
FESTO

SmartBird: an aerodynamic lightweight construction with active torsion

Flying like a bird

During the Hanover Fair 2011 the SmartBird was revealed for the first time to a wider audience. The bionic SmartBird, inspired by the herring gull, takes off, flies and lands autonomously. Its integrated design inspires new methods in energy-saving and lightweight design in automation.

Men have been fascinated by bird flight from time immemorial. Visionaries, scientists, flight pioneers – for them flying was one of the most fascinating challenges and one of the greatest adventures. They studied bird flight closely and analysed the anatomy of birds in detail. Inspired by the seagull, Festo has now managed to technically imitate bird flight with the SmartBird. The bionic bird is taking a revolutionary step towards an extremely energy and resource-efficient, lightweight design. The integration of coupled drive functions developed during this process provides wonderful inspiration for and an excellent insight into the optimisation of hybrid drive technologies. The many years' experience gained with the AirRay and AirPenguin bionic learning projects influenced the development of the SmartBird. The knowledge acquired during the project opened up new approaches and solutions for automation.

Integrated concepts
The SmartBird is pure fascination. Its integrated mechatronic, cybernetic design combines many separate solutions into one unique flying machine. The development was only possible as a result of the integration of intelligent mechanics and electric drive technology, discoveries made in fluid mechanics, intelligent control and feedback control systems and condition monitoring. This was combined with constant scientific validation and the transfer of knowledge gained in practice.

Determining overall efficiency in true running.

Aerodynamic efficiency of 80%

While being developed SmartBird was tested and measured in accordance with the work of French physiologist Étienne-Jules Marey (1830 – 1904). He made birds fly in a circle and studied their flight. A test device called a brake dynamometer was specially developed to determine the electromechanical effectiveness. SmartBird and its previous models have an electromechanical effectiveness of about 45%. When measured in a true run, aerodynamic effectiveness values of up to 80% were recorded.

Active torsion
SmartBird takes off, flies and lands autonomously – just by flapping its wings. Its wings not only move up and down but rotate in a controlled way. This is made possible by the active articulated torsional drive. This, combined with a complex control unit, achieves electromechanical efficiency of up to 45% in flight mode. The active torsion of the wing works without additional drive aids and helps to achieve aerodynamic efficiency levels of up to 80%. The wings beat and twist in a cycle of a few milliseconds and bring about the optimum flow conditions of the air on the wing. The SmartBird operates without any rotating parts in the outer shell and is thus unlikely to injure people.

Perfection in motion
The SmartBird's flight is made up of two principal movements. Firstly, the wings beat up and down whereby a lever mechanism causes the deflections to increase from the torso to the wing tip. Secondly, the wing twists so that the leading edge points upwards during the upwards stroke and the wing has a positive angle of attack.

The wing consists of a two-part arm wing spar with an axle bearing on the torso, a trapezoidal joint and a hand wing spar. The SmartBird's propulsion and lift are achieved solely by flapping the wings and it only needs about 25 watts of power. All this with a total weight of about 450 grams and a wing span of two metres.

Those involved in the project present the SmartBird: Markus Fischer, Head of Corporate Design at Festo; Dipl.-Ing. Agalya Jebens and Dipl.-Ing. Kristof Jebens, JNTech GbR; Rainer Mugrauer, Effekt-Technik GmbH; Dr. Wolfgang Send, ANIPROP GbR; Günther Mugrauer, Effekt-Technik GmbH (from l. to r.).

The technology in detail
The SmartBird's arm wing generates lift and the hand wing beyond the trapezoidal joint provides propulsion. The spars on the arm wing and the hand wing are torsionally stiff. At the end of the hand wing is a servo motor for active torsion which rotates the whole wing against the spar via the external rib of the wing. If the SmartBird lifts its wings the servo motor moves the end of the hand wing to a positive angle of attack that is then converted to a negative angle of attack within a fraction of the wing beat period. The torsion angle remains constant between these two phases. With this sequence of movements the airflow on the profile is used optimally to create thrust. The battery, motor and transmission, the crank mechanism and the control and feedback control system are housed securely in the torso. The on-board electronic system provides precise control of the wings. In addition, the control parameters can be set and optimised in real time. This guarantees the bird's flight stability and thus its operational safety.

Transfer into practice
The applications of coupled drives for linear and rotary movements as used in the SmartBird range from generators for extracting energy from water, so-called stroke wing power generators, to new actuators in process automation. Spurred on by a paradigm shift in bionics, Festo has for a few years now been developing products such as the adaptive gripper DHDG that has already been accepted in industry. ■

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