THE MOMENTUM SOURCE METHOD FOR ROTOR-AIRFRAME INTERACTION

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1. INTRODUCTION

To numerically simulate aerodynamics of rotor-airframe interaction in a rigorous manner, we need to solve the Navier-Stokes system for a rotor-airframe combination in a single computational domain. This often imposes a heavy computational. An efficient alternative is the momentum source method developed by Rajagopalan and his co-workers [1-6]. A rotating rotor can be replaced by time-averaged momentum sources in the governing equations

The momentum source method, which employs the Navier-Stokes system to predict the rotor-airframe interaction, was adopted in this study. The magnitude of the momentum source is usually evaluated by the blade element theory, however this often results in poor accuracy. Therefore, the momentum source from simulation data using the Navier-Stokes equations was evaluated only for a rotor system. Momentum source data was then fed to the stationary computational domain enclosing the airframe. Computations were carried out for the simplified rotor-airframe model (the Georgia Tech configuration) using STAR-CD and the results were compared with experimental data.

2. NUMERICAL METHOD

The computation was carried out in two steps. First, the RANS simulations for a rotor-alone moving mesh system was performed at a given set of conditions : angular speed, free stream velocity, and angle of attack of the rotor plane. Then, the time averaged steady flow field around the airframe was simulated in a stationary computational domain where a rotor-disk plane is embedded to account for the momentum source.

To obtain the momentum sources, the lift and drag forces for each discretized blade segment have to be calculated first. These forces are then converted to momentum source term. IF F is the time- averaged resultant aerodynamic force per one revolution on the blade, then $-F$ must be the momentum source in the momentum equations. For a time-averaged solution, only a fraction of $-F$ is to be added at rotor-plane disk cell. This fractional time is multiplied by $-F$. Then the time-averaged source term is added to the momentum equations.

3. RESULTS

The time-averaged pressure distribution on the airframe surface was calculated to compare with the measured pressure distributions. Figures 1 shows that the present analysis predicts better than the Zori and Rajagopalan's momentum source method which employed blade element theory [5].

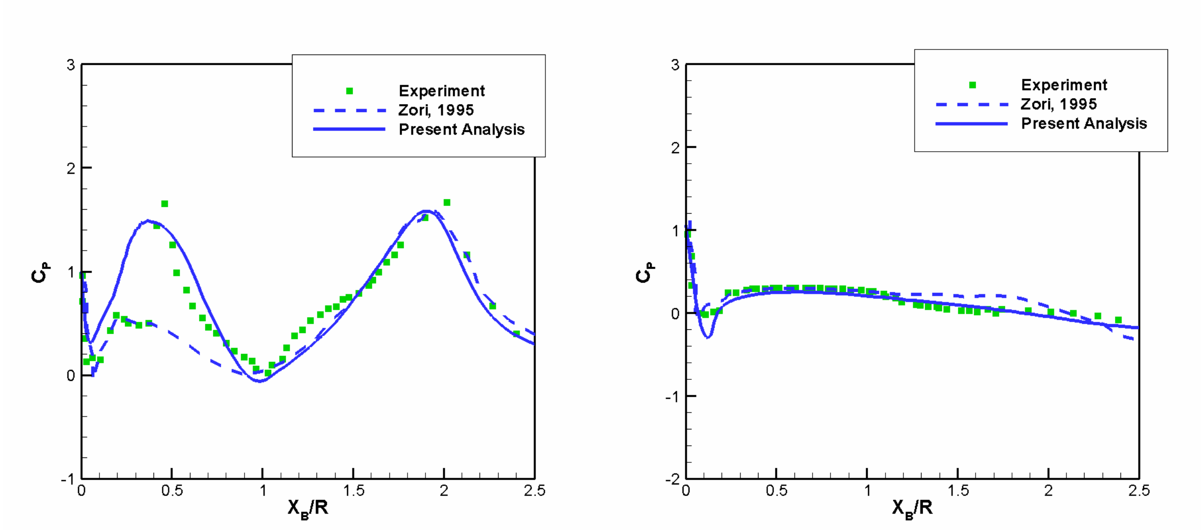

Figure 1. Time-averaged pressure distribution on the top of the airframe(left) and on the bottom of the airframe(right)

4. CONCLUSIONS

In this study, the momentum source model is employed to simulate rotor-airframe interaction. Instead of adopting blade element theory to calculate the momentum source, we first carry out Navier-Stokes computation for a moving rotor independently. Using this output, we solve RANS equations for the airframe flow field in a stationary grid system in which disk cell is embedded to account for the momentum source. The results of the present computation are compared with the experimental data. The comparison clearly demonstrates that the present method can be an economic approach to deal with the rotor-airframe interaction with good accuracy.

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