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A study on sloshing due to vibrations of Partially Filled Liquid Tank Subjected to Variable Acceleration.

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ABSTRACT:- *Sloshing can be defined as dynamic load acting over a tank structure as a result of the motion of a fluid with free surface confined inside the tank. Liquid sloshing is a kind of wave motion inside a partially filled tank. Sloshing has widespread applications in many industries including automotive, aerospace, ship building manufacturing. The goal of sloshing simulation is to first study the sloshing pattern and then improves the tank design to reduce noise levels, stresses on the structure and optimize the baffle arrangements. The sloshing phenomenon is of great practical importance to the safety of the liquid transport. Under external excitations, with large amplitude or near the natural frequency of sloshing, the liquid inside a partially filled tank is in violent oscillations. Fuel slosh can be generated by many ways: abrupt changes in acceleration (braking), as well as abrupt changes in direction (highway exit-ramp). Repetitive motion can also be involved if a sloshing resonance is generated. These sloshing events can in turn affect the overall performance of the parent structure. In this paper an attempt done on sloshing tank about Vibration of Partially Filled Cylindrical Tank Subjected to Variable Acceleration.*

KEYWORDS:- Sloshing, Impact, Baffle, Simulation

I. INTRODUCTION

The tanker used for the transportation of liquid over the road-ways is an integral part of the Carrier Vehicle. The tanker is expected to withstand the unbalanced forces on account of the transit over uneven and irregular surfaces contours of the road as also due to sudden acceleration or deceleration. As a result, `sloshing' of the liquid is experienced within the tanker. Different aspects of analyses are necessary to design the tanker but sloshing analysis is also one of the prominent aspects for reducing its detrimental effects over structure of tanker. Sloshing can be the result of external forces due to acceleration and deceleration of the containment body. Of particular concern is the pressure distribution on the wall of the container reservoir and its local temporal peaks that can reach as in road tankers twice the rigid load value.. Motion of a fluid can persist beyond application of a direct load to the container; the inertial load exerted by the fluid is time-dependent and can be greater than the load exerted by a solid of the same mass. This makes analysis of sloshing especially important for transportation and storage tanks. Due to its dynamic nature, sloshing can strongly affect performance and behavior of transportation vehicles, especially tankers filled with liquid. In fact, a significant amount of research has gone into developing numerical models for predicting fluid behavior under various loads. Hence liquid sloshing is a practical problem with regard to the safety of transportation systems, such as oil tankers on highways, liquid tank cars on railroads, oceangoing vessels with liquid cargo, propellant tank used in satellites and other spacecraft vehicles, and several others in this study, the vibration of a tank partially filled with liquid under motion modeled as mass lumped is investigated.

(G. Popov et al., 1992) in this study of liquid behaviour in rectangular road containers undergoing a turning or braking manoeuvre is presented and discussed. The steady-state solution in terms of liquid heights, forces and overturning moments is derived analytically from the hydrostatic equations. The transient response of the liquid is obtained via numerical solution of the continuity, Navier-Stokes and free-surface equations. The governing equations are discretized in a Eulerian mesh and solved with respect to the no dimensional primitive variables together with the boundary conditions at rigid walls and the free surface using a modified marker-and-cell technique. Such an approach allows one to take into account all basic nonlinearities proper to the sloshing problem and to obtain the damped frequencies and magnitudes of the sloshing parameters. **(Omar Badran et al.., 2012)** The Vibration of Partially Filled Cylindrical Tank Subjected to Variable Acceleration studied the vibration of a cylindrical tank partially filled with liquid under motion modeled as mass lumped is investigated. A three-dimensional quasi-static model of a partially-filled tank of circular cross-section is developed and integrated into a comprehensive three-dimensional vehicle model to study its dynamic performance as a function of acceleration, and the fill volume. The liquid load movement occurring in the roll and pitch planes of the tank is derived as a function of the longitudinal acceleration, and then the corresponding shifted load is expressed in terms of center of mass coordinates and mass moments of inertia of the liquid bulk, assuming negligible influence of fundamental slosh frequency and viscous effects. The vibration characteristics of the partially filled tank vehicle are evaluated in terms of load shift, forces and moments induced by the cargo movement, and dynamic load transfer in the longitudinal direction. The semi analytical response is obtained by means of SimuLink™ Matlab Software. The effects of longitudinal aceleration of the tank system on the liquid surface inclination and consequently shifting of centroids and moment of inertia are illustrated.

