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Research on Optimized Design of Fiber Reinforced All-purpose Snowboard Production

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Abstract: The successful holding of the Beijing Winter Olympics has urged the ice-snow sports greatly in China. As an important snow sports, snowboarding is becoming more and more popular with sports enthusiasts, and the demand for skiing equipment is increasing greatly. But the finished products cannot meet the growing consumer market, and how to choose and manufacture more in line with demanding snowboards has become a major concern. With good performance on specific strength, fatigue resistance, thermal stability, fiber reinforced composite material has become the mainstream equipment, covering more market proportion. This paper starts with the material selection and production process of snowboard, and discusses a production design scheme which is more suitable for the individual needs of consumers.

Keywords: Ice-snow Sports; Snowboard; Composite Materials; Production Process.

1. Current Status of Snowboarding in China

In the early days, snowboards were made of wood. However, wooden boards had limitations such as a single structure, poor torsional strength, and susceptibility to temperature and humidity. By the 1960s, they were gradually replaced by snowboards made of fiberglass composites, carbon fiber composites, and other materials. The widespread use of composites greatly enriched the types of snowboards in terms of stiffness, torsional strength, weight, and structural composition, improving their applicability to various slopes and allowing riders to perform better. Currently, snowboards are generally classified into three categories based on skiing venues and forms: all-purpose, park freestyle, and backcountry.

Snowboarding in China is still in its infancy. Most amateur riders have a limited understanding of and selection criteria for equipment, and their skill levels are generally low. The snowboard market is not as popular as other sports equipment markets. When purchasing snowboards, consumers often have to choose from a limited number of brands. Especially in the selection of fiber-reinforced composite snowboards, they cannot make scientific choices based on their physical fitness, movement habits, safety factors, and economic considerations. All-purpose snowboards, on the other hand, meet the current market demand, with strong adaptability to machine-groomed slopes, high acceptance among beginners, and relatively low prices.

Therefore, this paper focuses on factors such as skiers' physical conditions, technical characteristics, competitive level, usage scenarios, and economic applicability. Based on traditional snowboard production processes, we further improve and optimize the production process in terms of skier customization and material selection, discussing a production process for composite snowboards that is more suitable for the actual needs of the sport and beginner enthusiasts.

2. Optimization of Snowboard Size and Shape Parameters

2.1. Optimization of Snowboard Size Parameters

Generally, choosing an all-purpose snowboard involves considering the rider's height first. An empirical formula is:

$$H_2 = H_1 - 20 \tag{1}$$

Where L is the length of the snowboard and H is the height of the user, both in cm.

Table 1. Empirical Parameters for the Size of Men's Single Snowboards

Size (cm)	Recommended Weight (kg)	Waist Width (mm)	Stance Width (mm)	Tip/Tail Length (mm)	Effective Edge Length (mm)
144-145	50-70	244	460-576	282-285	990-1100
149	50-70	245-248	472-586	286-290	1020-1162
152-153	55-75	246-252	484-596	288-292	1040-1192
155-156	60-80	250-255	494-606	292-296	1060-1216
158-159	65+	252-257	504-616	294-300	1090-1240
163	65+	255-259	514-626	298-306	1120+

However, this method is often used for purchasing finished snowboards or renting equipment temporarily. Factors such as the rider's body type, skill level, skiing habits, and slope conditions are not considered. To better meet the needs of users, in addition to the length of the snowboard, the following parameters should be considered: weight, waist width, stance width, and effective edge length (related to skiing habits). In particular, the rider's weight has a significant impact on the stability and speed of skiing, and should be combined with height to better choose the corresponding board shape parameters.

Taking a completely symmetrical camber board shape for men as an example, the general design parameters for the size of men's single snowboards are shown in Table 1.

When designing snowboards for individual users, it is necessary to refer to empirical parameters and fully consider the user's own characteristics to accurately design and manufacture the size. According to the empirical parameters: the larger the weight of the user or the exceeding of the recommended weight range, the larger the size of the snowboard should be to ensure stability during skiing; if the user's shoe size exceeds the range of H/(6.876-7), the waist width of the board should be increased accordingly to prevent the snowboard boots from sweeping the snow and hindering the movement during carving practice. Conversely, if the shoe size is smaller, the rider can appropriately reduce the waist width to increase the flexibility of the movement; the stance width can be adjusted according to the user's lower leg length or habitual stance width, but full consideration should also be given to the rider's movement habits and tilt angle during forward and backward skiing. Riders who cannot fully master the transition between forward and backward edges should appropriately increase the length of the stance width; the design of the tip and tail can use a completely symmetrical shape to reduce design costs and improve adaptability to the venue, or can be designed as a one-way symmetrical or asymmetrical shape according to the user's needs; the effective edge length can be designed according to the user's competitive level or skiing habits. Riders seeking more maneuverability can increase the effective edge length, while riders focusing on practicing sidecutting or turning techniques can appropriately reduce the effective edge length.

