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Research Article

DYNAMIC ANALYSIS OF INDUCED BLAST LOADED CONTAINMENT VESSEL

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ABSTRACT

Release of high pressure air due to some ignition of bombs and explosives that causes explosions is called as blast. Bombsare used in various works such as in construction of tunnels for road and railways, flattening of buildings so that new construction can take place. In some area explosions are used for creating terror among the citizen like terrorist use vehicle bombs, other places where explosions likely occur is in nuclear power plants where due to unsafe isolation could lead to devastating explosions. The paper presents a design concept for containment vessel that need to withstand internal explosions. ABAQUS software is used for numerical simulation of containment vessel. Parametric studies are carried out using the proposed model of containment vessel. It is observed from the studies that the pressure versus time, displacement versus time and the strain energy curve for blast containment vessel is obtained.

INTRODUCTION

Explosive bombs were invented in 13th century by China, they were mainly used for war, as gun powder. They created such a shock that it gave devastating damage such as internal bleeding, rupture, dismembering parts of the human body. Nowadays explosives have been used in many applications such as flattening of areas, demolishing of building, mining purpose. Storing them is our primary concern, early days they were stored in wooden sheds which obviously is not safe from weather and environment accident but it was the only way because of limited resources. Now, since they are being used so, safety of workman is crucial. Recently there has been numerous study on how to store and utilize it properly but transportation is an issue, to rectify this problem, we are going to design a vessel which will not onlyprovide storage but also will be easy for transportation. (Pastrnak, *et al*., 2004) Explains the progress of a composite firing vessel with an increase in performance by filament wound wires and is transparentradiographically, the goal is to contain a limited number of explosives in nuclear power reactors. It consisted of a vessel havingtwo-meter diameter which was constructed to hold up to 35kg of TNT without failure. It is also used for various applications such as test the intensity of explosives and for easy mobility of explosives. The objective was to reduce exposure to public and workers which iscaused by explosives due to ignition. It mainly elaborates construction of vessel. It was concluded thatcontainment with wrapped filament can be used which is light weighted, the openings were sealed so as to reduce exposure due to explosion. Introductionaboutexplosion and its effect on buildings have been explained in this paper. Blast

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pressure has been predicted and calculated using various formulasgiven by Brode (Ngo, *et al.*, 2007) (1955) and finding the full pressure in rebar due to explosion by Newmark (Ngo, *et al.*, 2007) and Hansen (Ngo, *et al.*, 2007) (1961). Building reactionis done by single degree of freedom system. The various failure modes of constructs both local as well as global due to explosion is done, various building components have been taken into account such as beams, slabs. We conclude that,guidance for understanding various load cases and provisions on how to prevent structural failures due to these loads must be introduced in Indian Standard code books. (Li, *et al.*, 2013; Simon and Clubley, 2014) Gives the brittle and ductile failure of the vessels which is subjected to internal explosion. Numerous calculation such as structural response due to internal detonation and assessment of damage regularities of containment. Three pressure rod gauges were used to find the overpressure at various points and electric resistance gauge was used to estimate hoop and axial strain in the experiment. It was noted that the peak overpressure decreases with an increase in longitudinal distance. (Describes the use of containment vessel when the explosive charges are kept at the center, it consists of using HE (High Explosive) materials and products for detonation experiments. They are used to analyze extreme pressure from shock behavior of materials accomplished by HE charges which when detonated drives the metals with high-pressure, extreme-temperature regime and increase-strain rate while the dynamic analysis is done through radioactive images. (Sindhura and Elavenil, 2014; Vinothina and Elavenil, 2016; Giglio, 1997) Studies the design of concrete vessel which is to resist both internal and external explosions. Partial prestressing has been applied at areas where stresses have been focused mainly on the transition zones and near the openings. Various design modifications have been done including integration with structure, the benefits are: - Avoiding stiff corners, saving supporting structures which will be needed to transfer dead load and impact loads, providing resistance of the combined structural system. It was concluded that the containment design having integral system is capable to withstand the various loading conditions, non-metallic is more beneficial than steel liners and finally partial prestressing might be beneficial (Benham and Duffey, 1974; Zheng, *et al.*, 2006; Li, *et al.*, 2010). The main goal of this paper is to provide design considerations for the blast loading in vessels using 13.5kg(30lb) HE charges inside a HSLA-100(High Strength Low Alloy) steel vessel with inner diameter of 6ft. Loading developed due to the explosion is estimated by using empirical and numerical methods. The results were that when analyzing the overall impulse of system, blast and fragment loading should be taken together, ductile and non-ductile failure analysis is completed with simplified methods and finally the vessel design met all requirements of current code cases (Ko, *et al.*, 1977; Shujian, *et al.*, 2016; Thomas, *et al.*, 2003).

