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NUMERICAL SIMULATION AND EXPERIMENTAL VALIDATION OF A SYNTHETIC JET ACTUATOR FOR ACTIVE FLOW CONTROL

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Flow control plays a significant role in aeronautics field. Increasing lift and drag reduction using active flow control system, piezoelectric (PZT) synthetic jet actuators, have been investigated. Results from multi-physics simulation and from measurement are presented in this paper. Proper determination of actuator's parameters, geometry and working conditions will help to increase efficiency of flow control system. The synthetic jet is a jet-like mean fluid motion obtained by an alternate suction and ejection of fluid through an orifice bounding a small cavity. This is generated by a time periodic oscillation of a diaphragm built into one of the cavity's walls. Scheme of a synthetic jet is presented in Figure 1.

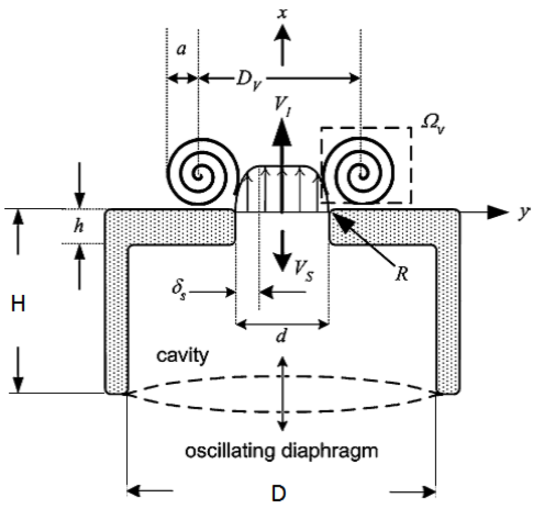

Figure 1 Scheme of a synthetic jet (Holman et al. 2005).

Actuator's geometry has been defined. Two membrane diameters D_1=18 mm and D_2=25 mm, orifice diameter d = 1mm and actuator height H = 1 mm in both cases. Simulations were performed for wide range of forcing frequencies up to 5 kHz and driving voltages up to 100 V.

Deformation of a moving diaphragm is simulated in LMS Virtual.Lab using 3D Finite Element model (Figure 2 left). Material properties and boundary conditions on the edge are applied. From the nodes located on the diaphragm cross-section, diaphragm displacement profile is exported and used as an input for a CFD model (Figure 2 right).

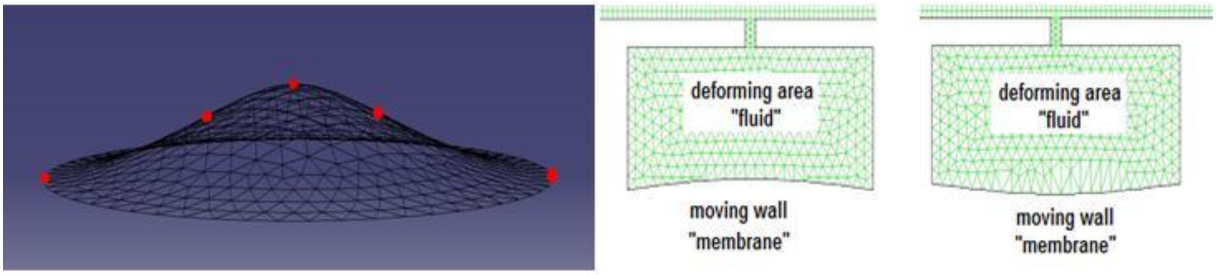

Figure 2 FE 3D deforming membrane model (left) and demonstrative 2D CFD model (right).

Preliminary CFD simulations of a vortex structure on the orifice exit were performed using ANSYS FLUENT. Moving Deforming Mesh method for the more accurate simulation of the volume change as a result of membrane oscillation was applied. Shear Stress Transport k-ω turbulence model was applied. Velocity vectors and velocity profile in the blowing cycle (forcing frequency f=5 kHz) are presented in Figure 3. Vortices created at the orifice exit are visible.

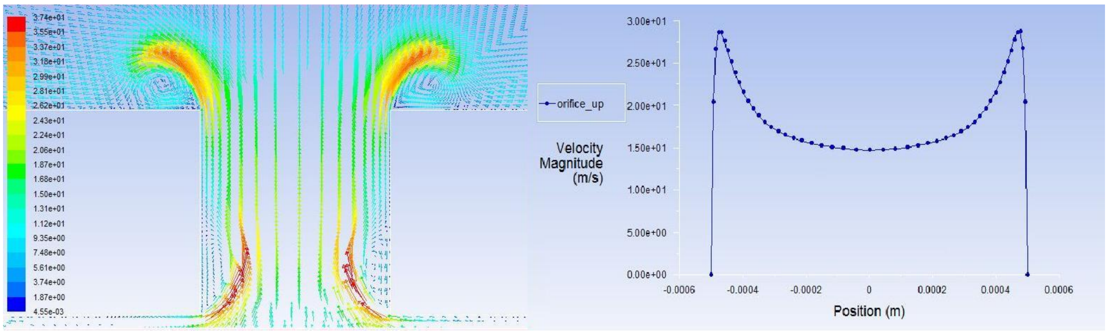

Figure 3 Velocity vectors (left) and velocity profile on orifice (right) in blowing cycle (D=18mm).

To investigate real velocity of the jet on the actuator exit Constant Temperature Anemometry (CTA) measurements are presented. CFD model optimization process is ongoing to maximize jet velocity from the actuator. Influence of actuator exit edges shape and angles are under investigation to provide detailed configuration for planned fully 3D unsteady synthetic jet simulations.

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References.

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