11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

VORTEX ELEMENT METHOD SCHEME FOR NUMERICAL SIMULATION IN FSI-PROBLEM FOR CLAMPED-CLAMPED CYLINDRICAL SHELL

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Key words: *Vortex Element Method, Incompressible Medium, Vorticity, Vorton, Aeroelasticity, Elastic Cylindrical Shell, Frequency Spectrum, Flow Induced Vibrations.*

Pure lagrangian vortex methods are suitable for engineering analysis when it is necessary to compute unsteady aerodynamic loads in complicated FSI-problems. Lagrangian vortex element methods allow to simulate dynamics of 3D vortex structures with small numerical diffusion because in these methods vorticity is 'primitive' variable and we use integral formulation of governing equations. Computational cost of these methods is small in comparison with grid CFD methods.

Vortex element methods are well-known and well-developed for vortex structures dynamics simulation in unbounded regions because perturbation-decay boundary condition is satisfied automatically. However boundary condition on body surface satisfaction is non-trivial problem. There are some approaches based on Discrete Vortex Method [1], Vorticity Flux approach [2], some other ideas [3]. Vorticity flux-based approach shows its advantages when solving coupled FSI-problems with deformable bluff bodies.

In the present research the vortex element method with vortex fragmentons is used for clamped-clamped elastic cylindrical shell oscillations simulation exited by unsteady hydrodynamic loads. The original Vortex fragmenton mathematical model [4] usage allows to simulate effectively both vortex wakes and vortex layers on bodies surfaces. For numerical simulation of vortex structures evolution in the inviscid flow this approach allows to obtain more accurate results in comparison with other known types of vortex elements. In order to satisfy no-slip boundary condition on the body closed vortex frameworks are constructed on the panels which approximate the surface. Vortex frameworks circulation can be computed using well-known algorithm [1]. Then according to vorticity flux model developed by Lighthill & Chorin [2] all the vorticity from surface vortex layer becomes free and moves in the flow. In order to simulate such vorticity flux vortex frameworks are split up into separate vortex fragmentons. Growing vortex wake near the cylindrical shell is shown on Fig. 1

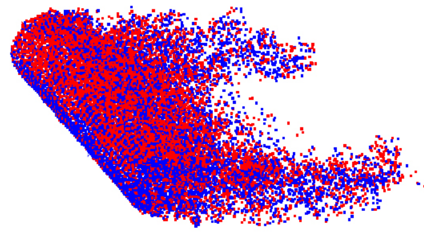

Figure 1: Growing vortex wake near the cylindrical shell. Point denote vortex fragmenton markers positions

Shell dynamics is simulated using modal analysis method. Eigenfrequencies and eigenforms are computed using Finite Element Method software MSC.Nastran. Surface mesh on the shell is built with Patran preprocessor, and it is used both for dynamics analysis and flow simulation. Nodes of shell elements are the same as the panels vertexes. For example, two views on instantaneous deformed shape of the shell are shown on Fig. 2.

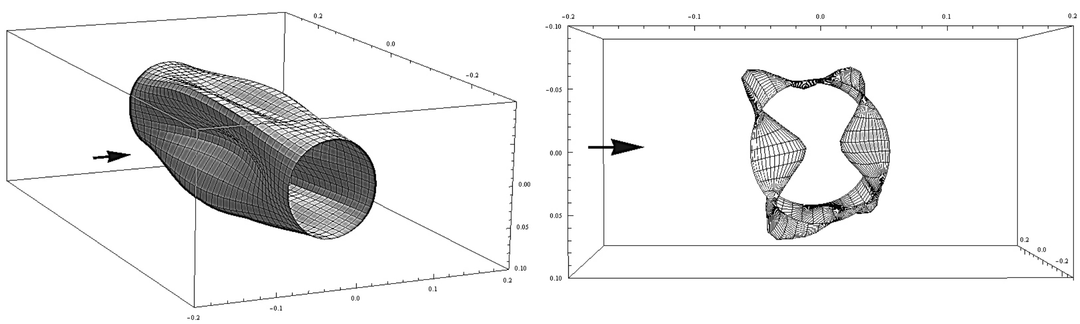

Figure 2: Deformed shape of the cylindrical shell. Shell deflection is increased by 100 times. Arrow denotes incoming flow direction

The obtained results are compared with experimental data and numerical results obtained using normal-based approach in vortex method.

The developed algorithm and original software allow to simulate directly vortex induced vibrations in the 3D flow for shells and structures with arbitrary shape.

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