Application of Method of Fundamental Solutions and Generalized Lagally Theorem to Dynamic Interaction of Vortices and Solid Bodies

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The dynamic interaction of multiple solid bodies and vortices in an inviscid, irrotational and incompressible flow is studied by the method of fundamental solutions (MFS) with the use of the generalized Lagally theorem. To generate the flow field when there are multiple solid bodies present, infinite numbers of image singularities located in each solid body are used to ensure no penetration boundary condition. Further, the precise positions and strengths of these image singularities are in general unknown for irregular shaped body. However, these difficulties can be overcome numerically with the application of the MFS. With the computed positions and strengths of these singularities, the generalized Lagally theorem can describe the unsteady hydrodynamic force on each rigid body exhibiting arbitrary motion, and the dynamics of the system can be studied through the equations of motion. The present method is first validated by the problem which has a circular cylinder and a vortex. The trajectories of both the cylinder and vortex are generated and compared to the half-analytic solutions. To ensure the present method can be applied to the multiple solid bodies problem, a cylinder moves at constant unit velocity toward a stationary identical one is considered. The forces on both moving and stationary cylinders are given and the results are in agreement with the literature results. The trajectories of both cylinders and vortices of the problem that a forced cylinder moves at constant velocity together with a pair of tail vortices located at their equilibrium positions, i.e. there is no relative motion between cylinder and vortices, toward an identical cylinder which is free to move are prescribed and compared to the results by half-analytic method. The results show that the behavior of the trajectory of the free cylinder changes a lot due to the addition of the tail vortices behind the forced cylinder. The interaction of the tail vortices and the free cylinder can be explained clearly by interchanging the fluid impulse and body momentum.

Keywords: Method of fundamental solution, Potential flow, Lagally theorem.