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Temperature Control of Soft Drinks on Vehicle with Portable Storage Thermoelectric Cooler

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Abstract

This study aims to design a control system with fuzzy logic on a system of cooling the storage of soft drinks with thermoelectric coolers. This storage can be carried in a vehicle using a DC electric power from a photovoltaic solar cell mounted on the roof of the car. Under certain conditions the energy source of cigarette lighter in a car can replace the solar cells. The test results show that a temperature of 15°C can be reached within 30 minutes with fuzzy control, while without fuzzy control the time needed in 63 minutes, 30 minutes longer.

Keywords: *Fuzzy TEC; Peltier effect; POTECO; photovoltaic-on roof; soft drinks*

1. Introduction

The generation of thermoelectric technology (TE) has developed rapidly in the past decade because of its ability to convert thermal into electrical energy. Likewise, solar cell technology is often combined with a thermolectric either as a cooling solar cell or as a source of electrical energy in parallel with PV. Recent researches involving thermoelectric as an electric energy generator or thermoelectric with photovoltaic can be refer to [1-7].

In contrast, TE applications as coolants that utilize DC electric current sources are also intensively studied. Several related papers such as on [8, 9] and that combines TE as a coolant and a power plant at the same time [10]. The working principle can be seen in Fig. 1, where TE as a TEC cooler and as an electric energy generator is TEG.

The problem in the TEC application is temperature control that is in accordance with the wishes. Control systems in TEC applications are still rarely done. Therefore, this study will display temperature control schemes using fuzzy logic compared with no fuzzy programs as preservatives or soft drinks coolers on portable boxes. Temperature control is very useful that suits the needs of cooled objects. The thermoelectric phenomenon as a cooler is known as the Peltier effect [11]. The use of buck converter with fuzzy-PID control from DC motor energy sources has been displayed by Jumiyatun and Mustofa [12]. This control characteristic can be applied to this TEC paper research.

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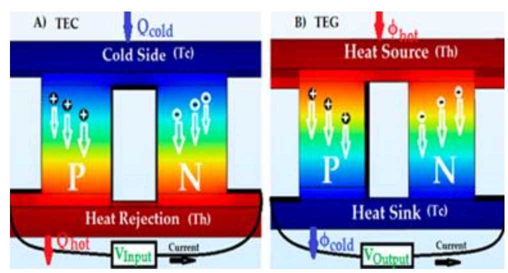


Figure 1. working principle of; (A) Thermoelectric Cooler; (B) Thermoelectric Generator [10]

2. Portable Storage of Soft Drinks on Vehicle

The need for drivers and passengers on vehicles will treat fresh and cold drinks throughout the trip cannot be ignored. Therefore, it needs the storage cooler by utilizing the Peltier effect of the thermoelectric cooler (TEC) that utilize a DC electric current supply from photovoltaic solar cells that can be placed on the vehicle roof. Besides that, if soft drink needs are still needed until the night during the trip, the DC source can be obtained from the cigarette lighter plug on the car. The model of this cooler storage is abbreviated

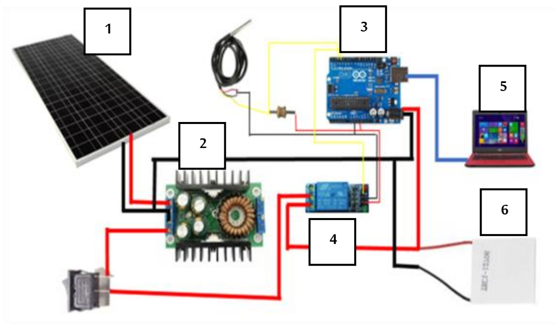


Figure 2. Experimental set-up; (1) PV; (2) Converter step-up step-down; (3) Arduino; (4) Relay 12 V; (5) LCD; (6) TEC

POTECO (Portable Storage Thermoelectric Cooler) as explained as follows.

3. Experimental Set-up

The design of this test can be seen in the scheme of Fig. 2 and block diagram in Fig. 3 which places polycrystalline solar cell as DC power energy sources. From Fig. 2, PV produces voltage with an average of 19 Volt. This voltage goes to the buck boost converter with an output setting of 12 Volt. This output is the source for TEC and Arduino. Relay is connected between 12 Volt and TEC voltage output which will disconnect/connect depending on the control commands of Fuzzy Logic contained in Arduino. The LCD functions to display temperature. The polycrystalline PV solar cell is Solartech with a capacity of 85 Wp, a buck converter circuit step up-step down, a thermoelectric TEC 12706 for cooling soft drinks in the storage, a relay, and then Arduino as controller. The control method used is fuzzy logic to make the temperature constant at 15° C.

4. Results and Discussion

To verify the POTECO scheme above, the cooler has been created as shown in Fig. 4(a) by placing the TEC module on the side wall of the container. Cold side of the module is inside the container of the refrigerator and hot side is in contact with the

