Frost Preventive Control System of Freezer

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Abstract. Freezer is widely used by the people as a place to store frozen food that has a cooling temperature reaches -28 °C. Factors that affect the performance of the freezer is an unstable electric current, frost and others things [1]. The most frequent problem found is frost. Previous research shows that the thickness of the frost up to 5 mm and 10 mm of freezer energy consumption up to 20% and 33%. The formation of frost is a common physical phenomena that occur at environmental temperature conditions freezer and humidity. The heat exchange occurs and the water molecules in the air condenses as the temperature in the freezer is below the dew point and causes frost growth. The prevention formation frost by means of the air moist in the freezer absorb and condensation with tools. Tools make air circulation, after which the air moist not returned in the freezer. The experimental study verifies the tools can reduce consumption power up to 11% in 2.5 hours. This can be one of the alternatives for the community in order, to maintain the freezer good condition also reduce power consumption so that the freezer is more durable and energy efficient.

1. Introduction
Freezer is widely used by people as a place to store frozen food that has a cooling temperature reaches -28 °C. Freezer has huge energy saving potential. That affect the performance of the freezer is an unstable electric current, frost and others things [1]. The most frequent problem found is frost. In low temperature the air in the freezer absorb moist and condensation bring on the water molecules and getting frost with low temperature in freezer so the process produce frost[2].

Air moist composed by vapor and air. The water vapor content of air can be expressed humidity [3]. It’s mean water vapor in the air as ratio of the maximum capacity that the air can hold its temperature. Condensation process is air moist cooled bellow temperature called dew point and condensation nuclei must be present [4].

Frost will hinder the heat exchange of evaporator, it will greatly reduce the refrigerator cooling efficiency and increase energy consumption [5]. Previous research shows that the thickness of the frost up to 5 mm and 10 mm at freezer. Energy consumption up to 20% and 33% [3]. Frosting conditions was influenced by air moist, wall temperature and air velocity [5]. But at present most research is conducted for air source heat pump heat exchanger. In order to solve the problem that we can reduce frost using we tools. The tools or we call it anti frosting that can applied in refrigerator and other refrigeration.
frost can prevention frost with removing mosit air in the chest freezer. So that we can solve reduce frost and achieve the goal of energy saving.

2. Methods

2.1. The principle of condensation process
Normally, air contains in atmospheric 1-3 % water vapor by volume. Conduct condensation by lowering the temperature to the dew point. Anti-frosting condensate the humid air in the freezer. Condensation process using thermoelectric coolers (TEC). Thermoelectric coolers operate according to the Peltier effect. The effect creates a temperature difference by transferring heat between two electrical junctions. A voltage is applied across joined conductors to create an electric current. When the current flows through the junctions of the two conductors, heat is removed at one junction and cooling occurs. Heat is deposited at the other junction. The main application of the Peltier effect is cooling. However the Peltier effect can also be used for heating or control of temperature. In every case, a DC voltage is required.

\[
\Delta T = T_C - T_H \\
T_C = \Delta T + T_H
\]

Where \(\Delta T\) = Difference temperature between side.

\(T_C\) = Temperature of the cold side.

\(T_H\) = Temperature of the hot side.

On the equation 1 and 2 when hot side peltier has lower temperature make a cold side lower that before. The temperature difference between the two sides is about 40 °C- 70 °C. To create a lower temperature of the hot side, usually used heat sink, fan, thermal pasta, water block and other things.
2.2. The principle of input sensor

Anti-frosting work depends on conditions on the humidity of temperature, water and frost in the freezer.

2.2.1. Humidity and temperature sensor. Humidity and temperature are detected because frosting process is air moist with lower temperature Anti-frosting using DHT11 to detect moisture and temperature in the freezer. DHT11 is a sensor that can measure two parameters at once. DHT11 has a small size, low power consumption and distance transmission signal up to 20m. They are some of the advantage of this sensor.

