Study on a New Type of Air-exchange Device for Refrigerated Container

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Abstract. In order to optimize the inconvenience of the switch operation of the existing air-exchange device and the loosening problem in the complex environment during transportation, a new type of air-exchange device for container is designed in this paper. The device adopts rotating opening, embedded sealing structure of sealing plug and combined with spring function, which effectively realizes the stability and reliability of the opening and closing of the air-exchange device. The structure is simple and the operation is also convenient. Therefore, the new air-exchange device has a wide application prospect in refrigerated containers.

1. Introduction

With the continuous improvement of people's living standards, the consumption demand of fresh vegetables and fruits has increased strongly. In order to meet the market demand and provide consumers with high-quality fresh fruits and vegetables and other perishable food, the use of refrigerated containers has been greatly increased. Refrigerated container is a kind of cold chain logistics equipment which can maintain a certain temperature and humidity and has a certain air conditioning function. When transporting fresh fruits, vegetables, flowers and other perishable goods with respiration, in order to discharge excessive CO₂ in the container in time, supplement appropriate oxygen, and maintain the normal respiration of the goods in the container, proper air-exchange should be carried out according to the requirements of the goods in the container. The air-exchange of container is usually accomplished through its unique air-exchange device. In the process of air-exchange, the exchange of hot and cold air will increase the thermal load of the refrigeration unit of the refrigerated container, increase the energy consumption of refrigeration unit, and affect the accuracy of temperature control in the container. Therefore, the air-exchange device for refrigerated container needs to complete the air-exchange process quickly in a short time to reduce the time of interconnection between the inside and outside of the container, so as to improve its air-exchange quality. In addition, when refrigerated containers are closed, they must have reliable air tightness and heat insulation to prevent air leakage of air-exchange devices in complex transportation environment, which directly affects the transport quality of refrigerated goods and energy consumption of refrigeration units. Based on the above analysis, in view of the complexity of the transportation environment of refrigerated container and the diversity of the goods loaded, this paper designs an air-exchange device which can realize quick opening or closing, stable operation and high reliability. Under the premise of guaranteeing normal air-exchange volume, it can shorten the air-exchange time, improve the air-exchange efficiency and minimize the external heat load of refrigeration unit.
2. The structure of the air-exchange device

In order to realize the rapid air-exchange of refrigerated container, the air pressure difference between the upper and lower parts of the evaporator of the refrigerated container can be used as the driving force of the air-exchange device. The specific method is: the air intake of the air-exchange device is connected with the suction space of the evaporator fan, and the air vent of the air-exchange device is connected with the outlet space of the evaporator fan. By means of the differential pressure between the inlet and outlet of the fan, the rapid air-exchange of the air-exchange device can be realized. The installation position of the air-exchange device in the container is shown in Fig. 1.

![Fig. 1 installation position of the air-exchange device in the container](image)

**Fig.1** installation position of the air-exchange device in the container

1 air-exchange device 2 refrigerated container body

The air-exchange device is composed of air hole sheet, O-groove, clamp, baffle, guide rod, limit plate, moving plate, spring, thrust bearing, sealing plug, air hole and other components, as shown in Fig. 2.

![Fig. 2 profile of air-exchange device](image)

**Fig.2** profile of air-exchange device

1 air hole sheet 3 clamp 4 baffle 5 U-shaped handle 6 guide rod 7 limit plate 8 moving plate 9 thrust bearing 10 rotating shaft 11 sealing plug 12 spring 101 air hole 102 O-ring

Considering the special requirements of the air exchange device (air tightness, heat insulation, reliability, convenient operation), the connection between its components is described in detail: there are threaded holes on the back of the air hole sheet, the threaded holes are arranged in rectangular arrangement, and the air hole sheets are bolted through the threaded holes to connect the container. In addition, a circular groove is arranged at the back of the air hole sheet, and an O-ring is embedded in the circular groove. There are grooves on the front side of the air hole sheet, and there are clamps in the grooves, which fixedly connect the air hole sheets, and there are baffles in the clamps. The baffles are butterfly-shaped and fixedly connected with U-shaped handle. The back side walls of the air hole sheets are fixedly connected with two guide rods, and the ends of the two guide rods are fixedly connected with the limit plate, and both guide rods run through and slide with the moving plate. The guide rods are round rods with smooth surfaces, and it is cover with a spring (the spring adopts a cylindrical helical spring). One end of the spring is fixed to connect the limit plate, and the other end is fixed to connect the moving plate. The moving plate is equipped with thrust bearing. The outer ring of the thrust bearing
connects with bearing seat by interference fit and the bearing seat is fixed to connect the moving plate by bolt connection. The thrust bearing connects with the rotating shaft by transition fit, and the front end of the rotating shaft is fixed to connect with the baffle after penetrating the air hole sheet. The baffle fixedly connects the sealing plug, and the outer part of the sealing plug extends into the air hole and expands with the air hole sheet.

