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NOVEL COLLABORATIVE DESIGN METHOD FOR LIGHTWEIGHT OPTIMIZATION DESIGN OF VEHICLE LOAD-BEARING PARTS

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ABSTRACT–The design of new energy vehicle load-bearing structural components using traditional experience may lead to low material utilization efficiency. This makes it difficult to reduce the quality, or material shortage, which will increase the number of product design iterations and design cycle. Fortunately, the increasingly mature structural topology optimization technology can effectively solve this problem, and can provide a structural basic feature with high material utilization efficiency for parts according to the structural optimization objective. In addition, the rapid development of special casting technology makes it easier to process parts with complex shapes. Herein, a collaborative design method combining structural topology optimization design, material lightweight design and squeeze casting process was proposed to realize the lightweight of new energy vehicle load-bearing structural parts more effectively. The collaborative design method was applied to the steering knuckle design of a vehicle, and the results show that the method has a significant lightweight effect and can obtain the aluminum alloy steering knuckle with better quality.

KEY WORDS : Vehicle load-bearing parts, Lightweight design, Structural topology optimization, Squeeze casting process, Collaborative design method

1. INTRODUCTION

With the rise of new forces in car manufacturing, the automobile is not only a tool for daily travel, but also a kind of travel experience, which also broadens the new development direction for the automobile industry. Countries have listed lightweight as the core technology for the development of energy-saving and new energy vehicles (Nealer and Hendrickson, 2015; Lu *et al.*, 2019). Major car companies and suppliers are also committed to automotive lightweight research, including: research and development of lightweight structure, with the least material to achieve the best stress state of the structure, research and development of lightweight new materials and lightweight new technology (Park and Park, 2018; Primo *et al.*, 2017). Structural optimization technology is widely used in the research of lightweight structures (Ballo *et al.*, 2020). At present, there are four research directions in structural optimization technology. They are size optimization, topology optimization, shape optimization, and topography optimization, respectively. Among them, topology optimization technology, as an important means in structural conceptual design stage, can effectively shorten the design cycle and save the design cost, and has been highly valued (Senne *et al.*, 2019). The results of topology optimization can be used as a primary reference during the conceptual design period, as opposed to determining a truly effective design before the overall design concept is selected (Li *et al.*, 2015). Introducing topology optimization into early design phases, such as the conceptual design phase, can effectively filter out poor designs and produce the most promising designs for later design phases. This can also reduce the design cycle by reducing trial-and-error iterations (Ma *et al.*, 2020). Because of these advantages, topology optimization has been applied to the design of many automotive parts, such as chassis, body and engine components. Aslan *et al*. (2020) achieved a lightweight optimal design of a suspension arm by using topology optimization and size optimization. Zhang *et al*. (2021a) employed the equivalent static loads method (ELSM) to perform multi-load topology optimization on the body-in-white (BIW) of the BEV. Talay *et al*. (2021) studied the optimization of automotive aluminum support bracket using topology optimization, topometry optimization, and size optimization.

In the research of new lightweight materials, hot materials include light and high-quality materials such as magnesium alloy, aluminum alloy, glass fiber, carbon fiber and so on. Among them, aluminum alloy material has the advantages of low density, high specific strength, but also has the advantages of good formability, good process,

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