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Author: Prof. Jingyu Zhang
Nanjing University of Aeronautics and Astronautics,, China, zjyhxm@nuaa.edu.cn

EXPERIMENTAL INVESTIGATIONS ON FLOW FIELD CHARACTERISTICS OF IMPINGING-FILM COOLING

Abstract

Impinging-film cooling is a hybrid cooling strategy with which advantages of impingement jet cooling and film cooling could be achieved simultaneously. It has been applied to liner cooling of combustors in aero-engines. Although there have been large amounts of studies on impinging-film cooling, experimental investigation about the flow field characteristics is rare because flow measurements in impinging-film structures are difficult considering the small size of structures. The present study investigated the flow field of f-type and t-type impinging-film cooling structures by means of particle image velocimetry (PIV). The actual geometrical dimensions of impinging-film structure were amplified so that the PIV was capable of measuring the flow field of impinging-film structure. The schematic diagram of experimental setup is showed in fig.1. In this experiment, the effects of blowing ratio (M) , temperature ratio (TR), turbulence intensity of hot flow (Tu), non-dimensional jet-to-plate pitch (Zn), non-dimensional spanwise spacing of jet holes (Yn), cross-sections of inducting slab (rectangular or triangular) and the layout of cooling scheme (f-type and t-type) on the flow field were analyzed. The results show that the increase of M moves the entraining vortices downstream, decreasing the hot gas closes to the wall. However, the higher M enhances the mixing in the shear layer because of the reinforced vortices on the end of inducting slab (see Fig.2). The influence of TR (0.73 0.91) on flow field of impinging-film is very little. The augment of Tu reinforeces the mixing in the shear layer and the entraining effects at the exit of slot. The rise of Zn increases the size of entraining vortices, the depth of coolant film and the flow separation between the wall and coolant. The increase of Yn degrades the uniformity of velocity on the spanwise section. Compared with inducting slab with Rec cross-sections, the one with Tri cross-sections removes the entraining vortices downstream and the small vortices on the end of inducting slab, which decreases the mixing in the shear layer. The inducting slab with Tri cross-sections results in that coolant is attached to the wall effectively (see Fig.3). Compared with t-type impingement-film, the mixing of shear layer in f-type is weaker and f-type has a thinner coolant film, as shown in Fig.4.