AIJREAS VOLUME 1, ISSUE 1 (2016, January) (ISSN-2455-6300) Online
Anveshana's International Journal of Research in Engineering and Applied Sciences

THE STUDY OF SLOSHING PERFORMANCE IN THREE DIMENSIONAL TANKS FOR DIFFERENT VOLUME FRACTION OF FLUID WITH TIME INCREMENT STEP AND ACCELERATION WITH CFD APPROACH

Suresh Patil G L
Research scholar
J.N.T.University
Hyderabad
glspatil@gmail.com
+91 8792257538

Dr.BAnjaneya Prasad
Professor (Mech Dpet) & D.E
J.N.T.University
Hyderabad
baprasadjntu@gmail.com
+91 9441124725

Dr.D.Maheswar
Principal
KMIT
Hyderabad
dr9440212730@gmail.com
+91 9440122730

Dr.S.Chakradhar Goud
Principal
Sana Engineering Coll
Kodad, Telangana
cgsakki@yahoo.com
+919963287779

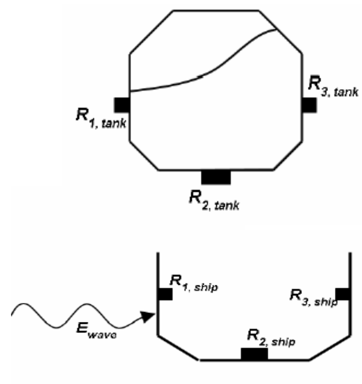
ABSTRACT

The research regarding the examination of sloshing has stated about the fluid containers. One of the chief factors in the area of marine hydrodynamic is the exact forecasting of impulsive load on internal structures. Whereas a serious devastation may occur on the structure of tanks because of a savior load at the time of forceful sloshing. Therefore these damaging cases will be informed to the oil containers, LNG and bulk transporters. However, in the 1950's and 1960's for the designing of spacious vehicles with tanks, lot of research and numerous experiments regarding sloshing performance were conducted. With the implementation of some mathematical techniques during this period a remarkable outcomes have been introduced for the two- and three-dimensional sloshing problems. According to the results of recent calculation, utilizing the flow simulation plans for common purpose such as FLOW3D, have also stated the need for the examination of sloshing .However, the application of the general purpose programs may be not proper for the prediction of impulsive loads, since the typical numerical treatment of wall condition can result in unrealistic flow simulation. In this study, volume of fraction method is considered in solving the present problem connected to ANSYS, a smooth simulation of fluid that flows in three-dimensional tank. The physical dimensions, relevant to the 3D style have been generated in ANSYS Workbench Geometry module. The affect of slosh on tank walls analyzed with 60% and 70% in its height of the tank.

Key words: Slosh, ANSYS, VOF method, tank.

1.0 INTRODUCTION:

Over the past few decades, the troubling factor of sloshing in clogged vessels has enabled us to carry on lot of research and study. The phenomenon of sloshing involves free surface movement of the liquid in the container owing to unexpected loads. Free surface liquid motion is very important factor in liquid storage tanks; airplanes fuel containers, space vehicles, missiles and satellites. Forces on liquid container's wall and moments will be severe when they are excited by frequencies near to resonant. Therefore to avoid failures, assessment of vigorous loads is necessary. Even though this sloshing trouble is challenging by itself, more detailed investigations are needed to consider the relation between the sloshing fluid and the structure contained within. In mechanical engineering sloshing is considered coupled with the container motion when assessing vehicle dynamics. As the experience with road tanker design indicates, it may be necessary to join sloshing and vehicle dynamics in one model when there is a strong coupling between the movement of the container and the sloshing fluid. The ship is disturbed by the wave excitation E-wave, which in turn moves the tank resulting in sloshing. The sloshing and wave excitation forces act at the tank boundary. The traditional approach splits the system above into a pure sloshing problem shown in figure 1(a) and a sea keeping problem shown in figure 1(b). However, this approach does not take cross-coupling between vessel movement and sloshing into account.



