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Numerical Analysis of the Crashworthiness Performance of Multicell Tubes Under Oblique Loads

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ABSTRACT

When a car crash occurs, the probability that the collision will be oblique and not entirely frontal is high. In this way, the current article evaluates by a finite element analysis, the crashworthiness performance of multicell structures subjected to oblique loads. In this sense, five multicell structures manufactured with 6063-T5 aluminum alloy were designed and evaluated by an oblique compression test. During the analysis, special emphasis was placed on determining the effect of the cross-section and the angle of incidence of the load (θ) on the energy absorption of the structures. For this purpose, values of θ equal to 0°,5°,10° and 15° were analyzed. To guarantee a correct comparison between tubes, all the structures had the same mass equal to 0.80 kg. Then, adjustments to the thickness were realized. In all cases, the most important indicators of impact resistance such as energy absorption (Ea), crushing force efficiency (CFE), and mean force (Pm) were calculated. According to the results, the angle of incidence of the load defined the plastic deformation mode of the structure. In this sense, a 47.75% decrease in the Pmax and Pm was observed as the angle θ increased. Moreover, at the end of the study, the MC-02 profile presented the best CFE with an average value of 0.74 at different loading angles. Thus, this structure could be considered as a baseline among engineers and designers for the design of structures subjected to bending loads.

INTRODUCTION

The Crashworthiness concept is one of the most critical concepts in automobile industry [1]. In this way, body-in-white is designed to withstand the dynamic forces during car crashes, saving the integrity of the passengers. Car crashes occur in different directions, however, according to [2] statically frontal and oblique crashes represent 34% of all reported accidents. With this in mind, the use of thin-walled structures as an energy absorption mechanism is studied by engineers and academics [5,6]. For the specific case of structures loaded obliquely, theoretical [3,4], experimental [7-8], and numerical [9,10] studies have been performed focusing on maximizing their plastic deformation. The main parameters analyzed are the geometric pattern, manufacture material, and the loading angle (θ). In this way, Karantza et al. [11] numerically and experimentally investigated the impact resistance of square aluminum profiles subjected to oblique loads. During the study, special emphasis was set on the variation of the load incidence angle