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Concepts of Technologies Based on Smart Materials to Improve Aircraft Aerodynamic Performance

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Abstract : The article presents selected concepts of technologies that use intelligent materials in aircraft in order to improve their performance. Most of the research focuses on solutions that improve the performance of fixed wing aircraft due to related to their previously dominant market share. Recently, the development of the rotorcraft has been intensive, so there are not only helicopters but also gyroplanes and unmanned aerial vehicles using rotors and vertical take-off and landing. There are many different technologies to change a shape of the aircraft or its elements. Piezoelectric, deformable actuator systems can be applied in the system of an active control of vibration dampening in the aircraft tail structure. Wires made of shape memory alloys (SMA) could be used instead of hydraulic cylinders in the rear part of the aircraft flap. The aircraft made of intelligent materials (piezoelectrics and SMA) is one of the NASA projects which provide the possibility of changing a wing shape coefficient by 200%, a wing surface by 50%, and wing deflections by 20 degrees. Active surfaces made of shape memory alloys could be used to control swirls in the flowing stream. An intelligent control system for helicopter blades is a method for the active adaptation of blades to flight conditions and the reduction of vibrations caused by the rotor. Shape memory alloys are capable of recovering their pre-programmed shapes. They are divided into three groups: nickel-titanium-based, copper-based, and ferromagnetic. Due to the strongest shape memory effect and the best vibration damping ability, a Ni-Ti alloy is the most commercially important. The subject of this work was to prepare a conceptual design of a rotor blade with SMA actuators. The scope of work included 3D design of the supporting rotor blade, 3D design of beams enabling to change the geometry by changing the angle of rotation and FEM (Finite Element Method) analysis. The FEM analysis was performed using NX 12 software in the Pre/Post module, which includes extended finite element modeling tools and visualizations of the obtained results. Calculations are presented for two versions of the blade girders. For FEM analysis, three types of materials were used for comparison purposes (ABS, aluminium alloy 7057, steel C45). The analysis of internal stresses and extreme displacements of crossbars edges was carried out. The internal stresses in all materials were close to the yield point in the solution of girder no. 1. For girder no. 2 solution, the value of stresses decreased by about 45%. As a result of the displacement analysis, it was found that the best solution was the ABS girder no. 1. The displacement of about 0.5 mm was obtained, which resulted in turning the crossbars (upper and lower) by an angle equal to 3.59 degrees. This is the largest deviation of all the tests. The smallest deviation was obtained for beam no. 2 made of steel. The displacement value of the second girder solution was approximately 30% lower than the first solution. Acknowledgement: This work has been financed by the Polish National Centre for Research and Development under the LIDER program, Grant Agreement No. LIDER/45/0177/L-9/17/NCBR/2018.

Keywords : aircraft, helicopters, shape memory alloy, SMA, smart material, unmanned aerial vehicle, UAV

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