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DESIGN OF COLD STORAGE WITH 3 TONS OF CHICKEN MEAT PRODUCTS

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ABSTRACT

The population of Indonesia has increased every year. This is the cause of the search for food needs, one of which is the need for chicken meat. Chicken farmers need to design so that the chicken meat products produced have good quality when consumed by the public. Apart from handling when the chickens are still alive, the quality of chicken that has been slaughtered for consumption also needs to be maintained. The refrigeration field is currently widely used for personal or commercial needs, including for the food industry. One of the applications in the refrigeration sector is cold storage. Due to the extensive research on cold storage, this research will only design a cold storage to store 3 tons of chicken meat. The purpose of this research is to design cold storage, select and identify refrigeration equipment and refrigeration control used in this cold storage design. In this study, the steam compression system uses a multi rack compressor. Cold storage is only to maintain the temperature of the chicken meat, not to cool the chicken meat. The result of this research is the total capacity of this design equipment is 5.4 kW. This cold storage uses 3 compressors, where 1 compressor is a backup compressor. Each compressor has a capacity of 2.7 kW. Equipment selection using Bitzer, Guntner and Danfoss software.

INTRODUCTION

The population of Indonesia has increased every year. This is the cause of the increasing need for food, one of which is the need for chicken meat. The increasing demand of the population means that the supply of chicken meat must be sufficient. Chicken meat is very popular and consumed by the community because the price is relatively affordable and can be obtained easily. Not only people in Indonesia who consume chicken meat from Indonesia, but also demand from abroad also needs to be met.

Chicken farmers need to design so that the chicken meat products produced have good quality when consumed by the public. Apart from handling when the chickens are still alive, the quality of chicken that has been slaughtered for consumption also needs to be maintained. In order to maintain the quality of chicken meat, a chicken meat handling system is needed, one of which is frozen food. Therefore, it is necessary for experts in the field of refrigeration to be able to help the supply of quality chicken meat when it reaches the public.

The refrigeration field is currently widely used for personal or commercial needs, including for the food industry. One of the applications in the refrigeration sector is cold storage. So the use of cold storage can be a solution for breeders and managers of the food industry. Therefore, this research will design cold storage.

Due to the extensive research on cold storage, this research will only design a cold storage to store 3 tons of chicken meat. This cold storage is placed in the export-import warehouse. Therefore, the formulation of this research is how to design cold storage for storage of 3 tons of chicken meat.

The purpose of this research is to design cold storage, select and identify refrigeration equipment and refrigeration control used in this cold storage design. The output to be produced in this study is a cold storage design. The results of this research can be in the form of recommendations for the construction of cold storage and its refrigeration and control devices. In this study, the steam compression system uses a multi rack compressor. Cold storage is only to maintain the temperature of the chicken meat, not to cool the chicken. This cold storage is designed only for a maximum capacity of 3 tons of chicken meat.

LITERATURE REVIEW

Cold storage

Cold storage is a room used to store products to be cooled. Often found in supermarkets, restaurants, hotels and other places that are used to store and preserve food ingredients. The volume of cold storage varies around 6 m^3 - 40 m^3 with temperatures around 0^oC - 10^oC for refrigeration which is to store the product and -40^oC - 0^oC for freezing which preserves the product.

The type of insulation used is usually polyurethane with different thicknesses according to the desired temperature. The cooling process uses a vapor compression refrigeration system, with the condensing unit located next to the cold storage or separate from the cold storage.

The factors that determine the amount of compressor capacity used are:

Heat Load Through Walls

Heat load through walls is heat that enters the room through the walls which is caused by the temperature difference between the environment and the room.

Air Exchange Expenses

The air that enters the room can automatically become a burden to the room, the air that enters the room is usually due to the opening and closing of the door and leaks through the gaps. The amount of air exchange depends on the size of the door, the frequency of opening and closing the door, the length of time the door is open, and the flow of air through the door.

