International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 8, Special Issue 4(2), April 2018)

Microcontroller Based Automated Blood Warmer

Adheena Dileep[1], Bimi R Babu[2], Josfin. V. Joy[3], Saju Simon. S. G[4]

[1,2,3]*UG Scholars,* [4]*Assistant Professor, Department of Biomedical Engineering, Noorul Islam University, Kumaracoil, K.K Dist (India)*

adheenadileep96@gmail.com, bimirbabu96c@gmail.com, josfinvjoy97@gamil.com, sajusimon.nta@gmail.com

***Abstract*-- Maintaining temperature is the prime consideration for the effective and safe handling of patient. Any problems regarding to it can lead to life threatening conditions for the patient. The normal human body temperature is 37°C. Blood and blood products are usually kept in cold storage to avoid bacterial growth and to preserve the functional integrity and sterility of blood. Blood warmer is a medical device which is used to warm the blood prior to transfusion. In this paper hot water vapour is used to warm the blood bag which is a convection method of heating that do not cause any damages to the blood components. The main advantage of this system is the automatic working of the heating coil. When the blood reaches the desired temperature, the coil will be automatically turned off and when it drops below the body temperature coil will be in on condition. LM35 is a very suitable temperature sensor and it is the heart of this device. In order to avoid damage to the blood components, care should be taken while warming the blood. Therefore we use a method to warm the blood using water vapour in low cost and efficient manner.**

I. INTRODUCTION

The total blood volume of an adult is approximately 5 litres, which contains about 8% of body's weight *[5]*. Blood transfusion is a medical procedure that is performed to replaces blood loss through injury, surgery or disease. The normal body temperature of the human is 37.5°C. Normally blood is stored at 4°-6° C in cold storage to avoid haemolysis and preserves sterility and functional integrity of blood components. It has been reported that the patients who received cold electrolyte solutions, blood and blood products are suffering from life threatening complications *[3]*.

The body temperature may drop to threatening level (a condition called hypothermia) when many units of cold blood are given in a shorter time. In order to avoid cardiac and general hypothermia in patients needing massive transfusion, the blood should be warmed at bedside *[10]*. Hypothermia due to massive and rapid transfusion in ill and injured patients has associated with adverse side effects which are very difficult to be reversed. Hypothermia is the main problem that affects the patients who have major trauma *[2]*. Crystalloid infusion and un-warmed blood results in coagulopathy and cardiac arrhythmias which leads to life loss. It is always important to warm the Intravenous (IV) fluid before administering the patients.

The blood bank has no responsibility to warm blood, which it delivers to the hospital ward at a temperature of between +2 °C and +10 °C. On average, it takes 10 minutes for a unit of blood to reach +10 °C at an ambient temperature of between +20 °C and +30 °C *[1]*. Cold blood can be delivered at a slow rate without ill effects. However, in cases where rapid transfusion is needed, e.g. if the patient demands a rapid transfusion of a large volume of blood, problems such as cardiac arrhythmia can be avoided if blood is warmed to +37 °C. Blood should never be warmed in a bowl of hot water, in hot towels or close to a heating device as this could lead to immense haemolysis and significant transfusion reactions. Specially designed blood warmers are obtainable that warm blood safely and this should be part of the vital equipment of a hospital ward, especially in the intensive care unit or operating theatre. The apparatus should be provided with a visible temperature monitoring device and an audible alarm, which should be checked periodically. Blood warmer warms human packed blood from 4°C to 37°C that is to a temperature that is safe for infusion. It is used with rapid transfusion in already hypothermic patients or rare conditions were cold fluid administration is problematic.

Conventional way of blood warming is to placing blood bag in the warmth water for approximate period of time. It has been reported that, in many cases temperature of blood exceeds the desired limit or many times not even reach to desired temperature rate. Convection heating method is usually used to warm the blood as the conduction and radiation heating may damage the blood content that is we increasing the temperature of surrounding air inside the box which will then cause to raise the temperature inside the blood bag *[4]*. The several other methods to warm IV fluids and bloods that are presently available includes immersing coiled IV tubing in a water bath, passing the IV tubing through a conductive surface interfaced with a counter current heated water bath, magnetic induction, microwaving the bag of fluid to be infused, adding heated saline to blood to be infused, passing the IV tubing through a heating block or through a plastic tube warmed with forced air, pre-warming fluids in a convection oven or in a microwave oven. But all these methods consume time and are not safe *[9]*. If temperature increases too fast that would damage the red blood cells and plasma content of blood at the same time.

