Numerical simulation of sloshing in fuel tanks using free-surface equations

Tatiana G. Elizarova * and Dmitrii S. Saburin†

*Keldysh Institute of Applied Mathematics, Russian Academy of Sciences,
125047 Moscow, Russia
e-mail: telizar@mail.ru, web page: http://keldysh.ru

† Moscow State University, Leninskie goru, 1,
119991,Moscow, Russia
Email: asoulofan@gmail.com - Web page: http://www.msu.ru

ABSTRACT

A study of a fuel sloshing and coupled pressure oscillations in tanks of modern icebreakers is of practical interest for the assessment of the loads on tank walls in varying navigation conditions. Estimation of the maximum wall loads is important for determining the safe speed limits when a vessel moves on the waves, or suddenly stops in a collision with ice barriers [1]. Numerical simulations of under-filed tanks can be made in a shallow water approximation, that significantly reduces the coast of simulations compared with a full 3D equation system.

In [2] an efficient new method of solving shallow water equations was proposed and tested. The method is based on the smoothing of classical equations over a small time interval. This procedure leads to the emergence of regularizing additives, which ensure the numerical stability of the algorithm in a wide range of Froude numbers.

In the paper we present results of the numerical simulation of sloshing in 10-percent tank fill with bottom shape taken into account for vessel velocity directed along the plane of symmetry of the tank and with angle to it. The real velocity evolution law is implied. Pressure distributions obtained in shallow water approximations correlate well with data, obtained in solution of 3D Navier-Stokes equations accomplished by free-surface evolution equation and turbulence model [1]. The numerical modeling of the problem in one-dimensional approximation in the symmetry plane of the tank ignoring the bottom shape can be found in [3].

REFERENCES

[1] A. O. Dukarskii, D. B. Kisilev, I. V. Tkachenko, V. N. Tryaskin, N. V. Tryaskin, and V. V. Yakimov," Mathematical modeling of fluid oscillations in the LNG cargo tanks in a collision with an ice barrier," *Morsk. Int. Tekhnol.*, No. 4, pp. 69–75, (2011).

[2] T.G. Elizarova and O.V. Bulatov "Regularized shallow water equations and a new method of simulation of open channel flows". *Int. J. Comp. and Fluids*. № 46. pp. 206–211, (2011).

[3] T. G. Elizarova and D S. Saburin "Numerical Simulation of Fluid Oscillations in Fuel Tanks", *Mathematical Modeling*, Vol. **25**, No. 3, pp. 75–88, (2013).