Product Load

The type of product and container will produce a large enough heat, especially for the load of fruit and vegetable products at temperatures above the freezing point will release respiration heat. Respiration heat is generated from the O2 reaction in the tissue of fruits and vegetables, this will certainly increase the cooling load of the room.

Other Expenses

Other expenses include lighting loads and equipment loads. Although usually in small amounts, this load cannot be ignored as it greatly affects room temperature.

Cooling load calculation

The components that need to be calculated cooling load are as follows:

1. Heat Load Through Walls, Floors and Roofs

a) Walls, Roofs

$$\frac{1}{u} = \frac{1}{f_o} + \frac{X_s}{K_s} + \frac{X_{pu}}{K_{pu}} + \frac{X_s}{K_s} + \frac{1}{f_i}$$

After getting the u value, then look for the load of the north wall (Qu), south wall (Qs), west wall (Qb) and east wall (Qt) and roof (Qa) using the following equation:

$$Q = U.A.\Delta T$$

b) Floors

$$\frac{1}{u} = \frac{1}{f_i} + \frac{X_b}{K_b} + \frac{X_s}{K_s} + \frac{X_{pu}}{K_{pu}} + \frac{X_s}{K_s}$$

After getting the u value, then find the floor load using the following equation:

$$Q_l = U.A.\Delta T$$

c) Total Load Through Wall

$$Q_D = Q_u + Q_s + Q_b + Q_t + Q_a + Q_l$$

2. Air Exchange Expenses
a) Indoor volume

$$V_d = (p - 2t_d).(l - 2t_d).\left(t - (t_a + t_l)\right)$$

b) Infiltration Rate
Using Table 10-7, Dossat

c) Air Exchange Factor
Using Table 10-6B, Dossat

d) Total Air Exchange Load

$$Q_{pu} = I.\Delta H$$

3. Product Load
a) Chicken Meat Load

$$Q_p = \frac{m.C_p.\Delta T}{n.3600}$$

b) Container Load

$$Q_w = \frac{m.c_p.\Delta T}{n.3600}$$

c) Plastic Load

$$Q_{pl} = \frac{m.c_p.\Delta T}{n.3600}$$

d) Total Product Load

$$Q_{PT} = Q_p + Q_w + Q_{pl}$$

4. Other Expenses
a) Human Load
Using Table 10-14, Dossat

$$Q_m = p\ x\ Q_e\ x\ \frac{tp}{24}$$

b) Lamp Load

$$Q_L = 60x\frac{tp}{24}$$

c) Total Other Expenses

$$Q_{LL} = Q_m + Q_L$$

5. Equipment Capacity

a) Total Expenses

$$q = Q_D + Q_{pu} + Q_{PT} + Q_{LL}$$

b) Total Expenses with Safety Factor

$$q_t = q + 10\%. q$$

Then, the equipment capacity:

$$Q = q_t \ x \ \frac{24}{RT}$$

II. RESEARCH METHODOLOGY

A. *Flow Chart*

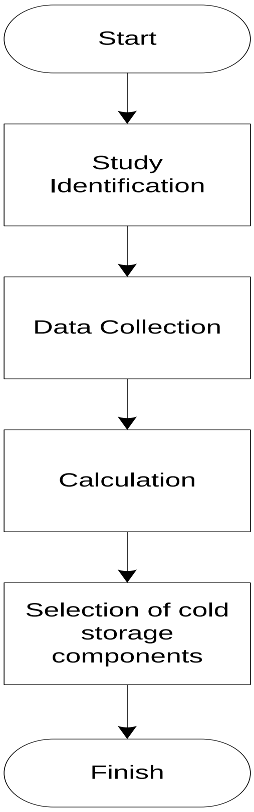

Fig. 1 Work Flowchart

Design Data

1. Initial Data
- Storage capacity = 3 Ton
- Ambient temperature = 30°C
- Chicken meat temperature = -16°C
- Room temperature = -18°C
- Chilling Time = 3 jam
- Operating Time = 18 jam
- Refrigerant = R-134a
- Container mass = 150,15 kg

