Multi-objective optimization of economic thickness of insulated compartment for refrigerator vehicles

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Abstract. Aiming at the multi-objective design problem for the refrigerated compartment, an optimal design model of the refrigerated compartment was established. The actual constraints of depreciation of insulating material for compartments increased the cost of transportation due to insulating materials and the cost of refrigeration due to compartment body transfer, compartment sealing and respiratory heat of cargo, its main design parameters were comprehensively considered. The maximum available space of the compartment and the minimum cost of single transporting were selected as objective function. Parameters of the refrigerated compartment were optimized with MATLAB software, and the available space of the refrigerated compartment and the cost of single transporting under different parameters were analyzed. Results showed that the optimized design method was suitable for refrigerated compartment. The optimized results of available space of refrigerated compartment and the cost of single transporting were different under different conditions. When the heat insulation material was respectively foaming with polystyrene, extruded polystyrene, polyurethane, in a longer transporting mileage from 50 to 500km, the corresponding optimal thickness of insulating materials of compartment body was thicker. Under the condition that the available space of refrigerated compartment reached the maximum and single transportation cost of the refrigerated compartment reached the minimum at the same time, when the average transporting mileage was 50km, the corresponding optimal thickness of heat insulation material was 0.11m with polystyrene, 0.09m with extruded polystyrene and 0.08m with polyurethane, while the available space of the refrigerated compartment was 12.0892m³, 12.7820m³, and 13.1375m³ respectively, and the corresponding cost of single transporting was CNY 5453.27, 4964.24 and 4847.98.

1. Introduction
The refrigerated compartment is one of the key components belong to refrigerated trucks. The structural design of the refrigerated compartment not only affects the quality of cargo transported but also is related to the cost-effectiveness and the efficiency of refrigerated transportation. The heating load, energy consumption and available space of refrigerated compartment are important parameters for the design of the carriage structure [1-4]. The above mentioned parameters will directly affect the cost-effectiveness and the efficiency of the refrigerated transportation [3-4]. In fact, when the shape and size of the refrigerated compartment are determined, the larger the available space of the refrigerated compartment, the higher the transport efficiency. But it also means the less the thickness
of insulating material, the higher the heating load of the refrigerated compartment, the energy consumption, and the transportation cost.

Liu G explored the energy consumption model of fruit and vegetable highway transportation [2-4]. Han L, He G and Ahmed carried out experimental tests and theoretical studies on the thermal insulation performance, the manufacturing and foaming technology, the design of the thermal insulation chamber, and the aging resistance of the heat insulation chamber [5-7]. Xie R optimized the heat transfer coefficient of the railway refrigerated car with the transportation cost as the objective function [8]. The optimum heat transmission coefficient and the maximum volume of the refrigerated compartment are optimized by multi-objective method [9]. Less of the above mentioned studies addressed the multi-objective problem of minimizing the transport cost and maximizing the internal volume of the carriage synchronously. At the same time, the transportation cost of the refrigerated compartment is determined by parameters such as the single transport mileage of the vehicle, the transportation speed, and the cooling cost during transportation. The cooling cost is determined by the thickness of the insulating material, and its thermal conductivity changes with these parameters. From this point of view, there are many factors affecting the parameters of these indicators, and the parameters of the design and calculation process are interrelated. Wang D put forward solutions to the multi-objective optimization design of the optimal thickness of each side of the refrigerated carriage [10] but did not take into account the important factor that the carriage has a large loading space requirement. Therefore, it is significant to optimize the designed thickness of thermal insulation material for the carriage which should simultaneously meets the minimum transportation cost and the maximum volume of the carriage.

According to the characteristics of refrigerated carriage transportation process, research analyzes the key parameters affecting transportation cost-effectiveness, and constructs a multi-objective design optimization model of the refrigerated carriage. The research in this paper provides design references for the production of refrigerating compartments.

