CFD Study on Effective Wake of Conventional and Tip-modified Propellers - DTU Orbit (30/07/2019)

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Tip-modified propellers have been developed to improve propulsive efficiency and to lengthen the lifting-surface span. A hydrodynamic distinction of tip-modified propellers consistently shown in model tests is 5-15% higher effective wake fraction compared to conventional propellers. The effective wake fraction is not from direct measurements but from an estimation based on an open-water curve correlation at the same thrust or torque coefficient as in the self-propulsion test. Open-water tests are conducted at 2-4 times higher Reynolds number than that depending on Froude scaling in self-propulsion tests. The effects of different Reynolds number on higher effective wake fraction of tip-modified propellers are investigated by open-water simulations with varying the propeller speed and evaluations of effective wake extracted from self-propulsion simulations on tip-modified and conventional propellers.

Open-water simulations show that the advance ratio at the design thrust is higher at a higher Reynolds number for both propellers and the advance ratio increase is smaller for the tip-modified propeller, which results in a higher effective wake fraction.

Effective wake fractions are evaluated by integrating velocity fields at a section 40% of the propeller radius upstream from the propeller plane in self-propulsion simulations. The difference of effective wake fraction from integrating velocity fields between tip-modified and conventional propellers is less than 1%. Based on the open-water simulation result and the effective wake fractions from integrating CFD velocity fields, 5-15% higher effective wake fractions of tip-modified propellers from the existing estimation method based on the open-water correlation at thrust or torque identity can be related mainly to the effects of Reynolds number.

However, the effective wake fraction from integrating a total velocity field with excluding a propeller-induced flow is about 10% higher for the tip-modified propeller. The propeller-induced flow is estimated separately by open-water simulations. Further studies are necessary with a more sophisticated way to estimate the propeller-induced flow by taking into account interaction effects between propeller-induced flow and hull wake.

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