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Advancing Entrepreneurial Knowledge Through Re-Engineering Social Studies Education

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Abstract : Propeller aircraft engines, and more generally engines with a large rotating part (turboprops, high bypass ratio turbojets, etc.) are widely used in the industry and are subject to numerous developments in order to reduce their fuel consumption. In this context, unconventional architectures such as open rotors or distributed propulsion appear, and it is necessary to consider the influence of these systems on the aircraft's stability in flight. Indeed, the tendency to lengthen the blades and wings on which these propulsion devices are fixed increases their flexibility and accentuates the risk of whirl flutter. This phenomenon of aeroelastic instability is due to the precession movement of the axis of rotation of the propeller, which changes the angle of attack of the flow on the blades and creates unsteady aerodynamic forces and moments that can amplify the motion and make it unstable. The whirl flutter instability can ultimately lead to the destruction of the engine. We note the existence of a critical speed of the incident flow. If the flow velocity is lower than this value, the motion is damped and the system is stable, whereas beyond this value, the flow provides energy to the system (negative damping) and the motion becomes unstable. A simple model of whirl flutter is based on the work of Houbolt & Reed who proposed an analytical expression of the aerodynamic load on a rigid blade propeller whose axis orientation suffers small perturbations. Their work considered a propeller subjected to pitch and yaw movements, a flow undisturbed by the blades and a propeller not generating any thrust in the absence of precession. The unsteady aerodynamic forces were then obtained using the thin airfoil theory and the strip theory. In the present study, the unsteady aerodynamic loads are expressed for a general movement of the propeller (not only pitch and yaw). The acceleration and rotation of the flow by the propeller are modeled using a Blade Element Momentum Theory (BEMT) approach, which also enable to take into account the thrust generated by the blades. It appears that the thrust has a stabilizing effect. The aerodynamic model is further developed using Theodorsen theory. A reduced order model of the aerodynamic load is finally constructed in order to perform linear stability analysis.

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