International Journal of Bio-Science and Bio-Technology
Vol.6, No.3 (2014), pp.123-132
http://dx.doi.org/10.14257/ijbsbt.2014.6.3.15

# Blood Warmer Using Peltiers

Park Suksantisakul[1], Noppadol Maneerat[2], Thongchan Nakprik[3] and Ruttikorn Varakulsiripunth[4]

*[1, 2]Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang Bangkok, Thailand 10520*
*[3]Department of Anesthesiology, Uttaradit Hospital, Uttaradit, Thailand 53000*
*[4]Faculty of Information Technology, Thai-Nichi Institute of Technology, Bangkok, Thailand 10250*
*[1]parkemon58@hotmail.com, [2]kmnoppad@kmitl.ac.th, [4]ruttikorn@tni.ac.th*

***Abstract***

*The purpose of this paper is introduces blood warmer system to easy for anesthesiologists and patients for infusion and facilitate of anesthesiologists work for using blood bag. The system is contained in a rectangular box, inside of which consists of two separate chambers: one housing the electronics inside have; circulating fans, heat sinks, transformer (12v, 100w, 8.3amp) and a PCB with an SG3525 IC for regulation of temperatures in the adjacent chamber and the other the blood warming components inside have is fitted with a shaker, EPDM(Ethylene Propylene Diene Monomer) cushion sheets, a digital thermometer, and two thermo-sensor. Two peltiers and EPDM cushion sheets are employed in the proposed system to quicken the warming of blood bags. Nonetheless, three experiments were conducted with three different blood warming configurations: using one peltier without the EPDM cushion sheets, two peltiers without the EPDM cushion sheets, and two peltiers with the EPDM cushion sheets. The finding indicates that the use of two peltiers together with the plates produces the best results.*

***Keywords:****-peltier; EPDM(Ethylene Propylene Diene Monomer); anesthesiologists*

## 1. Introduction

At present before anesthesiologists infuse blood into a patient's body, the blood which is preserved in a blood bag and stored in a cold storage is warmed to the patient's body temperature. Some current practices in hospitals to prepare blood for infusion are the use of a heat solder, warm water [1], the screw blood warmer [2], heater [3], running water as well as leaving the blood bags to room temperature. The methods are inefficient, time-consuming and inconvenient for the anesthesiologists. To improve work efficiency of the medical staff, this research paper has therefore introduced a higher efficiency blood warmer system. The system is portable and simple to operate. The proposed blood warmer system utilizes two peltiers of two differing temperatures. As one side of a peltier generates more heat than its other side, the hotter sides of the two peltiers are facing the blood shaker of the blood-warming chamber. The organization of this research paper is as follows: Section I is the introduction part and Section II is concerned with the workings of the peltiers. The design and concept of the proposed blood warmer system are respectively discussed in Sections III and IV. Section V deals with the experimental results. The conclusions and future work are provided in Section VI.

ISSN: 2233-7849 IJBSBT

## 2. Workings of Peltiers

A Figure 1 is the image of one of the two peltiers. The proposed system requires two peltiers. One peltier is fitted on a plaswood partition (*i.e.*, PVC foam sheet) dividing the two chambers housing the electronics and the blood warming components while the other is fitted on one outer wall of the box. As previously mentioned, the sides of the two peltiers that generate more heat are turned inside facing the blood shaker (see Figure 5).

**Figure 1. The Photo Image of a Peltier**

Figure 2 illustrates the workings of a P-N type peltier of this research work. The workings start with the peltier being fed with a direct current (DC). The electrons that travel between the P-type (low energy) and N-type (high energy) semiconductors are next absorbed whereby heat is generated on the "absorbed" side (*i.e.*, blue color). The electrons then travel from the N-type (high energy) semiconductor back to the P-type (low energy) semiconductor, generating heat on the "released" side (*i.e.*, red color). The temperature of the heat generated on the "released" side is much higher, compared to the "absorbed" side. The "released" sides are those facing the blood shaker in the blood-warming compartment of the box.

