FEM-based analysis of coupled vibrations: eigen modes of a structure-fluid dynamic system

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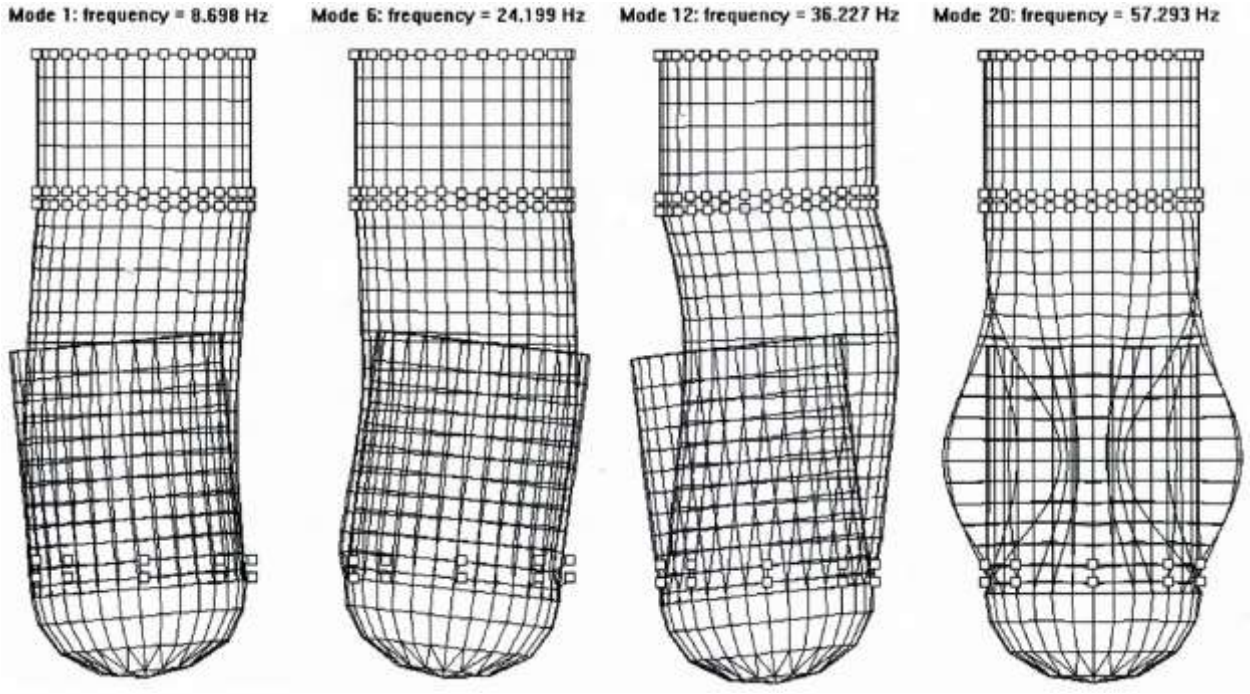
This numerical analysis is based on some components of the author's method: FEM-based analysis of nonlinear statics and dynamics of structures and relevant modules of the ***NewTone*** software system. The analysis of coupled vibrations covers the calculation of eigen modes of 3D structures immersed in fluid and (or) containing it in internal cavities. The analysis method was developed in 1996-1997 as part of the author's collaboration with the Research Institute of Applied Mathematics and Mechanics (NIIPMM) at the N. E. Bauman Moscow State Technical University and implemented in the version 1.5 of ***NewTone***. This method is applicable for determining the dynamic characteristics of a nuclear reactor structure, in particular, for the purpose of vibration-noise diagnostics during operation.

Version 1.5 of ***NewTone*** uses the technique of finite element modeling of small structural vibrations in a viscous incompressible fluid. The analyzed structure can have an arbitrary spatial configuration. Its mechanical interaction with the fluid is described by the concept of added mass. The main modules of the version 1.5 perform the following operations:

- construction of finite element models of the structure and volumes of the fluid interacting with it;
- calculation of the added mass matrix for each volume and its attachment to the inertia matrix of the structure;
- calculation of eigen values (natural frequencies) and mode shapes of the structure with these added masses.

The developed method and the software involve the use of **special finite elements with unconventional shape functions that can effectively model various volumes of fluid, including thin layers**.



User interface of the version 1.5 of *NewTone* by example: Calculation of coupled (structure-coolant) vibrations of a WWER-type reactor. Postprocessing: Eigen modes

Additional information can be found in the following documents and articles:

Spirochkin YK (1997) Sistema vibroshumovoi diagnostiki reaktornykh ustanovok tipa WWER. Programmnoe obespechenie dlya konechnoelementnogo analiza konstruktsii: NewTone. Versiya 1.5. Spetsialnaya konfiguratsiya dlya raschyota dinamicheskikh kharakteristik konstruktsii v zhidkosti. Rukovodstvo polzovatelya (System of vibration-noise diagnostics of reactor installations of the WWER type. Software for finite element analysis of structures: NewTone. Version 1.5. Special configuration for calculation of dynamic characteristics of structure in fluid. User's manual). Concern “Rosenergoatom”. Center for Non-destructive Testing and Diagnostics: DIAPROM, Moscow

NIIPMM (1997) Matematicheskoe modelirovanie dinamicheskikh protsessov i diagnostika oborudovaniya pervogo kontura AES s WWER-1000 (Mathematical modeling of dynamic processes and diagnostics of equipment of the primary circuit of NPPs with WWER-1000). Research Institute of Applied Mathematics and Mechanics (NIIPMM) at N. E. Bauman Moscow State Technical University, Moscow (Contributors: Kinelev VG, Drong VI, Perov SL, Spirochkin YK)

Spirochkin YK (1998) Konechnoelementnoe modelirovanie dinamiki obolochek, vzaimodeistvuyuschikh s tonkimi sloyami zhidkosti (Finite element simulation of the dynamics of shells interacting with thin layers of fluid). Prikladnye problemy prochnosti i plastichnosti. Chislennoe modelirovanie fiziko-mekhanicheskikh protsessov: Mezhvuzovskii sbornik (Applied problems of strength and plasticity. Numerical modelling of physical and mechanical processes: Interuniversity collection), Issue 58, p 110-121

Spirochkin Y (2011) Special finite elements in structural dynamics. Vibration Problems ICOVP 2011. Supplement. The 10th International Conference on Vibration Problems. Technical University of Liberec, Liberec, Czech Republic, p 168-173.

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