2. Construction of model

The structure of the refrigerated compartment is usually shown in Figure 1. The inside and outside of the compartment are equipped with glass fiber reinforced plastics (FRP) with a thickness of 0.03 m, and the middle is filled with insulation material. For the design of the refrigerator, the optimal insulation thickness should be obtained according to the requirements of the use of the refrigerator and the dimensions of the refrigerator. It not merely needs to minimize cost $S$ of the single transport, but should consider maximizing the available space $V$ of the refrigerated compartment. In this case, the thickness of the refrigerated compartment insulation layer, the average operating mileage, and the type of insulation material can be established as optimal design variables by establishing two objective functions of minimum refrigerating operation cost and maximize available space in the refrigerated compartment.

$$X = (\delta_1, L_1, \lambda_1)$$

$\delta_1$-Thickness of insulating material for type medium refrigerated compartment, m; $L_1$-Average Mileage of Single Refrigeration Transportation; $\lambda_1$-Thermal Conductivity of Thermal Insulation Material, W/(m·K)

1-Glass Fiber Reinforced Plastic; 2-Insulation Material for Carriage Body Inside and Outside Surface

**Figure 1.** Schematic diagram of the plane structure of carriage body.
2.1. Operation cost model of single refrigeration transportation

The operation cost $S$ of single refrigeration transportation should include refrigeration compartment depreciated cost $S_1$, refrigeration energy consumption cost $S_2$ during transportation, and operation expenditure cost $S_3$ caused by the increase of refrigeration materials [8]. This paper mainly researched on short-distance transportation. The loss of carriage on short-distance transportation is less, so the cost due to loss of carriage would be ignored.

$$S = S_1 + S_2 + S_3$$  \(2\)

2.1.1. Depreciation Cost of Refrigerator. Compartment depreciated cost $S_1$ can be expressed by the following formula [8].

$$S_1 = C_1 F \delta b$$  \(3\)

In formula above:
- $F = \sqrt{F_F F_w}$
- $F_w = 2(LH + WH + LW)$
- $F_F = 2(2\delta_1 - 4\delta_2 + (W - 2\delta_1 - 4\delta_2)(H - 2\delta_1 - 4\delta_2) + (L - 2\delta_1 - 4\delta_2)(W - 2\delta_1 - 4\delta_2))$
- $C_1$ is the price of unit thermal insulation material, CNY/m$^3$;
- $F$ is the equivalent heat transfer area of carriage body, m$^2$;
- $b$ is the scrap depreciation rate;
- $F_F/F_w$ is the area of inside/outside surface of the carriage, m$^2$;
- $L/W/H$ is the carriage shape size, width, and height, m.

2.1.2. Cost of refrigeration. The refrigerated compartment should be pre-cooled to the specified temperature before being transported. The heat produced by pre-cooling is related to the volume of the refrigerated compartment, the specific heat capacity of insulating materials and the mass of the compartment. Since the refrigerated compartment should maintain the appropriate temperature during transportation, the refrigeration equipment in the refrigerated compartment should produce the sufficient refrigerating capacity to offset the heat gained in the compartment. More the heat gained in the compartment, longer the single operation time, bigger the available space, and the more refrigerating capacity is required. Conclusively, the refrigeration cost is the sum of the cost of pre-cooling and the cost of refrigeration during transportation. Refrigeration energy consumption cost $S_2$ can be expressed by the following formula [8].

$$S_2 = C_2 \left( Q' + \frac{C_2 Q}{\eta v_p} \right)$$  \(4\)

$$Q' = \frac{G C_v (t_e - t_n)}{2 \tau 3600} = \frac{m (V' - V)}{2 \tau 3600}$$  \(5\)

In formula above:
- $V' = L \times W \times H$
- $C_2$ is the cost of refrigeration power per watt-hours, CNY/W·h;
- $Q'$ is the heat produced by pre-cooling, W·h;
- $Q$ is the heating load of the refrigerated compartment in transit, W;
- $\eta$ is the efficiency of the refrigeration equipment;
- $L$ is the average mileage of single transport refrigerated vehicle, km;
- $v_p$ is the average speed of refrigerated trucks, km/h. The data can be obtained from Equation (7) below [11]:

$$C_3 = (501.3328 - 12.3304 V' + 0.10198 V'^2) \times 10^{-6}$$  \(6\)

$U$ is the annual average daily traffic after conversion to a medium-sized standard car, unit; $G_1$ is the mass of refrigerated compartment, kg; $C_T$ is the specific heat capacity of insulated carriage body, J/(kg·K); $\tau$ is time, s; $m_d$ is the density of refrigerated compartment, kg/m$^3$; $V'$ is the volume of refrigerated compartment, m$^3$; $t_e$ is the temperature of the external surface of the refrigerated compartment, K; $t_n$ is the air temperature in the refrigerated compartment, K.

