ABSTRACT

The thesis embodies analytical and experimental study of the collapse of large diameter bubbles under the influence of the gravity field and in the neighbourhood of finite rigid and free surfaces. Investigations regarding the application potential of the fluid jet, formed due to the asymmetrical collapse of the bubbles, to metal forming have also been carried out.

Two distinct cases of bubble collapse relevant to explosive metal forming have been considered. In the first case, the bubble is assumed to be initially spherical and at its maximum size, and located between a finite rigid surface below and a free surface some distance above it. The pressure gradient due to the gravity is neglected and the collapse is assumed to occur under one atmosphere pressure. In the second case, the growth and the collapse of the bubble are assumed to occur when the bubble is close to a finite rigid surface in a gravity field while the free surface is held at a fixed pressure.

The problem has been solved under the assumptions that the liquid is non-viscous and incompressible, that the flow is irrotational, and that the effect of surface tension is negligible. The above assumptions enable the problem to be solved in terms of velocity potential which satisfies the Laplace's equation in the field. The solution is obtained in finite time steps, by solving the Laplace's equation on an electrical network analogue. The boundary conditions are specified with the help of a method which has been developed to deal with the two free surfaces and the gravity field which are required

to be considered in the problem. Bubble profiles and the profiles of the free surface at different stages of collapse are thus obtained.

It is found that when a bubble is located close to a finite rigid surface and if a free surface of fluid is provided above the bubble or when the bubble is of sufficiently large diameter so that there is significant pressure difference in its top and bottom surfaces due to gravity field (hydrostatic pressure falling in the direction towards the rigid surface ) the bubble collapse pattern is altered. In both the cases it is found that the velocity of the bubble surface (at the axis of symmetry) increases in the beginning of the collapse, but the final jet velocities are lower compared to the case when only rigid surface is causing asymmetry in the collapse.

In an experimental setup designed and fabricated for the purpose, copper diaphragms are deformed by shock waves and asymmetrically collapsing bubble created by firing explosive detonators inside a tank. The time deflection history of the diaphragm at its centre is monitored with the help of a phototube and collimator setup. Results thus obtained show that the presence of a rigid surface under suitable conditions causes the bubble to collapse in such a way ~~so~~ as to give rise to deformation in diaphragms. Addition of free surface above the bubble helps in increasing further the deformation caused due to the bubble collapse. It is found that whenever the final deformation of the diaphragm occurs with the bubble collapse, it is deformed into a rounded shape.

The conditions of the bubble collapse which result in the largest amount of deformation experimentally have also been studied analytically. It is found that the optimum results ~~have been~~ are obtained when the collapse of the fully grown bubble towards jet formation starts early in the time history.

It has been observed that the motion of the diaphragm is controlled by its initial acceleration if the deformation is caused by the shock waves transmitted through water. This, however, does not hold in the case when deformation is brought about by bubble loading.