2.2. Optimization of Snowboard Manufacturing Materials

The main materials for snowboards made of composite materials include: top sheet, composite fiber layer, core, base, sidewalls, and edges, as shown in Figure 1 [3]. Each layer of material provides different functions and can be customized according to the user's physical condition and skiing characteristics to better meet their needs.

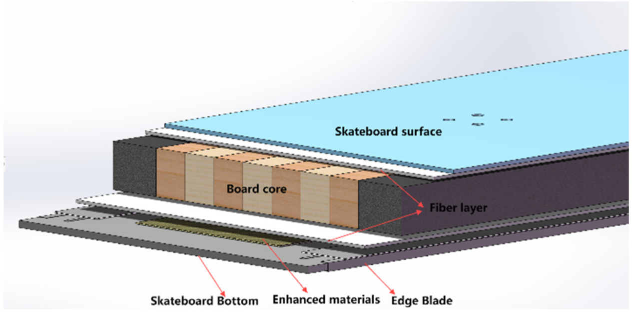

Figure 1. Schematic Diagram of Snowboard Composition

(1) Core Selection. The core is located in the center of the snowboard and mainly ensures the overall strength, hardness, and elasticity of the snowboard. The production process of using multi-layer wood materials for plate-like structural equipment has been widely used and verified in the production of table tennis rackets. This method can also be referenced and promoted in the production of snowboard cores. The uneven distribution of wood properties in traditional snowboard cores may lead to local deviations in mechanical properties. The emerging snowboards made of single polyester fibers or other materials have poor shock absorption and turning performance. The core can be made of multiple types of wood pressed and cut, ensuring better sports performance in all parts of the snowboard. After comparison and sorting, the performance characteristics of commonly used core wood materials are shown in Table 2. According to the stress characteristics during skiing, wood materials with higher strength and hardness can be used as core boards, and wood materials with lower density and high toughness can be used as composite layer boards to reduce the weight of the snowboard and improve shock absorption. During production, the width and pressing order of each layer of wood can be comprehensively adjusted according to the characteristics of the wood. For example, for riders with good skiing skills and core strength, the proportion of hard wood cores (such as birch, ash, and beech) can be appropriately increased to achieve the purpose of increasing skiing speed; for riders with poor strength, general snowfield environment, and high shock absorption requirements, more softwood (such as paulownia and white poplar) can be used.

Table 2. Performance Characteristics of Core Wood Materials

Type	Birch	Paulownia	Balsa Wood	Ash Wood	Beech Wood	Poplar Wood	White Poplar Wood	Bamboo Wood
Performance Features	High strength, high hardness, high density	Low density, high shock absorption, low strength, low hardness	Low density, very low hardness	High hardness, high density, but low yield rate, difficult to machine	High hardness, high density	High toughness, good elastic deformation, high density	High toughness, low density, low cost, low strength	High strength, high hardness, low toughness, poor elasticity

(2) Selection of Fiber-Reinforced Composite Materials. The fiber layer is placed on both the top and bottom of the core to protect the core, as it has a high specific strength and specific modulus, which can provide the necessary torsional strength for the skateboard [2]. Considering the manufacturing cost and comprehensive performance, thermosetting resin matrix composites can be prioritized in the production, such as glass fiber-reinforced composites, aramid fiber-reinforced composites (AFRP), and carbon fiber-reinforced composites (CFRP) [4]. The matrix can use epoxy resins, nylon, etc., among which epoxy resins not only have good mechanical properties and corrosion resistance but also can serve as an adhesive between the core and the fiber layer.

Table 3. Mechanical Properties of Commonly Used Reinforcing Fibers

Type	Brich	Density (g/cm^3)	Tensile Strength (GPa)	Elastic Modulus (GPa)
Carbon	T300	1.76	3.53	230
	AS4	1.79	3.93	221
Aramind Fiber	K29	1.44	3.0	60
	K149	1.47	2.4	160
Glass Fiber	C-type	2.52	3.3	68.9
	E-type	2.58	3.4	72.3