2.2.2. Water and frosting sensor. Frost is a matter a complex structure and it is composed of vapor and ice crystals. There are a lot research results on the frost layer structure model. Figure 3 shows the Yonko-Sepsy model of frost and the main structure of ice crystal in frost.
Figure 4 shows the structure diagram of frost sensor or water sensor composed by bakelite or mica plate and aluminum wire. It should get connected to the circuit and voltage should be passed through the wires. If there is no frost and water, the resistance between the wires will be very high and there will be conduction between the wires in the sensor. If there is water and frost, the water drop will fall on the sensor which will also decrease the resistance between the wires and wires on the sensor board.

Using DHT11 and frost detector sensor with advantages of low price, good consistency and easy to install.

2.3. The principle of anti-frosting
Using chest freezer with size x x cm. The unit can work normally in the range temperature of -40°C to 5°C. Air in the chest freezer is 300L with humidity of 60% - 80%. Test equipment in first condition freezer with room temperature of 20°C – 25°C and with humidity of 60% - 80%.

Installation Anti-frosting at chest freezer as shown in figure 5. After Anti-frosting turned on, the moist air in the freezer will be inhaled with the pump, flowed to condensation process in Anti-frosting. Condensation process in Anti-frosting consists of TEC, heat sink and fan. After that air status value of humidity and low temperature is lower than that before. Then the air of low temperature and low humidity returns back to the freezer with other pump. Anti-frosting do circulating air during the experiment around 2.5 hours.

Figure 5. Experimental apparatus system schematic diagram.

Information: 1. Pump, 3. Temperature and humidity sensor, 4. Frost sensor, 5. Fan, 6,8. Heatsink, 7. Thermoelectric coolers (TEC).
Figure 6. System control chart.

The test system control diagram is shown in figure 6. There are 3 main system diagram, input, process and output. Input process consist humidity, temperature freezer and water at wall water and Microcontroller processing the input. Output from the process are pump, peltier and fan. The Anti-frosting can reduce humidity with control a velocity pump and fan also a voltage of peltier.

3. Results and discussion
Experiment test is comparing energy consumption between freezer with Anti-frosting and freezer without Anti-frost is performance. We give some conditions for Anti-frosting testing: 1) not opened the door freezer; 2) opened the freezer door every 30 minutes for 30 seconds; 3) opened the freezer door every 60 minutes for 1 minutes. All experiment during 150 minutes and produce 3 sample at each conditions.

We can get the average energy consumption freezer conditions 1 from figure 7. Consumption freezer with Anti-frosting is lower than freezer without Anti-frosting in 150 minutes. Anti-frosting can reduce consumption power up to 7%.
From figure 8 we can see energy consumption freezer with Anti-frosting in conditions 2 is lower than freezer without Anti-frosting in 150 minutes. Anti-frosting can reduce consumption power up to 5%.

Figure 9 shows the consumption freezer with Anti-frosting in conditions 3 is lower than freezer without Anti-frosting in 150 minutes. Anti-frosting can reduce consumption power up to 11%.

Result of all experiment comparing energy consumption between freezer with Anti-frosting and freezer without Anti-frosting frost in 3 conditions. Performance from freezer with Anti-frosting it’s lower than freezer without Anti-frosting in 150 minutes.

4. Conclusions
The experimental study verifies the tools can reduce consumption power 5% until 11% in 2.5 hours. It can solve the reduce. It can solve the consumption energy because frosting. We designed a tool can reduce a frost thickness based humidity air with condensation process and also Anti-frosting can reduce consumption energy chest freezer, but has some disadvantages.

Anti-frosting experimental during 2.5 hours made the thickness of frosting less than 5 mm. Chest Freezer size too large is not compatible for Anti-frosting because tool can’t condensation quickly the air. Consumption energy Anti-frosting it’s 70 Watt. If want tools compatible for freezer, must need huge energy. Anti-freezing is difficult to applied in other refrigerators.
5. Future work
Anti-frosting system should be develop by it design that applicable with any type of freezer.

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