1 (a): The sloshing trouble 1(b): The sea keeping problem

Fig 1: The sloshing trouble for LNG tankers

2.0 SLOSHING MOTION–VOF MODEL

The physical sloshing problem doesn't not apt for traditional steady-state CFD, as it is inherently transient and, more significantly, the movement of the liquid in the area will result in the motion. The first problem can be dealt with effectively when quasi steady-state solutions, termed 'coefficient loop iterations' in CFD, which are used in conjunction with a time marching scheme to evolve the flow in time. (VOF) Volume of Fluid multiphase design in ANSYS FLUENTTM 15.0 was used to predict the

motion of the Kerosene fuel inside the tank when the tank is under accelerated motion. The model of VOF was designed to capture the position of interface between two or more immiscible fluids (air and Kerosene).
The Kerosene was supposed to occupy about 25% of the total volume of fuel tank.
The properties of the Kerosene fuel are given in Table.1.Volume as per which, dissection of each of the liquid in each and every calculated cell is directed all through the domain by sharing one set of energy equations between the fluids. The model relies on the truth as to which the fluids are not interpenetrating. In each controlling volume, the fraction of the degree of all stages connected to the unison and considerations, which were taken as Pressure-based solver must be used. However, the design of VOF is not obtainable together with the density -based solvers. All control volumes must be filled with either a single fluid phase or a combination of phases. The VOF can't not be permitted in annulled areas where there is no sort liquid is available expect only one of the phases that is described as a contracted model gas. There are no restrictions on utilizing constricted fluids, consisting of user-defined functions. When the VOF model is supposed to be used the stream intelligent episodic flow (either indicated at the rate of mass flow or specified pressure drop) cannot be modeled. The second-order regarding implied preparation of time speed will not be exploited with the clear scheme of VOF ideal. When tracking particles in parallel, the DPM model cannot be used with the VOF model if the shared memory option is enabled

Table 1. Properties of Kerosene.

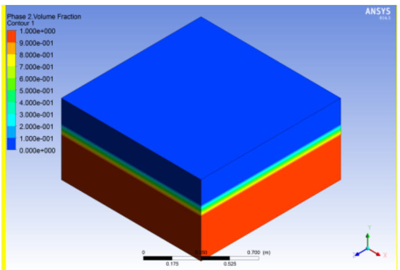
Property (units)	**Value**
Density (kg/m3)	780
Specific heat (j/kg-k)	2090
Thermal conductivity (w/m-k)	0.149
Viscosity (kg/m-s)	0.0024

The VOF formulation in FLUENT is generally used to compute a time-dependent solution, but for problems with a steady-state solution, that is feasible to perform a steady-state calculation. A stable condition of VOF estimation is rational only when solution is independent in the primary conditions and there are certain discrete limitations regarding the inflow for the individual phases. As the form of the exterior a revolving cup rely on the beginning stage of fluid, such troubles can be resolved by using the time-dependent formulation. On the other hand, the stream of liquid in a canal with a section of air on top as well as a special bay of air will also be resolved with the stable state formulation. To find the sloshing behavior of gasoline in the tank with different percentage volumes with acceleration CFD replication of sloshing for various degree of portions of gasoline with 60% and 80 % with time increment step and acceleration.

3.0 MODELLING OF SLOSHING TANK

Tank dimensions are taken from the normal containers utilizing for the transportation of fluid materials by ship transportation which are available in local fabrication industry. Present model consists of a 3-dimensional liquid storage rectangular tank which is partially filled with gasoline (ρ=999.98 kg/m3, μ=0.00103 kg/m-s). The tank dimensions are 1.2*0.6*1.2 m3. Water fill level in tank is 60% and 80% of total height of tank and the rest part is occupied with air. During the excitation mode, tank is supposed to go under sloshing effect which creates pressure and forces on tank wall. By using the physical dimensions appropriate 3D structure was generated in ANSYS Workbench Geometry module. The boundaries in the areas calculated areas were named inner wall, outer wall and ambient wall. The selections and limitations for inlet and are through the divider and forceful channel correspondingly. In temporary situations the Pressure-based solver is exploited. As well as Partial pace algorithm which can be exploited by blending Pressure rapidity Method as the time of the flow is dependable. Reiteration of time development facilitates to make process of calculation with less CPU severity. Green-Gauss Node based spatial separation scheme was used.

