11th. World Congress on Computational Mechanics (WCCM XI)
5th. European Conference on Computational Mechanics (ECCM V)
6th. European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

Optimization of Functionally-Graded Configurations for Crashworthiness Design of Thin Walled Structures

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Key Words: *Crashworthiness, Thin-Walled Structures, Functionally Graded Thickness, Functionally Graded Foam*

Abstract:
Foam filled thin-walled structures have exhibited significant advantages in light weight and energy absorption [1-3]. Unlike existing structures with uniform thickness and foam materials, this paper introduces functionally graded thickness (FGT) [4] and/or functionally graded foam (FGF) [5] with changing wall thickness and foam density. As a key topic, crashing characteristics of FGT and/or FGF structures are evaluated and compared with conventional structures with uniform wall thickness and foam density [2]. It is shown that the gradient exponent that controls the variation in thickness or foam density has significant effect on crashworthiness. To optimize crashworthiness of the FGT/FGF tubes, the Non-dominated Sorting Genetic Algorithm (NSGA-II) and/or multiobjective particle swarm optimization (MOPSO) are employed to seek for an optimal gradient, where a surrogate modeling method, specifically response surface method (RSM), is adopted to formulate the specific energy absorption (SEA) and peak crashing force functions. The results yielded from the multiobjective optimization indicate that the FGT/FGF tube is superior to its uniform thickness/foam counterparts in overall crashing behaviours. Therefore, FGT/FGF thin-walled structures are recommended as a potential absorber of crashing energy.

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