Advances in Automobile Engineering
ISSN: 2167-7670

Xu et al., Adv Automob Eng 2018, 7:1
DOI: 10.4172/2167-7670.1000178

Commentary Open Access

Design of Energy-Absorbed Structures and Materials with Graded Configurations in the Automotive Body

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Commentary

In the past years, there has been an unremitting pursuit of lighter and safer energy-absorbing structural elements in the automotive body structure for better fuel economy, less gas emission and passenger safety. Recently, crashworthiness of advanced structures and materials with graded effects raised enormous concerns [1-3]. Graded structures/materials could considerably reduce weight and improve performance by making reasonable designs of the gradient parameters.

The investigations on energy-absorbing configurations considering gradient properties are quite extensive and abundant. Those structures/materials may be thin-walled components, cellular materials like foams or honeycombs, or composite structures of these two. The gradient effects may arise from geometrical parameters such as diameter, width, wall thickness etc., (Figure 1). Additionally, they can be also caused by variable material properties including density, strength and even material type. What's more, the applied load conditions are also multifarious such as axial crushing, transverse or oblique loading, ball impact, etc.

In general, the introducing of gradients brings bigger flexibility and wider design domain in related energy-absorbing structures and materials. The crashworthiness performance of these structures and materials could definitely be further improved by appropriate design optimization. There is no doubt that design optimization techniques would always play an important role in this process to obtain optimal solutions with different objectives, constraints and design variables.

However, it is worth noting that the introducing of gradients may result in some difficulties in manufacture of such structures and materials. Fortunately, this obstacle could be eliminated with the advance of manufacturing science and process technology. For example, various tailoring and forming technologies can be employed to fabricate the structures with graded properties. Thus, it would be not difficult anymore to obtain thin-walled structures with a graded property in most cases. Some mature production technologies, such as Tailor Welded Blank (TWB), Tailor Rolling Blank (TRB) and Tailor Hot Stamping (THS), etc, have been widely applied in various engineering fields, especially in the automotive industry. The components produced by those technologies are all representations of thin-walled structures with gradient effects. Although the manufacturing of metal foams with graded density is still a challenging task, the progress is being made in this field [4-9].

In sum, theoretical analysis, experimental investigation, numerical simulation and design optimization have been extensively adopted in the studies on energy absorption of graded structures and materials under impacting events. It could be speculated that the performance of related strutures would be further improved and much more reasonable designs with graded structures/materials will emerge continuously. Further research about gradient effects on energy-absorbing structures and materials may still be driven by actual vehicle applications as well as scientific innovations, the multi-scale design of cellular structures, as an example.

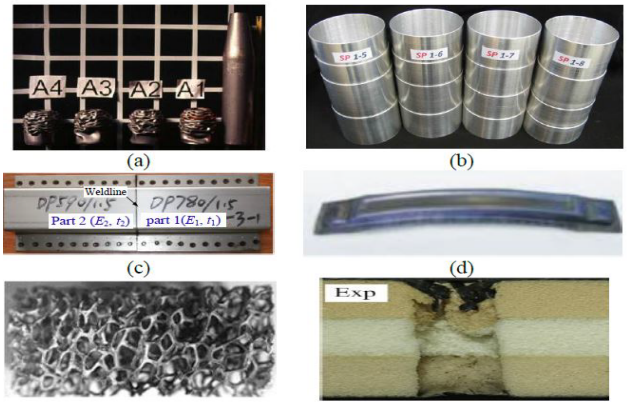

Figure 1: Energy-absorbed structures and materials with graded configurations: (a) Graded diameter; (b) Graded thickness; (c) Tailor welded tubes; (d) Graded material property; (e) Graded foam; (f) Graded sandwich.

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Received February 11, 2018; **Accepted** February 14, 2018; **Published** February 19, 2018

Citation: Xu F, Zhang S, Wu K (2018) Design of Energy-Absorbed Structures and Materials with Graded Configurations in the Automotive Body. Adv Automob Eng 7: 178. doi: 10.4172/2167-7670.1000178

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