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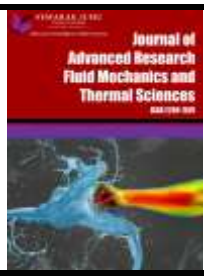

The Improvement of Energy Efficiency in Refrigeration Systems using Ultrasonic Sensors

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ABSTRACT

Climate change is still an important issue that needs concrete support and action. Refrigerant is also one material that affects global warming and international have plans to reduce the use of HFC refrigerants. Thailand also uses R404A refrigerant, which is an HFC refrigerant with a GWP of up to 3, 129and Thailand plans to reduce its use by 15% in 2030. R404A is the most widely used HFC refrigerant today because it can be used in both refrigeration and air conditioning systems. In the refrigeration system, which uses about 1ton of refrigerant, when a leak occurs, in addition to affecting global warming and maintenance costs, it also affects the energy consumption of the refrigeration system. From data on the amount of refrigerant used in 2022, it was found that the use of refrigerant for maintenance is 25 tons, averaging 2 tons per month. This research will present the optimization of the maintenance refrigeration system by decreasing carbon emissions using ultrasonic sensors to keep the refrigerant level. The ultrasonic detects flat gas in refrigeration systems, which can detect fluid leaks rather than leaks. detector or using a sight glass. The results of the research found that when the refrigerant leak can be fixed quickly, it will save the use of refrigerant and help reduce energy. When fixing a leaking refrigerant system, 1) 10% will reduce energy by 7%. 2) 20% will reduce energy by 17% 3) 30% will reduce energy by 59%. This system will be able to be expanded to other stores and air conditioning systems in the future.

1. Introduction

The retail business continues to grow every year. In Thailand by 2023, there will be more than 1,500 supermarkets [1]. Some supermarkets are open 24 hours and consume a lot of energy. Most of the energy consumption is refrigeration, while the air conditioning and lighting systems consume energy respectively. Although energy efficiency has been developed in each system, to achieve the integration of each system [2]. The energy management system (EMS) therefore helps to save energy [3]. Climate change is still an important issue that needs concrete support and action. Refrigerant is

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also one material that affects global warming and international have plans to reduce the use of HFC refrigerants as shown in Figure 1 [4]. Thailand also uses R404A refrigerant, which is an HFC refrigerant with a GWP of up to 3,129 and Thailand plans to reduce its use by 15% in 2030 as shown in Figure 2 [5]. In the refrigeration system, which uses about 1 ton of refrigerant, when a leak occurs, in addition to affecting global warming and maintenance costs, it also affects the energy consumption of the refrigeration system [6]. From data on the amount of refrigerant used in 2022, it was found that the use of refrigerant for maintenance is 25 tons, averaging 2 tons per month [7]. In terms of maintenance, whether it is preventive maintenance or breakdown maintenance. The system should keep the system's performance by keeping the refrigerant amount care of the system so that it does not leak will reduce carbon emissions and reduce the energy use in the system [8].

