Blast energy absorption of metal cans

Sivakumar PALANIVELU

Supervisor(s): Wim Van PAEPEGEM, Joris DEGRIECK

I. Introduction

The entire world faces the problem of industrial, military and civil engineering structures due to terrorist activities. The failure of critical load bearing members such as beams, pillars, columns etc., and its debris cause major human causalities. Hence a preventive solution is needed to safeguard the civil engineering structures and to avoid human causalities due to explosion (Figure 1). Out of many proposed solutions, the concept of sacrificial cladding structure has attracted more attention in terms of its functionality. The sacrificial cladding structures can have two layers. The function of the outer layer is to distribute the blast pressure more evenly to the inner core which deforms progressively and absorbs most of the energy from the blast load, so that the main load bearing members of the civil engineering structures will be safeguarded. In connection with the above application an experimental (blast test) and numerical investigation was carried out using empty cola cans. The result from the numerical simulation was compared with the experimental results.

Figure 1: Effects of blast load.

Sivakumar.Palanivelu is with the Department of Materials science and Engineering (IR10) Ghent University (UGent), Gent, Belgium. E-mail: Sivakumar.Palanivelu@UGent.be.

II. Experimental analysis

A. *Materials*

The used empty cola cans were utilized for this experimental study. Out of two different types of cans available in the market (made of steel and aluminium), the cans which made of steel were used for this study. Special care was taken to choose the cans without defects (indents and scratches) induced during the consumption of the beverage. The secondary explosive C4 (RDX) was used to create the blast pressure.

B. *Test Setup*

The schematic representation of the blast test set-up which was used for the blast tests is shown in Figure 2. The energy absorption of these empty cola cans was studied for a stand-off distance of 30 cm with C4 mass of 20g.

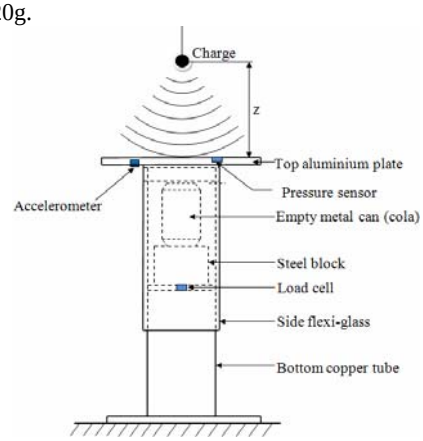

Figure 2: Experimental set-up.

III. EXPERIMENTAL AND NUMERICAL ANALYSIS

A. *Experimental analysis and its results*

The crushing pattern of empty cola cans from the different blast tests is shown in Figure 3. Based on the thickness distribution of the empty cola can, it can be concluded that the initial deformation should occur at the mid-wall location of the can due to its lesser thickness. However, it can be noticed from Figure 3 that the initial deformation occurred at different points of the can along its length. This may due to the geometric imperfection caused by the manufacturing process. The energy absorption of these cans was calculated based on Equation 1.

$$E_d = \int_0^{l_{max}} P(l)dl \quad (1)$$

where, $P(l)$ is the instantaneous crushing load corresponding to the instantaneous crushing deformation length dl. l_{max} is the maximum crushing length of the empty cola can.

Figure 3: Failure pattern of empty cola cans

B. *Numerical analysis and its results*

The empty cola can was modelled with shell elements. The top aluminium plate and the bottom resting plate were modelled as rigid plates. A surface-to-surface contact algorithm was established between the top rigid surface and the empty cola can with friction coefficient of 0.2. The deformation of the can was captured from the displacement of the top rigid surface and the reaction force was extracted from the interface force between the empty cola can and the bottom rigid surface.

The failure modes obtained from the numerical simulation are shown in Figure 4. These results can be very well compared with the ones presented in Figure 3.

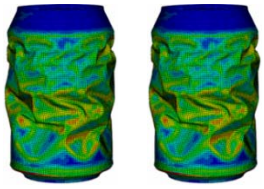

Figure 4: Numerical failure pattern of empty cola can.

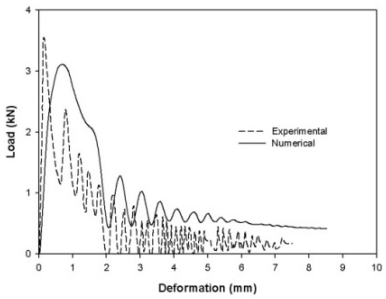

Figure 5: Comparison of experimental and numerical results

IV. CONCLUSION

The blast energy absorption characteristics and the crushing mechanism of the empty cola cans were investigated. A numerical simulation was carried out with the Johnson-cook material model. The failure patterns of the cans and the corresponding energy absorption levels were comparable with the experimental results. Using this numerical model further analysis can be done to study the effect of different variables such as the mass and the diameter of the top plate on energy absorption of the cans.

REFERENCES

[1] Guruprasad S. and Mukherjee Abhijit, *Layered sacrificial claddings under blast loading Part I -- analytical studies.* International Journal of Impact Engineering, 2000. **24**(9): p. 957-973.