Design of monitoring system for drying and storage of shallot

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Abstract. Thermo electric cooler is an environmentally friendly cooling component because it does not produce harmful substances such as Freon or CFC which is usually produced by refrigerant and air conditioning so as not to damage the ozone layer in the atmosphere of the earth as well as global warming. In principle, TEC has a capability called peltier effect that is the temperature difference when the component is fed by an electric current. On one side of the TEC will absorb the heat and on the other side release the heat, in conditions absorb the heat of the TEC side becomes cold, while the heat-releasing side will be hot. With such unique capabilities, TEC can be applied to an air conditioner and heating device, so it can be used for other purposes or interests and without having to contribute harmful substances to the environment and atmosphere.

1. Introduction
Refrigerator and Air conditioner is not eco-friendly, because they use Freon and CFC. It can make ozone layering erosion and causing global warming. Substitute refrigerant and AC with Thermoelectric cooler (TEC) expect to reduce that Phenomenon [1-3]. TEC is a technology semiconductor that can convert two forms of energy are electrical and heat energy [4-6]. The ability conversion from electric potential difference to temperature mentions the Peltier effect [7]. And the ability conversion from temperature difference called the Seebeck effect [8].

Shallot is an important commodity for cooking needs for Indonesian foods and the other many benefits of shallots. But in going through all processes, the shallots will suckling weights or grow buds and getting rotten. The weights will reduce 25-40% in the drying process and 17% in the storage process [9].

So that the suckling weights problem needs a solution. For the problem Thermo electric cooler (TEC) expected can solve the problem. Hence, in this research Thermo electric cooler (TEC) submitted to solve the problem. This research describes the manufacture of cooler and heater make use of the Peltier effect that produces the difference temperature on each side (cool side and hot side). Using eight Thermo electric cooler (TEC) and combined with other components like a heatsink, cold sink, and fan. Cold sink as cool side will be cooler and heat sink as a hot side will be a heater. By treating shallots on coolers and heaters it is expected to be able to handle and provide solutions to this problem.

2. Thermo Electric Cooler (TEC) and Humidifier
The working principle of TEC is based on the Peltier effect in figure 1, when the DC current flow into
Peltier element that consists of several pairs of P-type semiconductors (i.e. lower energy semiconductors) and N types (semiconductors with higher energy) will cause one side of Peltier’s element to be cool because the heat energy is absorbed [7, 10]. And the other side will be hot because of the heat removed. And the otherwise if the currents are reversed.

A humidifier is a misting device or mist maker that works at high frequencies to produce water dots like white mist and creates moisture in the air.

**Figure 1.** Principle working of TEC.  **Figure 2.** Design of system for drying and storage shallots.

### 3. Research Method

The method of this research was divided into four stage: design and assemble of circuits, testing of TEC performance, nest data analysis of the result, applying it to the object, and the conclusion is the last step in the method in this study.

*Design and assemble of circuits* as follows:

- Hardware assemble consist of making body and tool frame, TEC assemble and installation, installation of humidifier and installation of circuits.
- The designing of software composed of the coding program in arduino for supporting the hardware.

Design of system for drying and storage shallots show in Figure 2. For the designing of cooler and heater room, the system use 8 of TEC. TEC, cold sink and fan will absorb the heat, so that the room temperature will be decreased, and the other side the heat sink will receive the heat and release it into the heater room. So, the room temperature rises, besides that the incandescent lamp helps increase the room’s temperature. Humidity in each room will decrease as long a the TEC works, So to increase the humidity is needed to use humidifier and fan.

Arduino will control the component connected. In this system, the DHT11 sensor will read the temperature and the humidity in each room and the Arduino can provide further action by controlling relays that connected with TEC, lamps, and humidifiers.

### 4. Result and Analysis

#### 4.1. Results of TEC configuration at coller room

The testing process for a cooler room using several sets of TEC like Figure 3, 4 and 5. We used three kind of combination series and parallel circuit.
The temperature obtained from the series of temperature combinations listed in figure 6 is around ± 25 °C for coolers and 31.5 °C for heaters. The temperature produced by the TEC can change depending on outside temperature of TEC. At the night condition, the temperature will be lower than afternoon, so that to reach the desired temperature must added an incandescent lamp at the heating side.

4.2. Result of testing process for heater room
Testing process in heater room using by TEC2-2-2-2 circuit and combined with several incandescent lamps. The configuration of TEC at Figure 3-5 can be seen that the best cooling temperature is at the 2-2-2-2 combination of TEC. Also the addition of a 60W incandescent lamp can help raise the heating temperature. Therefore this tool will use TEC combination of 2-2-2-2 with addition of incandescent lamps. The result with addition a humidifier to this condition would be increase the humidity in the cooling or heating room as seen at figure 7.
Figure 7. Temperature rise using TEC and lamps in heater room.

