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Interactive comment on "Derivation of an Impulse Equation for Wind Turbine Thrust" *by* Eric J. Limacher and David H. Wood

Anonymous Referee #2

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Review of the manuscript "Derivation of an Impulse Equation for Wind Turbine Thrust" by Eric J. Limacher and David H. Wood

The manuscript aims to present a derivation of the thrust of a wind turbine. To do so, the authors use the momentum equation expressed in the "impulse" formulation as presented by Noca et al {Noca, F., Shiels, D., Jeon, D.: Measuring instantaneous fluid dynamic forces on bodies, using only velocity fields and their derivatives. Journal of Fluids and Structures, 11(3), 345-350, 1997.}. The work by Noca et al is relevant to enable determining the loads around a body/force field exclusively by integrating the velocity field (and the derived vorticity field) over a control surface. This is relevant for experimental work when pressure measurements are not available. The authors aim to present a formulation for determining the thrust form the velocity field nearby the

turbine. Such a formulation would be useful. However, the work presented lacks in several aspects: 1- Clarity of the manuscript. a. The paper is mostly clearly written in terms of the use of language. b. The structure of the derivation is not always clear, and terms of the equations are presented or referenced without clear identification. I found it very difficult to follow the derivations, namely because there are no supporting figures and the interpretation of the control surfaces considered is very difficult. 2- The work is not novel in the final derivation presented, as this has been achieved previously by Glauert (I am aligned with the other reviewer in this point) and is clearly presented in {Glauert H. (1935) Airplane Propellers. In: Aerodynamic Theory. Springer, Berlin, Heidelberg} . The derivation by Glauert presents the differential for along the streamline of the variation of the total pressure, which is what the authors now present in an integral approach. 3- Incompleteness of the derivation. In Glauert's work, the jump of stagnation enthalpy is equaled to the jump in pressure and equaled to the thrust. However, the derivation implicitly assumes azimuthal velocities (by the rotational velocity downwind of the actuator), but ignores the effect of vorticity. The authors also neglect the effect of vorticity across the control surface, and that is why they reach the same result. The statement in line 145 " For the vortical wake to appear stationary in the rotating frame, âĎę must be parallel to U0 everywhere that vorticity is non-zeroâĂŤ that is, vortex lines and streamlines are aligned in the rotating frame âĂŤ by which n ÂůâĎę(x × U0) = n Âů U0 (x ×âĎę) and the two integrals in square brackets identically cancel, . . ." implies a rigid wake. Also, even in the case of a rigid wake the statement is not correct, as vortex direction and streamlines do not need to be aligned. It is a convenient simplification, but then we come back to the solution by Glauert. Although the attempt is very interesting and could be useful, the work is not yet complete.

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