Compressor Load Analysis Of Air Blast Freezer (ABF) Design For Capacity Of 250 Kg

Syawaluddin, Anwar Ilmar Ramadhan, Ery Diniardi, Erwin Dermawan

Abstract: In this study Air Blast Freezer (ABF) to freeze 250kg of bread dough in 1 hour with the amount of space ABF requested as much as 2 room. The purpose of the research is to select the required compressor ABF with the calculation of the load obtained. The condition of each room has a heat load of 41.5 kW with target room temperature -35̊C. The result is total compressor capacity 58.2 kW x 2 compressor or 116.4 kW, while the calculation load according to condition of end of room ABF is equal to 37.81 kW x 2 room or equal to 75.62 kW , 40.78 kW difference, or enough to make one more ABF room with the same design and capacity.

Index Terms: Air Blast Freezer (ABF), load, compressor

1 INTRODUCTION

Air blast freezing is the process of taking a product at a temperature (usually chilled but sometimes at ambient temperature) and freezing it rapidly, between 12 and 48 h, to its desired storage temperature which varies from product to product [1-3]. Typically, the evaporator temperature in a blast freezer refrigeration system ranges between -35°C and -52°C. Slow freezing produces large ice crystals, which grow through cell walls, permitting an accelerated penetration of oxygen, causing rancidity and browning of meat and enhancing the danger of higher drip on thawing [4]. Therefore, rapid freezing is required to maintain food quality as it produces small ice crystals due to a higher number of nucleation points from which ice crystals form [5]. In the food industry, freezing methods have been developed to speed up the clotting process that allows the product to freeze in a short time. Rapid freezing will result in small ice crystals that will minimize the texture damage of the frozen material [6]. In addition, the freezing process also causes freeze shock in microorganisms and no adaptation stage of microorganisms with temperature changes thereby reducing the risk of growth of microorganisms during the freezing process takes place. Among the fast freezing techniques the industry employs is Air Blast Freezer (ABF) [7-8] In this study, ABF was used to freeze 250kg of bread dough in 1 hour with 2 room ABF room. Found each room has a heat load of 41.5 kW with target temperature of -35̊C. Each ABF room is supported by a 62WBHE compressor with ammonia refrigerant. So that the calculation of load and compressor selection needed.

2 RESEARCH METHOD

This research was conducted for calculation of ABF calorie water load based on analytical program. Here are the steps that will be done to complete the analysis is: The calculation of the heat load uses an existing formulation.

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Here are the objects that are calculated as heat load: (1) Heat load from outdoor, (2) Infiltration load, (3) Heat load from product, (4) Heat load from shelf and base board for product, (5) Heat load from cooling fan, (6) Heating load from lamp, (7) Heating load from floor heater, (8) Selection of compressor load.

3 RESULTS AND DISCUSSION

3.1. Heat Load from Outdoor Through Wall

Below is a picture of the shape of the ABF space dimension that will be designed, can be seen in Figure 1.

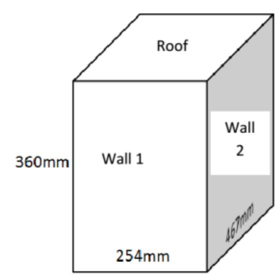

Figure 1. *Wall Screen Dimension ABF Room*

To simplify the calculation, from the data taken, a schematic image of the ABF space dimension is made as shown in Figure 1 above. Furthermore, using the formula and assuming an outdoor temperature of 25 °C and from the 15 °C floor and the thermal conductivity value, we will find use equation (1-6):

$$q_{transmission\ Roof} = U.A.(to\text{-}tr)\ \text{[kcal/h]} \quad (1)$$

Earned by value of 85.4 [kcal/h]

$$q_{transmission\ floor} = {}_{I}.A.(to\text{-}tr)\ \text{[kcal/h]} \quad (2)$$

Earned by value of 42.7 [kcal/h]

$$q_{transmission\ wall\ 1} = U.A.(to\text{-}tr)\ \text{[kcal/h]} \quad (3)$$

Earned by value of 65.8 [kcal/h]

$$q_{transmission\ wall\ 2} = U.A.(to\text{-}tr)\ \text{[kcal/h]} \quad (4)$$

Earned by value of 121.0 [kcal/h]

$$q_{transmission\ wall\ 3} = U.A.(to\text{-}tr)\ \text{[kcal/h]} \quad (5)$$

Earned by value of 65.8 [kcal/h]

$$q_{transmission\ wall\ 4} = U.A.(to\text{-}tr)\ \text{[kcal/h]} \quad (6)$$

Earned by value of 0.0 [kcal/h]

The value of the heat load through wall 4 is 0 kcal / h because the side is attached with 1 other ABF. Thus, the total $q_{transmission}$ is 380.9 kcal / h.

