Research on the Reduction Design of Fragile Product Cushion Packaging under the Green Development Concept

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Abstract. This article aims to study the reduction design of fragile buffer packaging under the concept of green development. Through the analysis of the advantages and disadvantages of existing cushioning packaging materials, in view of the current situation that corrugated paper cushioning packaging uses a lot of materials, and the cumbersome molding has led to the wide application of plastic packaging materials, the design principle of fragile cushioning packaging under the green development concept is proposed. Taking glass cups as the design object and corrugated paper as packaging materials, three different prototype glass buffer packagings were designed. The reduced-quantity design of corrugated cardboard buffer packaging provides a solution for replacing plastic with paper. From an environmental and economic point of view, reduced-quantity buffer packaging is feasible.

1. Introduction
In recent years, e-commerce has developed rapidly, and the environmental problems caused by online shopping packaging have attracted more and more attention \cite{1}, especially fragile products like glass and ceramics, which not only need outer packaging boxes in the logistics and transportation process, it is also necessary to use inner packaging to wrap objects or fill gaps. At present, plastic cushion packaging is widely used, which is less environmentally friendly and does not meet the current needs of green development. This paper analyzes the existing cushioning packaging materials, taking glass cups as an example, replacing plastic with paper, and designing the reduction of cushioning packaging for fragile products.

2. Overview of fragile products and their packaging

2.1. Fragile goods
Fragile products refer to glass products and ceramic products with stable chemical properties and poor impact resistance, such as glass cups, ceramic vases \cite{2}. For fragile items, the most important function of its packaging is to prevent damage and realize cushioning. The so-called buffering refers to the energy generated by the packaging material that can withstand vibration and impact during the transportation of the product \cite{3}.

2.2. Fragile packaging
The packaging of fragile products includes two parts: outer packaging and inner packaging. The outer packaging is usually required to have a certain degree of pressure resistance and puncture resistance to
protect the fragile products from being intact during their transportation and storage and palletizing conditions. The main function of the inner packaging is to provide fixation and buffer [4]. Qualified inner packaging can protect fragile products from shock and vibration during transportation and reduce the damage rate of the items.

3. Current status of cushioning packaging materials for fragile products at home and abroad

3.1. Current status of foreign buffer packaging materials
Different attributes of different commodities have created different packaging needs, and packaging materials have become more and more diversified. The development of packaging materials abroad is more advanced than domestic. For example, the Korrvu packaging developed by Sealed Air in the United States [5]. This kind of packaging uses a high-strength, high-elastic film to suspend the product in the box. It not only has good protection performance, but also has strong versatility. It is suitable for various types and shapes of products. Its transparent film packaging is available. For transportation, it can also be used for display and sales. What's more worth mentioning is that this kind of packaging is completely environmentally friendly and recyclable. The only drawback is that it is relatively expensive. From an economic point of view, it is temporarily difficult to popularize and apply. However, with the development of society, in the future, simple and environmentally friendly packaging like Korrvu in the United States may be able to replace other packaging and become the mainstream.

3.2. Development and application status of domestic cushioning packaging materials
The development of domestic packaging materials is relatively slow. Cushion packaging for fragile products commonly used in the market can be divided into two categories: plastic and paper. Plastics mainly include bubble film, foam plastic and cushion air column. The air bubble film is light in weight, and the cushioning performance is generally required to wrap fragile products in multiple layers; the foam is light in weight and has good shock and impact resistance; the cushioning air column has good cushioning performance and light weight, which is more environmentally friendly than other plastic packaging, but it is easy to pierce when encountering sharp objects, thus losing the protection performance. Paper-based packaging materials mainly include honeycomb cardboard, corrugated cardboard and pulp molding. Honeycomb paperboard has high strength and good cushioning performance, but it is heavier than corrugated paper, and it is difficult to fold and insert operations; corrugated paperboard has a lower cushioning price than honeycomb paperboard, and has good cushioning performance, suitable for cutting, folding, pressing, and inserting operations; pulp mold. The plastic raw material is waste paper, which can be stacked and transported conveniently, but the cushioning performance is weaker than honeycomb paperboard and corrugated paperboard. The common shortcoming of paper-based packaging materials is poor moisture resistance, but they can be recycled and reused and are the best degradable packaging materials [6]. Therefore, from an environmental perspective, plastic packaging is not an ideal packaging material. Compared with other paper-based packaging materials, corrugated cardboard has a lower price and good cushioning performance. It is also suitable for cutting, folding, and inserting operations. Therefore, corrugated cardboard is the best choice for small and fragile packaging materials. In the analysis of the application status of packaging materials for fragile products, it is found that the current transportation packaging of fragile products in my country is still mostly plastic packaging materials. Although plastic packaging materials are not environmentally friendly, they have the advantage of being easy to use. Like plastic bubble films, they can be transported by wrapping and wrapping, and the cushioning performance after multi-layer long winding is better, so they are used in small products with low value. It is widely used. Because most of the paper-based cushioning packaging has complex structure, cumbersome molding process, and lack of protective performance, the use rate in the transportation of fragile products is low. Therefore, in order to improve the practicability of the corrugated cardboard cushioning packaging, try to design The cushion packaging design is simple and convenient.
4. Design principles for the reduction of fragile buffer packaging under the concept of green development

The purpose of this research on the design of cushioning packaging for fragile products is to reduce the use rate of plastic packaging materials in the transportation of fragile products, improve the application of paper packaging in the transportation and packaging of fragile products, so as to practice the concept of green development. Therefore, in combination with the actual packaging needs, this packaging structure design needs to follow the three principles of stability, convenience and ecology.