(3) Fiber Layer Selection. When laying fiber layers, different types of composite materials can be reasonably selected according to needs. As shown in Table 3, compared with glass fiber, carbon fiber and aramid fiber have lower density and better tensile strength and elasticity, making the snowboard lighter and providing better tensile strength. The carbon fiber listed in the table has better mechanical properties and can be the first choice for advanced riders; while glass fiber has a more balanced comprehensive performance and a lower price, generally meeting the needs of most riders. At the same time, due to the anisotropy of fiber-reinforced composites, the (α/90°/0°/-a) laying method is commonly used during fiber weaving and laying [4]. Based on this, the laying angles of each layer of fibers can be adjusted according to the direction of the rider's bindings and the habitual tilt angle during carving, so that they match the rider's center of gravity and the direction of force during skiing, giving the snowboard better tensile strength and elasticity. In addition, according to the characteristics of different fibers, the matrix can also try to use nylon, chopped carbon fiber, and melt deposition 3D printing technology to form laminated plates for fiber-reinforced composites [5], optimizing the bonding method between the core and the fiber layer, further enhancing the tensile strength and toughness of the snowboard, and trying to apply it to the production of personalized snowboards that pursue extreme performance.

2.3. Snowboard Shape Selection

The commonly used board shapes and their applicable scenarios are shown in Table 4.

Table 4. Snowboard Shapes and Applicable Scenarios

No.	Snowboard Shape	Applicable Scenarios	Tip/Tail Shape
1	Camber	All-mountain, more suitable for machine-groomed slopes	Twin (completely symmetrical)
2	Rocker	More suitable for backcountry, powder snow, park, and flatland	
3	Hybrid Camber	All-mountain, combining the advantages of camber and rocker	

When optimizing the choice of board shape, the user's scene and skiing needs should be considered first. Camber (positive camber) snowboards have better grip on snow and higher applicability to various terrains, providing better turning performance during carving or sidecutting, and are relatively suitable for advanced riders. Rocker (reverse camber) snowboards have flexible front tip steering and better buoyancy on machine-groomed slopes or powder snow, making them more suitable for speed or flatland freestyle. Hybrid Camber is a new type of board shape in the market, combining the advantages of camber and rocker, with high adaptability for riders, increasing snowboard buoyancy while maintaining good sidecutting performance. The bottom shape can be made into "M" shape, "W" shape, or other shapes according to needs. During production, the rider's stance width should be fully considered to design a more reasonable camber distance and height.

Manufacturing all-purpose snowboards requires adaptability to various terrains for forward and backward skiing, and symmetrical board shapes have better compatibility for beginners. Directional, weight-shifted, or asymmetrical board shapes have higher production costs and a smaller audience. Therefore, a completely symmetrical shape is recommended for the tip and tail.

3. Optimization of Snowboard Production Process

After fully collecting the basic information of the rider, such as height, weight, shoe size, skill level, skiing characteristics, and usage scenarios, we communicate with the rider before manufacturing, jointly design and determine the snowboard size, select materials that match the rider's characteristics, and study and determine the production plan. Among them, epoxy resin is selected for the bonding between the composite material layer and the core, base, and top sheet under the consideration of bonding effect and high-temperature forming effect [6]. The specific material selection and production process are shown in Figure 2.

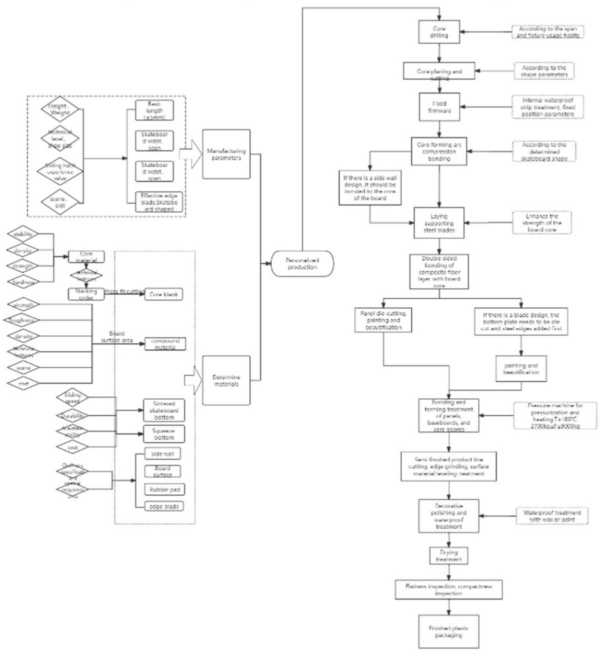

Figure 2. Material Selection and Production Process

4. Conclusion

This paper discusses the production process of fiber-reinforced all-purpose snowboards in detail, especially from the perspective of skiers. It compares various factors affecting skiing, such as venue, technique, and the rider's physical condition, with each link of snowboard production, providing a better production plan for market and consumer customization, providing a more detailed and complete method for material selection, and has certain reference value for the manufacturing of composite ice-snow sports equipment, providing more industrial development ideas for the future ice-snow sports manufacturing industry.

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