Crashworthiness study of axial impact in cylindrical aluminium tubes

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A thin-walled cylindrical tube, when subjected to an axial load, will be folded and will absorb an impact energy. In the design of a frontal cylindrical tube for absorbing the kinetic energy during car accidents, there were a lot of theoretical and experimental researches that have defined the characteristics of the tube during cars accidents. After studying most of these researches, it was found that the theoretical approach usually simplified the problem and could not be used confidently in design. Experimental approach usually faced difficulty when the material was changed.

In this paper, a computer simulation program joined with the response surface methodology was planned to find the tube characteristics in axial impacts. The problem parameters were dimensional measures of an aluminium circular tube including thickness, diameter and length. The output of the work was to find the variation of the absorbed energy and mean crash force of the tube with the parameters in the applicable automotive ranges. Also, our results were compared with some available theoretical approaches.

K e y w o r d s: response surface method, energy absorption, aluminium tube

Nomenclature

D – tube diameter [m]
T – tube thickness [m]
L – tube length [m]
P_{m} – mean crash force [N]
H – half-wavelength of fold [m]
M_{P} – full plastic bending moment of tube wall per unit length [N]
m – geometry eccentricity factor – i.e. ratio of outwards fold length to total fold length
N – number of circumferential lobes in non-axisymmetric buckling
V – Vickers hardness number [$\mathrm{kg\,mm^{-2}}$]
δ_{e} – effective crushing distance [m]
σ_0 – flow stress [MPa]
σ_{Ult} – ultimate tensile stress [MPa]
$\sigma_{0.2}$ – 0.2 % proof stress [MPa]

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