DEVELOPMENT OF MULTIBASIS WEIGHT REINFORCED THERMOPLASTIC COMPOSITE

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Abstract

This paper discusses a novel light-weight reinforced thermoplastic (LWRT) composite featuring multi-basis weight developed by Hanwha Azdel. LWRT composites are widely used in the automotive industry after being thermoformed into desired shapes. This novel material offers new benefits for automotive body parts, including but not limited to, ensuring the ease of side airbag deployment, cost-effective option for overhead systems (e.g. sunroof headliner), enhancing fuel efficiency, and reducing greenhouse gas emission.

This new type of material consists of a core and surface finish layer. In this paper, we will focus on the core layer, which is a light-weight chopped-glass, fiber-reinforced, thermoplastic composite with a porous structure. It is able to be molded into various thicknesses. By strategically adjusting the basis weight, or weight per unit area, across the width of the material via a wet-lay process, the flexural peak load and stiffness on the edges can be changed by up to three times compared with the rest of the material. The mechanical properties were tested by ASTM D790 method. The physical properties, including basis weight, glass content, and as-produced thickness, can be controlled to meet different requirements. It was shown that the fiber and resin were uniformly distributed by our process. Moreover, a variety of configurations and layouts can be achieved to satisfy various applications.

Introduction and Background

In the automotive industry, a product with lighter weight, lower cost, and higher fuel efficiency is always favorable. The increasing demand for improving fuel efficiency is triggered by the concerns of global warming. The Environmental Protection Agency (EPA) has been regulating the automotive companies to reduce vehicle exhaust emissions and fuel consumption without sacrificing occupant safety. Empirically speaking, 10 % weight reduction contributes approximately 8-10 % of fuel economy improvement [1-2]. The trend of weight reduction has driven a continuous decrease in the amount of steel and cast irons. LWRT is capable of reducing vehicle weight and improving fuel efficiency. The composite materials (e.g. SuperLite®) manufactured by Hanwha Azdel Inc., are much lighter (0.3-0.6 g/cm^3) than steels and cast irons. Another advantage of using LWRT is that it has much better formability than other materials, which gives more room of manufacturability and functionality for the original equipment manufacturers (OEMs)[3]. For the manufacturing process, polypropylene (PP) and chopped glass fiber (GF) are agitated in water to form an aqueous suspension. The suspension then is transferred to a web-forming section and water is removed thereafter. After that, a continuous PP/GF web is formed and the LWRT is produced following heating and consolidation.

Headliner boards require stiffness for easy handling and high performance, but if the boards are too stiff, consistent deployment of the side curtain airbags may be impaired. Usually, lower basis weight results in lower mechanical properties (e.g. flexural peak load, stiffness, etc.). By offering boards with lower basis weight on the edges, we are expecting to improve the side airbag deployment while maintaining desired overall headliner stiffness. The basis weight profile can be adjusted by changing the design of web-forming section.

Experimentation and Manufacturing

Materials

The LWRT material core was sandwiched by two skin layers, the entire structure was consolidated to achieve a composite sheet. The core material basis weight was varied in the cross-machine direction, with a target basis weight on both edges around 1000 g/m^2 and a heavier basis weight around 1200 g/m^2 in the center part. The sheet layout is demonstrated in Figure 1. Following production, the sheets were heated and molded in a press to achieve a desired thickness.

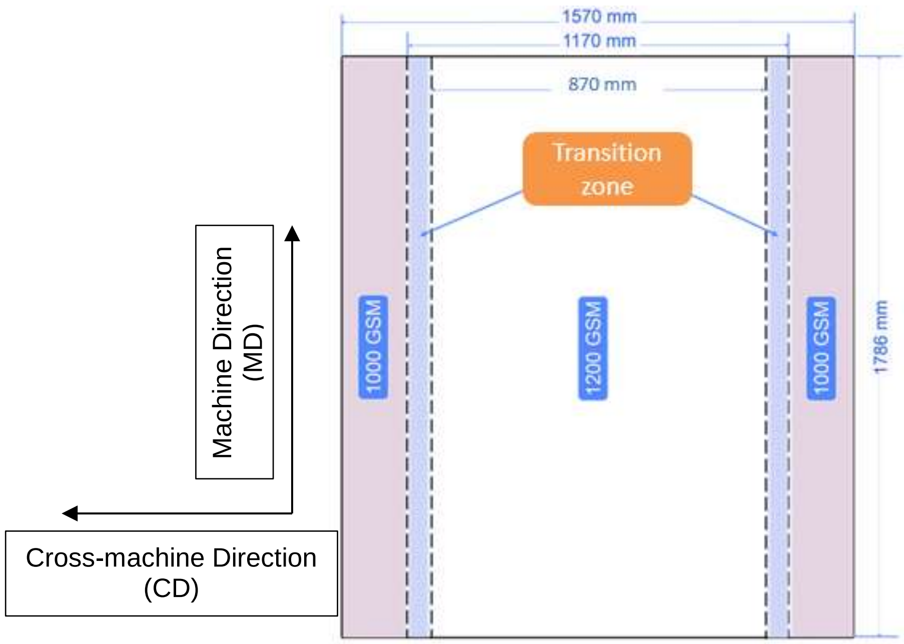

Figure 1. Multi-basis weight sheet layout

Characterization

Basis weight, glass content, and as-produced thickness were measured following standard internal testing procedure in our lab. The flexural properties of the molded specimens were evaluated based on ASTM D790 method; after the mechanical test, the basis weight and glass content were re-checked to ensure the consistency of the molded specimens.