4.3. Result of testing with water load and without load

| Room Condition | 0 (off) | 1 | 2 | 3 | 4 | 5 | 6 |
|----------------|--------|---|---|---|---|---|---|
| **Cooler**     |        |   |   |   |   |   |   |
| Temperature °C | 30.2    | 27.5 | 26.5 | 26.5 | 25.5 | 24.5 | 24.5 |
| Humidity %     | 88.5    | 85.5 | 80.5 | 82.5 | 81.0 | 79.5 | 79.5 |
| **Heater**     |        |   |   |   |   |   |   |
| Temperature °C | 31.3    | 37.5 | 40.0 | 40.5 | 40.5 | 42.5 | 42.5 |
| Humidity %     | 88.4    | 55.0 | 41.0 | 40.0 | 40.5 | 42.0 | 43  |

| Room Condition | Cooler | Heater | Water Temp. °C |
|----------------|--------|--------|----------------|
| **Temp. °C**   |        |        |                |
| 1               | 28.5   | 32.0   | 26.8           |
| 2               | 25.0   | 41.5   | 26.1           |
| 3               | 25.5   | 41.0   | 25.8           |
| 4               | 25.5   | 40.5   | 25.6           |
| 5               | 25.5   | 40.0   | 25.6           |
| 6               | 25.5   | 40.5   | 25.4           |
| 7               | 25.5   | 41.5   | 25.3           |
| 8               | 25.5   | 40.5   | 25.2           |

The both the cooler and the heater at testing process without loads did not experience significant changes of temperature and humidity, as seen table 1.

The result of testing proses with load can be seen at table 2. The temperature and humidity in the testing process with water loads do not have significant changes in both the cooler and the heater.
4.3. Result of testing dryer method
The following are the results of the comparison using the dryer method and the conventional method. Depreciation that occurs with conventional methods is quite significant, namely more than 60 grams on the 10th day. Whereas with the dryer only shrinks 40 grams with the same storage time.

![Graph: Comparison of conventional and dryer method.](image1)

**Figure 8.** The comparison of conventional and dryer method.

4.3. Result of Testing Cooler Method

![Graph: Comparison of conventional and cool method.](image2)

**Figure 9.** The comparison of conventional and cool method.

Figure 9 shows the results of the comparison using the cooling method and conventional methods. Depreciation that occurs with the conventional method is quite significant at 62 gram on the 10th day. While the dryer only shrinks more than 40 grams with the same storage time.

5. Conclusion
The conclusion of this research are in this study successfully applied the ability of the Peltier effect of the thermo electric cooler (TEC) as a cooling and heating device. According to its ability to produce differences in hot and cold temperatures, on the cold side, the TEC is used in cooling or cooling rooms as a cooling medium and preservation medium, while on the hot side the TEC is used in heating or drying rooms as a heating room and dry media. In this study using 8 pieces of TEC 12706 were arranged in a combination of 2-2-2-2, 1-2-2-2, and 1-1-2-2-2. The circuit 2-2-2-2 circuit is used because the
circuit is quite easy and fast to decrease room temperature, quite stable and the power consumption is not large. A comparison of the shallot’s condition after the storage is the shallots have more red color/ fresher and the suckling weights only 43 grams with cooler and 61 grams and two shallots bulb getting rotten with conventional methods. A comparison of the post-harvest shallot process using a dryer is faster achieved, and the shrinkage is even smaller at 40 grams compared to the process of using conventional drying methods that shrinkage of 73 grams. The cooler is at 25°C and 70%, while the dryer is at 37°C and 35%.

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Reference
[1] Goldsmid H J 2010 Introduction to Thermoelectricity (Urdorf: Springer Series in Material Science)
[2] Riffat S B, Omer S A, and Ma X 2001 Renew. Energy 23 313–323
[3] Cengel Y and Ghajar A 2015 Heat and Mass Transfer: Fundamentals and Applications, (New York: McGraw-Hill Education)
[4] Riffat S B and Ma X 2003 Appl. Therm. Eng. 23 913–935
[5] Chang Y W, Chang C C, Ke M T, and Chen S L 2009 Applied Therm. Eng. 29 2731
[6] Meng J H et all 2013 Applied Energy 108 340–348
[7] Gurevich Y G and Velazquez J E 2014 Peltier Effect in Semiconductors (New York: John Wiley and Sons)
[8] Bakker F L, Flipse J, and Wees B J 2012 Journal of Applied Physics 111, 084306
[9] Djali M and Putri S H 2013 International Journal on Advance Science Engineering Information Technology 3 2 61-65
[10] Simons R and Chu R 2000 Sixteenth Annual IEEE Semiconductor Thermal Measurement and Management Symposium (San Jose, CA, 21–23 March 2000), pp 1–9