SELECTED ENGINEERING PROBLEMS
NUMBER 4
INSTITUTE OF ENGINEERING PROCESSES AUTOMATION
AND INTEGRATED MANUFACTURING SYSTEMS

Edyta KRZYSTAŁA*, Łukasz KOŁODZIEJ

Department of Theoretical and Applied Mechanics, Faculty of Mechanical Engineering,
Silesian University of Technology, Gliwice, poland
*Edyta.Krzystala@polsl.pl

ANALYSIS OF INFLUENCE OF SHOCK WAVE BLAST PRESSURE OVER HUMAN ORGANISM

Abstract: In the article the topic of influence of shock wave pressure in an explosion over human body was presented. Within the thesis preliminary numerical simulations with the use of CONWEP method in Ls Dyna program was carried out, the aim of which was to appoint maximum pressure impulse dependent on the charge distance from the object, the method of explosion and the size of charge. Further on the contrastive analysis was carried out as for the achieved values of maximum pressure impulse for spherical and semi-spherical explosion.

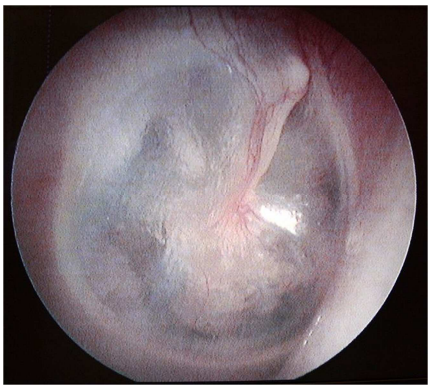
1. Introduction

Living organisms largely are resistant to higher pressure activity. However the effects accompanying the phenomenon such as strong winds of blast and the impact of the head wave cause the fling of objects, people and animals. Indirectly it leads to many fractures, effusions, inner injuries or even death [3,6]. Analyzing soldier's injuries based in Afganistan or Iraq it was stated that shock wave after the explosion causes a very rapid intracranial pressure increase. Injuries caused by shock wave can result in the appearance of intracranial haematoma, skull fracture, brain oedema along with bits of shrapnels, skin burns, eyeball damages, alimentary canal and respiratory tract's burns done by toxic gases coming out of charge explosion [7].

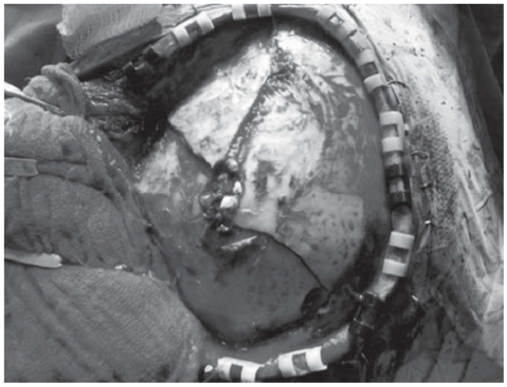
In respect to great pace of explosion and power, at present the research key element is to define pressure's impulse in the initial stage of explosion. The pressure arises the shock wave which can contribute to the damage of living organisms in the place of its force. Blast parameters having the greatest influence upon human damages are: maximum pressure value, and time of shock wave's pressure positive phase. Even the low mass charge is able to create shock wave causing death of people being close to the explosion [6].

2. Influence of blast shock wave pressure over human organism

A human being is able to withstand the pressure of 40pm (about 275 kPa). As a result of high pressure inner injuries can occur such as tympanic-membrane perforation (fig.1), however these are not life threatening injuries. A very important element is the lasting time of positive phase pressure. Analyzing different cases of injuries it was stated that pressure of 20 ps (138 kPa) in a long lasting time can lead to death [8]. Half of all the analyzed in [1] head injuries were caused by after-explosive shock wave activity. Figure 2 presents a fractured soldier's skull bone damaged by shrapnel's penetration.



Rys. 1. Human ear drum [4]



Rys. 2. Fractured soldier's skull bone damaged by shrapnel's penetration [1]

We can distinguish 4 main injury categories caused by explosion [3,6,7].

- Primary injury – concerns direct shock wave activity over a human body. Highly susceptible to this kind of activity are inner organs containing air e.g. alimentary canal and lungs. The skin tissue is more resistant to shock wave pressure activity that's why primary injuries can remain unnoticed during external examination.
- Secondary injury- is caused by wind of blast which carries charge shrapnels and other elements destroyed during the shock wave expansion. External injuries occur then on the whole body surface
- Third-rate injury- occurs as a result of displacing the body by the shock wave. Life threatening is the combination of third-rate and primary injuries because they can result in limb amputation.
- Fourth-rate injury- is a result of a combination of a few factors e.g. poisoning, thermal injury or negative psychological aspects.

3. Numerical simulations

Within the thesis numerical simulations were carried out whose aim was to get the pressure value for the air burst circular charge as well as surface burst semi-circular charge (fig. 3). For blast simulation LS Dyna program and implemented Long Blast function were used. This type of simulation consists in model charge with pressure field occurring in a defined charge explosion. The field is calculated by means of Conwep algorithm. This method however has a few limitations inter alia, the size of charge cannot exceed 40 000 kg and it allows to analyze only the influence of a wave over the object. In questions with the wave being repeatedly reflected the algorithm is not sufficient [2].

