Investigation into the Discrepancies Between Computational Fluid Dynamic Lift Predictions and Experimental Results

by

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Abstract

An analysis of current computational fluid dynamics capabilities in predicting mean lift forces for two dimensional foils is conducted. It is shown that both integral boundary layer theory and Reynolds Averaged Navier Stokes algorithms provide the same over-prediction of lift forces when properly converged. It is also shown that the over-prediction is insensitive to turbulence model details.

Experimentation and computational fluid dynamics modeling show that discrete vortices are shed with significant sizes and distinct frequencies. These vortices are shown to result in significant cfd prediction errors when they are asymmetric in size or shape. Inaccuracies in flow predictions in the near wake appear to result in an effective change in the Kutta Condition due to pressure biasing associated with vortex asymmetry. The net result is a consistent overprediction of mean lift.

Based on an analysis of over 1000 historical experiments an empirical model is developed to allow the error in predicted lift coefficient to be anticipated based on the local flow conditions at the trailing edge of the foil. A series of experiments are conducted and reported to test the accuracy of the empirical model. The result is a significant improvement in mean lift prediction and pressure profile for both RANS and IBLT.

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