Form Table 10-1, Dossat:
- Concrete 150 mm, k = 1,73 W/mK
- Stainless steel 1 mm, k = 14,5 W/mK
- Polyurethane 98 mm, k= 0,025 W/mK
- Outer surface convection coefficient, f_o = 22,7 W/m^{2}K
- Inner surface convection coefficientf_i = 9,37 W/m^{2}K

Cold storage dimension:
- Length = 5 m
- Wide = 5 m
- High = 3 m
- Anteroom = ½ Length

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2. Product Placement

Whole chicken meats are stored in Styrofoam which is covered by plastic. Then the chicken meats are placed into 9 parts in 3 racks. So, there are 3 partitions in 1 shelf.

a) Cold Storage Design

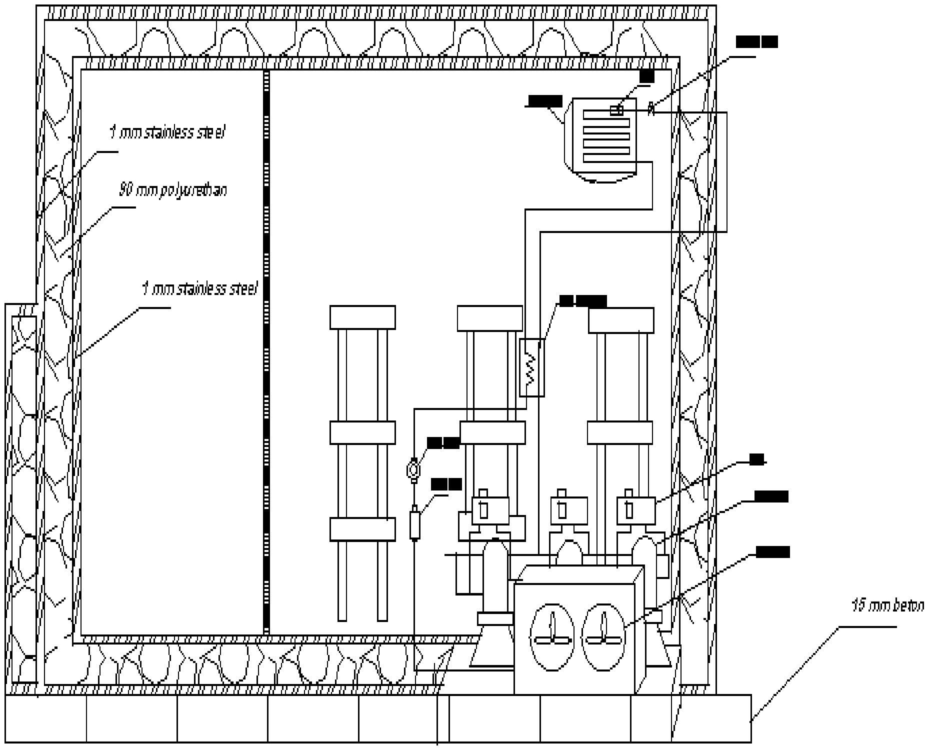


Fig. 2 Cold Storage Design

b) Piping Diagram

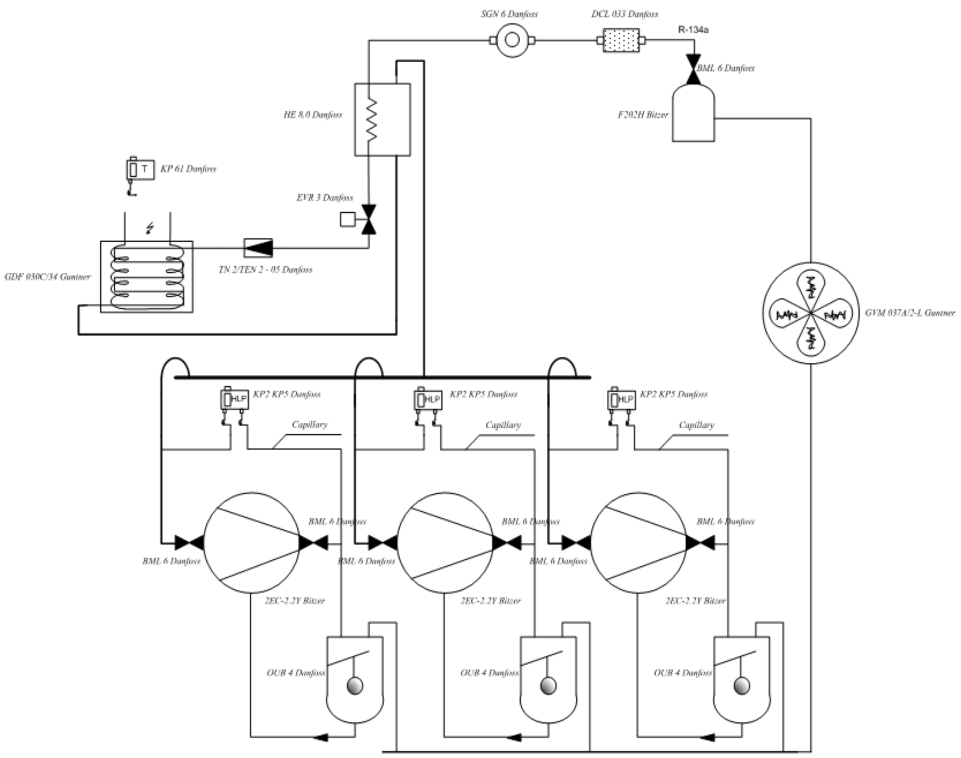


Fig. 3. Piping Design

c) Electrical Diagram

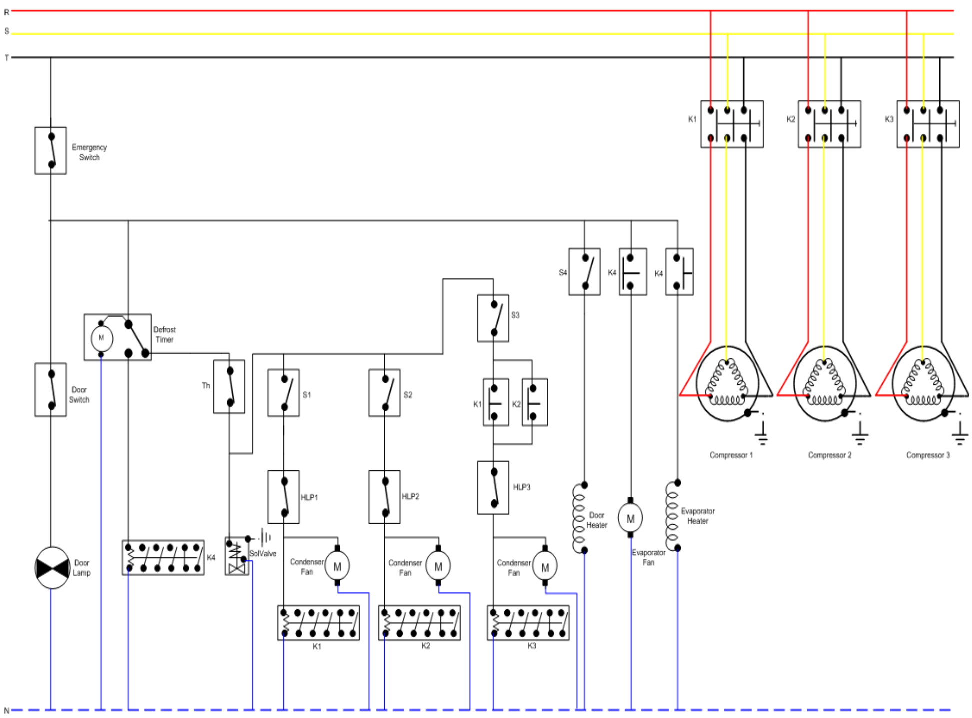


Fig. 4. Electrical Design

d) Insulation Construction

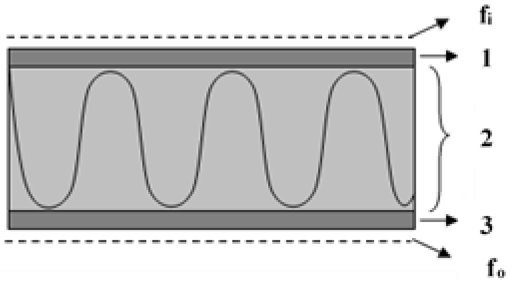


Fig. 5. Wall Construction

Table 1 Wall Construction and Insulation

