressured through a nozzle to atomize into abundant discrete fine droplets which then impact on the heated surface directly, forming a thin liquid film on the surface. Heat is removed by three main mechanisms, including nucleate boiling (surface and secondary nuclei), convective heat transfer, and direct evaporation from the surface of film [2, 3]. Many devices are used under vibration environment, such as airborne or shipborne equipment. However, few related researches have been reported, and the effect of vibration environment on spray cooling is unknown. Determining the effect of vibration on spray cooling is significant to the thermal management of those devices.

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