

Innovative design and application of the Re-gas Circular Express Box in a double carbon background

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Abstract. In recent years, with the vigorous development of e-commerce, China's express delivery industry has experienced a peak of development. However, the production of express garbage during this process has led to serious environmental pollution problems. The relevant national policies have also set higher requirements for the reduction, standardization, and recycling of express boxes. Therefore, it is urgent to reduce the size of the express box. It has been observed that many express delivery companies have joined the "green revolution" of promoting express delivery boxes. However, due to factors such as cost and safety, the utilization rate of circular express delivery boxes has not improved. Based on the current situation analysis, this study will address the existing problems and challenges of the current circulating box in practical applications. It will consider designing a green, shared, and circulating express box that can be implemented with existing technology. Therefore, this study is based on RFID technology to conduct innovative research and development, design a circular shared express box named Re-gas, and establish a closed-loop system for the supply chain of express boxes. This will promote the green and efficient transformation of the express industry. However, because the designed and manufactured express box samples have not been tested, and due to limitations imposed by application scenarios, cost control, and industry barriers, the project may have some defects and challenges.

1 Introduction

The Chinese government proposes to increase the national independent contribution, adopt more powerful policies and measures, strive to reach the peak of carbon dioxide emissions by 2030, and achieve carbon neutrality by 2060^[1]. According to the statistics and estimation in "Production Characteristics and Management Status of Express Packaging Waste in China," the carbon emission of express boxes in the whole process, from production to garbage disposal, surged from 611,500 tons in 2010 to 23.9584 million tons in 2022. However, the recovery rate of express boxes has not yet reached 20%, and these express wastes are endangering the natural environment's health with a growth rate of over 45%. To solve this problem, the Chinese government has put forward the standards and requirements of green packaging^[2]. Under the "Green Revolution" tide, many express delivery companies have submitted their solutions. JD.COM and SF Express have successively developed circulated express boxes such as "Qingliu BOX" and "Feng-BOX," but the existing circulating boxes do not combine portability with protection and safety, and their actual circulation times are small. Therefore, finding a solution to realize the sharing cycle of express boxes, reduce the generation of express garbage, save resources, and protect the environment is an urgent problem to be solved.

In order to address the dilemma more effectively, this study has designed an innovative Re-gas shared express box under the influence of recycling and sharing economy. This study will introduce how to share, recycle, and reuse Re-gas express boxes, focusing on their structure, technology, and application system. The aim is to reduce costs and increase efficiency. Additionally, this study proposes a unique multi-subject joint operation mode for the Re-gas circulation box, which enables "benefit sharing and risk sharing" throughout the entire supply chain of express boxes. The circular express box solution suggested in this study aims to contribute to environmental protection and conservation, promote the clean, low-carbon, green, and sustainable development of the express delivery industry, and aid the country in achieving carbon neutrality as soon as possible^[3].

2 Application status and problem analysis of circulation box

2.1 Circulation box application status

At present, China's express delivery industry has reached a peak of development, but it has brought along environmental pollution caused by express garbage. Finding ways to reduce the size of express boxes has

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become a pressing issue that the government is closely monitoring and urgently needs to address. Promoting the use of reusable recycling packaging can effectively reduce the amount of waste generated from express packaging^[4]. The Code for Green Packaging of Mail encourages companies to use recyclable express boxes and establish information systems and recycling facilities and equipment for these boxes. It also encourages delivery companies, third-party organizations, and delivery companies to establish a platform for sharing recycling express boxes and gradually expand the use of these boxes. With the support of relevant national policies, many express delivery companies have joined the "green revolution" of express packaging, including Jingdong Logistics, Suning Logistics, SF Express, Shentong, and Yuantong, who have made attempts in the field of green recycling boxes. Since 2016, the Cainiao Alliance launched the "Green Movement Plan", followed by JD.COM's "Green Logistics Plan", Suning's "Green City Plan", and SF Express's "Fengjing Plan".

2.2 Problems Existing in the Application of Circulation Box

The Circulation box has been on the market for 8 years but due to its poor design, high application costs, and low consumer willingness, it is still relatively rare in the market.

2.2.1 The design scheme of circulation box is imperfect

The existing design scheme of the circulation box does not combine portability with protection, and the actual circulation times are small. For example, SF's "Feng · BOX" offers better protection, but it is not light enough. Although the "Qingliu Box" on JD.COM is light in style, its protection is not high.

2.2.2 Application cost is difficult to control

The production cost of circulating boxes is much higher than that of traditional cartons. Additionally, the costs of cleaning, disinfection, maintenance, and reverse logistics of circulating boxes need to be taken into account.

