Analysis of Vortex Line Cutting and Reconnection by a Blade[1]

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— The essence of vortex reconnection involves the cutting of vortex lines originating from one region and reconnecting to vortex lines originating from another region via the diffusion-regulated annihilation of vorticity. Vortex cutting by a blade is a special case of the more general class of vortex reconnection problems, with an important difference being that vorticity is generated at the reconnection site. In this study, a series of Navier-Stokes simulations of orthogonal vortex cutting by a blade with different values of vortex strength are reported. The three phases of vortex reconnection identified in the literature are found to have counterparts for the vortex cutting problem. However numerous differences between the mechanics of vortex cutting and reconnection within each phase are discussed. In addition, comparisons are made between the temporal changes of the maximum and minimum components of vorticity for vortices of differing strength but still within the vortex cutting regime. The vortex cutting results are also compared with predictions of a simple analytical model that incorporates the key elements of a stretched vorticity field interacting with a solid surface, which is representative of the vortex cutting mechanism near the blade leading edge.

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