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# DISCRETE OPTIMIZATION DESIGN OF TAILOR-WELDED BLANKS (TWBs) THIN-WALLED STRUCTURES UNDER DYNAMIC CRASHING

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**ABSTRACT**−Tailor-welded blanks (TWBs) thin-walled structures have been widely applied in field of automotive and construction due to their significant advantages in saving weight and improving crashworthiness. To further understand and improve crashing performance of TWB structures, this paper conducts parametric analysis and optimization design on TWB thin-walled tubes. Firstly, the numerical model of dynamic crashing event of different TWB tubes is derived from physical experiments. The parametric analysis results show that the material and thickness combinations have significant effects on the crashing performance. The energy-absorbed characteristics and deformed modes of TWBs are superior to those of tubes with uniform thickness. Then, two optimization cases of TWB tubes are presented through analysis of mean (ANOM) and updating orthogonal array, in which the thickness property and material types are considered as design variables. The results demonstrated that the performances of the optimized structure are much better than those of the initial counterpart.

**KEY WORDS** : Dynamic crashing, Discrete design, Finite Element Analysis (FEA), Thin-walled structure, Tailor-Welded Blank (TWB)

## 1. INTRODUCTION

Thin-walled structures have drawn more and more attention and been widely used in automobile, aerospace and transportation engineering for high energy absorption capacity. Some semi-empirical formulas of crushing collapse of thin-walled tubes were theoretically studied (Cao and Wang, 2015; Kuczek, 2016; Qi and Yang, 2014; Song *et al*., 2012; Wierzbicki and Abramowicz, 1983). The theoretical method could provide some design guide to improve the performance of thin-walled structures with uniform geometrical features. For the special vehicle body with relatively complex configuration, different materials such as high-strength steels (Costas *et al*., 2013; Sato *et al*., 2013) and cellular materials (Attia *et al*., 2012; Li *et al*., 2013; Yin *et al*., 2011; Zarei and Kröger, 2008) have been employed to a large extent. In addition, various section shapes including single or multi-cell sections (Zhang and Zhang, 2013, 2014), and other sections with graded thickness (Sun *et al*., 2014; Xu, 2015; Xu *et al*., 2015; Zhang and Zhang, 2015; Zhang *et al*., 2014, 2015) are also adopted. Unfortunately, most of those thin-walled structures were made of the same or single material, which prevented from exerting higher crashing capability. Furthermore, those thin-walled structures may not meet the growing requirements of lightweight (Davies *et al*., 2001, 2002; Zadpoor *et al*., 2007).

Based on abovementioned descriptions, it would be important to introduce new structural configurations (Zuo and Saitou, 2017). To satisfy the requirements of productivity and quality, the laser welding processes have showed many advantages in manufacturing engineering such as deep penetration with narrow welds, low heat input, small distortion level and so on. Generally, the tailor-welded blank (TWB) technology could combine blanks with different thicknesses/materials into a single one prior to the forming process. In other words, the advanced structure refers to thin sheets with multiple material and/or thickness welded together to create a single structure, and then be formed into components (Bandyopadhyay *et al*., 2015; Merklein *et al*., 2014). The applications of TWB technology have proven effective to tackle the troublesome problems of reducing weight and increasing production efficiency (Li *et al*., 2015; Xu, 2015; Xu *et al*., 2014a, 2014b, 2018a, 2018b).

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