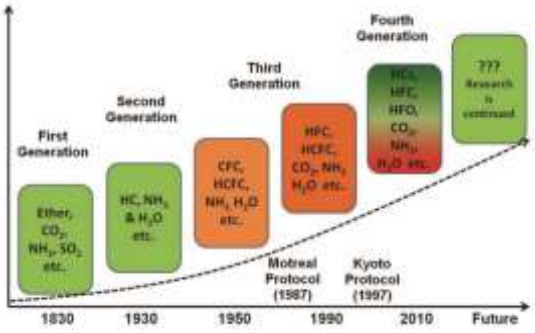


Fig. 1. The progress of refrigerant

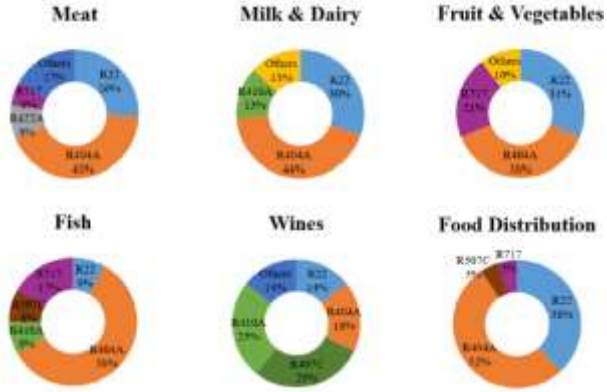


Fig. 2. The refrigerant used in industry

The compressor rack in the supermarket has 4 options to see the refrigerant amount; (1) low liquid alarm at the receiver tank, the low liquid alarm sensor will be installed at the lowest location of the receiver tank. The sensor will connect to MDB and show an alarm this is basically to see the refrigerant amount but the refrigerant amount at the lowest location of the receiver tank will affect cabinet temperature problems because when the low refrigerant the cooling capacity will decrease and affect to compressor's high operating percentage and high-power consumption [9]. (2) The cabinet temperature at the farthest location in daytime peak load. Normally the run time of the cabinet the cabinet should achieve the setpoint temperature within 15 minutes. If the temperature cannot achieve the setpoint temperature within 30 minutes that can analysis the system will have a normal leakage refrigerant amount, (3) seen by a manual at-sight glass liquid piping line. The A mean is the refrigerant no leakage can be seen the bubbles are not generated. The B is a small refrigerant leakage but the technicians are very difficult to analyze because sometimes in high ambient temperatures or dirty condensers or damaged fan condensers the small amount will happen in some time and continue back to A refrigerant with no leakage. If the refrigerant amount leaks until C large amount of refrigerant the system will have cabinet temperature problems because when the low refrigerant the cooling capacity will decrease and affect to compressor's high operating percentage and high-power consumption. The appearance of the sight glass in A, B, and C conditions is shown in Figure 3.

A: Full refrigerant amount B: Small leakage C: Large leakage

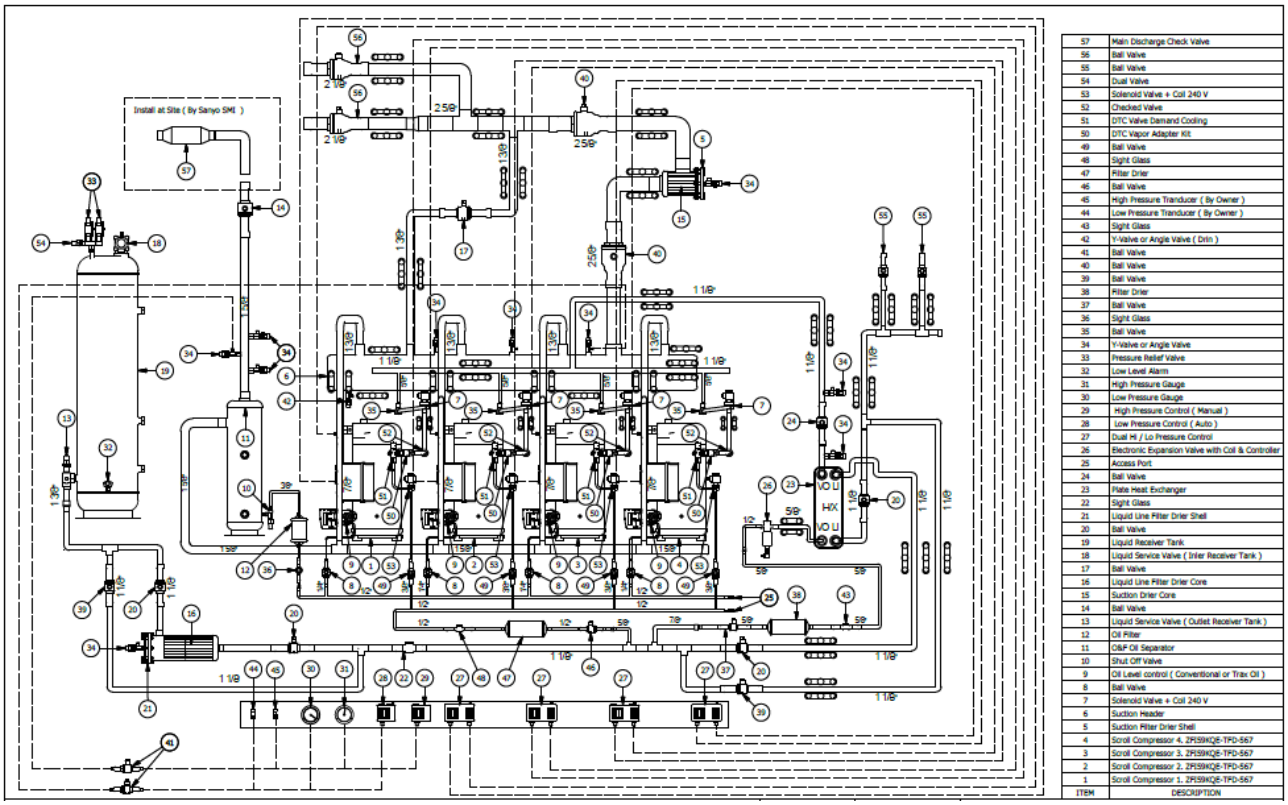
Fig. 3. The appearance of the sight glass in A, B, and C conditions

(3) Receiver tank sight glass at compressor rack. In the daytime peak load is the time is the time that requests the cooling capacity to archive the cabinet temperature and heat rejection for the condenser. If cannot see the refrigerant level at the bottom sight glass that means the refrigerant leaks a large amount. The receiver tank sight glass at the compressor rack is shown in Figure 4. (4) Measure the temperature and pressure at the system design. The measuring system and commissioning near the design point means the system will have a full refrigerant amount that can be calculated by the formula evaporator temperature (Convert by low pressure) + Differential temperature = Cabinet temperature, and Condenser Temperature (Convert by high pressure) - Temp difference temperature = Ambient temperature. This research will present the optimization of the maintenance refrigeration system by decreasing carbon emissions using ultrasonic sensors to keep the refrigerant level. The ultrasonic detects flat gas in refrigeration systems, which can detect fluid leaks rather than leaks, and a detector uses a sight glass or see the cabinet temperature at the farthest location or measure the temperature and pressure at the system design [10-14].