 

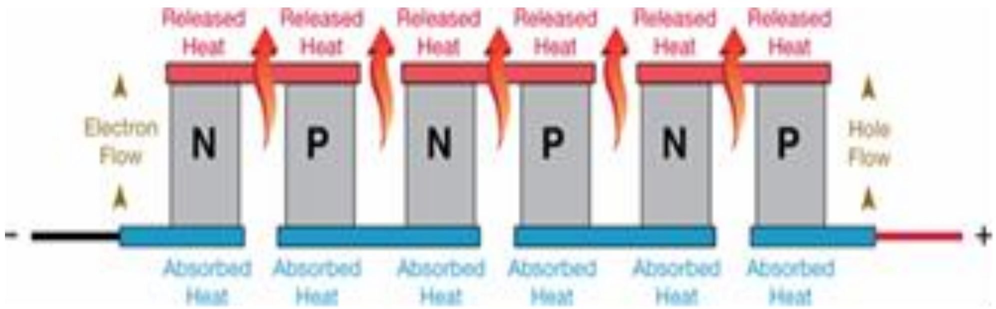


**Figure 2. The Workings of a Peltier Whereby Absorption of Electrons Occur and Heat Generated**

The P-type and N-type semiconductors of a peltier are made from Bismuth (*Bi*) and Tellurium (*Te*), respectively. The intensities of free electrons of *Bi* and *Te* are different at the same temperature even though both substances belong to the alloy group. As illustrated in Figure 3, the P-type and N-type semiconductors are "*sandwiched*" between two ceramic substrates and the semiconductors are of cube shape. The arrangements of the P-type and N-type cubes are such that no P-type cube is adjacent to an N-type cube and vice versa. The P-type cubes are electron-deficit whereas the electrons of N-type cubes are in excess.

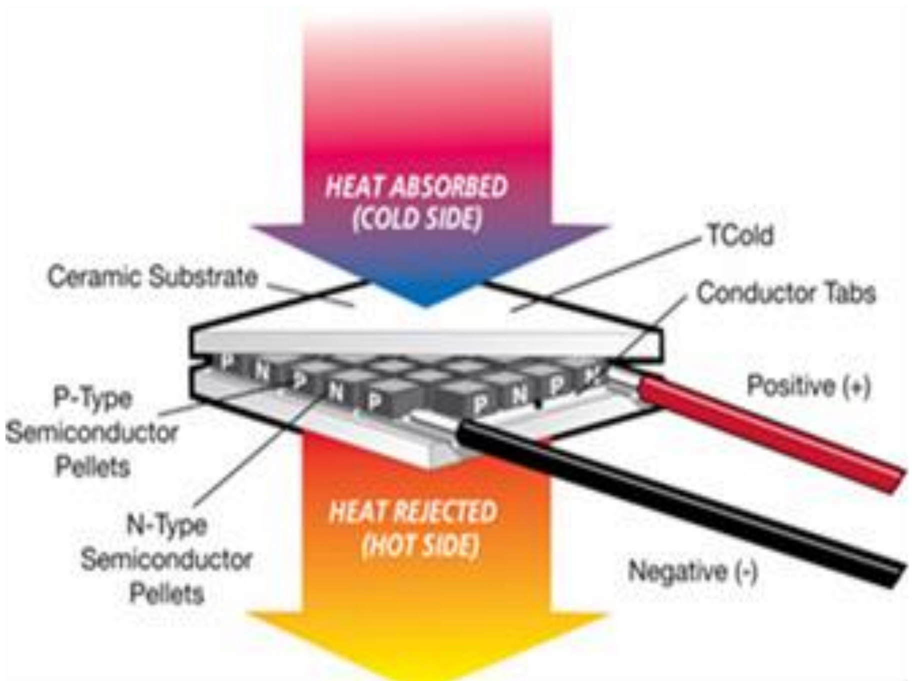


**Figure 3. The Cross-Section of a Typical Peltier**

 

## 3. Design of the Blood Warmer System

The design of the proposed blood warmer system employs two peltiers for speedy warming of the blood. The entire system is contained in a rectangular PVC foam sheet box (*i.e.*, plaswood) of 40x33x18.5 cm. (W x L x H) with a transparent acrylic top cover, as shown in Figure 4. Figure 5 shows the inside of the box which is divided by another sheet of plaswood into two chambers, of which one is for the electronics and the other for the blood warming components. The electronics compartment consists mainly of a transformer (12v, 100w, 8.3amp) and a PCB with an SG3525 IC for regulation of temperatures in the adjacent chamber. The other compartment is fitted with a shaker, EPDM cushion sheets, a digital thermometer, and two thermo-sensors, the temperature input from one of which is displayed on the digital thermometer while that from the other is fed into the circuit in the electronics chamber. The circuit feeds more current to the peltiers if the temperature in the blood warming chamber drops below the pre-set temperature or reduces if the temperature reaches or rise above the pre-set temperature.