2.2.3 Consumers' willingness to recycle is low

For a long time, consumers have become accustomed to discarding unpacked express boxes as waste and disposing of them as general domestic garbage at will. Judging from the popularization and use of actual recycling boxes, consumers' awareness of recycling is still very weak. Although most people will recycle the recycling box as required, there are also cases where consumers refuse to recycle and dispose of it at will. The uncertainty of consumers' willingness to recycle affects the popularization and use of circular express boxes. Additionally, there are problems such as low product standardization and untimely data link of circulation box logistics^[5].

Considering the shortcomings of the existing circulating box in design, economy, convenience, and security, this study carried out innovative research and development and designed a circulating shared express box named Re-gas. The design scheme strictly controls the application cost of the recycling box, standardizes the design of the box, and improves the recovery rate of the recycling box to promote the green and efficient transformation of the express delivery industry^[6].

3 Design and development of Re-gas cycle box

3.1 Design concept

Re-gas circulation box is named after four keywords: "Recyclable", "green", "air" and "shared", which embodies its characteristics of recycling, green, air buffer and shared use. The specification of the box body is designed as a cuboid of $175 \times 95 \times 60$ mm, with an opening on one side and a concave broken line between the two transverse sides, which is convenient for folding and transportation after compression. Inflatable membrane interlayer is used to replace filler inside, and inflation valve is connected externally. Square opening is surrounded by three-loop annular zipper, and zipper is fixed and protected by pull ring.

3.2 Development process

First of all, carry out market research to clarify the special needs of transportation of small commodities such as cosmetics and ornaments. Secondly, the preliminary scheme of Re-gas circulation box is designed according to the demand. Then, the technology is realized, including the application of RFID technology, the selection of inflatable film interlayer and the material selection of zipper and pull ring. Finally, the practical application test is carried out to ensure the feasibility and effect of the circulation box in practice.

3.3 Key Design Requirements and Target Recognition

3.3.1 Key Design Requirements

The design requirements of Re-gas recycling box include: sharing, recycling, recycling and green degradation; Cuboid shape, unified specifications; Inflatable film interlayer is adopted inside; The exterior is sealed with zipper and pull ring; Equipped with RFID chip to facilitate information tracking and management.

3.3.2 Target Recognition

The main objectives of Re-gas circulation box include: improving logistics efficiency; Protect user privacy; Reduce logistics costs and improve enterprise profits; Reduce environmental pollution and realize green

logistics; Promote the sustainable development of logistics industry.

3.4 Research and development phase

The research and development phase consists of the following three steps.

3.4.1 Design phase

In this stage, the main market research, clear user needs, and based on user needs to design a preliminary plan of Re-gas cycle box.

3.4.2 Technology implementation phase

This stage mainly carries out technical research and implementation, including the selection and application of RFID chips, the selection and production of inflatable film spacers, and the selection of zippers and pull rings.

3.4.3 Test phase

This stage mainly carries out practical application testing, including the convenience of the use of the circulation box, the inflating and deflating operation of the inflating film compartment, the information entry and reading of the RFID chip, the sealing of the zipper and the pull ring.

3.5 Composition and structure of Re-gas cycle box

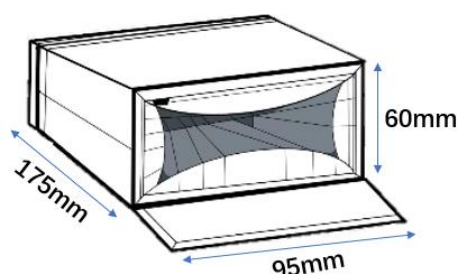


Fig. 1. Re-gas Circulation Box

After investigation, it has been found that small and scattered commodities such as cosmetics and ornaments have more packaging and transportation problems compared to ordinary objects. In light of this phenomenon, this study designed a cuboid-shaped box with dimensions of 175×95×60mm. As shown in Figure 1, the box has an opening on one side and a concave broken line between the two transverse sides, which makes it convenient to fold and transport after compression. An inflatable membrane interlayer is used instead of filling inside the circulating box, and an inflatable valve is connected externally. The square opening is surrounded by a three-loop annular zipper, and the zippers are secured and protected by a pull ring.

3.5.1 Description of the main parts and their functions

(1) RFID electronic chip

An electronic tag is implanted in the outer layer of the Re-gas circulation box, making it convenient to track the box's circulation and record its usage.

(2) Zipper protective cover

To prevent the circulation box from leaking air and losing its protective effect on the transported goods, the extension surface of the box body is used as a protective cover at the sealing place, and the zipper is used to seal it, ensuring that the goods do not fall out of the express box.

(3) Straw fiber pull ring

A straw fiber pull ring is added at the zipper joint outside the box body for fixed protection, ensuring that the circulating box is not opened during the transportation process by the express delivery company and is completely delivered to the receiving consumers. When the consumer picks up the goods, they personally open the special pull ring and place it into the recycling area for recycling and degradation.