Wall	**Thick(m)**	**K(w/m.K)**	**H(w/m^2.K)**
(1) Stainless Steel	0.001	14.5	-
(2) Polyurethane	0.09	0.025	-
(3) Stainless Steel	0.001	14.5	-
Convection Coefficient, fo	-	-	22.7
Convection Coefficient, fi	-	-	9.37

RESULTS AND DISCUSSION

After calculating the cooling load using the formula described, the resulting equipment capacity value is 5.16 kW. The next step is to select cold storage equipment and components. Some of the software used in the selection of these equipmentis:

- *SoftwareBitzer + Programme*.
- *SoftwareGuntner Product Calculator 2004 Customer*
- *Software Coolcat Danfoss* 2005

The results that have been obtained using the software above are as follows:

B. Refrigeration Components

1. Compressor

The compressor used is the Semi-Hermetic Reciprocating Compressor 2EC-2.2Y Bitzer model.

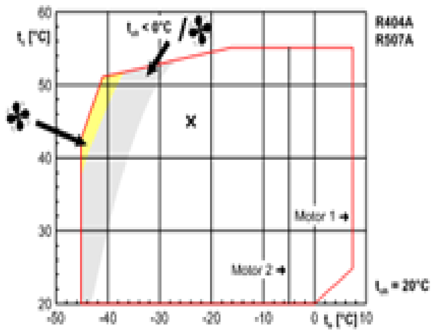
Bitzer SOFTWARE Version 5.0	08/01/2009 / All data subject to change.

Compressor Selection: Semi-hermetic Reciprocating Compressors

Input Values