CONCEPTUAL FRAMEWORK

The complete study is done through various process and has been described in (Fig. 1) 1 showing various stages.

ANALYTICAL INVESTIGATION

The model consists of a steel spherical containment vessel with 200 mm diameter and 500 mm thickness. 500g charge mass of TNT explosive was placed at 70 mm from the bottom. The blast effect is increased from the bottom to the top. The material properties of steel are described in Table 1, dimension of vessel is tabulated in Table 2. (Fig. 2) shows the dimensions of the containment vessel (Cousin and Evrard, 2015; Zhao, *et al.*, 2012; Jagadeep, *et al.*, 2009).

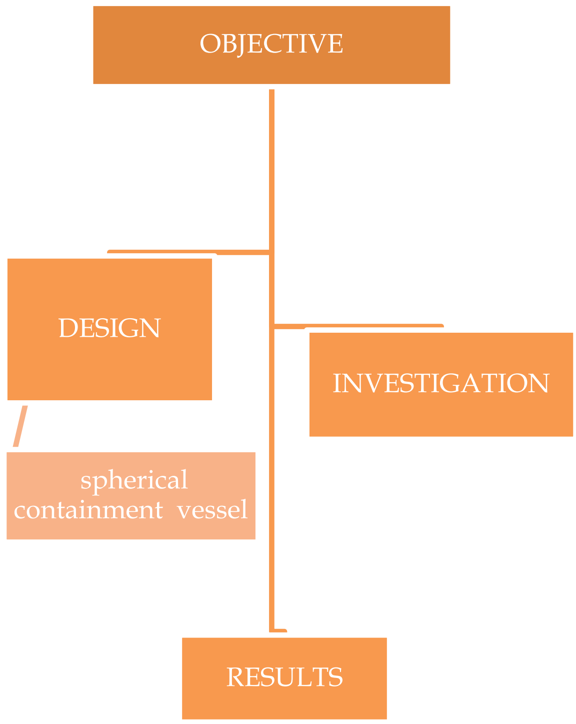

Fig. 1 Methodology.

Table 1. Material properties

Variable	Value
Mass density	7850 kg/m^3
Young's modulus	210 GPa
Poisson's ratio	0.3

The designed model is depicted in (Fig. 3) with an opening provided at the top for inserting explosives in the spherical vessel. (Fig. 4) shows meshing of the vessel before applying the loads.

RESULTS AND DISCUSSION

The displacement vs. time and pressure vs. time history produced due to internal blast loadingis analyzed by using ABAQUS. Displacement vs. time is shown in (Fig. 5) and pressure vs. time is shown in (Fig. 6). The explosives were placed at the bottom of the vessel (Fig. 5-7).

Analysis has been done for various conditions at which the blast effect emerges in such a way that the blast first starts from the bottom. It can be seen from (Fig. 8 and 9) that the blast loading starting from the bottom and slowly moves upwards engulfing the whole vessel, effects are observed step by step (Brendan, *et al.*, 2006; Sayandip and Helen, 2016; Sirous, 2006).

Table 2. Member properties

Variable	Value
Diameter	200 mm
Radius	100 mm
Thickness	500 mm

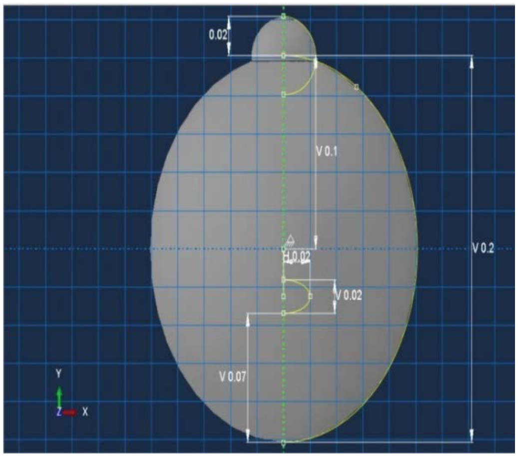

Fig. 2 Dimensions of containment vessel.