Fig. 4. The receiver tank sight glass at the compressor rack

2. Methodology

The refrigeration system used in this research is 20hp 4 units scrolls compressors, which uses about 1 ton of R404A refrigerant. The ultrasonic sensor installation at the liquid piping outlet of the receiver because the liquid piping outlet in normal condition should be no flat gas. The additional sensor to see the different results of different conditions such as liquid temperature and discharge temperature to measure the data after the systems complete 6 Months. The power consumption is measured by a 3-phase power meter for the refrigeration system. The Ultrasonic sensor for measuring flat gas is shown in Figure 5 and Figure 6.



ITEM	DESCRIPTION
57	Main Discharge Check Valve
56	Ball Valve
55	Ball Valve
54	Dual Valve
53	Solenoid Valve + Coil 240 V
52	Checked Valve
51	DTC Valve Damand Cooling
50	DTC Vapor Adapter Kit
49	Ball Valve
48	Sight Glass
47	Filter Drier
46	Ball Valve
45	High Pressure Trandcuer (By Owner)
44	Low Pressure Trandcuer (By Owner)
43	Sight Glass
42	Y-Valve or Angle Valve (Drin)
41	Ball Valve
40	Ball Valve
39	Ball Valve
38	Filter Drier
37	Ball Valve
36	Sight Glass
35	Ball Valve
34	Y-Valve or Angle Valve
33	Pressure Relief Valve
32	Low Level Alarm
31	High Pressure Gauge
30	Low Pressure Gauge
29	High Pressure Control (Manual)
28	Low Pressure Control (Auto)
27	Dual Hi / Lo Pressure Control
26	Electronic Expansion Valve with Coil & Controller
25	Access Port
24	Ball Valve
23	Plate Heat Exchanger
22	Sight Glass
21	Liquid Line Filter Drier Shell
20	Ball Valve
19	Liquid Receiver Tank
18	Liquid Service Valve (Inler Receiver Tank)
17	Ball Valve
16	Liquid Line Filter Drier Core
15	Suction Drier Core
14	Ball Valve
13	Liquid Service Valve (Outlet Receiver Tank)
12	Oil Filter
11	Oil&F Oil Separator
10	Shut Off Valve
9	Oil Level control (Conventional or Trax Oil)
8	Ball Valve
7	Solenoid Valve + Coil 240 V
6	Suction Header
5	Suction Filter Drier Shell
4	Scroll Compressor 4, ZF55KQE-TFD-567
3	Scroll Compressor 3, ZF55KQE-TFD-567
2	Scroll Compressor 2, ZF55KQE-TFD-567
1	Scroll Compressor 1, ZF55KQE-TFD-567

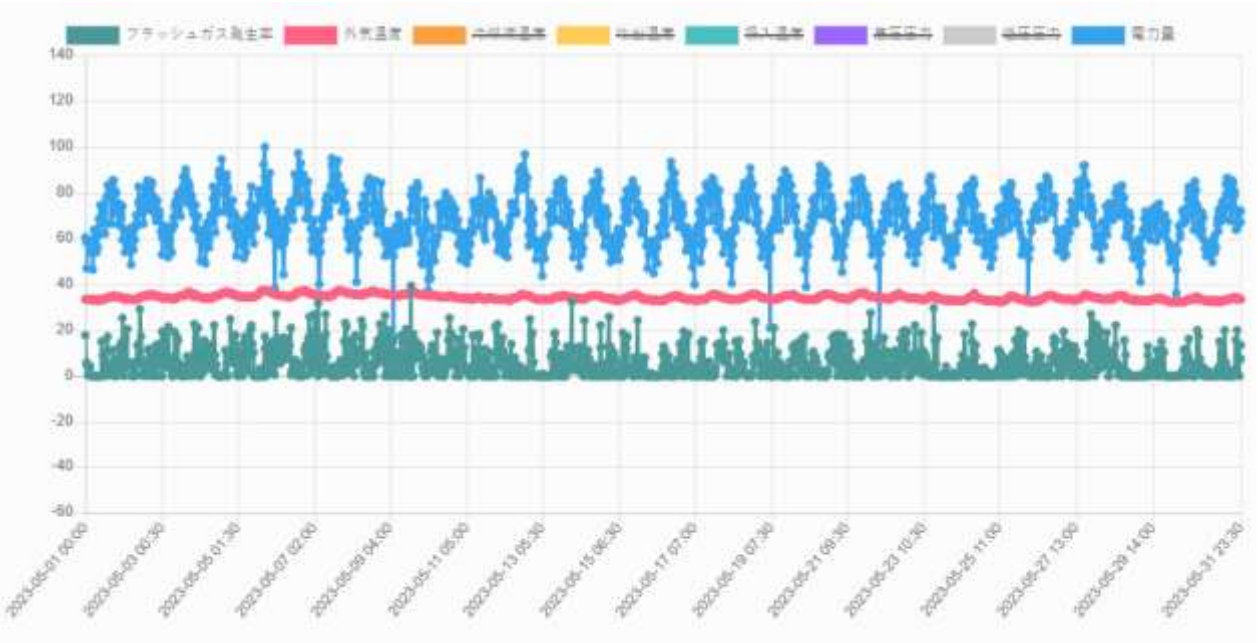
Fig. 5. The diagram of the refrigeration system