In addition, heat sinks and circulating fans are fitted in both chambers and the outer walls of the proposed system to help with uniform heat distribution in the blood warming compartment. The installation of the heat sinks and fans also shortens the time required for blood preparation. The two peltiers each are fitted on the dividing plaswood wall and on the outer wall of the blood warming chamber opposite the one fitted on the dividing wall. Figure 6 is included here to illustrate the schematic of the circuit of the proposed blood warmer system.

**Figure 4. The Top View of the Proposed Blood Warmer Box with the Electronics and the Blood-Warming Mechanisms on the Left and Right Chambers, Respectively. During Operation, the System is Covered with EPDM and an Acrylic Top Cover to Retain the Heat**

 

**Figure 5. The Top View of the Blood Warmer System without the EPDM and Acrylic Top Cover. The White Tray is the Shaker on which a Blood Bag is Placed**

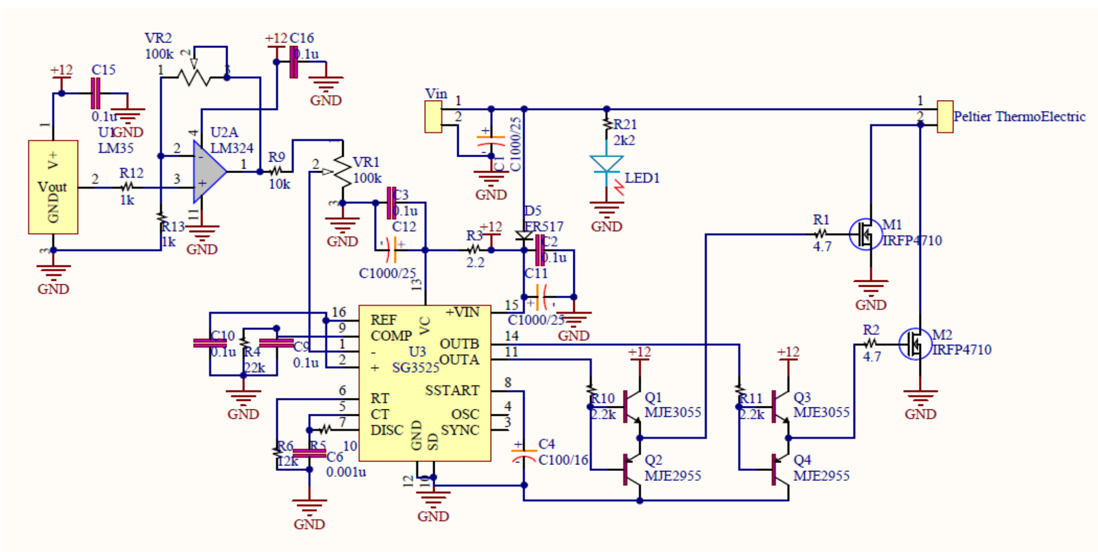


**Figure 6. The Schematic of the Circuit of the Blood Warmer System**

## 4. Principle of the Blood Warmer

After the blood warmer system is switched on, the two peltiers will be heated until the temperature inside the blood warming compartment reaches the pre-set temperature point. Once reached, the temperature inside stabilizes for a period of time until there is a change in the inside temperature. As briefly described in the preceding section, when the inside starts to get cool and the temperature drops below the pre-set point, the duty cycles of the pulse width modulation (PWM) become wider whereby the two peltiers are re-heated. In case of the temperature inside the blood warming chamber rising above the pre-set point, the PWM duty cycles get narrower and thereby normalize the inside temperature to the pre-set level. Figure 7 depicts the operating principle of the proposed blood warmer system which is a continuous loop of operation according the above descriptions. Since the proposed system is fitted with a shaker (as seen in Figure 5) which continuously sways back and forth while switched on, neither blood sedimentation nor coagulation occurs inside the blood bag. Thus, the blood on the shaker is always ready for infusion.

