HIGHER-ORDER POLY-REGION BOUNDARY ELEMENT METHODS FOR UNSTEADY NAVIER-STOKES FLOWS

M.M. Grigoriev[a] and **G.F. Dargush**[b]

Department of Civil Engineering
State University of New York at Buffalo, Amherst, NY 14260
[a]mmg3@eng.buffalo.edu, and [b]gdargush@eng.buffalo.edu

In this presentation, the higher-order boundary element methods (BEM) most recently developed by the authors [1-3] for unsteady convective heat diffusion at high Peclet numbers are extended to unsteady Navier-Stokes flows in two dimensions. We utilize the poly-region BEM formulation proposed earlier for the steady Navier-Stokes [4] and Boussinesq [5] flows, and introduce region-by-region implementation of the time-dependent Oseenlets within the poly-region boundary element framework. Temporal variations of the boundary velocities and tractions are approximated using quartic time interpolation functions [6]. We should note that the proper numerical implementation of the time-dependent Oseenlets requires a closed form integration of the kernels over time intervals for the quartic time functions. Similar to the most recent developments [1-3], we facilitated a semi-analytical approach to allow an accurate integration of the time-dependent Oseenlets over finite time intervals. Furthermore, we consider quartic boundary elements and bi-quartic volume cells to ensure a high level resolution in space. Similar to the previous developments [4-6], coefficients of the discrete boundary integral equations are evaluated with the sufficient precision to ensure exceptional accuracy of the boundary element formulation.

To demonstrate the attractiveness of the poly-region BEM formulation for the time-dependent Navier-Stokes flows at high Reynolds numbers, we consider two numerical examples in detail. The first numerical example considered in this study involves the well-known driven cavity flow when the fluid is initially at rest, and then starts to accelerate due to the translating upper lid. We study the flow field for Reynolds numbers beyond 10,000 and investigate the stability of the two-dimensional flow in the cavity. The second example problem in this presentation is the unsteady flow around the circular cylinder. Similar to the first problem, we investigate velocity and pressure fields around the cylinder for very fine boundary element discretizations and compare the BEM solutions with the data available in the literature.

References

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