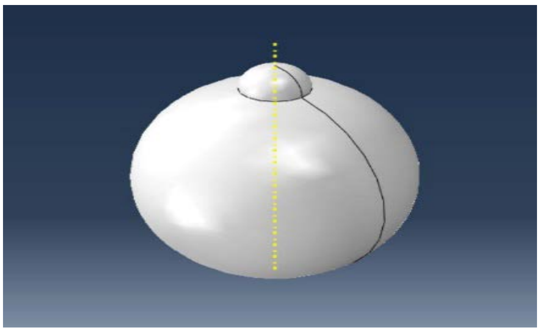

Fig. 3 Designed vessel.

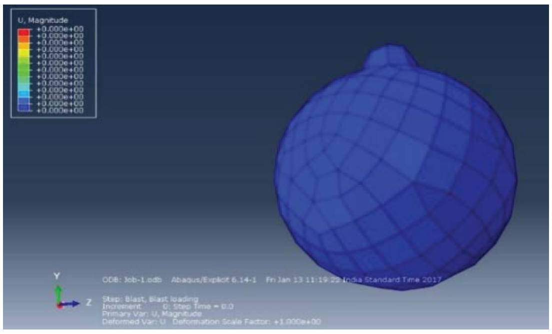

Fig. 4 Meshing.

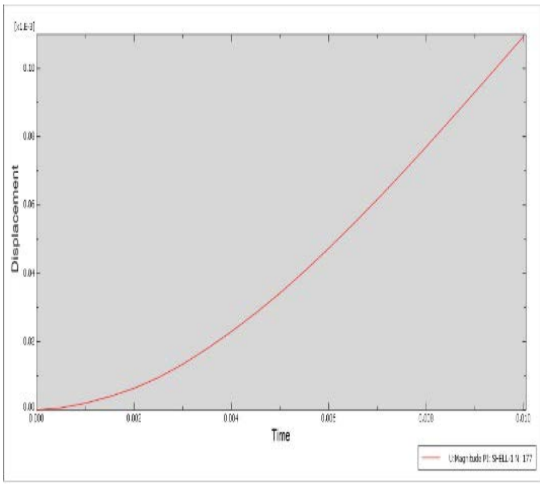

Fig. 5 Displacement-time historyanalysis.

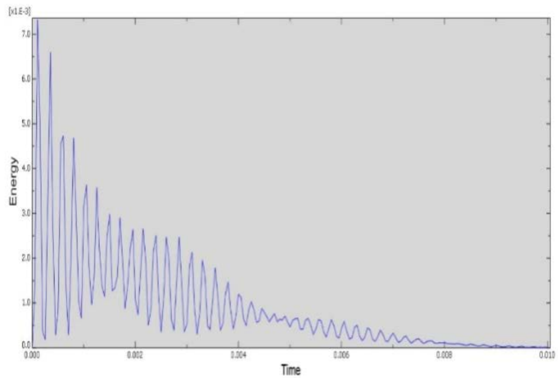

Fig. 6 Strain energy curve.

(Fig. 10) shows the maximum stress affecting the vessel. This modal can be used for investigating blast wave propagation to estimate blast intensity and quality of explosive charges for industrial and commercial purpose. It is able to with stand maximum stress of 120 N/mm^2 at around 1 to 2 milliseconds then the stresses start to decrease until it reaches zero. (Fig. 9) shows the formation of stress due to internal blast load inside the spherical containment vessel (Robert, *et al.*, 1993; Ghani, *et al.*, 2007; Duffeyand and Rodriguez, 2001).