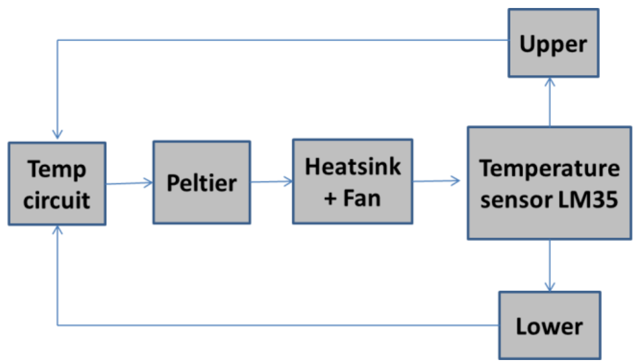


**Figure 7. The Operating Principle of the Proposed Blood Warmer System**

## 5. Experimental Results

Three experiments were conducted with three different blood warming set-ups: First, using one peltier without the EPDM cushion sheets; second, using two peltiers without the EPDM cushion sheets; and, third, using two peltiers with the EPDM cushion sheets. The first, second and third configurations require 1697, 400 and 369 seconds, respectively, to reach the pre-set temperature of 37 degrees Celsius. The last configuration in which two peltiers were used together with the plates produces the best results as it takes the least amount of time for the inside temperature of the blood warming chamber to reach the pre-set temperature level. Nevertheless, the initial temperatures of all the three were slightly different. The temperatures of the first, second and third configurations are respectively 27.5, 29.5 and 25.5 C. As seen, the third configuration requires the least amount of time (*i.e.*, 369 seconds) to achieve the pre-set level of temperature despite the lowest initial temperature (*i.e.*, 25.5 C) vis-à-vis the other two. In general, the lower the initial temperature, the longer the time it is required to reach the desired 37 C point. Figures 8, 9 and 10 illustrate the experimental results of the first, second and third configurations, respectively.

