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The evaluation of a low-order propeller performance and wake prediction capability for the calculation of power effects

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ABSTRACT

An analytical method was developed for the prediction of the performance of a propeller or wind turbine and the propagation of a vortical streamtube in the propeller's wake. The combined method is a product of compatibility between Blade Element Momentum Theory and Vortex Theory. The theoretical foundation of the combined method was discussed in sufficient detail to be translated into an algorithm for solving this type of problem. The algorithm was shown to be suitable for analysing the performance and trailing wake of an arbitrary propeller if the geometry of the blade is given. Published wind tunnel test data from various research institutions was used to compare the performance determined by the prediction model to the actual performance. A comparison with wind tunnel test data of an APC 8x8 Thin Electric propeller of simplistic geometry showed the propeller model to be adept at the prediction of thrust and adequate in predicting power. Further comparison with wind tunnel test results of a complex propeller developed at the CSIR indicated accuracy limitations in the propeller model primarily relating to insufficient consideration of 3-dimensional effects and a dependence on input data that accurately represents the physical conditions. The propeller model was extended to consider the performance of wind turbines and similarly provided useful predictions of the power extraction, particularly at higher advance ratios, in comparison with experimental results. An unsuccessful attempt was made to implement the propeller performance model results into a low-order panel method program. The intended combination was through the superposition of the propeller performance characteristics on the panel method inflow to enable the evaluation of propeller-airframe interactions.