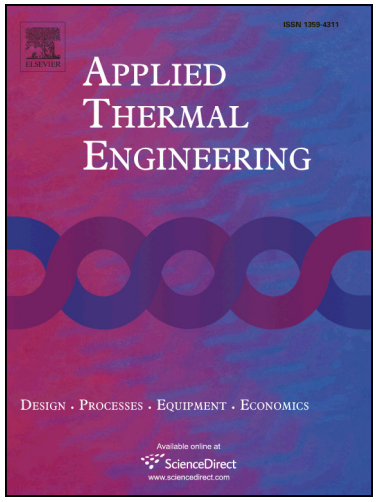

Research Paper

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PLASMA ACTUATOR SCALING DOWN TO IMPROVE ITS ENERGY CONVERSION EFFICIENCY FOR ACTIVE FLOW CONTROL IN MODERN TURBOJET ENGINES COMPRESSORS

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ABSTRACT

The present work was performed to investigate the employment of micro dielectric barrier discharge plasma actuators for mitigating separation, thereby decreasing wake losses and increasing efficiency, on a highly loaded compressor cascade. At this aim, firstly the experimental characterization of the control device was done. A dedicated activity was devoted to microelectronic technology adoption for micro plasma actuator fabrication, together with batch production of electrodes with photolithographic techniques. The actuation effect on quiescent flow was evaluated by measuring the induced wall-jet with particle image velocimetry. The actuator power consumption was estimated by recording the applied voltages and resulting currents.

Experimental results were then used to calibrate a multi-physics numerical model, for the prediction of the body forces induced by plasma actuator. Different algebraic models were compared. Numerical modelling was applied to predict the capability of micro plasma actuation to suppress flow separation into a highly-loaded subsonic compressor stator cascade. At first, simulations of the compressor cascade without active flow control were carried out and the results were compared with the literature experimental data. A good agreement was found between the experimental and the numerical results. Active flow control by the micro plasma actuator was then tested under different sinusoidal voltage amplitudes. It was found that the compressor pressure losses were reduced by increasing the applied voltage; actuation brought to a reduction in the pressure loss coefficient up to 14% and to an increase in static pressure up to 3%. When the actuator was on, the isosurface of the Q-criteria showed the reduction of secondary flow structures and the shape factor at the trailing edge of the midspan section was always lower than 2.2, confirming a reattachment of the flow. Furthermore, a conventional macro actuator found in the literature was also modelled and its actuation effect was compared to the one of the micro plasma actuator.

However, the analysis of the cost of actuation underlined that the adoption of micro actuation allowed reaching a higher gain when operating at lower voltage and same frequency.

KEYWORDS: Active flow control; micro plasma actuator; CFD; compressor cascade.

1 INTRODUCTION

At the present time, active flow control (AFC) has been extensively investigated in different applications, aimed to delay transition, suppress turbulence or prevent separation.