During transportation, the heat load $Q$ in the refrigerated compartment mainly includes the following items:

1. Heat transferred from the external environment through the carriage body [9]
\[ Q_1 = KF(t_m - t_n) \]  \hspace{1cm} (7)

In formula above:

\[ K = \frac{1}{\frac{1}{a_w} + \frac{1}{a_n} + \delta_1 + \frac{2\delta_2}{\lambda_2}} \]

K-Heat transfer coefficient of refrigerated truck, W/(m²·K); \( \delta_1 \)-Thickness of heat insulation material, m; \( \lambda_1 \)-Thermal conductivity of insulating material, W/(m); \( \delta_2 \)-Thickness of FRP, m; \( \lambda_2 \)-Thermal conductivity of FRP, W/(m·K); \( a_w \)-Heat transfer coefficient of external surface of refrigerated compartment, W/m²; \( a_n \)-Heat Transfer Coefficient of Refrigerated compartment Inner Surface, W/m².

The heat transfer coefficient of the inner and outer surfaces of the refrigerated compartment is related to the speed of the car [2].

\[ a_w = 9 + 3.5v_p^{0.66} \]

\[ a_n = 9 + 3.5v_n^{0.66} \]  \hspace{1cm} (8)

\( v_p \)-Air velocity in the carriage, km/h

(2) \( X \) Heat produced by the air and water vapor leaked from external of refrigerated compartment [9].

\[ Q_2 = \frac{\beta \rho V}{3600} [C_p(t_m - t_n) + \gamma(\phi_n X_n - \phi_m X_m)] \]  \hspace{1cm} (9)

In the formula above:

\[ V = (L - 2\delta_1 - 4\delta_2)(W - 2\delta_1 - 4\delta_2)(H - 2\delta_1 - 4\delta_2) \]

\[ \beta = \frac{0.4119v_p - 2.2671}{V} \]

\( \beta \)-Air leakage ratio of refrigerated compartment. (different values at different speeds); \( \rho \)-Density of air in the refrigerated compartment, kg/m³; \( V \)-Available space of Refrigerated compartment, m³; \( C_p \)-Specific Heat Capacity of Air at Constant Pressure, J/(kg·K); \( t_m \)-Temperature of air outside the refrigerated compartment., K; \( \gamma \)-heat produced by steam condensation, J/kg; \( \phi_m/\phi_n \)-Relative humidity of air outside/inside of the compartment; \( \chi_m/\chi_n \)-moisture content of saturated air outside/inside of the compartment, g/kg;

(3) Heat produced by the respiration of cargo

\[ Q_3 = \frac{1}{24 \times 3600} GE \]  \hspace{1cm} (10)

\( G \)-Mass of cargo, kg; \( E \)-Heat of respiration of cargo, J/(t·d)

(4) Heat produced by process of cargo handling [9].

\[ Q_4 = NQ_1 \]  \hspace{1cm} (11)

\( N \)-Handling coefficient, which is basically closed every hour; Take 0.1-0.25 for N when cargo doesn't be handling during the transportation; Take 0.4-0.6 for N when cargo be averagely handling 1-2 times during the transportation; Take 0.6-0.1 for N when cargo be averagely handling 2-3 times during the transportation; Take 1.0-1.5 for N when cargo be averagely handling 3-4 times during the transportation; Take 2 for N when cargo be averagely handling more than 5 times during the transportation.

(5) Heat produced by the motor

\[ Q_5 = M\epsilon_1\zeta \]  \hspace{1cm} (12)

\( M \)-motor power, W; \( \epsilon_1 \)-Thermal conversion coefficient (motor is in the refrigerated compartment; take 1 for \( \epsilon_1 \)); \( \zeta \)-Coefficient of motor running time (for \( \zeta \) take 0.33 when calculating)
2.1.3. Transportation Cost produced by the Increase Weight of Refrigerated Compartment. The weight of refrigerated compartment has increased, which is caused by installation of insulation material, therefore, the transportation cost produced by the increasing weight of insulation materials should be counted as part of single transportation cost. Operation expenditure cost $S_3$ can be expressed by the following formula [8, 11].

$$S_3 = C_{j} m F \delta \alpha$$  \hspace{1cm} (13)

$$C_j = (501.3328 - 12.3304 V_p^2 + 0.10198 V_p^2) \times 10^{-6}$$  \hspace{1cm} (14)