4.0 RESULTS AND DISCUSSION-The sloshing of kerosene in container loading with 60% of volume before acceleration and after acceleration which is applied with time steps showed in figures 4.1 to 4.6. In this situation, the filling level can be minimized up to 60% height of the container resulting in the construction of a passing wave and larger air pockets are being monitored when the flow breaks the container's side wall observed to be reduced as portion of time.



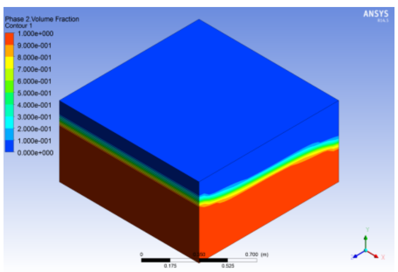
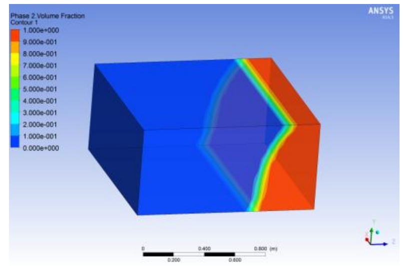


Fig.4.1 Volume portion of fluid at 0.005sec, Fig.4.2 Volume portion of liquid at 0.1sec.



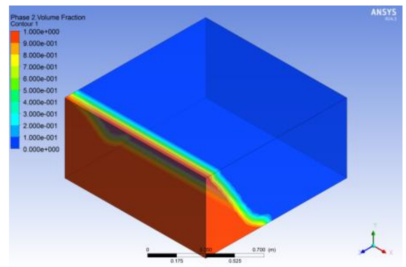
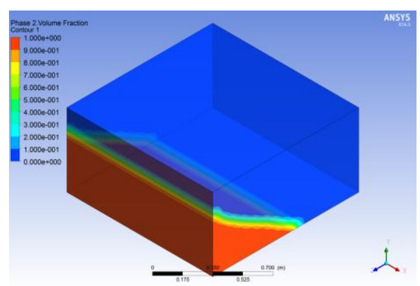


Fig.4.3 Volume portion of fluid at 0.7sec

Fig.4.4 Volume portion of fluid at 1sec



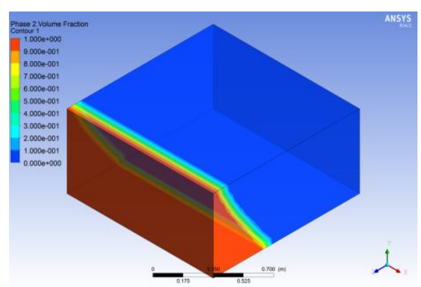
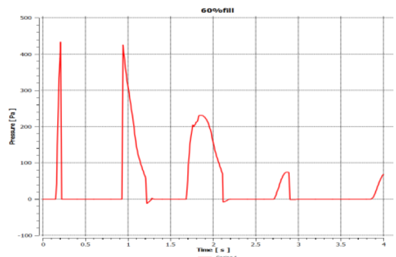


Fig.4.5 Volume fraction of liquid at 1.3sec

Fig.4. 6Volume fraction of liquid at 1.8sec

The fluid oscillating wave reduced as filling level is increased. The fluid compression started between 0.1 sec to 0.7 sec as shown in Fig.4.3 and where impact of slosh is continued after 0.3 sec.



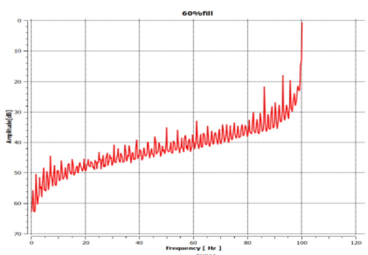
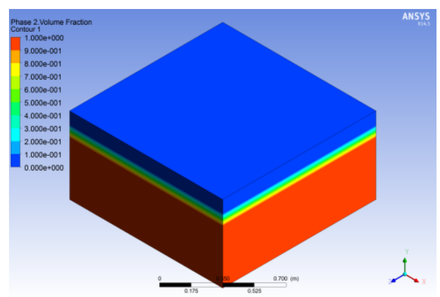


Fig.4.7 Variation of pressure v/s time Fig.4.8 Variation of Amplitude v/s frequency

Fig 4.7 shows pressure variation on tank walls in relation to the time when baffles were not inserted in the tank. The overall pressure variation pattern is uniform till 0.5 sec. With about zero pressure during the start, the maximum pressure exerted is 450Pa. The maximum pressure on the tank surface is seen between 0.2 to 1 seconds. From Fig. 4.8 is clear that maximum amplitude of longitudinal forces is higher at low fill level, because at higher fill level of fluid, slosh will not take place heavily.

