EXPERIMENTAL AND COMPUTATIONAL ANALYSIS OF THE FLOW INDUCED BY A PIEZOELECTRIC FAN

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ABSTRACT: The use of piezoelectric ceramics as actuators in flapping plate systems is interesting due to the low power consumption and high energy efficiency. Fluid flow is induced by these piezoelectric fans by converting electric energy into mechanical vibrations with the use of piezoelectric patches bonded to a passive elastic plate. By applying an alternating voltage the patch will periodically start to contract and expand (Fig. 1). If the frequency of the AC voltage is equal to the first resonance frequency of the structure, a sufficiently large dynamic tip deflection can be obtained, which is required to induce an air flow by the flapping plate. A considerable increase in heat transfer could be obtained by using these piezo fans for cooling of electronic devices [1]. Another application is applying these piezoelectric oscillating mechanical systems as flapping wings for MAVs [2]. The motion of the piezo fan is determined by the actuation frequency and the modal parameters. The structural optimization of these systems, in terms of optimizing the tip deflection and efficiency, does not necessarily match the optimization of the flow induced by the oscillating wing. This flow is characterized by a coupled fluid-structure interaction. A 2D assumption was made in many past studies found in the literature [3]. However the flow behind wings with finite span is significantly more complex than the flow behind infinite span wings. In this present study experimental high speed PIV measurements are conducted on a piezoelectric flapping wing with finite span operating at 84.8 Hz in air. The structure was operated at different tip deflection amplitudes, controlled by an integrated Laser Doppler Vibrometer system in the experimental set-up. The time resolved and RMS time-averaged results for different amplitudes are compared to 2D and 3D LES CFD simulations as a validation of the numerical method. Dominant Proper Orthogonal Decomposition (POD) modes were determined to obtain the dominant flow characteristics.

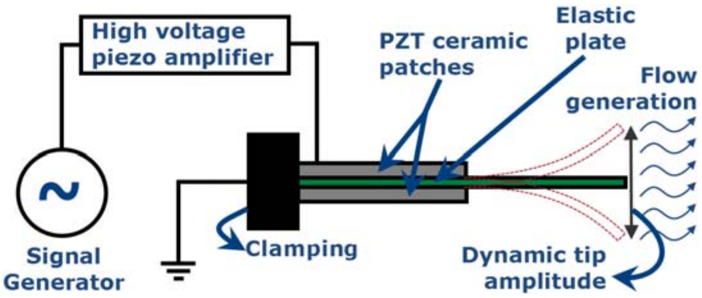

Fig. 1 The operating principle of a piezoelectric fan

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