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Applying Bitzer software in industrial refrigeration system design

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ABSTRACT: Today, with the advancement of science and technology, equipment manufacturers always provide to the market products for refrigeration systems with superior features. To choose equipment to suit the purpose and refrigeration needs of each specific system, it is necessary to calculate the most optimal design, ensuring both the cooling coefficient and the safety and reliability, while also ensuring the safety and reliability of the system. The device's performance is optimal. Therefore, this article proposes to learn about the application of Bitzer software in calculating and selecting equipment for industrial refrigeration systems.

KEYWORDS: Refrigeration systems, Bitzer software, Compressors, control.

I. INTRODUCTION

Currently, many different refrigeration systems are commonly used in factories and industrial enterprises, especially industrial product storage warehouses. Therefore, faced with many different technological requirements for refrigeration systems, it is necessary to design the system to ensure optimal refrigeration coefficient, calculate quickly and accurately, and choose the most suitable equipment. Applying technology in this calculation and design process is essential. This article will apply Bitzer software in the design process to calculate and select main equipment such as compressors, condensers, and throttles for industrial refrigeration systems to improve accuracy and reliability in the design process.

Refrigeration is a technique that creates an environment with a temperature lower than the normal temperature of the environment. There are many different views on the limit between cold temperature and normal temperature, but in general, the limit is the environment. Cold is an environment with a temperature less than 20^0C. In a cold environment, it is divided into two temperature zones. That is the low positive temperature range, this range has temperatures from 0 ÷ 20^0C and the remaining temperature range is called the freezing temperature of the product. Because this temperature range is the freezing temperature of water, depending on the type of product, the freezing temperature is different.

Refrigeration technology has been applied in many important fields. One of the important applications is in the food technology industry. According to statistics, about 80% of cold technology is used in food technology. Preserved foods such as meat, fish, milk... are foods that are easily damaged due to the effects of microorganisms and internal enzymes in the food, so they need to be refrigerated.

In general, a refrigeration system is a device used to lower the temperature of an object to serve other objects.

Figure 1. The industrial refrigeration system

Choosing working parameters for the refrigeration system is very important because if a reasonable and correct working mode is chosen, it will bring high economic efficiency. The working mode of the refrigeration system is characterized by the following 4 temperature parameters:
- Boiling temperature of the medium t_o (°C).

- Condensation temperature of the medium t_k (°C).
- Supercooling temperature of the liquid after the condenser: $\Delta t_{ql} = 10°C$
-Suction steam temperature to the compressor (superheat temperature): $\Delta t_{qn} = 10°C$

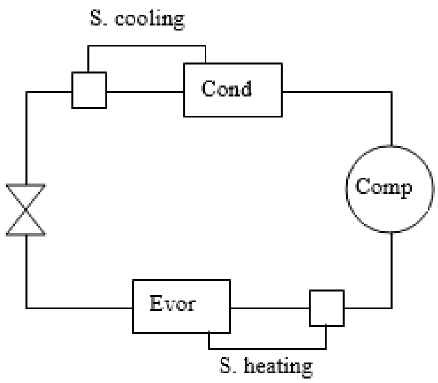

Figure2. The block diagram of the refrigeration system

The refrigerant vapor at the evaporator outlet has temperature t_o, pressure p_o and is superheated at the superheater to the superheated vapor state $t_{1'}$. The superheated steam is sucked into the compressor suction head by the compressor and adiabatically compressed to a high temperature, high pressure state then follows the pipeline into the oil separator. At the oil separator, the oil will be separated from the medium because the medium vapor changes direction suddenly. The separated oil is returned to the compressor while the refrigerant vapor continues through the pipeline to the condenser. Here, the refrigerant vapor is released heat to the environment thanks to devices that support the cooling process, condensing into liquid the refrigerant is brought to a high-pressure tank, the refrigerant changes its vapor state to a liquid state. The liquid refrigerant continues to be supercooled to a low temperature $t_{3'}$, then the refrigerant liquid from the high-pressure tank passes through the filter pin, then continues through the expansion valve to reduce temperature and pressure t_o, p_o, the refrigerant transfers from high temperature, high pressure state to low temperature, low pressure state. The liquid medium goes from the expansion valve into the evaporator, where the liquid medium receives heat from the environment that needs to be cooled, meets the boiling temperature, will boil and evaporate. The medium changes from the liquid state to the vapor state. The refrigerant vapor escaping from the evaporator is fed into the superheater to perform the superheating process, passing through the liquid separator and then being used by the compressor to close the cycle.

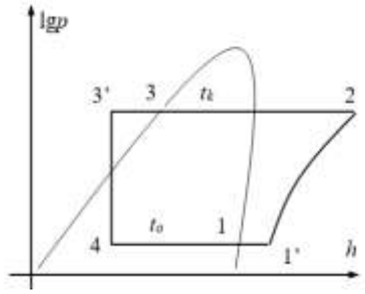

Figure3. The working graph

The working graph in Figure 3 shows the working cycle of a simple single-stage compression refrigeration system. The graph also shows the basic parameters of the working process corresponding to each main device in the structure diagram of Figure 2 including temperature, pressure, specific volume of refrigerant vapor sucked into the compressor, temperature too cold, too hot temperature, enthalpy to use in calculating heat output, heat gain, adiabatic compression work, cooling capacity of the system.