This can be also exposed when the tank is excited by natural frequency with excitation amplitude of 0.015 m/s2. For better analysis one more attempt done with 80% filled with 80% in its height. The Fig. 5.19 to 5.26 indicates the affects of slosh on tank walls.



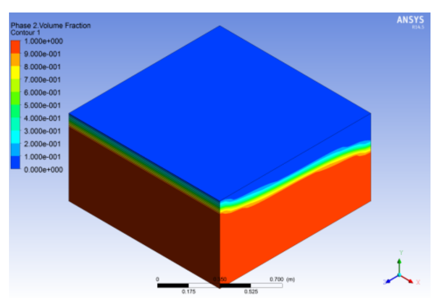
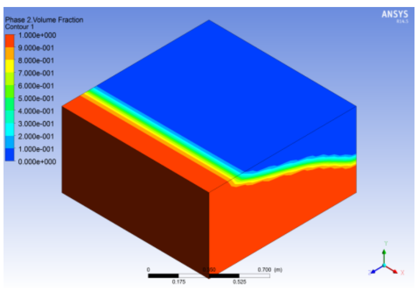


Fig.4.9 Volume portion of liquid at 0.01sec Fig.4.10 Volume portion of fluid at 0.1sec.

Fig.4.9 and Fig.4.10 displays the affect of slosh in tank in a fraction of time. It is clear from figures that the oscillating wave occurred in extremely a minute interval of time from 0.01 to 0.1 sec, this is due to height of kerosene level occupied in tank. Presently here is no mush space for slosh since tank is filled 0.48m height of 0.6m.



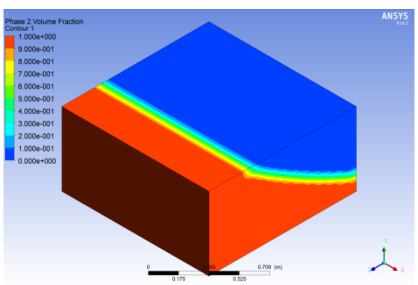
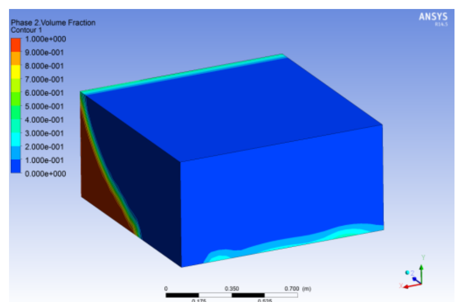


Fig.4.11 Volume fraction of fluid at 0.2sec

Fig.4.12 Volume portion of liquid at 0.3sec

In relation to the above mentioned case, the filling level is increased to 80% from 60% height of the container, bringing the development of a transient wave and bigger air pockets are being carefully verified at the time when the wave ruptures the container's side wall that can be studies to decrease portion of time. The fluid oscillating wave reduced as loading point is increased. The fluid compression started between 0.2 sec to 1.8 sec as shown in Fig.4.13 and Fig.4.14 compared to 60% fill, where impact of slosh is not taking place after 0.4 sec. The more the height of filling level the less of sloshing, but increased filling level effects the tank structure as the quantity of liquid compressed to be one part of the tank wall.