(4) Air valve

The circulation box needs to be inflated after placing articles inside, and consumers need to deflate it before removing the articles.

4 Application and operation of Re-gas cycle box

4.1 Application system of circulation box

The owner puts the goods to be transported into the Re-gas circulation box, injects air through the air valve to expand the airbag of the box, the internal film naturally fits the goods for buffer protection, and the external zipper and pull ring of the box are sealed. The logistics information and customer information are entered into the RFID chip by the express delivery company, making it convenient to read the information on the card for sorting, transportation, and distribution. Finally, the consumer removes the pull ring at the pick-up port of the express smart cabinet, opens the zipper, deflates, and takes away the items. The intelligent cabinet automatically demagnetizes the RFID chips and erases customer information^[7].

4.2 Circulating box operation system

The Re-gas circulation box can maximize its value only if it is operated reasonably. The operation circulation requires the cooperation of many subjects in the supply chain.

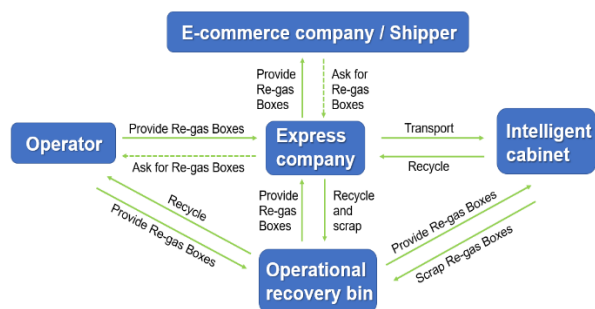


Fig. 2. Circulating box operation system

As shown in Figure 2. From two aspects, forward and reverse logistics, the entire process of Re-gas circular express box circulation is clearly visible under the joint operation of various entities. Specifically, e-commerce companies or shippers have a demand for packaging and shipping goods, so they request express delivery companies to use Re-gas express boxes for packaging and shipping. Express delivery companies initiate Re-gas orders to operators through information platforms. Operators then provide Re-gas express boxes to express delivery companies. Afterwards, the courier company can continue to act as a distributor and lease the Re-gas courier boxes to e-commerce companies or shippers in need. E-commerce companies and shippers use Re-gas express boxes to pack small or scattered goods, which are then shipped and delivered to designated smart cabinets by express delivery companies. Consumers can pick up these goods through small programs.

In comparison to traditional forward logistics, the value of Re-gas express boxes can be realized in reverse logistics. Through the operation and circulation mechanism, Re-gas express boxes can be recycled from consumers to smart cabinets, and retrieved by express delivery companies for recycling. Packaging that needs to be discarded will be recovered by the operator and sent to a recycling warehouse for proper disposal. With the cooperation and joint operation of multiple entities in the express supply chain, a closed-loop system of Re-gas express box supply chain is formed through reverse recycling and recycling.

4.3 Application technology of circulating box

4.3.1 RFID Technology

RFID tags are embedded in fixed positions of the circulation box to record various information such as production, use, recovery, and maintenance. Radio frequency technology allows for repeated reading and writing of electronic tags. Before shipment, the express delivery company inputs logistics information and customer information into the RFID chip. After the consumer picks up the items, the express intelligent cabinet automatically erases the information on the RFID chip, enabling it to be cycled back and forth. This technology offers advantages such as reusability, long service life, the ability to identify multiple targets simultaneously, high efficiency, password protection, and high security.

4.3.2 Modification Technology of PBAT + PLA Alloy

After careful consideration, the material of the circulation box is made through chemical grafting modification. PLA and PBAT are linked and branched to form a new alloy modified material of PBAT and PLA. This material is white and transparent, and can be greatly extended while being completely biodegradable. It is also harmless to the human body and the biological environment.

4.3.3 ERP system

In the operation of the entire system, an ERP system is used. This system is an efficient tool that can manage the logistics, capital flow, and information flow of the supply chain in an all-round and integrated way, share and utilize resources, and fully organize and effectively transmit information.

5 Application value of Re-gas Circulating Box

Today, with the promotion of sustainable development, the pollution problem caused by express boxes is related to their production materials and recovery rate. In order to solve these problems, the Re-gas shared express box designed and developed in this study has achieved innovation and transformation based on the existing express circulation box. The following is its application value.

5.1 Paperless realization of green and low carbon

The Re-gas shared circulation box is made of a two-dimensional code and an RFID chip, and the mobile phone equipped with a reading and writing APP can easily read logistics information. After express delivery, the circulation box can be put into use again only by emptying the data. It not only saves the use of materials and facilitates logistics management but also eliminates information security risks to a great extent^[8]. When the box is circulating, only the background database needs to be changed, and the two-dimensional code on the package does not need to be changed.

