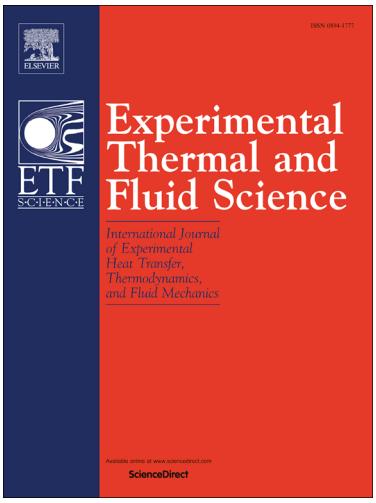

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Assessment of film cooling's surface quantities using pressure- and temperature-sensitive paint: comparisons between shaped and sand-dune inspired holes

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Abstract

Following the previous work [1], a comprehensive assessment was performed to further evaluate the film cooling's surface quantities behind shaped and sand dune-inspired holes. Adiabatic film cooling effectiveness, heat transfer coefficient, and net heat flux reduction (NHFR) were measured at four blowing ratios (M = 0.40, 0.90, 1.40, and 2.00). The measured quantities were compared side-by-side between the shaped and sand dune-inspired holes. The pressure-sensitive paint (PSP) technique was used to acquire high-resolution adiabatic effectiveness and the temperature-sensitive paint (TSP) technique was used to map the corresponding heat transfer coefficient over the surface. Nitrogen and air, with a density ratio of about one, were used as the coolant for the PSP and TSP tests respectively. The measured results showed that the adiabatic effectiveness of the Barchan dune-shaped injection compound (BDSIC) was significantly higher than that of the shaped hole. Improvements of 20% to 150% in the centerline and 30% to 400% in the laterally averaged effectiveness were observed behind the BDSIC compared to the shaped hole. As for heat transfer performance, although the BDSIC showed a 10% to 20% higher heat transfer coefficient, h_f/h_0, the measured spatially averaged NHFR still demonstrated an augmentation of 50% to 150% in heat flux reduction in comparison to the shaped hole. This paper represents the first effort to comprehensively evaluate the surface quantities behind BDSIC film cooling concept using both PSP and TSP techniques.

Keywords: film cooling; PSP and TSP; Barchan dune; adiabatic effectiveness; heat transfer coefficient; net heat flux reduction.