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Technical Comments

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Reply by the Authors to D. H. Wood

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ALL of the questions raised by Wood in regard to our Note[1] are based on the doubtful premise that a complex viscous flow phenomenon, such as boundary-layer separation delay on rotating wings, can be assessed by means of simple potential flow analysis. Even if at that time, when the paper[2] was published, the stall delay phenomenon was too little known, it is hard to understand how the rotational effects, mainly related to separated flow, could be explained solely by inviscid nature arguments. Moreover, both blade and airfoil pressure distributions calculated in Ref. 2 cluster around one curve when they are normalized by the peak value. This shows that the effect of the pressure change from a (two-dimensional) airfoil to a (three-dimensional) blade is on the pressure level rather than on the chordwise pressure distribution and implicitly on the boundary-layer separation.

Recently, computational fluid dynamics tools have been employed to investigate this phenomenon.[3,4] The calculations for a rotating blade in attached as well as in stalled conditions showed that the three-dimensional and rotational effects are strictly due to the Coriolis force, which sucks fluid from the separation bubble, leading to a relative reduction of its volume. The reduction of the bubble volume produces a pressure level drop along the suction side of the airfoils without significant changes of pressure gradients (particularly for turbulent flow). Thus, the blade loading is increased.

Our more recent paper[5] compared the rotational effects for inviscid flows with various pressure gradients and showed that as the blade adverse pressure gradient is decreased, the inner part of the blade without flow separation is increased.

In conclusion, it is our position that Wood is in error in stating without doubt that the inertial forces within the rotating blade boundary layer are of minor importance for stall delay.

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