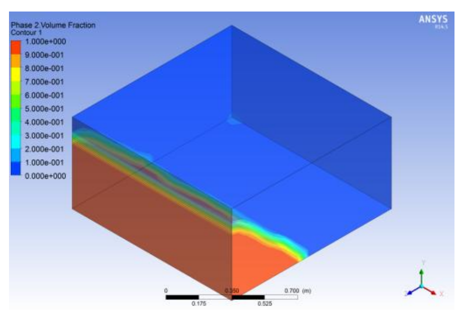
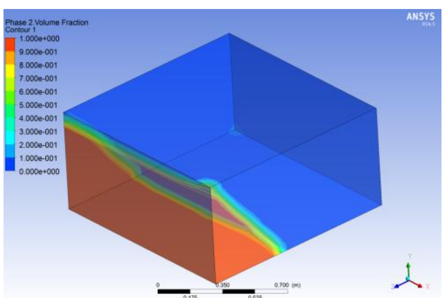


Fig.4.13 Volume portion of fluid at 1.8sec

Fig.4.14 Volume portion of liquid at 2.5sec

Fig. 4.13 and Fig. 4.14 shows, as there won't be any further slosh of liquid because of high level filling of tank. This causes stresses on side walls of tank results in damaging the tank structure. This difficulty may subdue by arranging the baffle inside the tank. Based on tank dimensions one or extra baffles can be arranged. Baffle act as obstruction in fluid flow whish absorbs the fraction of force applied due to acceleration of vehicle.



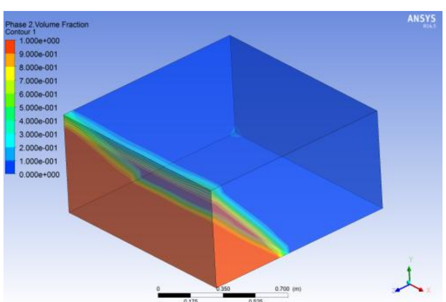
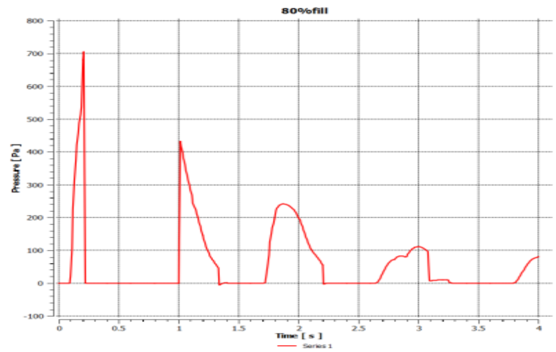


Fig.4.15 Volume portion of liquid at 3sec

Fig.4.16 Volume fraction of fluid at 4sec



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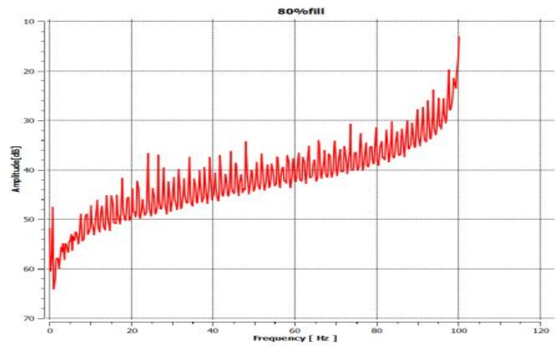

Fig.4.17 variation of pressure v/s time

Fig.4.18 Variation of Amplitude v/s Frequency

Fig 4.17 shows pressure variation on tank walls in relation to the time when baffles were not inserted in the tank. The overall pressure variation pattern is uniform till 0.5 sec. With about zero pressure during the start, the maximum pressure exerted is 450Pa. The maximum pressure on the tank surface is seen between 0.2 to 1 seconds. From Fig. 4.18 is clear that maximum amplitude of longitudinal forces is higher at low fill level, because at higher fill level of fluid, slosh will not arise heavily. This can also be indicated when the tank is excited by natural frequency with excitation amplitude of 0.015 m/s2.

5. CONCLUSION

It is observed that difference in pressure and amplitude for different filling heights of fluid in tank. The uniformity of oscillating pressure pulse is increased with increase of filling level.

Table no: 2 VOF v/s Frequency

S.No	Volume Fration	Maximum Frequency(Hz)
1	50	200
2	60	100
3	80	95

By the observation of above results, it is found that the sloshing behavior of liquid in the tank decreases with the enhancement of quantity of portion. The impact of sloshing when compared to previous editions is likely to be same as before without baffles in the tank. The structure will be failed as the frequency of sloshing is more than the normal rate of the container and hence considering the baffles in the tank may help to lessen the affect sloshing.

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