II. BITZER SOFTWARE APPLICATION FOR DEVICE SELECTION

Bitzer software is used in calculating and selecting main equipment of the refrigeration system such as compressors.

With Bitzer software, you can choose a single compressor, choose a condenser compressor cluster, choose a one-stage compressor, two-stage compressor, choose different compressor types, different media from which you can choose the optimal type to meet your needs. meet technology requirements.

The interface of Bitzer software is described in Figure 4:

Figure4. Bitzer software interface

Click to select the type of compressor that matches the technological requirements of the refrigeration system, select the SI system and

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update the parameters according to the required problem data.

Without losing generality, consider a refrigeration system with the following parameters:
Refrigerant: R22
Straight-line, 1-stage Freon compressor.
Refrigeration capacity of compressor:
Q_o = 9,8505(kW)
Look up Bitzer software with the software parameters:
Machine model: Standard type
Compressor type: Single compressor
Refrigerant: R22
Cooling capacity: 9,8505(kW)
Saturated evaporation temperature: -10^{o}C
Ambient temperature: 45^{o}C
Liquid gas temperature: 35^{o}C
Suction gas temperature: 0^{o}C
Load reduction condition: 100%
Power frequency: 50Hz
After entering the data, press the Run key, the system displays the results.

Figure5. Results from running the software

Figure 5 shows the results obtained for two types of compressors 4FES-3-40S and 4EES-4-40S.

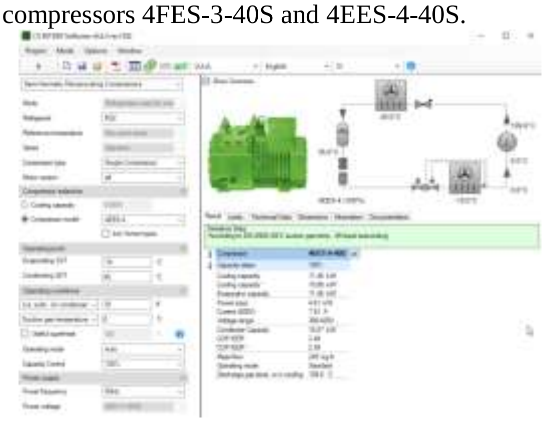

Figure6. Parameters of the 4EES-4-40S compressor

The boiling temperature of the medium depends on the temperature of the cold storage.
The condensation temperature depends on the temperature of the condenser's cooling medium.
We can observe the boiling temperature and condensation temperature right on the structure diagram described in Bitzer software, figure 6.

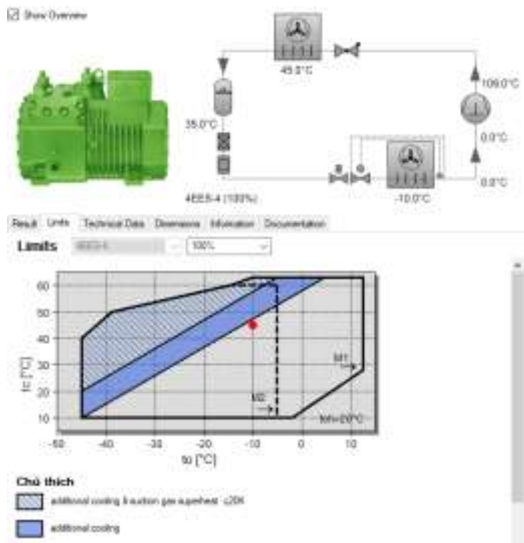

Figure7. Limit indicators of the 4EES-4-40S compressor

From the results obtained from the software, we can choose the half-kin piston compressor 4EES-4-40S with the following parameters:
Cooling capacity: 11,46 (kW)
Cooling capacity*: 10,88 (kW)
Evaporator capacity: 11,46 (kW)
Input power: 4,61 (kW)
Current: 7,91 (A)
Flow: 249 (kg/h)
Moto data:
Moto version: 2
Motor voltage (more on request): 380-420 (V) – 50 (Hz)
Max operating current: 12,2 (A)
Starting current (Roto locked): 53,5 (A)
Max power input: 6,9 (kW)
Technical Data:
Displaceement (1450 RPM 50Hz): 22,72 (m^3/h)
Displaceement (1750 RPM 50Hz): 27,42 (m^3/h)
No. of cylinder x bore x stroke: 4 x 46 mm x 39,3 mm
Weigh: 84 (kg)
Max. pressure (LP/HP): 19/32 (bar)
Connection suction line: 28 mm-11/8’’
Connection dischage line:16 mm-5/8’’

III. CALCULATE AND CHECK THE 4EES-4-40S COMPRESSOR IN THE FOOD PRESERVATION REFRIGERATION SYSTEM

a. Parameters of the refrigeration system cycle

Determine the cycle nodes 1, 1', 2, 3, 4 on the lgp-h graph as shown in Figure 3:

Point 1: Intersection of p_o and x = 1 (dry saturated steam)

Point 1': Intersection of p_o and t_{qn} (superheat temperature)

Point 2: Intersection of p_k and $s_1 = s_2$

Point 3: Intersection of p_k and x = 0 (liquid saturation)

Point 3': The intersection of p_k and the supercool temperature t_{ql}.