Problem statement and considerations:

In this paper an attempt done on to estimate the sloshing effect for the dynamic moment of tank by giving variable acceleration . The present study is a contribution to the overall dynamics of coupled “vehicle-liquid” systems performing some road manoeuvres. **Case 1:** Sloshing effect on tank with fixed baffle height and with same number of baffles with the liquid level of 60% volume fraction which were obtained as the optimal conditions as from the previous cases were taken into account and acceleration of $0.1\text{m}^2/\text{sec}$ was considered. **Case 2:** Sloshing effect on tank with fixed baffle height and with same number of baffles with the liquid level of 60% volume fraction which were obtained as the optimal conditions as from the previous cases were taken into account and acceleration of $0.5\text{m}^2/\text{sec}$ was considered.

II. METHODOLOGY

Dynamic behavior and structure integrity of heavy commercial vehicles carrying liquid cargo on the highways are greatly influenced by the moving cargo within the partially filled tank. **Geometry Modeling:** A 3-Dimensional rectangular tank of dimension 1.2m length, 1,2m width and 0.6m height, without baffle and with vertical baffle of height 0.3m, 0.36m.0.48m is drawn in ANSYS DESIGN MODULUR (DM). Thickness of baffle is taken as 2mm.

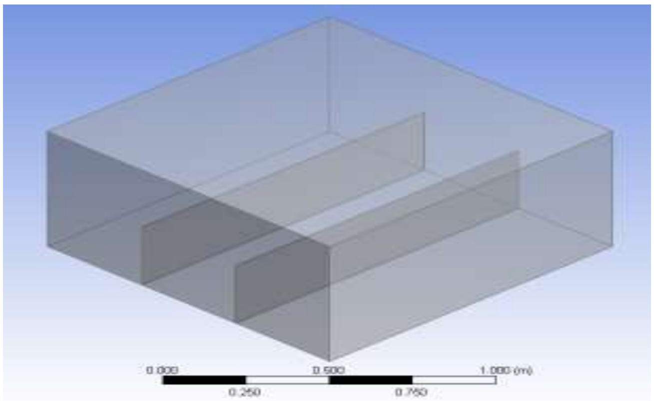

Figure 2.1 CAD Layout of the tank with two baffle

Mesh Generation: After creation of geometry, meshing is done in meshing tool. In present case uniform quadrilateral mesh is generated for all cases.

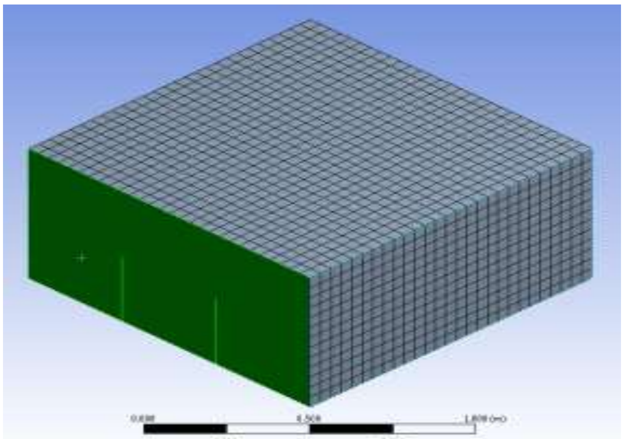

Figure 2.1 Mesh of the geometry with teo baffle

Domain	Nodes	Elements
solid	11368	9450

III. RESULTS & DISCUSSIONS

Case 1: 0.1m^2/sec acceleration : The below figures from 3.1 to 4.16 shows the sloshing effect of the tank subjected to 0.1m^2/sec acceleration for 60%volume fill with two baffles.

