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PLY OPTIMIZATION OF BACKREST SKELETON OF CARBON FIBER REINFORCED PLASTIC CAR SEAT BASED ON GREY EUCLIDEAN RELATIONAL ANALYSIS METHOD

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ABSTRACT–In this paper, an improved grey Euclidean relational analysis method based on Euclidean distance was proposed, which was based on the traditional grey relational analysis method. This method was applied to the material-structure integrated design of the backrest skeleton of a car seat. Firstly, the steel backrest skeleton of a car seat was replaced by carbon fiber reinforced plastics (CFRP), and the backrest skeleton was designed as an integrated structure. Its weight was reduced by 1.69 kg (39.12 %) while still meeting various seat performance test requirements. Then, the effect of the ply design on the performance of car seats with CFRP was studied, and the optimal layer scheme of CFRP backrest skeleton of car seats was obtained by combining the grey Euclidean relational analysis method. Finally, the method proposed in this paper was compared with the widely used method. The results showed that the optimization schemes obtained by the two methods greatly improved performance indicators, especially L_R_2 which had an improvement rate of 13.31 %. Additionally, the proposed method reduced computing resources by 95 %, indicating its ability to effectively balance optimization results and calculation efficiency.

KEY WORDS : Grey Euclidean relational analysis method, CFRP, Ply optimization, Car seat

1. INTRODUCTION

In recent years, with the increasingly prominent problems of energy consumption and environmental pollution caused by automobiles, the lightweight design of automobiles and their parts has received extensive attention from domestic and foreign researchers as well as automobile manufacturers (Li, 2020). As the largest component of weight in interior and exterior parts, car seats have a direct impact on occupant comfort and safety, so it has become the focus of automotive seat manufacturers (Xu, 2017). In the new lightweight high-strength materials, CFRP has low density, high strength and strong design ability, can be optimized for the layer angle, layer thickness and layer order to enhance the strength and stiffness of CFRP car seats (Cheng *et al*., 2021). At the same time, the application of CFRP materials to the car seat skeleton can obtain excellent impact resistance, fatigue resistance and corrosion resistance, thereby prolonging the service life of the car seat (Doroudi *et al*., 2021). Therefore, the application of CFRP materials to car seat skeleton and combined with structural design is of great significance to the improvement of performance of car seat while achieving lightweight.

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In order to better apply CFRP to the car seat structure to maximize the lightweight effect, domestic and foreign scholars have done a lot of research. Zhang *et al*. (2021) replaced the original steel backrest skeleton of passenger car seat with long glass fiber reinforced thermoplastic (LGFRT) and carried out topology optimization to achieve lightweight. Kim *et al*. (2017) prepared the seat beam components by optimizing the resin transfer molding process of CFRP. According to the tensile test results, the mass was reduced by 42 %. Bai and Ding (2017) carried out lightweight design of a car rear seat by comprehensively using CFRP and topology optimization technology. The results showed that the mass was reduced by 30.72 %. Although the above studies showed that CFRP has a good weight reduction effect in the lightweight design of car seats, due to the high production cost, difficult recycling and other factors, CFRP lightweight technology for car seats is still in the early stage of technical exploration (Gebhardt *et al*., 2021). At the same time, most of the research on the application of CFRP to car seat frames is limited to theory and simple structural design, and only for a single working condition, which has certain limitations. Therefore, in order to solve the above problems, the lightweight design should be carried out from the two aspects of material and structural optimization when meeting the requirements of various performance conditions of the car seat.