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Semi-trailer foodbox design and defining insulation material

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Food Box
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Abstract

Road transport is one of the most used transportation methods in the world. Semi-trailer vehicles play a very important role in road transport. These transports can take so long times and the drivers spend their most times in the road. The drivers need to daily requirement. One of the most important of these is to eat during the transport. To satisfy their daily needs to continue their comfort, they need to use a refrigerator. A refrigerator has ability keeping fresh of foods. The drivers use food boxes in semi-trailer but this food boxes without any insulation and refrigerator systems. In this article we found a solution to get fresh foods in these boxes.

Introduction

This text provides background information, description, and analysis of four major cooling technologies—vapor compression cooling, evaporative cooling, absorption cooling, and gas cooling. Vapor compression systems are currently the primary technology used in most standard domestic, commercial, and industrial cooling applications, as they have both performance and economic advantages over the other competing cooling systems. However, there are many other applications in which evaporative cooling, absorption cooling, or gas cooling technologies are a preferred choice.

Cooling technologies are generally divided into air conditioning and refrigeration applications. Air conditioning technologies are defined as those that are used for to maintain acceptable thermal comfort conditions for people and equipment in residential, commercial, and industrial buildings and spaces, typically in the neighborhood of 20–30°C. Refrigeration technologies are defined as those that are used to maintain temperatures near or below freezing (0°C) for safe storage of perishable items such as food and medicine, and operation of low temperature laboratory equipment [1-3].

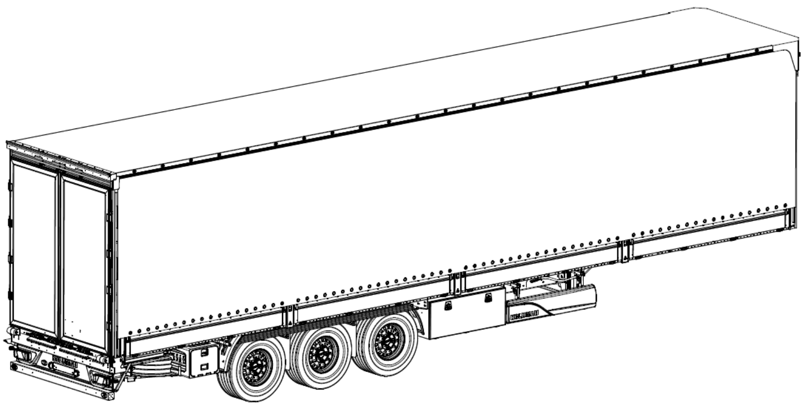


Figure 1. Semi – Trailer

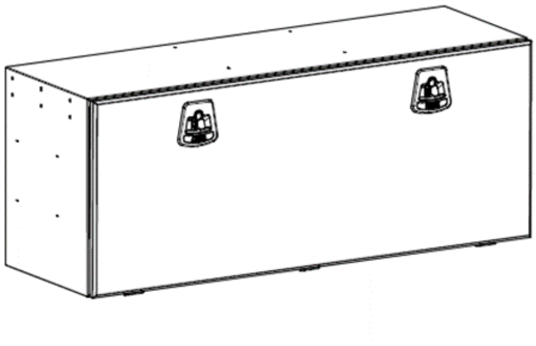


Figure 2. Food Box or Toolbox

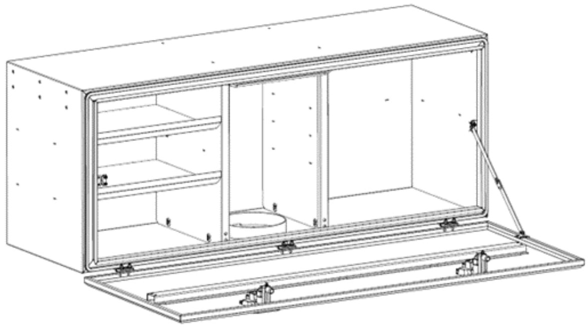


Figure 3. Food Box or Toolbox without insulation and refrigerator

Design Process

In this study, an area of approximately 0.132 m3 was determined in the foodbox of semi-trailer products. The characteristics of this determined volume are as in the Figure 4 and Figure 5.