$C_3$-Transport unit cost CNY/kg·km; $\alpha$-No-load coefficient; $\alpha = 1 + \varphi$ ($\varphi$ is the ratio of the empty refrigerating truck transport distance to the total transported distance)

2.2. Optimum model of refrigerated compartment

When the shape size of the refrigerated compartment is determined, there is a multi-objective optimization problem of minimize single transportation cost of the refrigerated compartment, maximizes the available space of the refrigerated compartment. The objective function of multi-objective optimization problem of the refrigerated compartment can be expressed as follows:

$$\min S(X) = S_1(X) + S_2(X) + S_3(X) = (A_1 + A_2) b + C_z (Q + \frac{C_p Q}{\eta} L) + C_j m F \delta \alpha$$  \hspace{1cm} (15)

$$\max \nu(X) = (L - 2 \delta_1 - 4 \delta_2) (W - 2 \delta_3 - 4 \delta_2) (H - 2 \delta_3 - 4 \delta_2)$$  \hspace{1cm} (16)

Considering the needs of available space, the thickness constraints of the thermal insulation material for the refrigerated compartment are as follows.

$$0.05 \leq \delta_i \leq 0.20$$  \hspace{1cm} (17)

For refrigerated trucks, the average mileage in a single transport process generally does not exceed 500 km. The average mileage of single transport process is in a certain range as follow.

$$0 \leq LL \leq 500$$  \hspace{1cm} (18)

2.3. Optimization solution model

Since the constraint condition of the nonlinear programming problem is a regular square, therefore, the MATLAB software can be used to solve the optimal value by literately solving the variable. For solving the multi-objective programming problem, firstly, the multi-objective problem could be transformed into a single-objective programming problem by linear weighting of the objectives. In the aspect of weight, the determination method of objective weight is adapted to determine the weight according to the numerical distribution characteristics of the target since the two objective functions are basically equivalent in the comprehensive evaluation [12]. The calculation method is as follows:

Step 1, according to the value of $LL$ change between 0 to 500, and value of thickness of heat insulation material $\delta_i$ change between 0.05 to 0.2, establishing different scheme $k$ (0<k<500), the index matrix of the cost $S$ and the available space $V$ of the refrigerated compartment is obtained.

$$D^k = \left[ S_1^k, S_2^k, S_3^k, \ldots, S_n^k \right]$$  \hspace{1cm} (19)

$$s_j^k = s_j(\delta_{i_1}) + s_j(\delta_{i_2}) + s_j(\delta_{i_3})$$  \hspace{1cm} (20)

$$v_j^k = v_j(\delta_{i_3})$$  \hspace{1cm} (21)

Step 2, establishing the ideal optimal solution $U^*$ and the worst solution $U_*$ of each scheme.
Step 3, establishing the relative deviation matrix of each scheme to the optimal scheme $U^*$ and the worst scheme $U^\text{w}$.

$$
R^k = \begin{pmatrix}
    r_{11} & r_{12} & \ldots & r_{1n} \\
    r_{21} & r_{22} & \ldots & r_{2n} \\
    \vdots & \vdots & \ddots & \vdots \\
    r_{m1} & r_{m2} & \ldots & r_{mn}
\end{pmatrix}
$$

$$
Y^k = \begin{pmatrix}
    y_{11} & y_{12} & \ldots & y_{1n} \\
    y_{21} & y_{22} & \ldots & y_{2n} \\
    \vdots & \vdots & \ddots & \vdots \\
    y_{m1} & y_{m2} & \ldots & y_{mn}
\end{pmatrix}
$$

Step 4, Establishing the indicator weights.

Calculate the angle cosine between the row vector of $R$ and the row vector of $Y$.

$$
\omega^k = \frac{\sum_{j=1}^{n} c^k_j \cdot c^k_j}{\sqrt{\sum_{j=1}^{n} (c^k_j)^2} \sqrt{\sum_{j=1}^{n} (c^k_j)^2}}
$$

Step 5, Normalize $c_s$ and $c_v$ to obtain the weight vector of the objective function.

$$
\omega^k = (\omega^k_1, \omega^k_2)
$$

Step 6, establishing a relative superiority matrix for each scheme and the ideal solution.

$$
M^k = \begin{pmatrix}
    m_{11} & m_{12} & \ldots & m_{1n} \\
    m_{21} & m_{22} & \ldots & m_{2n} \\
    \vdots & \vdots & \ddots & \vdots \\
    m_{m1} & m_{m2} & \ldots & m_{mn}
\end{pmatrix}
$$

Under the condition of value $L_l$ changes from 0 into 500, the comprehensive superiority value of each scheme is as follows:

$$
d^k_j = \omega^k_1 \cdot m_{1j}^k + \omega^k_2 \cdot m_{2j}^k
$$

Obviously, when $d^k_j$ is the largest, the corresponding scheme is the optimal one so that the economic thickness of the thermal insulation material can be obtained.

