COMBINED MECHANISM FOR MORPHING AND AEROELASTIC CONTROL

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ABSTRACT

Morphing of shape of aircraft wings is supposed to improve aerodynamic properties of aircrafts and contribute to Aviation sustainability. Optimized aircraft wings can suffer from deteriorated aeroelastic properties. Therefore challenge of combined morphing and aeroelastic control arises. Morphing requires weak structure (with low stiffness) where small forces can easily deform the wing shape. Aeroelastic control requires a rigid structure with a suitable bandwidth where the servo can provide aeroelastic stability.

The paper describes a new mechanism that combines both requirements of wing morphing and wing aeroelastic control. The new mechanism is based on the concept of mechatronic stiffness that enables significantly to increase the dynamic stiffness of structures. The novelty is also that the mechanism does not introduce the tangential (residual) forces into the wing skin. This is important in order to prevent the danger of buckling of wing skin. Therefor the new mechanism can easily deform the wing shape and then achieve the necessary dynamic stiffness.

The described new mechanism has been physically built as a downsized demonstrator with foreseen experiments in wind tunnel. The downsized demonstrator raised a great challenge to design and manufacture the new mechanism in limited available dimensions. This was successfully solved by taking advantages of mechatronic stiffness as the basis of the new mechanism. It enables to increase the available actuation force in the limited space.

The study described in the paper started with the investigation of different states of wing shape between which the wing shape is morphed with clear aerodynamic benefit. The choice was the morphing of wing trailing edge. The morphing of trailing edge replaces the function of flaps and the function of ailerons. The carried out simulation of corresponding flight scenarios demonstrates the reduction of aerodynamic drag by 30-40%.

The paper describes also the basic aeroelastic control by the proposed new mechanism. The study has continued with investigation of stabilizing control of flexible mechanism for morphing accompanied with aeroelastic properties of the aircraft wing. Various control concepts have been investigated that includes the traditional ones like LQR, MPC and the new ones like wave-based control (WBC) that is especially suitable for control of flexible mechanical systems.