4.1. Stability

Stability is the top priority in the design of cushion packaging for fragile products. The main purpose of the fragile product buffer packaging is to fix and buffer the fragile products. Only a safe and stable packaging structure can reduce and avoid the breakage of the fragile products during transportation. Therefore, the design must first ensure that the packaging is realized. Protective function.

4.2. Convenience

Convenience is the most important design of the cushion packaging for fragile products. Complicated packaging is not only difficult to form and process, but the cost will also increase accordingly, which ultimately leads to difficulties in practical applications. Therefore, for the design of cushioning packaging for fragile goods for transportation, it is necessary to make it easy for the seller to produce and assemble, for logistics personnel to stack and transport, and for buyers to open.

4.3. Ecological

Ecology is the basic requirement of the design of the cushion packaging for fragile products. In order to practice the green development concept of replacing plastic with paper, corrugated paper cushioning packaging is used to replace the commonly used plastic packaging in transportation packaging. The packaging material itself is degradable, so we also need to consider the rational use of resources to achieve packaging. Reduce the amount to avoid waste caused by excessive packaging.

5. Design analysis of cushioning packaging for fragile products

5.1. Design object selection

Glass is an amorphous inorganic material formed by high temperature melting, cooling and solidification of silicon dioxide and a variety of other metal oxides in a certain proportion [7]. The classification and code of my country's national economy industry pointed out that daily-use glass products refer to glass products used in restaurants, kitchens, toilets, house decorations and other types of daily life [8]. Daily-use glass products are the most common type of glass products with the highest usage rate. Among them, glass cups are a typical representative of daily glass products. For a long time, glass is the most important raw material for cups. Although with the continuous emergence of new materials, other materials, such as stainless steel, plastic, and paper cups occupy a part of the market, most people still consider glass cups to be the healthiest and safest of all materials. On the one hand, the glass cup does not contain organic chemicals during the firing process. On the other hand, the glass cup is easy to clean, and the smooth wall of the cup is not easy to breed bacteria and dirt. Therefore, this study takes the glass as an example to discuss the design of cushioning packaging.

5.2. Buffer packaging design material selection

Corrugated cardboard is a kind of composite cardboard used to make corrugated boxes by bonding one or more layers of corrugated paper between several layers of paper or cardboard. The wave-shaped flute structure makes corrugated paper more tough than ordinary cardboard, lighter, and has better cushioning properties [9]. Choosing corrugated cardboard as the packaging material designed for this
packaging structure can simultaneously meet the two principles of stability and ecology of the packaging structure design.

Corrugated cardboard can be classified according to thickness. It can be divided into A corrugated, C corrugated, B corrugated, E corrugated, and even K corrugated and combined corrugated. Combined corrugated corrugated cardboard has better performance than single corrugated corrugated in all aspects. For small and light products such as glass cups, large materials and small materials are used. Although E corrugated has a large number of corrugations and good compression resistance, the corrugation height is small and the cushioning capacity is weak. The inner packaging of fragile products mainly serves as a fixed buffer. Therefore, it is more suitable to choose A, C or B corrugated cardboard as a cushioning packaging material.

5.3. Cushion packaging design analysis

5.3.1. Classification of morphological prototypes of glasses

Gao Zhu et al. [10] proposed a product form prototype concept, using the most suitable bounding box of each appearance structure of the product as the basic structural unit of the form prototype to reconstruct the product form. This theory can be used to classify the shape of glass cups, and the classification results are shown in Figure 1. Among them, C1 is an independent unit, and the prototype is a body; C2 is a left and right structure, and the prototype is composed of two bodies; C3 is an upper, middle and lower structure, and the prototype is composed of three bodies. The morphological prototypes of the two types of glasses C2 and C3 are composed of a larger prototype body and a small protrusion. Without considering the size of each split, C2 and C3 can be regarded as the basis of the C1 morphological prototype. It is composed of increasing the number of splits. Taking the classification of product form prototypes as the core, the packaging design takes into account the commonality and individuality between the three types of form prototypes.

![Figure 1 Three types of glass prototypes](image)

5.3.2. Cushion packaging design

The three packaging schemes corresponding to the three different morphological prototypes are shown in Figure 2, and the plan view is shown in Figure 3.

![Figure 2 Cushion packaging design plan](image)

![Figure 3 Layout of the packaging plan](image)

The packaging schemes designed for the three different prototype glasses in Figure 2 are all integrated packaging that is formed by folding. The forming method is simple and consists of eight small faces. After forming, it is a rectangular parallelepiped and only a small amount of tape is required to seal. It can be packed for transportation. Among them, the packaging scheme corresponding to C1 products can be regarded as the basic scheme of the three schemes. Due to the different morphological prototypes, the clamping of the glass needs to be carried out from different
parts and in different ways. Therefore, both C2 and C3 are formed by partial adjustment on the basis of C1. When using the packaging solution, the user needs to first determine the shape prototype of the product to be wrapped, and then match the generated solution according to the respective glass cup size. Another advantage of this cushioning packaging is that changes in the number of products will not cause changes in the packaging structure. You can choose a single independent packaging or multiple combined packaging, which is more practical. It should be noted that although this kind of cushioning packaging for fragile products is formed by folding like ordinary outer packaging boxes, it is folded from the inside out, and the corrugated cardboard itself has a certain thickness, so there is a big gap between the design size and the manufacturing size. When the size is matched, the correction amount must be increased or decreased according to the orientation of each surface after forming to ensure that the size is reasonable after indentation and folding.

6. Conclusion
This paper adheres to the concept of green development, using corrugated cardboard as the material, and proposes a reduction and cushioning packaging design scheme for fragile products under different prototypes, which can be used as transport inner packaging for fragile products. This kind of reduction buffer packaging is simple to form and saves materials, which provides a solution for reducing the use of plastic packaging during the transportation of fragile goods and promoting the green and healthy development of the express transportation industry.

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