5.2 Information tracing system improves the recovery rate of circulation box

Relying on information technology, an information traceability system can be established. The RFID tag matched by each Re-gas circulation box is unique, which can help express delivery companies clearly track the logistics status of each express delivery. At the same time, with the RFID chip as the core, combined with the Internet, GPS, online service platform, database, and other support systems, we can accurately grasp the number, distribution, and flow direction of express circulation boxes, and then count the turnover days, times, recovery, and loss of circulation boxes in real-time. Combined with the deposit

system, incentive policy, and credit score system, it is possible to improve the recovery rate of recycling boxes^[9].

5.3 Repeated sealing with green pull ring reduces environmental pressure

Introduce pull ring accessories to realize repeated sealing and privacy protection. The Re-gas circulation box adopts an environmentally-friendly sealing buckle design independent of the box body, and the pull ring is made of straw fiber as a raw material. Consumers only need to break the pull ring to open the box body. At the same time, the straw fiber pull ring is green and recyclable, and the circulation box needs to be sealed repeatedly, but it will not pollute the environment.

5.4 There is no filling inside the circulation box to reduce the generation of express garbage

The foldable inflatable structure of the circulation box eliminates the need for fillers inside the package, reducing the production of excessive express garbage such as shock-proof bags and bubble films, and minimizing carbon emissions. The interior of the Re-gas circulation box is designed with the foldable inflatable structure of the circulation box eliminates the need for fillers inside the package, reducing the production of excessive express waste such as shock-proof bags and bubble films, as well as carbon emissions. The Re-gas circulation box features an inflatable airbag inside, using air instead of fillers to prevent collisions and falls, providing better protection. When goods are placed in the inflated state, the airbag film naturally conforms to the goods, providing 360-degree protection without any blind spots, resulting in a better protective effect compared to regular express fillers.

The Re-gas recycling box is a reasonable assumption for sharing, reusing, and recycling express boxes in the current situation. By allowing the circulation and sharing of express boxes while maintaining their original functions, it increases the number of times express boxes can be reused, reduces waste of express materials and resources, and contributes to low-carbon environmental protection. This is of great value and significance in promoting the green and sustainable development of the express delivery industry. However, since the designed and manufactured express box samples have not been tested and are limited by application scenarios, cost control, and industry barriers, the project may have defects and face certain challenges.

6 Comparative analysis of Re-gas recycling box and traditional express box

As shown in Table 1, this study compared the advantages and disadvantages of traditional express boxes and new recyclable express boxes from multiple dimensions such as resources, environmental impact and logistics efficiency.

Table 1. Comparative analysis.

	Traditional express box	Re-gas cycle box
Resource utilization efficiency	Low	High
Environmental impact	Pollute	Protect
Logistics efficiency	Low	High
User privacy protection	Strong	Weak

6.1 Resource utilization efficiency

Because of its recyclable characteristics, Re-gas recycling boxes have higher resource utilization efficiency than traditional one-time express boxes^[10].

6.2 Environmental impact

Due to its characteristics of one-time use, traditional express boxes produce a lot of packaging waste, which causes greater pressure on the environment^[11]. The recyclable and recyclable characteristics of the Re-gas cycle box greatly reduce its impact on the environment^[12].

6.3 Logistics efficiency

Re-gas recycling boxes can improve logistics efficiency through the information tracking and management of RFID chips, while traditional express boxes are relatively weak in this respect⁸.

6.4 User privacy protection

Re-gas recycling boxes protect user privacy through RFID chips and zippers, pull rings, etc., while the protection measures of traditional express boxes are relatively weak.

7 Summary

By collecting and sorting out relevant literature on the application status and development prospects of green recycling express boxes in the academic frontier, combined with the background, this study designed a more perfect green and shared express box - Re-gas recycling box based on RFID technology, in order to improve the actual utilization rate of recycling express boxes. Through the recycling of express boxes, the generation of express garbage is greatly reduced, and the resulting environmental pollution problem is alleviated. At the same time, a closed-loop system of the express box supply chain, jointly operated by all parties, is constructed to support the operation and circulation of Re-gas circular express boxes. Currently, although RFID technology has proven the feasibility of the above design in various scenarios, there are not enough complete typical cases to support the integrated design of this study. Additionally, due to limitations in application scenarios, cost control,

and industry barriers, the project may have defects and face challenges. Future research should focus more on supporting actual cases, so that the designed products can seek more realistic objective data support and feedback verification in specific application scenarios, and promote the design scheme to be more perfect and applicable in real life. It is believed that after overcoming all difficulties, the vision of sharing, recycling, and reusing Re-gas express boxes in the closed-loop system of the supply chain will be realized.

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