Compressor model	**2EC-2.2Y**
Refrigerant	R404A
Reference temperature	Dew point temp.
Evaporating SST	-24°C
Condensing SDT	45°C
Liquid sub-cooling	5K
Suction gas temperature	20°C
Power supply	400V-3-50Hz
Useful superheat	100%
Capacity regulation	100%

Application Limits (100%)



Output

Compressor model	**2EC-2.2Y-40S**
Cooling capacity	3.08 kW
Cooling capacity *	2.88 kW
Evaporator capacity	3.08 kW
Power input	1.96 kW
Current (400V)	3.81 A
Voltage range	380-420V
Condensing capacity	4.84 kW
COP/EER	1.57
COP/EER *	1.47
Mass flow	84.4 kg/h
Operating mode	Standard
Discharge temp.	121.0 °C

CERTIFIED PRODUCT ASERCOM

*Compressor-Performance data certified by ASERCOM (see T.Data/ Notes)

*according to EN12900 (20°C suction gas temp., 0K liquid sub-cooling)

Fig. 6. Example of Bitzer Software Results for Compressor Output

Condenser

The condenser used is the Air-Cooled Condenser type GVM 037A / 2-L Guntner.

Evaporator

The evaporator used is the Guntner GDF 030C / 34 type evaporator.