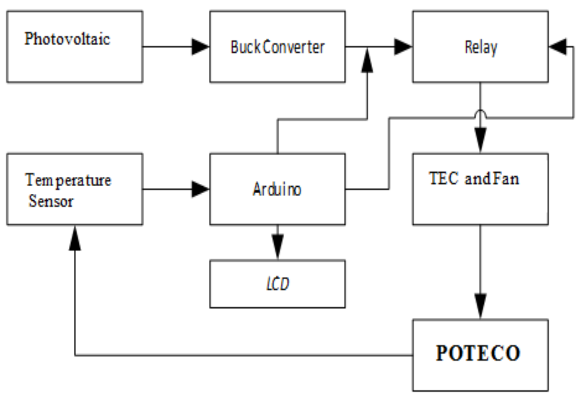
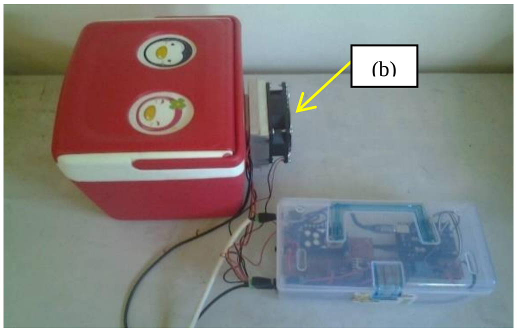
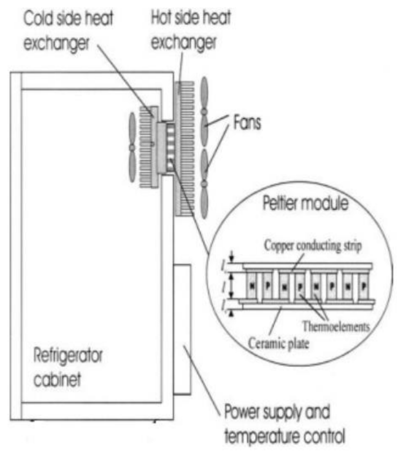


Figure 3. Block diagram of POTECO



(a)



(b)

Figure 4. POTECO (a) and the TEC module detail (b) [13]

Table 1. Temperature vs Time of POTECO

TEMPERATURE (°C)	TIME (MINUTES)
27.44	0
27	0.6
26	0.7
25	1.5
24	2
23	2.53
22	3.2
21	4.1
20	5.3
19	7.2
18	8.4
17	10.46
16	16.7
15	26.2
14	55.1
13.88	**63.37**

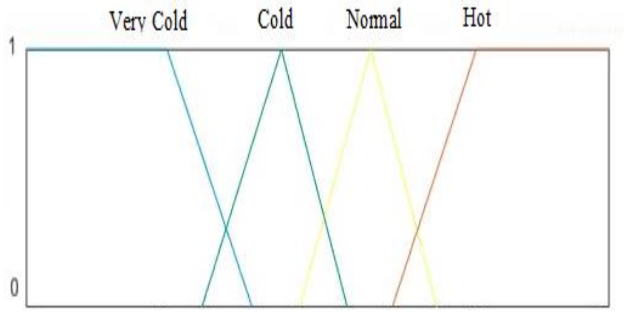


Figure 5. Fuzzy rule of POTECO

surrounding air in the vehicle cabin. Heat will be removed from hot side with help of Aluminum heat sink. Heat sink is connected on the hot side of the module. Min and Rowe [13] also put the TEC module like that as depicted in Fig. 4(b).

From the test results showed that the storage temperature reached 13.88°C in 63.37 minutes as the data in Table 1. This figure was obtained without system control.

4.1. Fuzzy controls

Fuzzy rules are simply made as shown in Figure 5. Furthermore, this fuzzy rule can be referred to [14].

The above rule means that:

1. If temperature **Very Cold** (<= 15), relay OFF 30 seconds
2. If temperature **Cold** (14 – 17), relay OFF 20 seconds
3. If temperature **Normal** (16 – 19), relay OFF 10 seconds
4. If temperature **Hot** (>= 18), Then relay ON

Or in the form of computer program:

```
if (temperaturenow <= 15) { relay off = 30 seconds}
else if (14 < temperaturenow && temperaturenow <= 17) { relay off = 20 seconds}
else if (16 <temperaturenow && temperaturenow <= 19) { relay off = 10 seconds}
else if (18 <= temperaturenow) {relay on}
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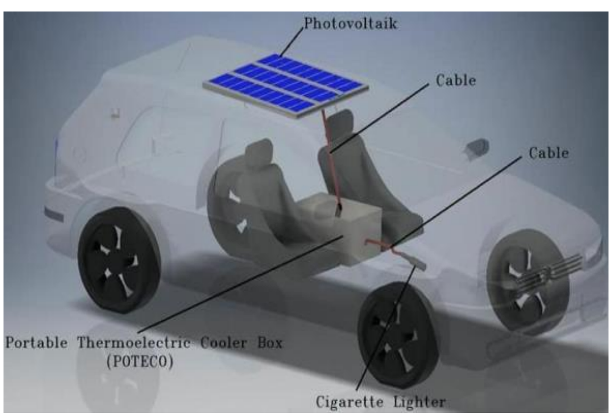

Figure 6. Work scheme of POTECO on vehicle

The results show that a temperature of 14.94°C is achieved in just 30 minutes, approximately 30 minutes faster than without fuzzy control. This number is also 13 hours faster than the time achieved by Aziz et al. [9] in the same TEC module, storage dimensions are almost the same as digital control methods. Furthermore, the POTECO storage if placed in the car cabin will look like in Figure 6 positioned between the driver and accompanying passengers in front.

5. Conclusion

In this experiment it was found that the fuzzy control design works well and is faster in reaching the cold side of the TEC temperature as early set-up. This possibility is caused by a source of DC electrical energy as the TEC input produces a large amount of power at 85 Wp. Further work is needed to assess the performance of cooling systems with variations in series and parallel TEC modules and the stability of the system for long periods of time. Furthermore, the cigarette lighter performance of the car needs to be tested as a DC power source.

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