FINITE ELEMENT MODELING AND EXPERIMENTAL VALIDATION OF NEWLY IMPROVED SYNTHETIC JET ACTUATORS

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ABSTRACT

THE PRIMARY OBJECTIVE OF ACTIVE FLOW CONTROL RESEARCH IS TO DEVELOP A COST-EFFECTIVE TECHNOLOGY THAT HAS THE POTENTIAL FOR REVOLUTIONARY ADVANCES IN AERODYNAMIC PERFORMANCE AND MANEUVERING COMPARED TO CONVENTIONAL APPROACHES. THE DEVELOPMENT OF SUCH SYSTEMS HAVE MANY IMPLICATIONS FOR AEROSPACE VEHICLES INCLUDING: REDUCED MECHANICAL COMPLEXITY AND HYDRAULIC FAILURE, REDUCED NOISE AND WEIGHT, LOWER ENERGY AND FUEL CONSUMPTION, LOWER DOWN-TIME AND MAINTENANCE, ENHANCED MANEUVERING AND AGILITY WITH ENHANCED AERODYNAMIC PERFORMANCE AND SAFETY. INTEREST IN ACTIVE FLOW CONTROL FOR AEROSPACE APPLICATIONS HAS STIMULATED THE RECENT DEVELOPMENT OF INNOVATIVE ACTUATOR DESIGNS THAT CREATE LOCALIZED DISTURBANCES IN A FLOWFIELD. A NOVEL CLASS OF DEVICES, KNOWN AS SYNTHETIC JET ACTUATOR, HAS BEEN DEMONSTRATED TO EXHIBIT PROMISING FLOW CONTROL CAPABILITIES INCLUDING SEPARATION CONTROL AND THRUST VECTORING. THE BASIC COMPONENTS OF A SYNTHETIC JET ACTUATOR ARE A CAVITY AND OSCILLATING MATERIALS. THE SYNTHETIC JET ACTUATOR DEVELOPED AT NASA LARC HAS A SMALL HOUSING IN WHICH A CYLINDRICAL CAVITY WAS ENCLOSED BY TWO METAL DIAPHRAGMS, 50 MM IN DIAMETER, PLACED OPPOSITE EACH OTHER. A PIEZOELECTRIC WAFFER (THUNDER) WAS ATTACHED TO THE CENTER OF THE OUTSIDE FACE OF EACH METAL DIAPHRAGM. THE PAIR OF PIEZOELECTRIC METAL DIAPHRAGMS WAS OPERATED WITH A 180° PHASE DIFFERENTIAL AT THE SAME SINUSOIDAL VOLTAGE AND FREQUENCY. WITH ACTUATION, A SYNTHETIC JET ISSUED FROM A 35.5MM LONG BY 0.5MM WIDE SLOT ON THE TOP OF DEVICE. IN THIS PROPOSED PROJECT, A FINITE ELEMENT MODEL OF SYNTHETIC JET ACTUATOR DEVELOPED AT NASA LARC IS INVESTIGATED. THE DEVELOPED FINITE ELEMENT MODEL CAN BE UTILIZED TO DESIGN AND DETERMINE THE PERFORMANCE OF SYNTHETIC JET ACTUATOR. THE ANALYSIS INCLUDES THE FE MODEL OF PIEZOELECTRIC ACTUATOR, FE MODEL OF PZT/CIRCULAR PLATE COUPLED SYSTEM, FE MODEL OF PZT/CIRCULAR PLATE/CAVITY COUPLED SYSTEM AND EXPERIMENTAL VALIDATION. THE PHASE-AVERAGE JET CENTER VELOCITY AND AMPLITUDE OF INPUT VOLTAGE OF PZT ARE PREDICTED BY THIS FINITE ELEMENT MODEL. THE THEORETICAL PREDICTION IS COMPARED TO EXPERIMENTAL RESULTS OBTAINED AT DA-YEH UNIVERSITY.

Keywords: SYNTHETIC JET ACTUATOR, PIEZOELECTRIC WAFFER, CAVITY, THUNDER, FLOW CONTROL

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