3. The working principle of the air-exchange device

When the cargo loaded by refrigerated container does not have air-exchange requirement, in order to prevent the thermal load of the surrounding air from entering the container through the air-exchange device, the U-shaped handle of the air-exchange device should be kept in a vertical state during normal operation of the refrigerated container. At this time, the two butterfly-shaped flanks of the baffle will be completely blocked by the restoring force of spring. The spring will be in a free state, and the sealing plug is just right in the air hole. The baffle and sealing plug form a complete blocking and sealing to the air hole, blocking the exchange of external air and the air inside the refrigerated container. In addition, even if refrigerated containers encounter complex and harsh environment (such as road bump, sharp turning, sudden stop, etc.) in the course of transportation, which causes great vibration to the container body, relying on spring tension and embedded design of sealing plug can prevent the accidental opening of the air-exchange device, thus greatly increasing the reliability of its use.

When the cargo loaded by refrigerated container has air-exchange requirement, the U-shaped handle can be pulled outwards. In the process of pulling the handle outwards, the spring gradually elongates until the sealing plug is separated from the air hole sheet. The air hole sheet no longer forms restrictions on the baffle, and the baffle can be rotated through the U-shaped handle. When the U-shaped handle is rotated to the horizontal state (as shown in Fig. 3), because the spring is stretched, the spring exerts a force in the direction away from the air hole sheet on the moving plate, so that the sealing plug can act on the blowhole through compression, generating friction between the sealing plug and the air hole sheet, leaving the baffle on the air hole sheet without automatic rotation, at which time the two air holes can be exposed. The external air and the internal air of the refrigerated container can be exchanged quickly.

4. The innovation of the air-exchange device

In the design process of the air-exchange device, the design requirements of air tightness, heat insulation, reliability and operation convenience are always tightly adhered to, in order to optimize the inconvenience of the switch operation of the existing air-exchange device and the problem of poor air tightness in the complex environment during transportation. It is mainly reflected as follows:

(1) It is easy to operate and can achieve quick open or close operation. Existing refrigerated container air-exchange devices mostly use sliding up and down to open the air outlet. This kind of air-exchange device needs to loosen all the fastening devices before opening, so the operation is more cumbersome. In the new type of air-exchange device, the air-exchange process can be started only by rotating the baffle, and the operation is convenient.

(2) It has good air tightness, heat insulation and high reliability. By adopting the sealing mode with
sealing plug embedded and combining with the spring application, when the air-exchange device is closed, the probability of automatic opening of the air-exchange device in the complex transportation environment of refrigerated container can be reduced, thus the reliability of the air-exchange device can be improved. When the air-exchange device is in the open state, it can also force the sealing plug to squeeze on the air hole sheet through the spring force, which produces reliable friction between the sealing plug and the air hole sheet to avoid automatic rotation, thus realizing the stable air-exchange process. In addition, when the air-exchange device is closed, the heat insulation performance inside and outside the refrigerated container will be greatly improved by using the material with good heat insulation performance for the sealing plug.

5. Conclusion
The air-exchange device for refrigerated container plays an important role in the transportation of refrigerated goods with the requirements of air conditioning. The air-exchange device which meets the design requirements of air tightness, heat insulation, reliability and convenient operation can not only ensure the quality of goods transportation, but also reduce the infiltration of external thermal load into the container and reduce the energy consumption of refrigeration unit of refrigerated container. Based on the above requirements, a new type of air-exchange device is designed with rotating opening, which can realize quick opening or closing operation and is simple and convenient. At the same time, through the use of the sealing mode with heat insulation sealing plug embedded, combined with spring force to ensure that the air-exchange device in both closed and air-exchange states can achieve stable condition, so as to achieve a higher reliability. Therefore, this new type of air-exchange device can have a wide application prospect in refrigerated containers by virtue of its unique performance advantages.

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