(7) The economic thickness of thermal insulation material under different value of $L_l$ is calculated sequentially. The calculation procedure is shown in Figure 2.
3. Example analysis

Examples: Considering the actual situation of refrigerated transportation and the relatively large breathing heat of green pepper, the transportation area takes Guangdong as an example, and the season takes summer as an example, which is representative. Therefore, taking refrigerated compartment with 5 tons of green pepper as an example, the summer refrigerated transportation in Guangdong Province as an example, the required temperature in the refrigerated compartment is 0℃ and temperature of the external surface of the refrigerated compartment is 45℃. The specific parameters are as Table 1:

| Parameter | Value |
|-----------|-------|
| $C_p$ | $1040 \text{ J/(kg·K)}$ |
| $t_w$ | $45^{\circ}\text{C}$ |
| $Q_0$ | $2350 \text{ W}$ |
| $\rho$ | $1.27 \text{ kg/m}^3$ |
| $\tau$ | $4000 \text{ s}$ |
| $\varphi_w$ | $0.5$ |
| $\gamma$ | $2500 \text{ J/kg}$ |
| $\nu_n$ | $0.6 \text{ m/s}$ |

Table 1. Parameters table.

The parameters mentioned above are tested and determined according to the reference [2-8].

There are three kinds of heat insulation materials used in the actual production process of refrigerated compartments, they are 100 mm extruded polystyrene, 120 mm foamed polystyrene and 100 mm. Different heat insulation materials lead to the different parameters of heat insulation.
materials for compartments. The optimization process is to substitute the relevant parameters of refrigerated compartments send into computer to calculate, which is as follows:

The function value of the thickness of heat insulation material corresponded to the available space of the refrigerated compartment is shown in Figure 3.

![Figure 3](image)

**Figure 3.** The graph of the relationship between thickness of heat insulation material and available space of the refrigerated compartment.

(1) When the heat insulation material of the refrigerated compartments is foamed polystyrene, The function value of the corresponding single transportation cost under different single-transport mileage is shown in Figure 4(a). The economic thickness of heat insulation of different single-transport mileage is shown in Figure 4(b). Figure 4(a) shows that When the thermal insulation material of the refrigerated compartments is foamed polystyrene, the average transport mileage is the same, and the thickness of insulating material of refrigerated compartments increases gradually between 0.05 m to 0.20m, the transport cost decreases exponentially with the increase of the thickness of insulating material; when the average transport mileage of a single time varies between 50 km to 500km, the longer the average transport mileage of a single time, the higher the transport cost, the smaller the thickness of heat insulation material, the greater the change in transportation cost caused by the change of mileage.

It can be known from Formula (4) that the total cooling cost consists of the pre-cooling cost before transporting and the cooling cost during transportation. When the transportation mileage is short, the pre-cooling cost accounts for a larger proportion in the refrigeration cost. When the transportation mileage is long, the cooling cost accounts for a larger proportion in transit. Therefore, when the transportation mileage is short, priority should be reducing the pre-cooling cost, appropriately reducing the thickness of heat insulation material, and increasing the volume of the refrigerating compartment. Figure 4(b) shows that when the heat insulation material is foamed polystyrene and the average transport mileage is between 50 km to 300 km, the optimum thickness of insulating material is 0.11m, and the optimum thickness of insulating material is 0.12m when the average transport mileage is between 300 km to 500 km. Considering the condition that the available space of refrigerating compartment reaches the maximum and single transportation cost of the refrigerated compartment reaches the minimum at the same time, when the transportation mileage is 50 km and the thickness of insulation material is 0.11 m, the optimal value of transportation cost is the smallest, which is CNY
and the optimal volume value in the refrigerating compartment is the largest, which is 12.0892 m$^3$.