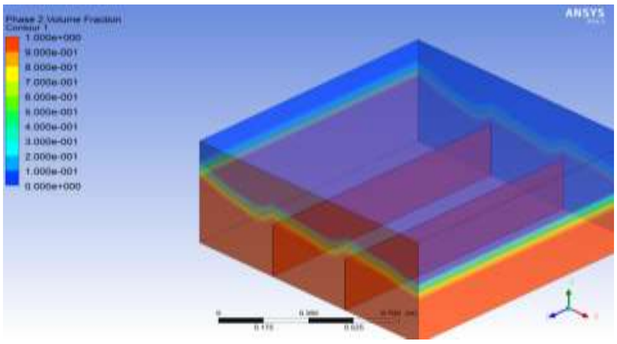

Figure: 3.1 Sloshing of tank with 0.1m/s2 acceleration at 0.1sec

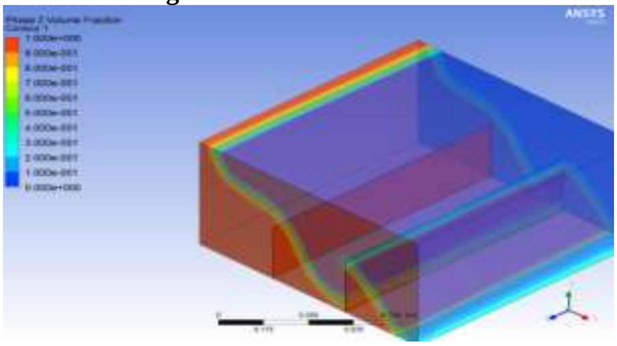

Figure: 3.2 Sloshing of tank with 0.1m/s2 acceleration at 1.2

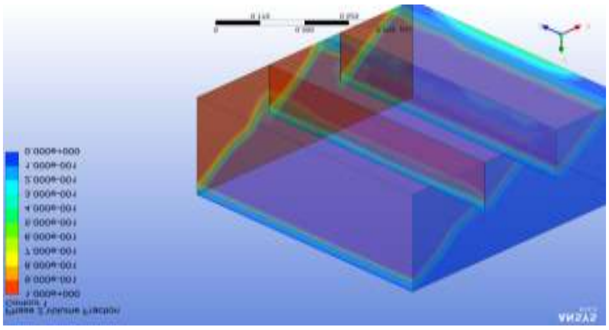

Figure: 3.3 Sloshing of tank with 0.1m/s2 acceleration at 2.2

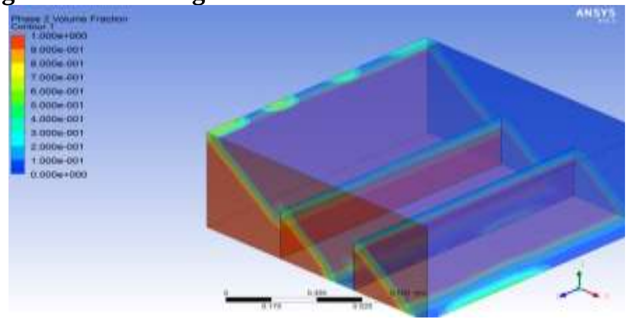

Figure: 3.4 Sloshing of tank with 0.1m/s2 acceleration at 4sec

From the below figure it was observed that the Amplitude of the sloshing wave has been decreased with the frequency of the wave for the give time and given acceleration of 0.1m^2/Sec