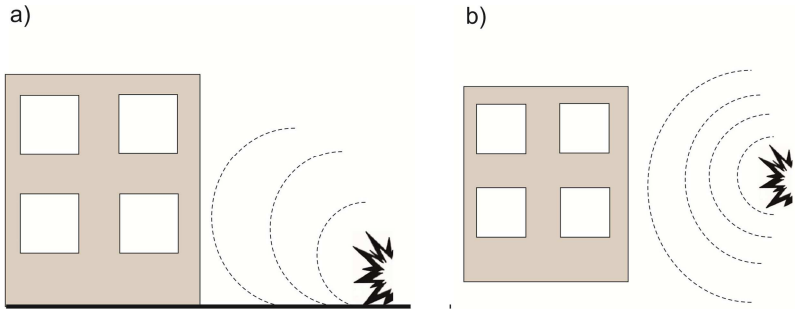


Fig. 3. The differences between two types of simulations used in Load Blast function in Ls Dyna program:a) surface burst, b) air burst [5]

Figure 4 presents Load Blast function. In order to carry out the simulation the charge mass, location coordinates, time of detonation and type of charge are given. The differences between these two types of simulations are presented in figure 3. For the shock wave analysis a model of square tile, 1 meter long and 6 mm thick, was used. A springy material with the parameters of constructional steel S235JR were chosen. The surface of the tile was loaded with pressure field of charge explosive power from 1 up to 25 TNT kg. For each charge mass the pressure field was appointed for changing distance from 1 to 100 meters. Numerical model is presented in Figure 5.

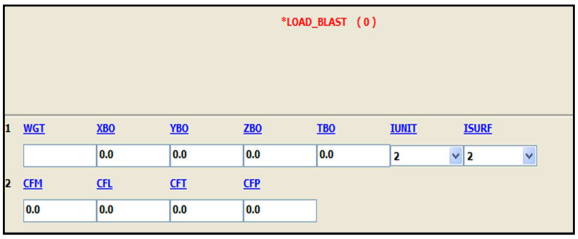


Fig. 4. Load Blast function in Ls Dyna program

Fig. 5. Numerical model

Sample numerical simulation results showing the contrast of blast pressure value in the air and on the surface are presented in Figure 6.

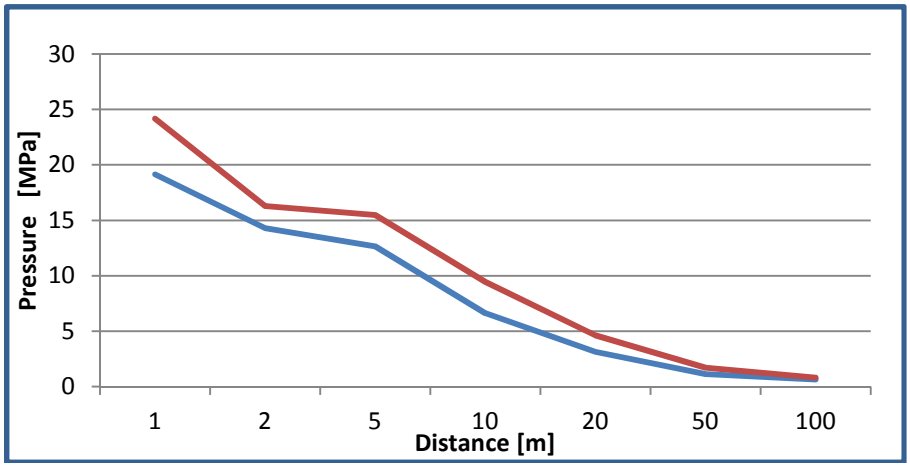


Fig. 6. Numerical simulation results showing the contrast of blast pressure value in the air and on the surface for 1 kg TNT charge (blue line – spherical burst, red line – semi-spherical burst)

4. Conclusion

An explosion is a quick changing and dynamic phenomenon during which a great number of energy is released in a very short time. Shock wave occurring after a charge explosion caused a rapid pressure increase. Maximum value of momentary pressure increases and positive phase period have a decisive influence over the consequently occurring injuries. The injuries can be categorized as primary, secondary, third-rate and fourth-rate ones. Each of these can be the cause of serious complications and with a mutual combination they can lead to death. The main organ susceptible to pressure value charges is the hearing apparatus.

References

1. Barciszewska A., Jankowski R., Nowak S., Piestrzeniewicz R., Żukiel R.: Brain damage as a consequence of the explosion pressure wave (in Polish), [online: 03.04.2013], www.neurochirurgia.amp.edu.pl/neuroskop/n10/1.pdf.
2. Czyż T.: Modeling of detonation phenomena in the Ansys Autodyn (in Polish), Gliwice 2009
3. Elsayed N. M.: Explosion and blast-related injuries, USA, 2008.
4. Krzyżak J.: Medicine for divers in a nutshell (in Polish), Publishing House KOOP-graf, Poznań, 2008.
5. Lahiri S.K., Ho L.: Blast loading due to conventional weapons (Conwep), USA 2011.
6. Phillips Y.III, Richmond D. R.: Primary blast injury and basic research: a brief history, 2000.
7. Stuhmiller J. H., Blast Injury translating research in to operational medicine, USA 2008.
8. Zipf R.K.: Effects of blast pressure on structures and the human body, [online: 04.02.2013] http://www.cdc.gov/niosh/docket/archive/pdfs/NIOSH-125/125ExplosionsandRefugeChambers.pdf.