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Plant leaf-mimetic smart wind turbine blades by 4D printing

F. Momeni, S. Sabzpoushan, R. Valizadeh, M.R. Morad, X. Liu, J. Ni

Abstract-

Scientists have reported that plant leaf veins grow into an optimized architecture not only to accomplish their biological and physiological functions but also to sustain the environmental loads. Researchers showed that the wind blade mimicking the leaf architecture could always have relatively lower internal strain energy, better static strength and stiffness, smaller stress intensity, and higher fatigue life compared with the conventional blade structures. However, the plant leaf-mimetic wind blade has so far remained at the level of simulations. Here, a new paradigm for design and fabrication of wind blades is demonstrated by 4D printing process, which combines several beneficial attributes in one blade. The proposed blade having the plant leaf structure can show reversible bend-twist coupling (BTC). It does not rely on conventional electromechanical systems such as sensors and actuators to determine proper deflection and change its shape. Additionally, the existing blades capable of BTC through passive methods have inherent flutter instability since they need to be flexible. The proposed blade may solve the flutter challenge. Lastly, this multi-functional blade can lead to eco-friendly wind turbines. Wind-tunnel tests, CFD, and performance analysis are performed on the proposed blade to demonstrate its applicability.

Index Terms- Plant leaf-mimetic wind blade; Bend-twist coupling; Flutter instabilit; Flexibility; Eco-friendly; 4D printing

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