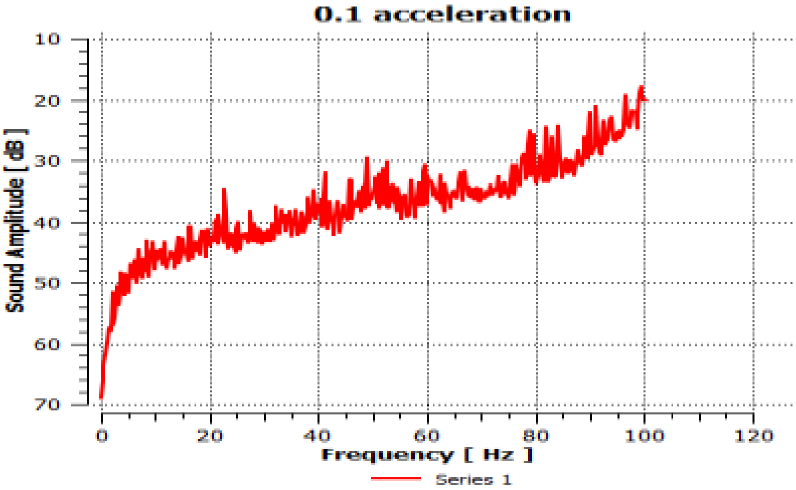

Figure: 3.5 Variation of Amplitude with respect to frequency

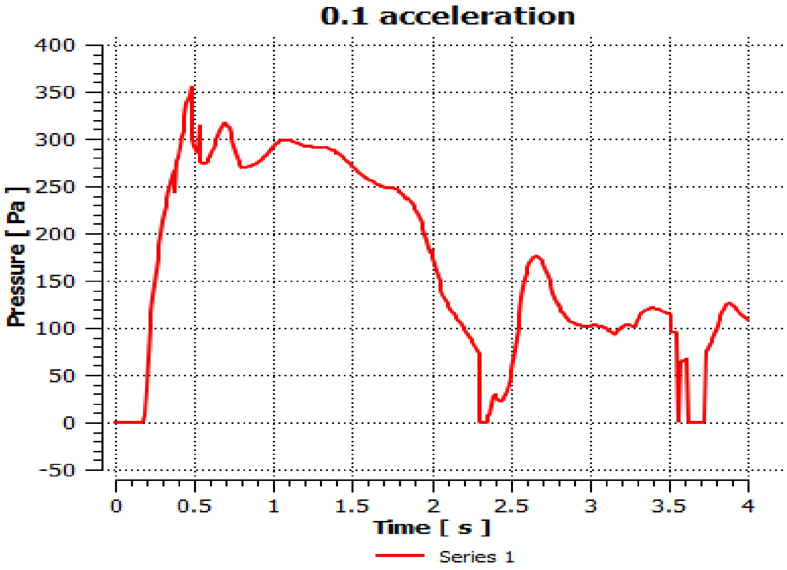

Figure: 3.6Variation of Pressure with respect to time in seconds

CASE 2: 0.5 acceleration:

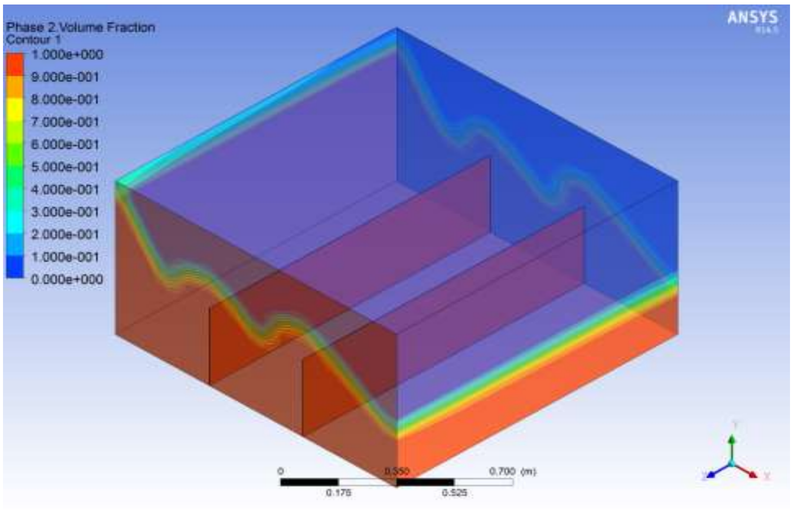

Figure: 3.7 Sloshing of tank with 0.5m/s2 acceleration at 0.2

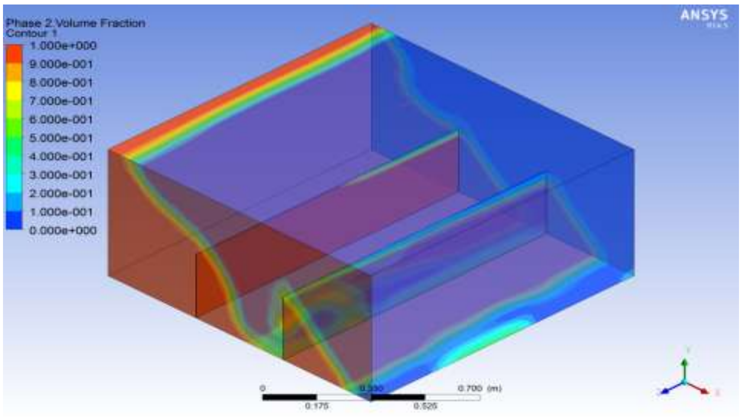

Figure: 3.8 Sloshing of tank with 0.5m/s2 acceleration at 1.4

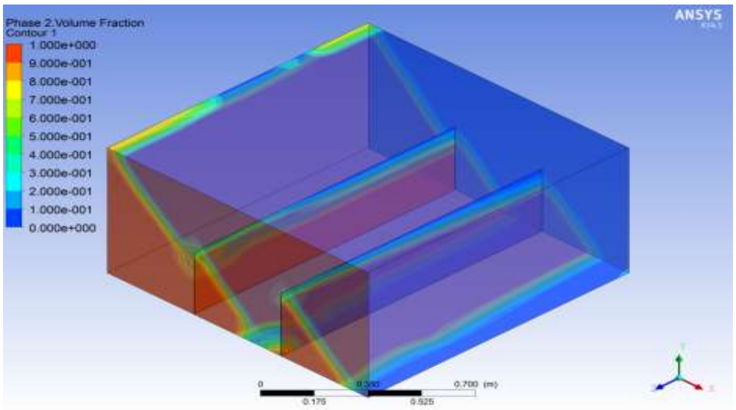

Figure: 3.9 Sloshing of tank with 0.5m/s2 acceleration at 3.2

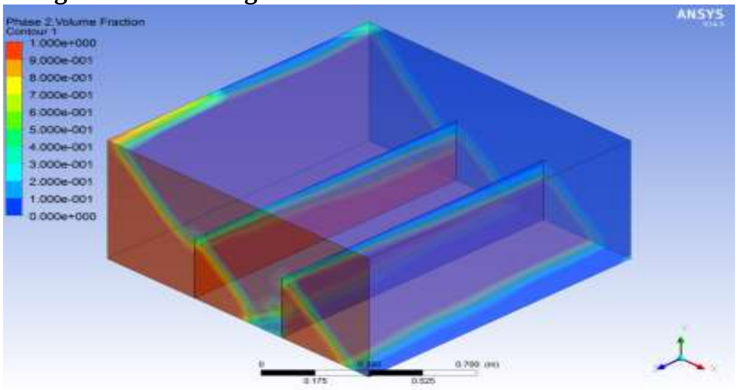

Figure: 3.10 Sloshing of tank with 0.5m/s2 acceleration at 4

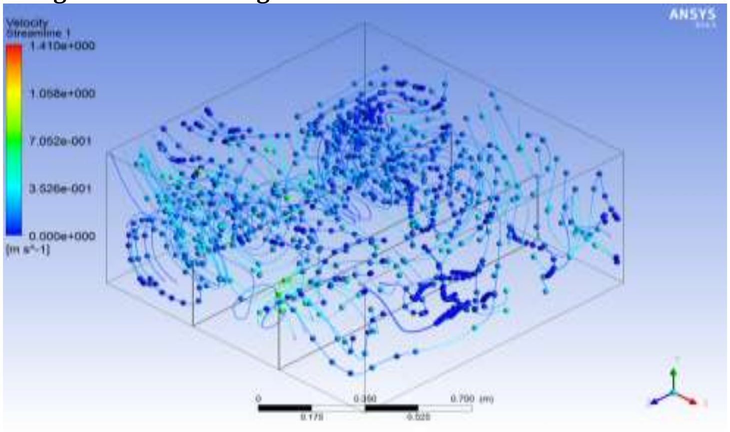

Figure: 3.11 Velocity stream lines

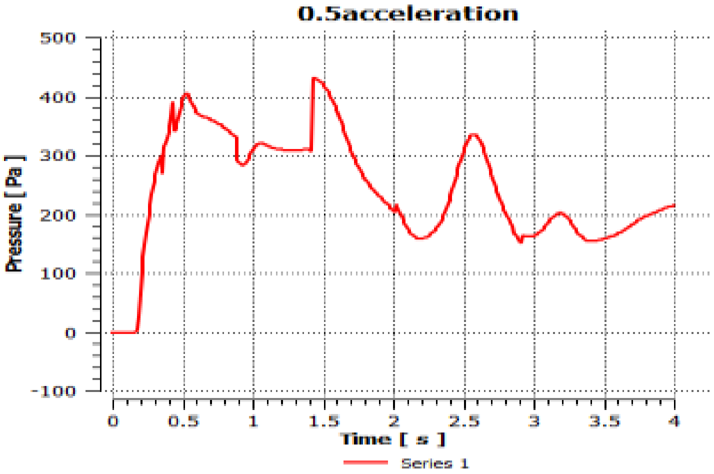

Figure: 3.12 Variation of Pressure with respect to Time

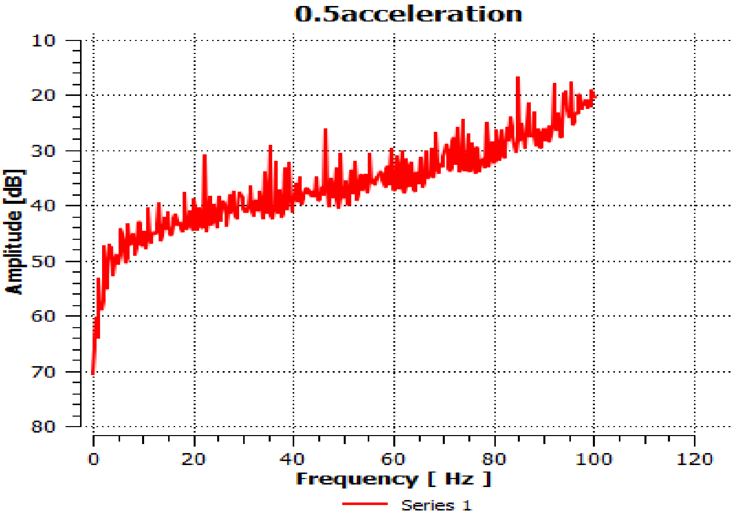

Figure: 3.13 Variation of Amplitude with respect to Frequency in Hz.

IV. CONCLUSIONS & FUTURE SCOPE

1. It was observed that the maximum sloshing of the liquid occurred at 0.5m2/sec acceleration
2. Nominal deference was found for the amplitude change with respect to frequency for both the acceleration cases.
3. The results showed that the acceleration is directly proportional to the inclination angle of the liquid surface in a partially filled moving tank
4. The inertia of the liquid is decreasing when acceleration is increasing

By considering the maximum sloshing of the liquid which was obtained at 0.5m^2/sec the sloshing effect of the same liquid can be studied by varying the liquids and effect of density of the liquid can be studied on sloshing phenomenon.

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