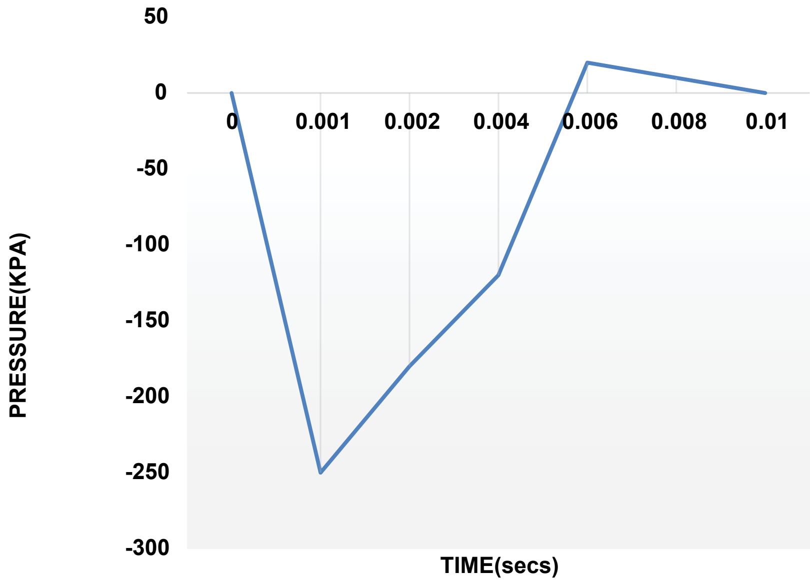

Fig. 7 Pressure vs. time graph.

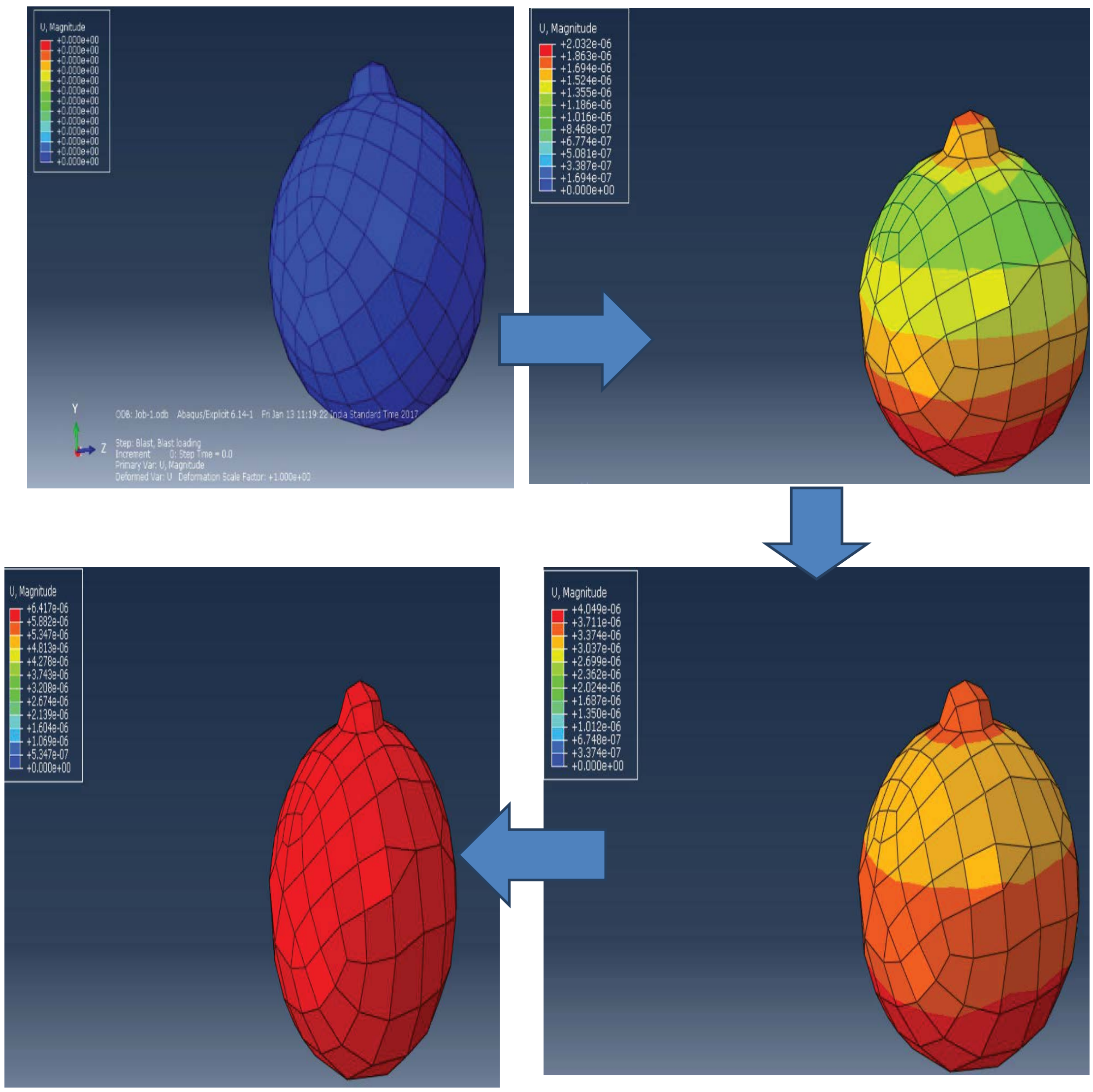

Fig. 8 Blast loading formation.