Figure 4. The analysis results when the heat insulation materials are foamed polystyrene: (a) Transportation cost; (b) Economic thickness of heat insulation materials.

(2) When the heat insulation material is extruded polystyrene, the function value of the corresponding single transportation cost under different single-transport mileage is shown in Figure 5(a). The economic thickness of heat insulation of different single-transport mileage is shown in Figure 5(b).

It can be seen from Figure 5(a) that when the heat insulation material is extruded polystyrene, the average transport mileage is the same, and the thickness of insulating material of carriage body increases gradually between 0.05 m to 0.20m, the transport cost decreases exponentially with the increase of the thickness of insulating material; when the average transport mileage of a single time varies between of 50 km to 500km, the longer the average transport mileage of a single time, the higher the transport cost of carriage. The smaller the thickness of insulation material, the greater the change in transportation cost caused by the change of mileage.

When the heat insulation material is extruded polystyrene, the economic thickness of heat insulation material increases with the increase of single transportation mileage. Because the thermal conductivity of extruded polystyrene material (0.030/m·K) is lower than that of foamed polystyrene material (0.045/m·K), the economic thickness of extruded polystyrene material is smaller than that of foamed polystyrene. Figure 5(b) shows that when the heat insulation material is extruded polystyrene and the average transport mileage is between 50km to 90 km, the economic thickness of the heat insulation material is 0.09m, and the economic thickness of the insulation material is 0.10 m when the average single-transport mileage is between 90 km to 500 km. Considering the condition that the available space of refrigerating compartment reaches the maximum and single transportation cost of the refrigerated compartment reaches the minimum at the same time, when the transportation mileage is 50 km and the thickness of insulation material is 0.09 m, the optimal value of transportation cost is the smallest, which is 5385.25 yuan, and the optimal volume value in the carriage is the largest, which is 12.7820m$^3$.

(3) When the heat insulation material is polyurethane, the function value of the corresponding single transportation cost under different single-transport mileage is shown in Figure 6(a). The economic thickness of heat insulation of different single-transport mileage is shown in Figure 6(b).

Figure 6(a) shows that when the heat insulation material is polyurethane, the average transport mileage is the same, and the thickness of insulating material of carriage body increases gradually in the range of 0.05-0.20m, the transport cost decreases exponentially with the increase of the thickness
of insulating material; when the average transport mileage of a single time varies between 50 to 500 km, the longer the average transport mileage of a single time, the higher the transport cost. The smaller the thickness of insulation material, the greater the change in transportation cost caused by the change of mileage.

When heat insulation material is polyurethane, the economic thickness increases with the increase of single transportation mileage. Because the thermal conductivity of polyurethane material is the smallest, the economic thickness of polyurethane material is the smallest among the three materials. Figure 6(b) shows that the average transport mileage is between 50 km to 70 km, the economic thickness of heat insulation material is 0.08 m, and the economic thickness of insulating material is 0.09 m when the average transport mileage is between 70 km to 500 km. Considering the condition that the available space of refrigerating compartment reaches the maximum and single transportation cost of the refrigerated compartment reaches the minimum at the same time, when the transportation mileage is 50 km and the thickness of the insulation material is 0.08 m, the optimal value of transportation cost is the smallest, which is CNY 4967.43, and the optimal volume value in the carriage is the largest, which is 13.1375 m³.

![Figure 5](image1.png)

**Figure 5.** The analysis results when heat insulation material is extruded polystyrene: (a) Transportation cost; (b) Economic thickness of insulation materials.

![Figure 6](image2.png)

**Figure 6.** The analysis results when heat insulation material is polyurethane: (a) Transportation cost; (b) Economic thickness of insulation materials.
4. Conclusions
In this research, weighted algorithm is used to optimization design the thickness of insulated compartment, minimized the transport cost, and meanwhile maximized the internal volume of the carriage.

(1) The result show that with the increase of the average transport mileage between 50 km to 500 km, the economic thickness of the three materials increases correspondingly.

(2) The optimization results shown that the thickness of heat insulation material of the current refrigerating compartment is not economic. When the average single transportation mileage is between 50 km to 500 km, the thickness of foamed polystyrene material is thinner; when the average transportation mileage is between 50 km to 90 km, the thickness of extruded polystyrene material is thicker; the thickness of polyurethane material is thicker when the transport mileage is between 50 km to 500 km.

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