ABSTRACT

Sloshing is a potential source of disturbance in liquid storage containers in general and liquid propellant containers in particular. The sloshing of liquid propellant in the fuel tanks of aircraft and space vehicles affects the performance, control and stability of the vehicles. The control of sloshing is essential for the stability of such vehicles. Baffles are generally used in the liquid propellant tanks to minimize the adverse effects of sloshing. The baffles effectively reduce the sloshing response, but impose an additional weight to the tank system. In order to avoid weight penalty, the baffle should be thin and lightweight for liquid propellant containers.

Fibre reinforced composite laminates are increasingly being used in aerospace applications due to several attributes like lightweight, outstanding specific strength, high specific stiffness, excellent fatigue and corrosion resistance, capability of being tailored for specific design uses, higher reliability and so on. The liquid propellant containers of aircraft and space vehicles, made up of lightweight composite materials are typical examples. The thin composite laminates may be used as slosh suppression baffles. The study of dynamic interaction of the liquid with thin-walled composite containers and composite baffles is not reported in the open literature. The present study investigates the effects of baffles on the sloshing response of liquid and also on the response of the liquid filled containers considering the coupled liquid-structure interaction effects.

The numerical treatment uses the finite element method to solve the complex liquid-structure interaction problems. The liquid is assumed to be incompressible and inviscid resulting in an irrotational flow. The governing differential equation for the liquid is solved using Galerkin finite element

technique with appropriate time-dependent boundary conditions, both linear and non-linear, at the liquid free surface and liquid-structure interface. The finite element equations of motion of liquid and structure domain are numerically integrated by Newmark's integration scheme.

The non-linear free surface problems are solved by mixed Eulerian-Lagrangian finite element method. The updated Lagrangian description of the free surface boundary of the liquid is utilized to keep track of the surface position at any time. The finite element equations of motion of the structure domain are numerically integrated by Newmark's integration scheme. The interaction effect between two fields is studied by transferring the structural normal velocity to the liquid domain and liquid pressure to the structure domain.

Finite element codes in Fortran 90 are developed to compute the linear and non-linear sloshing response of liquid in the liquid filled tank-baffle system. The sloshing problems in liquid filled rigid containers of different configurations with and without baffle are solved and the numerical results are compared with those available in the open literature. The liquid-structure coupling problems in liquid filled isotropic flexible tank with and without baffle are solved and computed results are compared with the existing ones.

Effects of different parameters such as composite baffles, lamination scheme and number of layers of laminate in the tank wall, on the slosh frequencies and coupled vibration frequencies in the liquid filled composite tanks have been studied. The effects of composite baffle parameters such as its dimensions and position in the tank wall, on the sloshing response of liquid and structural response of liquid filled composite tank are studied under translational base excitation considering both linear and non-linear free surface of liquid.