Stress values obtained from the analysis can be used for designing the vessels for various dimensions. The material adopted in this design will provide resistance to blast load caused by internal explosion (Fig. 10).

The pressure-time curve shown in (Fig. 7) states that the maximum pressure is at 250 KPa at 1 milliseconds, then it started to decrease to 6 milliseconds. There was an incremental of 20 KPa in 6 milliseconds because of suction that will be created in containment vessel after the internal explosion.

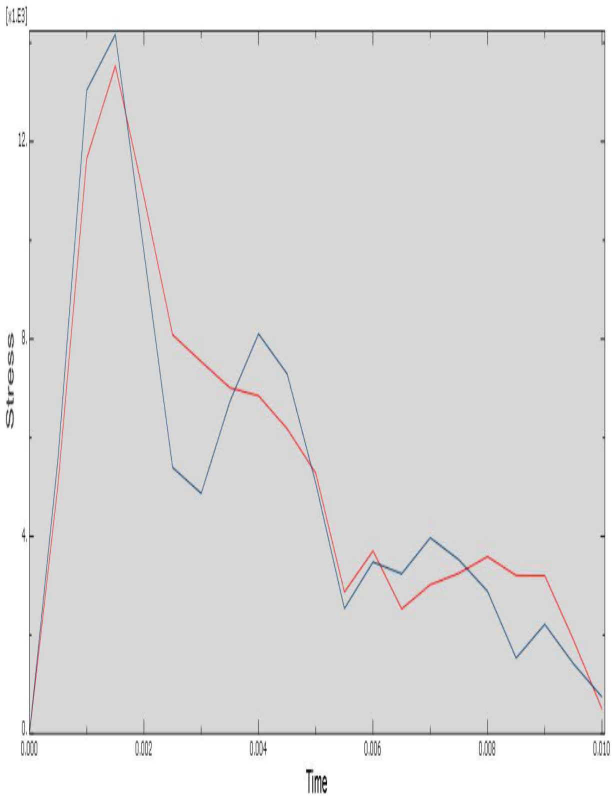

Fig. 9 Stress vs. time.

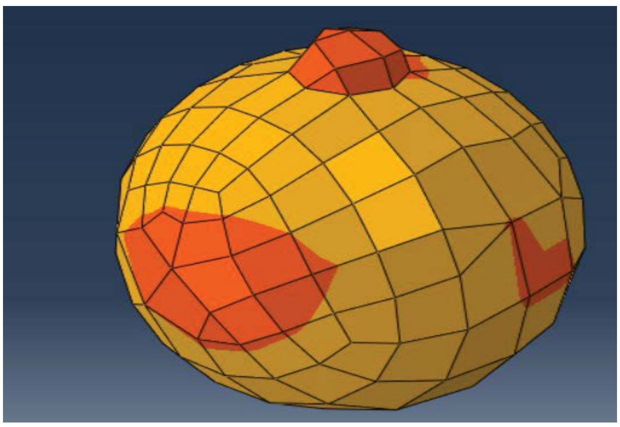

Fig. 10 Stress due to blast load.

CONCLUSION

It is concluded that:

• The spherical shell can be designed using ABAQUS for various parametric studies.

• The maximum pressure is at 250 KPa at 1 milliseconds, then it started to decrease to 6 milliseconds.

• There was an incremental of 20 KPa in 6 milliseconds because of suction that will be created in containment vessel after the internal explosion.

• The blast wave propagates first from the bottom then slowly to the entire vessel, from downwards to upwards.

• Attention has to be given at the bottom, centre and at top of containment vessel so as to resist the internal loading.

• The material is shown to have good strength but poor resistant to temperature. Hence the resistance is limited due to material property.

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