Results and Discussion

Basis weight and glass content distribution

Figure 2 shows the basis weight distribution across the machine direction (MD). As shown in

Figure 1, the width of the target transition zone on both side is 100 mm, and we were trying to avoid steep basis weight change around the transition zone. The glass content distribution of the sheet is shown in Figure 3. It was observed that the glass content across the machine direction is quite homogeneous, which indicates that the resin/fiberglass slurry was mixed very well in the web-forming section. The lower glass content on the edge is due to the lower glass content for the two skin layers.

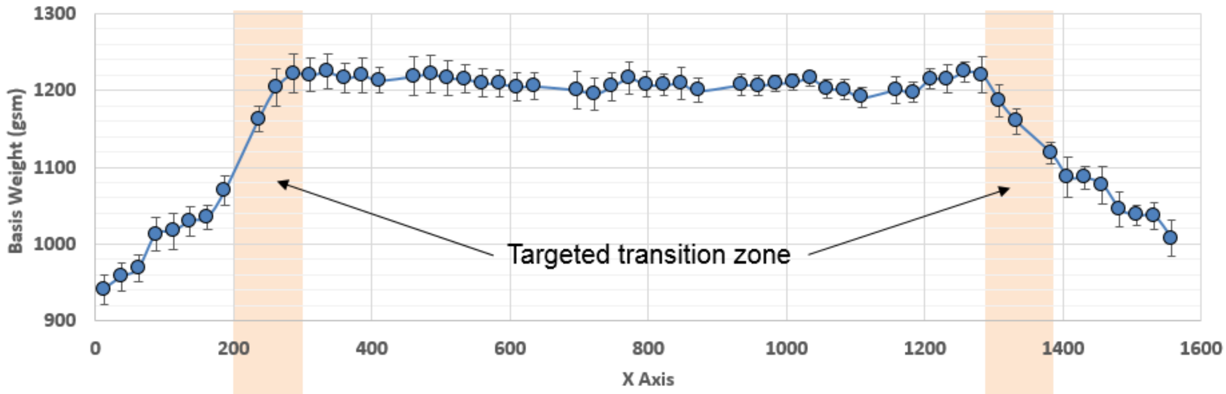

Figure 2. Basis weight distribution across the machine direction

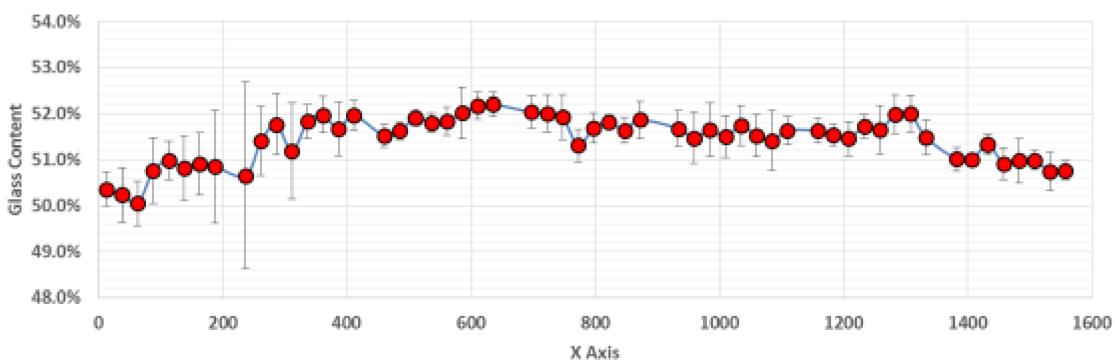

Figure 3. Glass content distribution across the machine direction

Mechanical property

The molded sheets were cut into certain dimensions according to ASTM D790 method. The desired molding thickness is around 2.5 mm, which is determined by both theoretical simulation and multiple molding trials. For the mechanical test, a length-to-thickness ratio of 30-40 was applied for all specimens, which ensures the failure is due to bending moment rather than inter-laminar shear strength. Figure 4 and 5 show the flexural peak load and stiffness of the molded samples. The specimens for mechanical tests cut along the MD direction were shown in blue dots, and the specimens cut long the CD direction were shown in red dots. Figure 4 indicates that the flexural peak load of this type LWRT material in the center is higher than that at the edges. Figure 5 shows the similar trend for stiffness of the molded samples.

