High order solver for the unsteady Navier-Stokes equations based on homotopy and perturbation techniques.

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ABSTRACT

An efficient solver for the 2D unsteady Navier-Stokes equations is presented. We used a classic time stepping scheme combined with a high order nonlinear solver. This method combines a homotopy technique and the asymptotic numerical method (ANM)[1,2]. The finite element method is used for the spatial discretization of the equations. The main purpose is to gain CPU time during computations. The technique presented here reduces the number of factorization of the operators. A pseudo-residual criterion prevents the asymptotic numerical method to use more right hand side vectors than needed for a given accuracy. This specific technique is compared to the classical first order Newton-Raphson solver. We show that a significant number of factorization are avoided, keeping at the same time a good quality of the solution.

The considered numerical example is the flow around a cylinder. The flow is periodic in time for a Reynolds number greater than 50. Calculations start from a steady solution [2] and reach a limit cycle (Fig.1). The classical Newton-Raphson, 1st order solver, leads to 6442 factorizations for a required accuracy η =10-5 to get the solution up to t=30s (Fig. 1). With the proposed numerical method, the number of matrix factorizations is equal to 340, the required accuracy being the same. This leads to a decrease of CPU times closet o 20%.

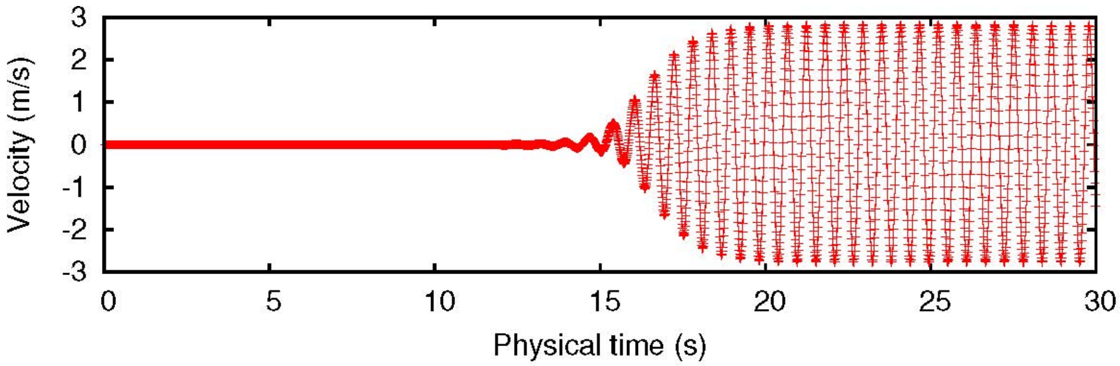

Fig 1 : Flow around a cylinder. Vertical velocity behind the cylinder.

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