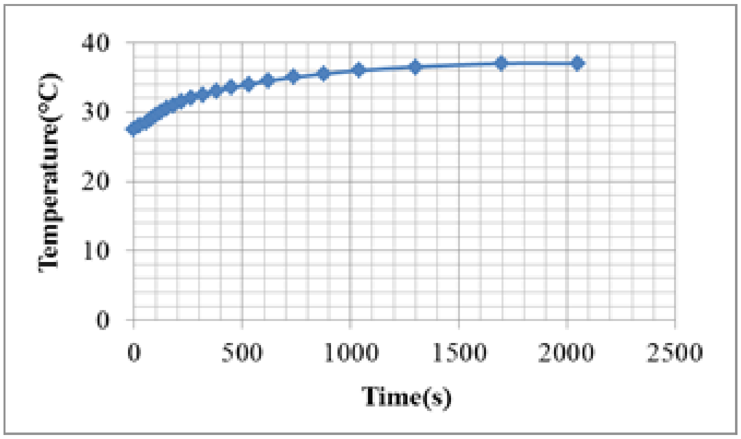


**Figure 8. Experimental Results of using One Peltier without EPDM Cushion Sheets (First Configuration)**

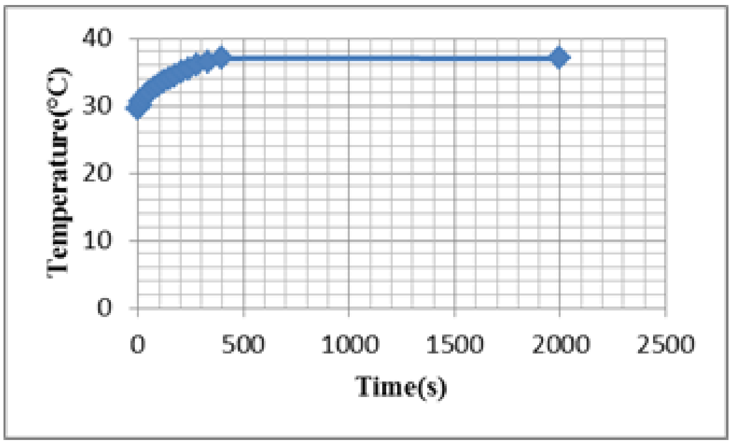


**Figure 9. Experimental Results of using Two Peltiers without EPDM Cushion Sheets (Second Configuration)**

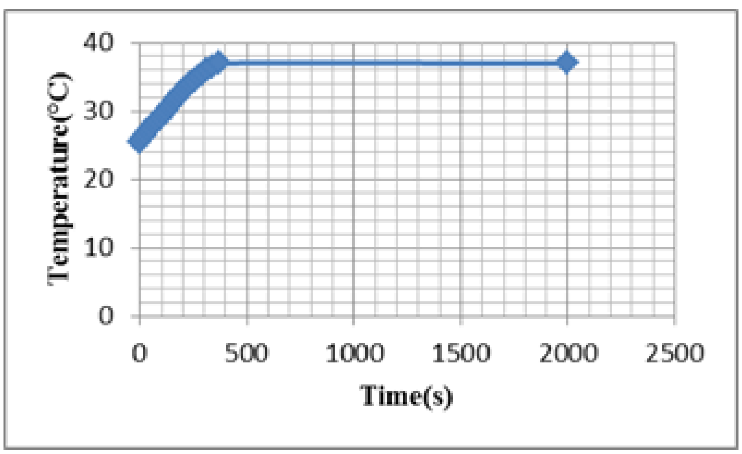


**Figure 10. Experimental Results of using Two Peltiers with EPDM Cushion Sheets (Third Configuration)**

## 6. Conclusions and Future Work

This research paper presents a more efficient blood warmer system which utilizes two peltiers with EPDM cushion sheets. The proposed system is contained in a rectangular PVC foam sheet (i.e. plaswood) box, inside which consists of two compartments. One compartment is fitted with the electronics while the other houses the blood warming mechanisms. In determining the use of two peltiers with EPDM cushion sheets as the optimal system, three experiments were conducted with three different warm warming configurations. The outcome confirms the two peltiers with EPDM cushion sheets configuration as the best system as it requires the least amount of time to heat the blood to the pre-set temperature point. The proposed system of this current research work is expected to be of great use to the anesthesiologists as it is easy to operate and portable.

Future research works could focus on the following areas to improve the performance the system. First, the gap between a peltier and a heat sink should be closed by filling it up with high-quality silicone as the gap reduces the heat transferred between the peltier and the heat sink. Second, the PID control method could be applied to the proposed system as it expedites the blood warming and thereby requires even less amount of time to reach the pre-set temperature.

## Acknowledgements

The authors would like to express deep gratitude to the Department of Anesthesiology, Uttaradit Hospital, for experimenting with the proposed blood warmer system in a real hospital setting. Sincere appreciation goes to the Department of Instrument and Control Engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, for the full support, without which this research work would not have materialized.

## References

[1] K. Jirapaet, "The Efficiency of the Siriraj Blood Warmer for in-line Blood Warming", Siriraj Hospital Gazettej, vol. 46, no. 4, **(1994)** April, pp. 263-269.
[2] S. Ghorashi, A. Hadi Maghzi, S. Nezami, H. Maghzi, N. Ghodratnejad, M. Mojtehedi and N. Nezami, "Introducing two new devises for blood warming", Journal of Research in Medical Sciences, **(2012)** March, pp. 281-285.
[3] C. E. Smith, M. D. FRCPC, Karl Wagner, MD,"Principles of Fluid and Blood Warming in Trauma", International TraumaCare (ITACCS), vol. 18, no. 1, **(2008)**, pp. 71-79.

## Authors

**Park Suksantisakul**, received the B.Eng. degree in Mechatronic Engineering from King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand in 2009. At present, he is studying for Master degree in the Department of Control Engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand. His current research interests are biomedical engineering, concurrent system design and electronic.

 

**Noppadol Maneerat**, received the B.Sc. degree in Physics from Srinakharinwirote University, Pitsanuloke, Thailand in 1990, the M.Eng. and Ph.D. degrees in Electrical Engineering from King Mongkut's Institute of Technology Ladkrabang(KMITL), Bangkok, Thailand in 1997 and 2006. He is now an assistant professor in Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand. His current research interests are protocol design, concurrent system design, communication network, biomedical engineering and image processing.

**Thongchan Nakprik**, received the B.N.S. degree in Nursing Science from Boromarajonani College of Nursing Uttaradit, Thailand in 1989, the M.PH. in Public Health from Naresuan University in 2004. She works as an anesthetic nurse in Anesthesiology Department, Uttaradit Hospital. Her current research interests are post operative pain and patient control analgesia devices.

**Ruttikorn Varakulsiripunth**, received the B.E. degree in Electrical and Electronics from Kyoto University, Kyoto, Japan in 1978. He obtained his M.E. and Ph.D. degrees in Electrical and Communication Engineering from Tohoku University, Sendai, Japan in 1983 and 1986, respectively. He is now an associate professor and Dean of Faculty of Information Technology, Thai-Nichi Institute of Technology. His current research interests are concerned with computer communication network including switching system, queueing analysis, flow and congestion control, multimedia communication, wireless communication, image processing and natural language processing.