Inviscid wake interaction with bodies: a theoretical investigation	
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Abstract

1. Analysis of scenario

There are many cases of wake interaction with bodies, an example is the interaction between a propfan and a wing. The state of the art into this research field uses the RANS CFD model as analysis tool.

The bibliography shows a great difficulty in predicting these unsteady flows, thus the common aeronautical practice suggests to model rotating parts with actuator disks, coupled with an inviscid flow field solution, or are produced experimental data useful for specific configurations. The drawbacks into these approaches are the computational and the economical costs. These drawbacks and the lack of information about these phenomena are the main reason to study them, and it can be shown that they are overcame by vorton methods. Vorton methods use the same assumptions of panel methods, but the velocity field is solved with a Laplace and a Poisson equation. This is done in order to use the Helmholtz velocity decomposition and then to model the wake vorticity as vortex particles, the vortons.

2. Statement of the problem

Introducing a vorton wake means to simulate the wake evolution as particle paths. The numerical error sources within particle path calculation can bring particles to penetrate bodies supposed impermeable.

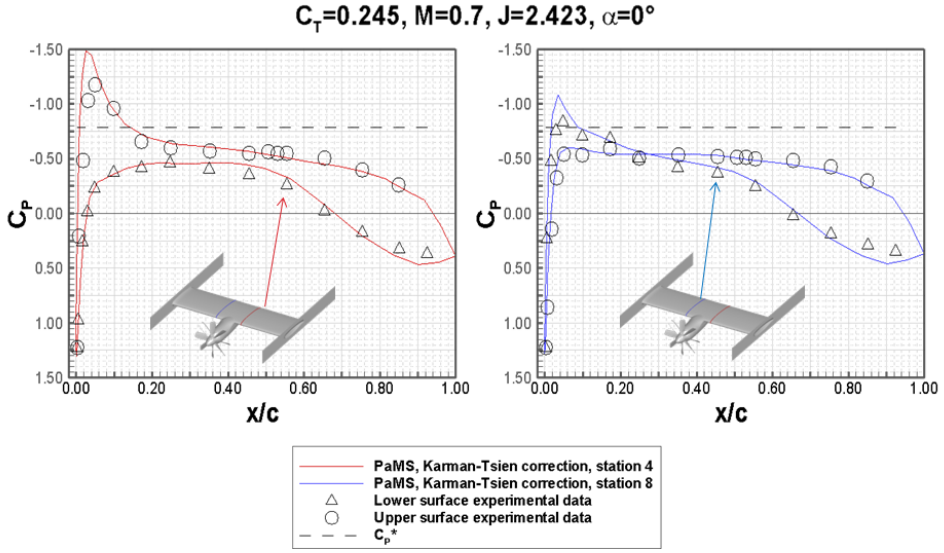
When it is considered an inviscid flow involving more bodies, the strength and shape of the wake is influenced by the mutual interaction with bodies: in order to correctly estimate the acting forces the penetration must be avoided.

3. Adopted methodology

The problem is solved creating a Matlab guide code, a 2D panel method which computes passive particles paths. Once found a countermeasure it is applied to the main program used into this thesis, the PaMS code, an open source unsteady panel method solver with a vorton wake formulation. It has been used to simulate the interaction between a couple of airfoils and a transonic propfan interacting with a wing, whose results have been compared with bibliographical experimental data.

4. Main results

The change applied in PaMS is a replacement which works when a particle enters inside, validated by the test cases. The first test case is about a pitch-heaving airfoil interacting with a fixed airfoil. This test case shows that PaMS is able to catch the frequency of the normal forces acting over these airfoils, which is the same on both and coincides with the motion frequency. The second test case shows a good fitting between the numerical and experimental data in the wing-propfan test case. These two results validate a vorton method as an interaction model between wake and bodies.

PaMS is also able to interface with structural solvers, thus, known the wake-body interaction, it is possible a pre-design sizing which lightens the economical efforts to run experimental setups, like aeroacustical tests or interaction tests between the elements of an airplane.

The results available at DIAS allowed to setup an experiment at the Air Force Academy in Pozzuoli in order to validate this method.