Point 4: The intersection of p_o and h_3 because the throttling process $h_3 = h_4$

Node point	1	1'	2	3	3'	4
t (°C)	-10	0	79	45	35	-10
p (bar)	3,75	3,75	18	18	18	3,75
h (kJ/kg)	1204	1208	1242	1059	1038	1038
v (m^3/kg)		0,063				
Status	Dry saturated vapor	Superheat vapor	Superheat vapor	Supercool liquid	Saturated liquid	Wet vapor

Table1. Node status parameter table.

b. Cycle calculation

- Specific cooling capacity q_o (kJ/kg)

$$q_o = h_1 - h_4 \ (kJ/kg)$$

In there:

h_1: Enthalpy of dry storm vapor after leaving the evaporator

h_4: Enthalpy of the medium after passing through the expansion valve

$$q_o = h_1 - h_4 = 1204 - 1038 = 166 (kJ/kg)$$

-Actual volume capacity of the compressor (compressed fluid flow through the compressor):

$$m = \frac{Q_o}{q_o} \ (kg/s)$$

In there:

Q_o = 10,88(kW): Refrigeration capacity of the compressor

m: Actual mass capacity of the compressor (compressed medium flow through the compressor)

$$m = \frac{Q_o}{q_o} = \frac{10,88}{166} = 0,065 \ (kg/s)$$

- Separate compression:

$$l = h_2 - h_{1'} = 1242 - 1208 = 34 \ (kJ/kg)$$

- Cooling coefficient:

$$\varepsilon = \frac{q_o}{l} = \frac{166}{34} = 4,88$$

- Heat released in the condenser q_k:

$$q_k = h_2 - h_3 = 1242 - 1059 = 183 (kJ/kg)$$

Therefore

$$Q_k = m.q_k = 0,065.183 = 11,895 \ (kW)$$

From $\Pi = \frac{p_k}{p_o} = \frac{18}{3,75} = 4,8$ *then* $\lambda = 0,72$

- Actual suction volume:

$$V_{tt} = m.v_{1'} = 0,065.0,063 = 0,0041 \ (m^3/s)$$

$$= 14,742 \ (m^3/h)$$

- Theoretical suction volume:

$$V_{lt} = \frac{V_{tt}}{\lambda} = \frac{14,472}{0,72} = 20,1 \ (m^3/h)$$

$$= 0,0056 \ (m^3/s)$$

- Adiabatic compression work N_s:

$$N_s = m.l = 0,065.34 = 2,21 \ (kW)$$

- The N_i indicator compression work is the real compression work, paying attention to losses during the real compression process such as volume loss, throttling loss...

$$N_i = \frac{N_s}{\eta_i} \ (kW)$$

where: η_i is the determined indicator efficiency

$$\eta_i = \lambda_w + b.t_o = \frac{T_o}{T_k} + b.t_o$$

$$= \frac{273,15 - 10}{273,15 + 45} + 0,0025.(-10) = 0,802$$

So: $N_i = \frac{N_s}{\eta_i} = \frac{2,21}{0,802} = 2,76 \ (kW)$

- Useful power N_e is the power measured on the crankshaft.

WithN_{ms} is work due to friction

p_{ms} is the friction pressure for a compressor using straight-line freon andp_{ms} = 49 – 69 (kPa) for straight-line freon compressor. We choose p_{ms} = 59 (kPa)

$$N_{ms} = V_{lt}.p_{ms} = 0,0056.59 = 0,33 \ (kW)$$

And then,

$$N_e = N_i + N_{ms} = 2,76 + 0,33 = 3,09 \ (kW)$$

-The power consumption of an engine$N_{el}$is the power measured on the engine's electrical connection panel.

$$N_{el} = \frac{N_e}{\eta_{td}.\eta_{el}} = \frac{3,09}{0,95.0,9} = 3,614 \ (kW)$$

Where: the transmission loss $\eta_{td} = 0,95$

The electric motor efficiency $\eta_{el} = 0,85 \div 0,95$

We choose $\eta_{el} = 0,9$

So, the safety factor is:

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$$S = \frac{N_{dc}}{N_{el}} = \frac{4,61}{3,614} = 1,3$$

This safety factor is within the allowable range from 1,1 to 2,1. Therefore, choosing the 4EES-4-40S compressor motor is completely suitable for the food preservation refrigeration system according to the above technological requirements.

IV. CONCLUSION

Through the results of running on Bitzer software and calculating and checking the parameters, it can be seen that the compressor, the main equipment in the industrial refrigeration system, was selected to meet the technological requirements of cooling capacity as well as coefficient. safety within allowable limits to ensure the system works safely and reliably. From there, it shows that applying Bitzer to the design and selection of industrial refrigeration system equipment contributes to improving accuracy, speed and reliability.

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