2. TXV

The TXV used is the Danfoss TN 2 / TEN 2-05 TXV type

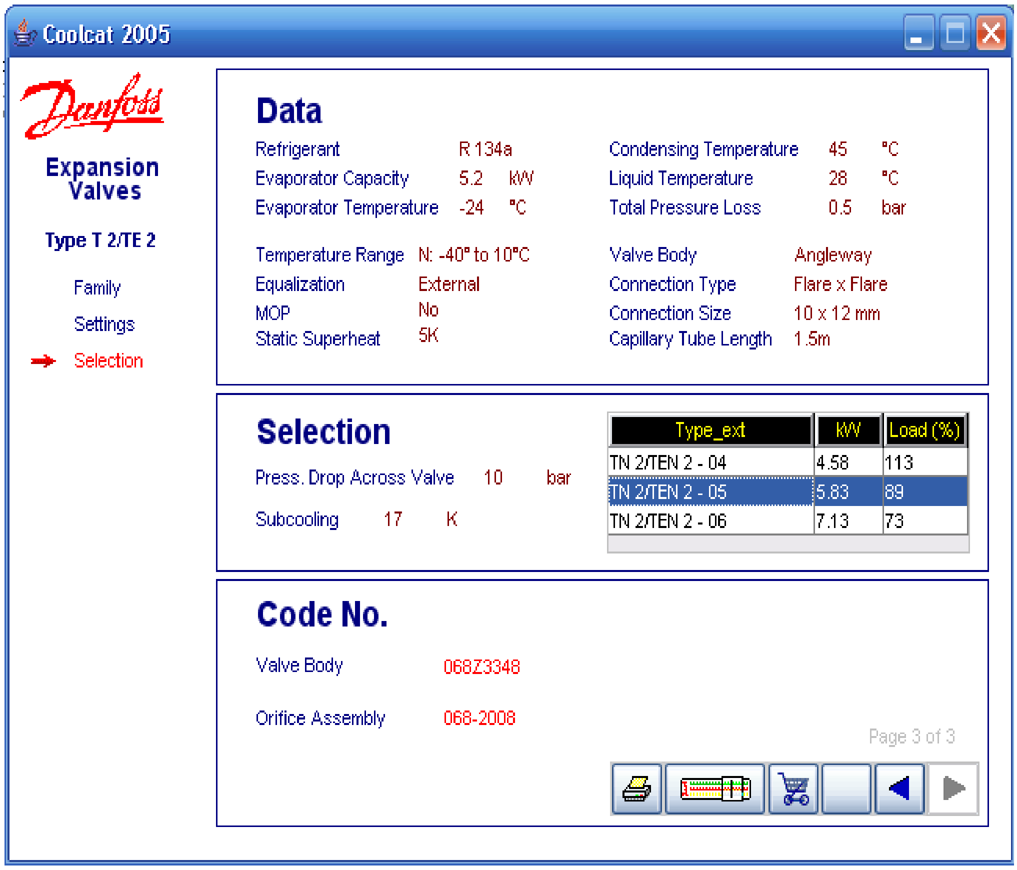


Fig.7 Sample Results for Coolcat Danfoss Software for TXV

3. Shut-off Valve
The shut-off valve used is the BML 6 Danfoss type.
4. Filter Dryer
The filter dryer used is the Danfoss DCL 033 type.
5. Sight Glass
The Sight Glass used is the SGN 6 Danfoss type.
6. Oil Separator
The oil separator used is OUB 4 Danfoss
7. Heat Exchanger
The heat exchanger used was HE 8.0 Danfoss
8. Liquid Receiver
The liquid receiver used is the F202H Bitzer type

Electrical components

1. HLP
The HLP used are the KP2 (low pressure) and KP5 (high pressure) Danfoss types.
2. Solenoid Valve
The solenoid valve used is the Danfoss EVR 3 type.
3. Thermostat
The thermostat used is the Danfoss KP 61 type

CONCLUSION

1. This design uses a large capacity vapor compression system using R-134a refrigerant.
2. The total capacity of this design equipment is 5.4 kW.
3. This cold storage uses 3 compressors, where 1 compressor is a backup compressor. Each compressor has a capacity of 2.7 kW.
4. Using several software in the selection of tools, namely:

- Software Bitzer + Programme.
- Software Guntner Product Calculator 2004 Customer
- Software Coolcat Danfoss 2005

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