Effect of orifice configuration on the penetration height in crossflow

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Abstract

In previous researches on jet in crossflow (JICF), which is applied for the liquid jet injection system of air-breathing propulsion systems or rocket engine system, more than 20 different correlations of jet penetration have been proposed. But, most of these studies were carried out using the single orifice injector (SOI). In this study, in order to define the interference effects of liquid jet penetration in crossflow, the double orifice injector (DOI) is adopted. First, the jet penetration correlation of SOI according to the crossflow temperature controlled by the vitiated air heater is proposed. The jet penetration height for heated crossflow is lower than that for cold crossflow because of the increase of crossflow velocity despite the lower density. The jet penetration correlation of DOI is derived for variations of injector orifice spacing. In the case of the DOI, since the front liquid jet acts as a shield of the rear liquid jet, the jet penetration with DOI is higher than that with SOI. With the DOI, the rear jet penetration height increased as the nozzle spacing decreases. And, the penetration height correlation for the rear liquid jet with DOI was developed. Therefore, an inverse relationship between nozzle spacing and jet penetration height is expected.

Introduction

The objective of this study is to present a set of penetration heights for double liquid jets injected into cross-flow and to describe the influence of the double liquid jets. Thus, the jet penetration height correlation for the single liquid jet injector and double liquid jet injector is determined.

Experimental setup and method

The experimental facility consisted of an elevated ambient pressure supply system, vitiated air heater (VAH), test section, and the pressure and flow rate measurement section. The elevated ambient pressure supply system consisted of a higher-capacity compressor, an air dryer, an air storage tank and a pressure control valve. In this study, the air conditions were set by the vitiated air heater (VAH). The test section had a height of 100mm and a width of 100mm. The visualization windows, made of tempered glass, were installed on 2 sides of the test section, and 1 on the top. In order to maintain constant quantity of crossflow, a sonic nozzle was installed in front of the test section, and to measure and control the pressure of the test section, a pressure regulating valve and an orifice were used. The pressure and flow-rate measurement section were composed of a pressure sensor, data acquisition board, and micro-manometer. Also, the liquid jet penetrations in the JICF were analyzed by the shadowgraph method using a high-speed digital camera and a stroboscope. The shadowgraphs of the liquid jet were taken with Canon EF 50mm f/1.8 lens, and were synchronized with the digital Camera (Canon EOS 20D) and the stroboscope.

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