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 8, Special Issue 4(2), April 2018)

We need to warm a blood in lowest possible time period, so we need a device which warms the blood gradually and precisely. Red blood cells and plasma exposed to temperature over 40oC may cause serious transfusion reactions. To attain all above intensions we need a controlled heating system so the blood warmer will increase the blood temperature up to 37oC in 15 minutes. Here the focus is on controlling the temperature parameter.

Need For Blood Warming

There is no need of warming blood when direct donor-to-patient and immediate indirect transfusions were used. Indirect, delayed transfusions of preserved and anti-coagulated blood became the norm, and preservation technology based on refrigeration arose after World War II. Blood banking and the storage of blood still demand that the collected blood units be kept refrigerated, for the most part in the liquid (unfrozen) state. This allows prolonged storage time that retard the metabolic deterioration of red cells (RBCs) and other components, and prevents the growth of any accidentally introduced pathogens. Presently, units of RBCs and whole blood (WB) are stored at 1 to 6°C, a temperature primarily determined by the requirements for the preservation of RBC functional integrity. Blood warming before transfusion has been a common practice since the early 1960s. When cold blood is directly delivered to patient's body, the body temperature drops to life threatening levels. Rapid and efficient blood-warming devices are of interest in order to administer large volume of cold blood safely and rapidly to the patient.

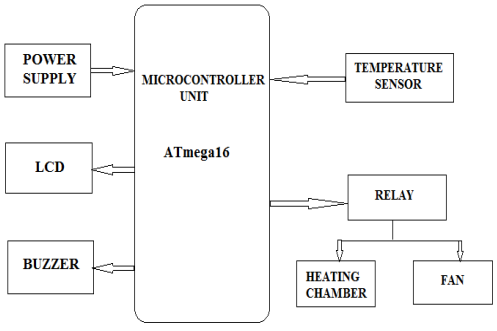

Fig 2.1. Block diagram of blood warmer

Our system consist of ATmega 16 microcontroller which is programmed in such a way that the system works properly, a temperature sensor LM35 that senses the temperature of the blood bag continuously, relay drive IC ULN 2803 which drives the relay, a buzzer for warning, a copper heating coil and a fan for cooling purpose.

II. Background Study

Accidental or uncontrolled hypothermia is a common problem among trauma patients *[6]*. It has been reported that up to 60% of patients admitted to regional trauma centers are hypothermic which means patients having a core body temperature of 35°C. In addition, core body temperatures of below 33°C can lead to cardiac arrhythmias, and temperatures below 28°C increase the risk for ventricular fibrillation. Therefore, efforts to warm the blood before transfusion in hypothermic patients in a timely manner is very important

Generally, several unconventional methods are used for warming blood before transfusion which could potentially result in red blood cell hemolysis and injuries *[7]*. General blood warming techniques in practice are use of normal microwave, immersing blood bag in hot water, placing blood sac near heaters etc. These methods can result in blood hemolysis due to overheating *[12]*. These transfusion conditions can only be reached with concurrent heating and transfusing, which is only possible with portable heating device for blood and blood product that has a high accuracy and quality.

III. Methodology

An efficient method is proposed for warming the blood using arduino based microcontroller. Blood should be warmed up to 37◦C before transfusion.For working of blood warmer, we take a 230 Volt AC (Alternating Current) power supply. To convert this into pure, filtered and constant DC (Direct Current), we use step down transformer, rectifier, filter and regulator respectively. A power switch is used to turn on the device whenever required. A copper heating coil is immersed into the water inside the water tub for boiling the water. As the water starts boiling to a particular temperature, hot water vapour comes out. The blood bag is hanged above the water so that the water vapour can easily warm the blood to the desired temperature. For sensing the temperature of the water vapour, we use temperature sensor LM35. Output of the temperature sensor is given to a microcontroller ATmega16 which is used to control and process the operation of blood warmer. It is programmed in such a way that our system works properly.

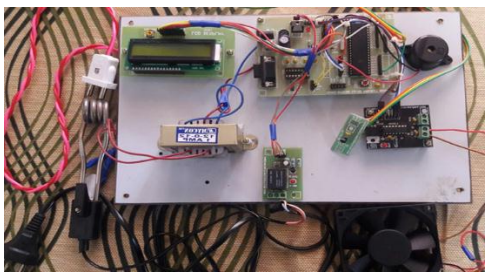

Fig 4.1. Blood warming system

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 8, Special Issue 4(2), April 2018)

Output of microcontroller goes to relay drive IC ULN 2803 which drives the relay. Basically there are two stages of relay. When it is normally opened (NO) fan turns on for heat dissipation and when relay is normally closed (NC) heating coil of 12Watt stops heating. When the temperature goes above 37°C, the heating coil will be automatically turn off and the fan starts rotating for cooling purpose. When the temperature drops below 36°C, the heating coil will be turned on. Microcontroller is also connected to the LCD display and buzzer. Output can be displayed in LCD screen.