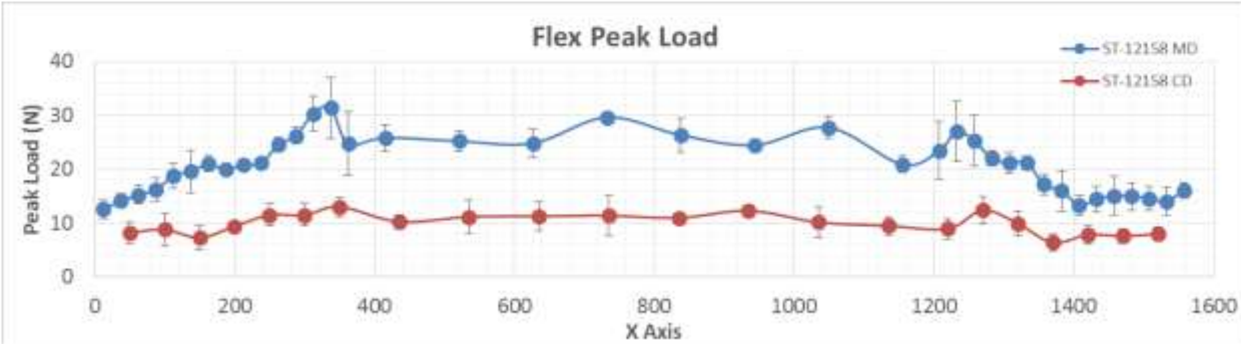

Figure 4. Flexural peak load across the machine direction

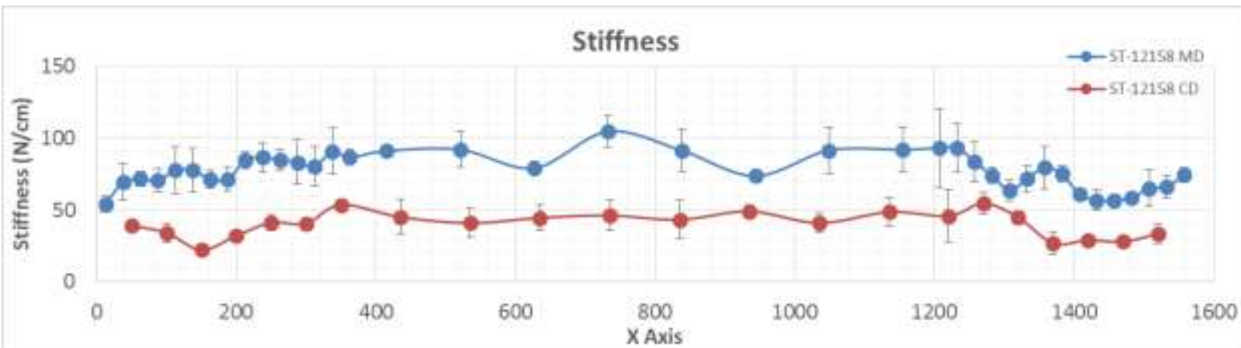

Figure 5. Stiffness across the machine direction

The correlation between flexural peak load and basis weight was also investigated by using statistical tools. Multi-variable regression analysis was performed by using Minitab® 18. The basis weight, glass content, and as-produced density were considered as variables (the variables can be proved that they are independent), and the flexural peak load was considered as response. Based on the output, which is shown in Table I and Figure 6, it can be concluded that there was a strong relationship between basis weight and flexural peak load.

Table I: Statistical summary by Minitab® 18

Regression Statistics	
Multiple R	0.923
R square	0.852
Adjusted R square	0.847
Observations	56

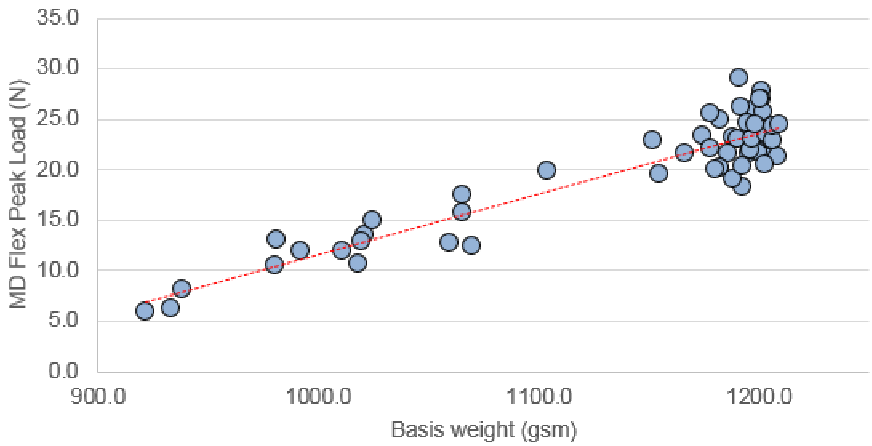

Figure 6. Correlation between basis weight and flexural peak load (specimens were cut along the MD direction)

Summary and Next Steps

LWRT with multi-basis weight has been developed in this study, and a controlled basis weight distribution in the cross-machine direction has been demonstrated. Since the mechanical properties are strongly related to the basis weight of the LWRT materials, the flexural peak load and stiffness can be tailored in different areas of the sheet to meet customer requirements. This technique will be further optimized so that basis weight on both edges can be better controlled.

Acknowledgements

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