SYSTEMATIC CORRELATION AND EVALUATION OF THE EHPIC HOVER ANALYSIS

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ABSTRACT

Free wake analyses, although available since 1969, have never gained wide acceptance for hover performance calculations due both to the typically high CPU execution time required per case and the difficulty involved in reliably representing a hover wake using a time dependent approach. Recently Bliss and Quackenbush have evolved a novel neutral stability / non-time-marching free wake approach that has shown considerable promise and is implemented in the Continuum Dynamics EHPIC hover code. Sikorsky Aircraft has conducted a systematic correlation evaluation of this code using the Sikorsky full scale hover test base. This test base includes blade number variations from 3 to 7, and equivalent linear twist variations from 0 deg. to -18 deg. In addition rectangular and trapezoidal, swept, and swept tapered tips are included. The primary intent of this study was to track the ability of the analysis to predict test results for a wide range of rotor geometries while adhering to a single, consistent set of guidelines for program input. The latter requirement assured that results would represent prediction ability as opposed to forced "correlation" for each specific geometry. Correlation of all rotors in this data base has been found to be good to excellent, with the exception of the older technology, low twist, six bladed rotors. The poor showing of these rotors may be due to the effect of exposed anti-abrasion strips and an observed oscillatory wake interference phenomenon.

INTRODUCTION

Despite today's focus on high speed rotary wing flight, hover performance remains a critical technology. It is almost always the chief designing factor for commercial aircraft, and often drives weight for military vehicles. In terms of performance sensitivity, hover calculation accuracy requirements clearly outweigh those of the limelight high speed flight regime. A 3% or 4% increase in expected high speed power absorption is not likely to jeopardize an otherwise healthy project. A similar problem with hover power prediction will strongly affect the project in general, and the activities of the weights engineers in particular.

Hover also has been, and continues to be, one of the most challenging analytical areas of our technology. This is due to the unique role played by the blade wake. Unlike forward flight, hover creates a trailing wake structure that "stays with the rotor". The rotor system is forced to continuously fly within, and endure, its own vorticity field. Needless to say, the geometry of that wake, the strength of that wake, and the analytical discretization of that wake, play a dominant role in our ability to account for its overwhelming impact on hover performance.

Past efforts to accurately account for hover wake influence have been divided between prescribed and free wake approaches. The prescribed wakes (References 1, 2, etc.) have, until recently, had the upper hand as far as application to day-to-day performance estimation. They were reasonably fast, reasonably accurate, and reasonably successful in providing acceptable blade designs. The only problem was that they were also reasonably far from reality when it came to the mechanics of wake transport. Although the laws of Biot-Savart and Helmholtz were not forgotten, they were somewhat ignored in the contest to find workable schemes. Wake filaments were not allowed to freely distort and descend in response to these well known edicts of wake behavior. Rather, they followed selected paths ordered by reasonable, yet semi-empirical criteria. Those of us who used these methods have long felt that we were probing ingenuity limits as well as performance limits. As technology evolved,

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