IV. Result

The proposed method help us to warm the blood to a temperature that is safe for transfusion. In this method heating coil is working automatically. We have conducted a study to measure the temperature variation between the blood bag and the water vapour. Based on this we have found that it takes approximately 15-16 minutes to warm the blood to the desired temperature. The below table shows the comparison of temperature between the water vapour and blood bag.

Table 5.1
Comparison of temperature between blood bag and water vapour

SL. NO.	Temperature of the water vapour (°C)	Temperature of the blood bag (°C)	Time taken (min.)
1	8	13	5
2	11	17	7
3	15	23	8
4	20	29	10
5	24	35	11
6	29	42	13
7	32	45	14
8	36	52	15
9	37	54	16

The temperature sensor is used to sense the temperature of the water vapour. When the temperature of the water vapour reaches 54° C the blood bag temperature will be 37° C, the alarm sounded and the coil will be automatically turned off. A fan is also included in this system which is turned on at this temperature for the cooling purpose. When the temperature of the water vapour drops below 52° C i.e, the temperature of the blood bag falls to 36° C then the heating coil will be automatically turned on. So this system warms the blood to the desired temperature.

V. Conclusion

Usually the blood is stored at a temperature from 4°-6°C in order to maintain its sterility and functional integrity. Administration of cold blood to the patients during rapid transfusion may cause life threatening conditions such as hypothermia and even life loss. So it is very important to warm the blood up to body temperature before the administration of blood to the patient. Here we are warming the blood using convection heating method that never cause any damages to the blood and blood products. This module is designed in such a way that it is so compact and easy to operate that it can be easily installed in ICU rooms and can be moved anywhere by just removing the power cord if necessary.

This is a portable warming devices for blood and blood products. These devices have several advantages including reduced contact with blood and blood products, instant preparation of blood for injections, decreased damage to blood and blood products, and precise controlling of heating process. Work is ongoing to further refine the design and to produce a prototype to meet the objective of warming blood in less than 10 minutes. The device will be invaluable in resource-limited settings, where quick blood transfusions are required to save lives.

REFERENCES

[1] Daniel AlexandruVisan, "Temperature control system based on adaptive PID algorithm implemented in FPAA"2011 ISSE.

[2] Helm M, Lampl L, Hauke J, Bock KH. [Accidental hypothermia in trauma patients.]

[3] Sayali Shirurkar, Abhishek Sinha, Supriya Patil, Ankush Patil**.** **[**Implementation of Blood Warmer before Transfusion Process Using Microcontroller AT89S52]

[4] R. J. Muha, S. M. Gates and J. T. YalesJr, "Digital temperature programmer for isothermal and thermal desorption measurements", Rev. Sci. Instruments., vol. 56, pp. 613-614, 1985

[5] V.Sowmya, N.Gowripriya, Dharani.M.K "Microcontroller Based Portable Paramedic Blood Warmer for Transfusion"

[6] J.-R. Yang and J. T. Lue, "A microcomputer based programmable temperature controller", IEEE. Trans. Instrum. Meas., vol. IM-36, no. I, pp. 87-91, 1987

[7] O. I. Mohamed, S. Shoji and K. Watanable, "A Digitally Programmable Temperature Controller based on phase-locked loop", IEEE. Trans. Instrum. Meas., vol. 37, no. 4,pp.582-585, 1988

[8] Principles of Fluid and Blood,Warming in Trauma,Charles E. Smith, MD, FRCPC, 1 and Karl Wagner, MD

[9] Gregory JS, Flancbaum L, Townsend MC, Cloutier CT, Jonasson O. Incidence and timing of hypothermia in trauma patients undergoing operations. J Trauma 1991;31:795-800.

[10] Bernard SA, Buist M. Induced hypothermia in critical care medicine: a review. *Crit Care Med* 2003;31:2041-51.

[11] 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.

[12] S. Ghorashi, A. HadiMaghzi, 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

[13] Adhikary GS, Massey SR. Massive air embolism: a case report. J ClinAnesth 1998; 10:70–2.

[14] Benumof JL. Minimizing venous air embolism from reinfusion bags. Anesthesiology 1999; 91:1962.