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REGULAR PAPER

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Schlieren visualization of micro gas turbine exhaust plume with different shapes of nozzle

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Abstract Schlieren visualization of the plume ejected from the microgas turbine nozzle was conducted to understand infrared signal characteristics of various shapes of the exhaust nozzle. At the same time, the precise temperature distribution and infrared signal measurement were performed and compared. The maximum thrust of the microgas turbine used in the experiment is 230 N, the maximum speed of revolution is 108,500 rpm, and the maximum exhaust gas temperature is 750 °C. Seven nozzles were used for this experiment which included a cone nozzle, five square nozzles with aspect ratios (AR) ranging from 1 to 5 and an S-shaped nozzle with aspect ratio 6. The infrared signal emitted from the exhaust plume decreased as the aspect ratio increased. Schlieren flow visualization images show that cone nozzle had a uniform flow pattern, while square nozzle had a bright triangle pattern in the dispersed plume. As the aspect ratio of square nozzles increased, a bright triangle pattern reduced in size. On comparing Schlieren visualization with the temperature distribution, it can be understood that the triangular shape of core plume plays a major role in the temperature diffusion with the surrounding air. Based on the temperature distribution and the results of the Schlieren visualization, three types of exhaust plume models are suggested. These three models are homogenous plume, intermediate plume and two-dimensional plume with hot core, which correspond to the cone nozzle, the AR2 square nozzle and AR5 square nozzle, respectively.

Keywords Schlieren visualization · Micro gas turbine · Exhaust plume · Shapes of nozzle · Infrared signal

1 Introduction

Stealth technology reduces or masks the generation of infrared, electromagnetic and acoustics waves from an aircraft and prevents aircraft's detection from the sensors. An aircraft most likely to be detected from the infrared signal radiated from the hot sections of propulsion system, so reduction of the infrared signals from the propulsion system can be regarded as an important factor in development of stealth technology for aircrafts (Varney 1979; Mahulikar et al. 2007). In an aircraft, the main contributors for infrared signals are engine hot sections, nozzles and exhaust plumes while other sources include aerodynamic heating of the aircraft's surface skin and reflection of surface radiation and sunlight from the aircraft (Mahulikar et al. 2007). Researchers have studied infrared signals radiating from aircraft for different atmospheric effects and

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