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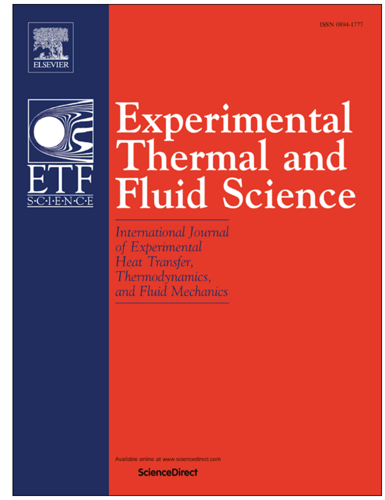

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Experimental investigation on the propagation characteristics of pressure oscillation in direct contact condensation with low mass flux steam jet

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Abstract
The propagation characteristics of pressure oscillation in direct contact condensation with low mass flux steam jet have been investigated experimentally. Steam is injected into subcooled water at one atmosphere pressure with steam mass flux and water temperature range of 186-272 kg/(m^{2}s) and 293-343 K. The pressure oscillation propagates in the form of wave with stable dominant frequency, however the wave intensity attenuates with the increasing distance from the oscillation source. The root mean square of pressure wave p_{rms} attenuates rapidly with the increasing dimensionless radial distance from the nozzle exit. At about dimensionless radial distance R=100, the p_{rms} is attenuated by about 90%. Although the dominant frequency of the pressure oscillation is constant during the propagation, after R=100, there will be not enough energy for the pressure oscillation to resonate with relevant equipment. A correlation equation to calculate the root mean square of pressure oscillation along the radial distance is given. The prediction errors are within ±30% compared with the experimental data.

Keywords: Pressure oscillation; steam jet; propagation; low mass flux condensation

Nomenclature

A	Amplitude of pressure oscillation	p_{i}	The sampling pressure, kPa
d_{e}	Exit diameter of nozzle, mm	p_{rms}	Root mean square of pressure oscillation, kPa
f	Frequency, Hz	p_{∞}	Ambient pressure, kPa
G_{e}	Steam mass flux, kg/(m^{2}s)	R	Dimensionless radial distance
H	Submerged depth of nozzle, mm	T_{w}	Water temperature, K
k	Total number of samples	X	Dimensionless axial distance
p_{av}	Average pressure, kPa	τ	Time, s

1. Introduction

Direct contact condensation has been widely used in number of industries including nuclear power plants, chemical industry and renewable energy systems due to its high heat transfer efficiency. For example, in nuclear power plant pressure relief system, the high pressure and temperature steam is injected into subcooled water pool when the pressure of nuclear reactor pressure vessel is higher than the safe value. The steam is condensed rapidly due to the high heat transfer efficiency. However, in the process of steam-water direct contact condensation, the water pressure around the steam plume will oscillate due to the expansion and contraction of the steam plume. The load of pressure oscillation is harmful to the pool wall, structures and relevant equipment in the pool. Moreover, when the frequency of pressure oscillation is low, it will resonate with the pool wall, structures and relevant equipment and may results in a failure of the equipment and pressure relief system [1]. Therefore, it is very important to investigate