SPRINT 4 REPORT

➔ Know how much energy to supply, for each container, in a determined trip, with an exterior temperature of 20 ºC, and a travel time of 2h30

To know the necessary energy, we need to know first the power needed to supply for each container. To know the power, we need the total thermal resistance of the materials involved in the construction of the container and the difference of temperatures (outside and inside). After the calculation of the power, we need to know the time in seconds and the multiply it by the power.

Container of 7ºC:

Thermal resistance of Wood: 0.15 K/W

Thermal resistance of Fiberglass: 1.09 K/W

Thermal resistance of Corten steel: 3.85×10^{-5} K/W

$$\dot{Q} = \frac{\Delta T}{Rt} = \frac{20-7}{0.15+1.09+3.85\times10^{-5}} = \frac{13}{1.24} \approx 10.48W$$

$$E = \dot{Q} \times T = 10.48 \times 9000 = 94320\,J$$

Container of -5ºC:

Thermal resistance of Wood: 0.15 K/W

Thermal resistance of Polystyrene: 1.43 K/W

Thermal resistance of Corten steel: 3.85×10^{-5} K/W

$$\dot{Q} = \frac{\Delta T}{Rt} = \frac{20-(-5)}{0.15+1.43+3.85\times10^{-5}} = \frac{25}{1.58} \approx 15.82W$$

$$E = \dot{Q} \times T = 15.82 \times 9000 = 142380\,J$$

➔ Know the total energy to be supplied to the set of containers in a certain established trip, assuming that all the containers have the same behaviour

Using the calculations made on the previous parameter, we can calculate the needed energy to keep the containers refrigerated at a certain temperature.

Supposing a trip takes 2 hours and 30 minutes, which is equivalent to 9000 seconds, and the exterior temperature during the trip is 20°C, we can calculate the energy required for a set of containers.

Suppose now, a boat is loaded with 13200 containers refrigerated at 7°C and 10000 containers are refrigerated at -5°C.

Containers refrigerated at 7° Celsius:

$$13200 \times 10.48W = 138336\,W = 138.336\,kW$$

Containers refrigerated at -5° Celsius:

$$10000 \times 15.82W = 158200\,W = 158.200\,kW$$

So, in total, it would be needed:

$$138336 + 158200 = 296536\,W = 296.536\,kW$$

- Know how much energy to supply to the container cargo, in a voyage (or route), depending on the position of the containers on the ship. Admitting that the interior containers, or the sides not exposed directly to the "sun", maintain the initial temperature, or of departure. However, the exposed sides may present temperature variations during the trip

In this parameter we calculated the temperature to a set of containers of different temperatures and with two conditions, assuming they are exposed or not.

Firstly, for a set of 10 containers with a temperature of 7ºC that are not exposed. The first thing we did was to calculate the area of the container and then using the area we calculated the total resistance. After that we calculated the power with by dividing the difference of temperature (the temperatures suffered in the travel and the temperature of 7ºC) with the total resistance. To get the energy necessary for a specific container we summed the power multiplied by the different temperatures. In the end, to obtain the needed energy for a set of containers, we multiplied the energy of 1 container by the number of containers of that set.

For a set of 10 containers with a temperature of -5ºC that are not exposed, the calculation was the same that we used in a set of containers of 7ºC.

For the containers that are exposed, the only calculation changed is the area because we will only consider the faces that are exposed.

Set of 10 containers that are not exposed, with a temperature of 7ºC:

Assuming that we have only two different temperatures (20ºC and 18ºC)

Calculation of the area:

$$(2.393 \times 5.9) \times 2 + (2.350 \times 2.939) \times 2 + (2.350 \times 5.9) \times 2$$

Calculation of total resistance:

$$\frac{0.02}{0.13 \times 69.78} + \frac{0.05}{0.046 \times 69.78} + \frac{0.0015}{39 \times 69.78}$$

Calculation of power:

$$Q = \frac{20 - 7}{0.0178}$$

$$Q = \frac{18 - 7}{0.0178}$$

Calculation of energy:

$$E = (730.34 \times 20) + (617.98 \times 18) = 25730.44J$$

Calculation of energy required for a set of 10 containers:

$$E = E \times 10 = 25730.44 \times 10 = 257304.4J$$

Set of 10 containers that are exposed, with a temperature of -5ºC:

Assuming that we have only two different temperatures (20ºC and 18ºC)

The only difference will be calculation of the area because we'll have a different number of faces exposed. Assuming that we have 5 side faces exposed, 3 front faces exposed, and 4 top faces exposed.

Calculation of the area:

$$(2.393 \times 5.9) \times 3 + (2.350 \times 2.939) \times 5 + (2.350 \times 5.9) \times 4$$

Calculation of total resistance:

$$\frac{0.02}{0.13 \times 132.35} + \frac{0.05}{0.046 \times 132.35} + \frac{0.0015}{39 \times 132.35}$$

Calculation of power:

$$Q = \frac{20 - 7}{0.0094}$$

$$Q = \frac{18 - 7}{0.0094}$$

Calculation of energy:

$$E = (1382.98 \times 20) + (1170.21 \times 18) = 48723.38J$$

Calculation of energy required for a set of 10 containers:

$$E = E \times 10 = 25730.44 \times 10 = 487233.8J$$

- ➔ Know how many auxiliary power equipment are needed for the voyage, knowing that each one supplies a maximum of 75 KW

For the calculations on this parameter, we used a travel time of 1.5h, an energy of 300KJ and a power of 75KW. To know the number of auxiliary equipment needed, we have to divide the energy by the multiplication of time and power.

$$Auxiliary\ power\ equipment = \frac{Energy}{Power \times Time} = \frac{300}{75 \times 1.5} \approx 3$$

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