3.2. Infiltration Burden

Since using the final unit on this calculation it will use the formula:

$$q\ \inf = \rho u,r \times Vcs(hu - hu,r).n \quad \text{[kcal/h]} \quad (7)$$

Assuming outdoor temperature 25̊C and room temperature ABF-35̊C, it will get infiltration load: 765.7 [kcal/h]

3.3. Heat Load from the Product

a. Heat Bread taken from the initial temperature of the product core with the assumption of 22̊C according to the performance on the design sheet to the freezing point of product -4̊C, then use equation (8).

$$Q_{freezing\ 1} = m_{bread}.Cp_{bread}.(\Delta T_{bread})\ \text{[kcal/h]} \quad (8)$$

Obtained value of 4420 [kcal/h]

b. Latent heat dissipation at freezing point used equation (9).

$$Q_{freezing\ 2} = m_{bread}.q_{bread}\text{[kcal/h]} \quad (9)$$

Obtained value of 10000 [kcal/h]

c. Freeze the Bread Dough to the desired temperature at the bread dough core at -18C, to find use eq (10).

$$Q_{freezing3} = m_{bread}.Cp_{bread}.(\Delta T_{bread})\ \text{[kcal/h]} \quad (10)$$

Obtained value of 1505 [kcal/h]

So, the total $q_{product}$ is 15925 kcal / h.

3.4. Heat Load from Shelves and Aluminum Board Products

By using the same formula with the calculation of product load then obtained can be use equation (11) and (12):

$$q_{rack} = m_{rack}.Cp_{rack}.(\Delta T_{rack})\ \text{x Qty [kcal/h]} \quad (11)$$

obtained value of 1089.0 [kcal/h]

$$q_{base\ board} = m_{baseboard}.Cp_{baseboard}.(\Delta T_{baseboard})\ \text{x Qty [kcal/h]} \quad (12)$$

obtained value of 1724.4 [kcal/h]

Thus, the total $q_{product}$ of the rack and base board products is 2831.4 kcal / h.

3.5. Heat Load from Fan

Assuming the heat load of each fan of 2.2 kW with the fan count of 4 pieces, then q_{fan} = 8.8 kW = 7568 kcal / h.

3.6. Heat Load from Lamp

As it is known that the lamp used is 45.9 Watt power that amounts to 2 pieces in each room ABF. That's what we got.

$$q_{lamp} = 45.9\ \text{Watt x 2} = 91.8\ \text{W} = 79.12\ \text{kcal/h}$$

3.7. Heat Load from Floor Heater

The floor heater used has a heat load of 187 W with a total of 4 pieces.

$$q_{heating\ floor} = 187\ \text{Watt x 4} = 748\ \text{W} = 643.28\ \text{kcal/h}$$

That way, we can know the total amount of heat load in the room ABF is equal to 28395.9 kcal/h. With a safety factor of 15%, then this design uses a load of: 28274.9 kcal/h x 1.15 = 32516.16 kcal/h equivalent with 37.81 kW.

3.8. Selection of 62WBHE 900rpm Compressor

Then using Table 1 can be determined the compressor selection calculation results.

Table 1. *Type compressor with capacity*

Type compressor	Capacity (kW)	Absorbed Power	COP
62WA 1200rpm	31.6	21.7	1.46
42WBHE 900rpm	43.2	29.6	1.46
42WBHE 1000rpm	48.0	33.0	1.45
42WBHE 1100rpm	52.7	36.5	1.44
42WBHE 1200rpm	57.4	39.9	1.44
62WBHE 900rpm	58.2	38.9	1.50
62WBHE 1000rpm	64.5	43.3	1.49
62WBHE 1100rpm	70.8	47.8	1.48
62WBHE 1200rpm	77.0	52.3	1.47

By using analysis software, can know how exactly the compressor capacity type 62WBHE 900rpm. It was found that 62WBHE 900rpm compressor has a cooling capacity of 58.2 kW with 38.9 kW of power (absorbed power). From that value, we can know the value of COP compressor by dividing the value of compressor capacity with its power requirement.

4 Conclusion

Based on the research results obtained as follows

1. The calculation result of ABF heat load according to the last condition is 37.81 kW per room or 10% lower than the initial calculation result which reach 41.5 kW.
2. Two 62WBHE compressors with a total capacity of 116.4 kW and a current 50% efficiency rating exceeding the total heat load of the ABF room of only 75.62 kW can even meet the capacity of the same 1 ABF room as before with a heat load of 37.81 kW.

ACKNOWLEDGEMENT

The authors would like thanks to the Institute for Research and Community Service (LPPM) of Universitas Muhammadiyah Jakarta, which has funded this research through the UMJ Internal Grant.

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