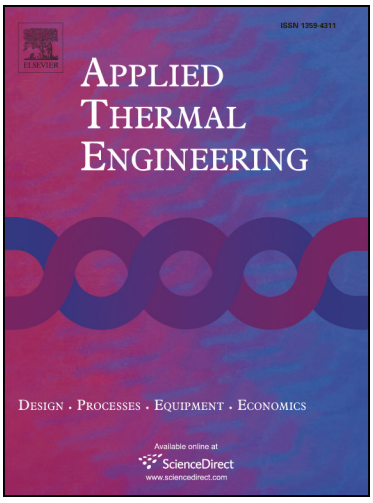

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Effects of operational parameters on liquid nitrogen spray cooling

Yixiao Ruan[1], Yu Hou[1], Rong Xue[1], Gaoqiao Luo[2], Kuizhang Zhu[2], Xiufang Liu[1], Liang Chen[1,*]

[1]State Key Laboratory of Multiphase Flow in Power Engineering, Xi'an Jiaotong University, Xi'an 710049, China

[2]Anhui Province Key Laboratory of Cryogenic Technology, Hefei 230088, China

*Corresponding author; E-mail: liangchen@mail.xjtu.edu.cn

Abstract: To determine the influence of design parameters on droplet evaporation and distribution of liquid nitrogen (LN_2) spray cooling, experimental and numerical studies are performed by varying the mass flow rate, flow velocity, droplet diameter, injection orientation, and droplet velocity. The results demonstrate that backward injection yields the highest droplet evaporation ratio, which is 40% and 10% higher than the evaporation ratios obtained through forward and transverse injections, respectively. Counter-rotating vortex pairs are observed in the transverse injection, which improves the temperature distribution via convective mixing. Reducing the droplet diameter provides a more effective means of enhancing the evaporation than increasing the droplet velocity, and a linear increase in the droplet evaporation is observed by reducing the droplet diameter from 0.6 to 0.2 mm. The results and findings provide guidelines for the design of LN_2 spray cooling systems for cryogenic wind tunnels.

Keywords: spray cooling; liquid nitrogen; wind tunnel; computational fluid dynamics

1. Introduction

Wind tunnels are used for aerodynamic testing of proposed aircraft models. The most efficient means of achieving a high Reynolds number in these wind tunnels is by increasing the gas density through lowering the gas temperature [1]. The National Transonic Facility (NTF) and European Transonic Wind Tunnel (ETW) have adopted the method of spray cooling with liquid nitrogen (LN_2) to reduce the gas temperature, thereby achieving a high Reynolds number [2, 3]. LN_2 spray cooling plays an important role in the operation and