Fig. 6. Ultrasonic sensor for measuring flat gas

3. Results

The result of measuring flat gas in a refrigeration system using an ultrasonic sensor is shown in Figure 7 which measures 1 month to see the difference of flat gas. The maximum flat gas is 40% and the minimum is 0% means that sometimes flat gas happens in some conditions in the system. In this case, the setpoint of flat gas in a refrigeration system maximum of 40-50% to protect refrigerant leakage in systems to save carbon emission protect the damaged product in the cabinet, and save the power consumption for archiving the cabinet setpoint when low capacity. The result of measuring flat gas in a refrigeration system using an ultrasonic sensor is shown in Figure 8 which measures 7 Days to see the reason for the difference of flat gas. At night time which is low operating with low ambient temperature, the result shows 0-10% flat gas which means a good heat rejection effect on refrigerant volume in the refrigeration system. The measure of flat gas 0-30% in day time means

when the ambient temperature increases the percentage of flat gas will increase too. In this case, to reduce the percentage of flat gas cans an additional 4 options for measuring refrigerant amount.



• Flat gas percentage, • Liquid Temperature, • Discharge Temperature

Fig. 7. The result of measuring flat gas in 1 Month

• Flat gas percentage, • Liquid Temperature, • Discharge Temperature

Fig. 8. The result of measuring flat gas in 7 Days

For the power consumption testing with refrigerant leakage 10%, 20%, and 30% as shown in Figure 9 and Figure 10 when fixing a leaking refrigerant system, (1) 10% will reduce energy by 7%. (2) 20% will reduce by 17% and (3) 30% will reduce energy by 59%.

Fig. 9. The result of measuring flat gas in 24 Hours

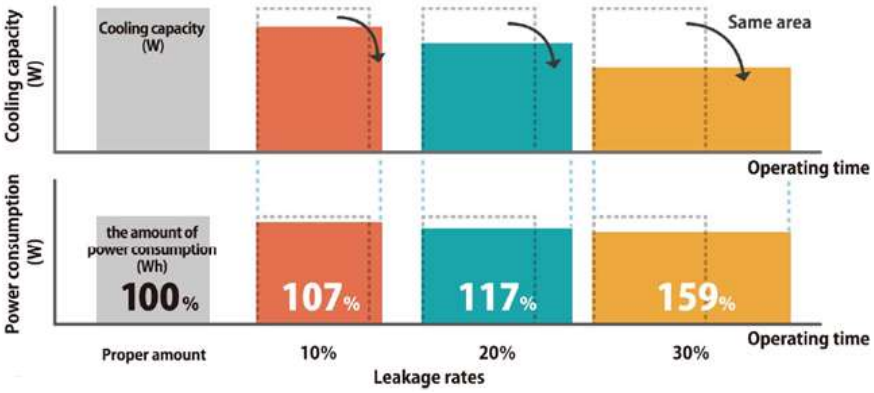


Fig. 10. The result of measuring power consumption with refrigerant leakage percentage

4. Conclusions

The refrigeration system that measures flat gas in a system using an ultrasonic sensor can protect against refrigerant leakage in systems to save carbon emission protect the damaged product in the cabinet, and save the power consumption for archiving the cabinet setpoint when low capacity. For setting a flat gas setpoint should see the result in 1 Month. The results of the research found that when the refrigerant leak can be fixed quickly, it will save the use of refrigerant and help reduce energy. When fixing a leaking refrigerant system, 1) 10% will reduce energy by 7%. 2) 20% will reduce by 17% and 3) 30% will reduce energy by 59%. This system will be able to be expanded to other stores and air conditioning systems in the future.

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