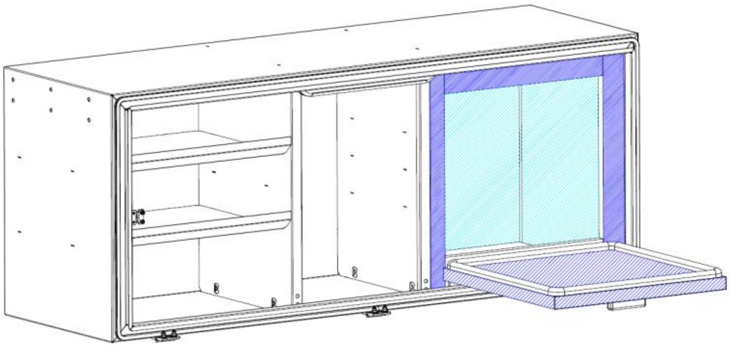


Figure 4. New design food Box or toolbox with insulation and refrigerator

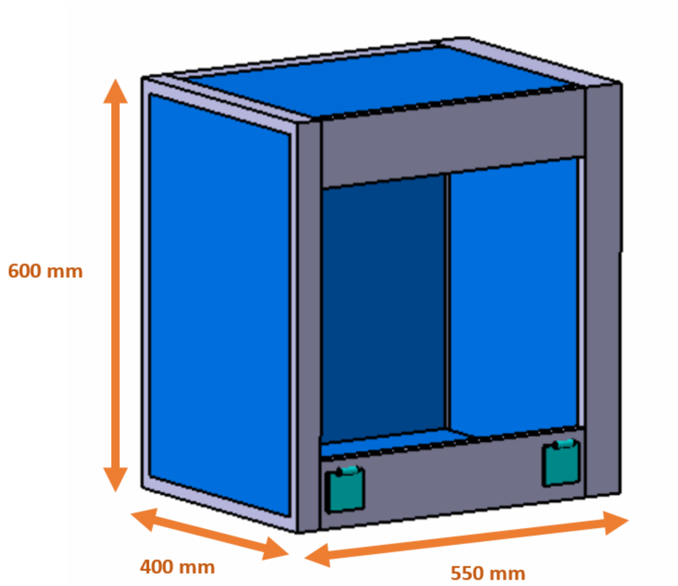


Figure 5. Schematic view of insulation box and dimensions

Total volume of foodbox: 0.5 m^3
Volume of insulation box: 0.132 m^3
Outside Surface Area of insulation box: 1.58 m^2

Defining the thickness of the insulation material

The main aim of the defining of the insulation material is directly related with heat transfer from outer side to inner side.

To keep at lower temperature of the inner volume of the box necessary calculation should be made.

The air conditioning plate was chosen as the insulation material. That material specification as follows.

KOD	: C302-0030
THICKNESS	: 25 MM
THERMAL COND	: @25°C: 0,025 W/M.K

Figure 6. Air Conditioning Plate

Cooling loads calculations

Cooling Load Calculation for cold rooms. In this article we'll be looking at how to calculate the cooling load for a cold room.

Cooling load capacity coming from changing products

In the next step, we calculated the cooling load according to the temperature coming from the new product replacement in the cold room. In this calculation we assumed that cooled the product in the refrigerator is apple.

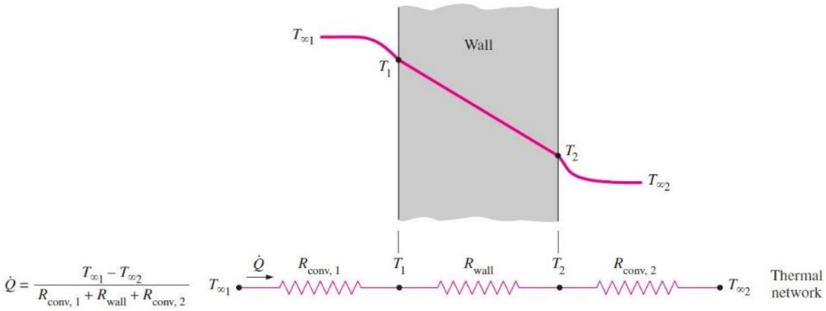
Q1 = M x Cp x (Tproduct– Tinside)/ 3600	Q1: kw / day
Q1 = 10 x 3,65 x (20–3) / 3600 kwh/day	M(mass)apple: 10 kg
Q1 = 0,17 kwh/day x 1000 (Convert to Watt)	Cp(specific heat capacity): 3.65 kJ/kg °C
Q1 = 172 Wh/day	Tproduct: 20 °C
Q1 = 172 Wh/ 24h	Tinside: 3 °C
Q1 = 7,2 W	

Cooling load capacity coming from absorption

Q2 = M x Resp / 3600	Q2: kw/ day
Q2= 10 x 1,9 / 3600	Mapple: 10 kg
Q2 = 0,0052 kwh / day	Resp: 1,9 kj/kg
Q2 = 5,3 Wh/day	
Q2 = 5,3 Wh/ 24h	
Q2= 0,22 W	

Heat loss from walls

To define how much peltier modules should be used in this design, heat loss energy calculated by below formulas:



$$\dot{Q} = \frac{T_{\infty 1} - T_{\infty 2}}{R_{conv,1} + R_{wall} + R_{conv,2}}$$

Q=(40-3)/(0,015+0,63+0,025) *Qheat loss=55,2 W*

Boundary Conditions
We assume that outside temperature of air T∞1 is 40°C
We assume that inside box temperature of air T∞2 is °C is 3°C
Refrigerator Box Dimensions:

$$Rconv = \frac{1}{h*As} \ (°C/W) \qquad Rwall = \frac{L}{k*A} \ (°C/W)$$

$Rconv,1=1/(42*1,58)$ $Rwall=0,025/(0,025*1,58)$

$Rconv,1=0,015$ °C/W $Rwall=0,63$°C/W

$Rconv,2=1/(25*1,58)$

$Rconv,2=0,025$ °C/W

Conclusion

In this design, the insulation material is determined by calculating the heat losses in order to make our refrigerator box suitable for cooling according to the boundary conditions. Initially, the wall thickness was determined as 25 mm. According to this wall thickness, the thermal conductivity coefficient was calculated as 0.025 W/M.K. According to our calculations, the insulation material is technically the product with the code C302-0030.

With the study, insulation material was selected by determining the cooling area we need in the foodbox for semi-trailer products. With these data to be used, the cooling system to be integrated into the determined area has been made applicable.

References

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