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 HYD -RAULIC FAILURE, REDUCED NOISE AND WEIGHT, LOWER ENERGY AND FUEL CONSUMPTION, LOWER DOWN -TIME AND MAINTENANCE, ENHANCED MANEUVERING AND AGILITY WITH ENHANCED AERODYNAMIC PERFOR -MANCE AND SAFETY. INTEREST IN ACTIVE FLOW CONTROL FOR AEROSPACE APPLICATIONS HAS STIMUL -ATED THE RECENT DEVELOPMENT OF INNOVATIVE ACTUATOR DESIGNS THAT CREATE LOCALIZED DISTUR -BANCES IN A FLOWFIELD. A NOVEL CLASS OF DEVICES, KNOWN AS SYNTHETIC JET ACTUATOR, HAS BEEN DEMONSTRATED TO EXH -IBIT PROMISING FLOW CONTROL CAPABILITIES INCLUDING SEPARATION CONTROL AND THRUST VECTOR -ING. THE BASIC COMPONENTS OF A SYNTHETIC JET ACTUATOR ARE A CAVITY AND OSCILLATING MATER -IALS. THE SYNTHETIC JET ACTUATOR DEVELOPED AT NASA LARC HAS A SMALL HOUSING IN WHICH A CYLIND -RICAL CAVITY WAS ENCLOSED BY TWO METAL DIAPHRAGMS, 50 MM IN DIAMETER, PLACED OPPOSITE EA -CH OTHER. A PIEZOELECTRIC WAFER (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 SL -OT 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/CIR -CULAR PLATE/CAVITY COUPLED SYSTEM AND EXPERIMENTAL VALIDATION. THE PHASE-AVERAGE JET CENT -ER VELOCITY AND AMPLITUDE OF INPUT VOLTAGE OF PZT ARE PREDICTED BY THIS FINITE ELEMENT MO -DEL. THE THEORETICAL PREDICTION IS COMPARED TO EXPERIMENTAL RESULTS OBTAINED AT DA-YEH UN -IVERSITY.

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

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