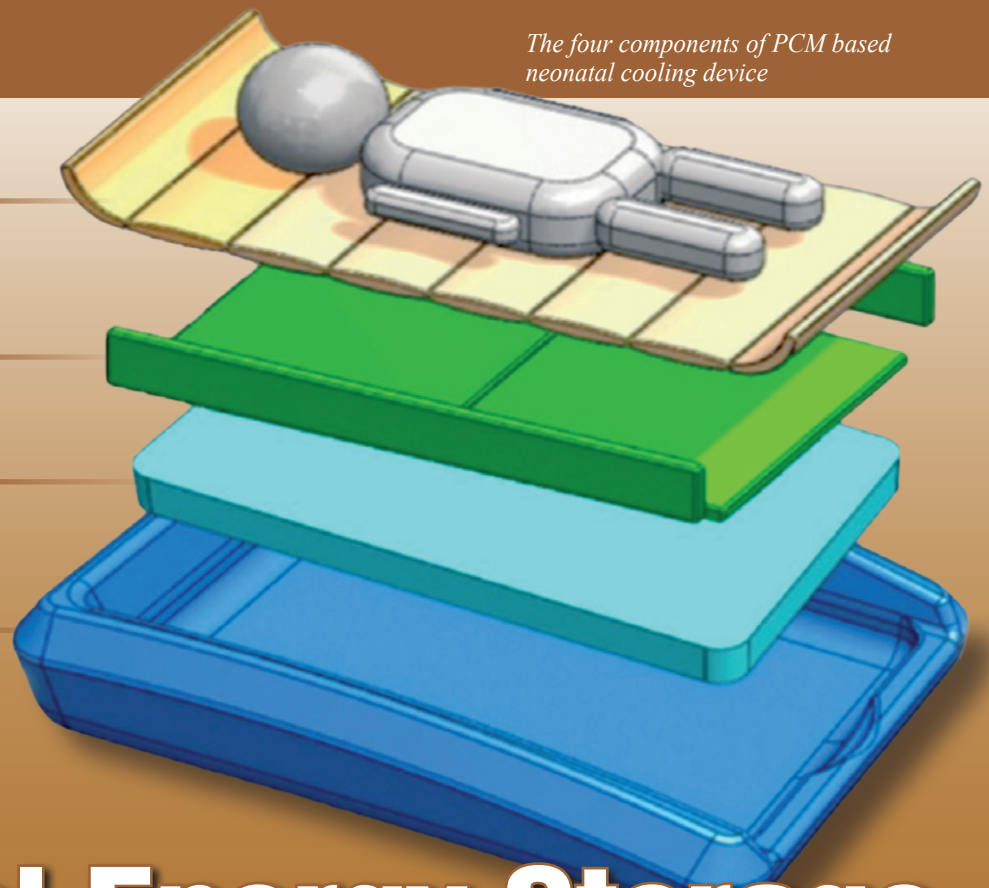


Conduction Mattress

PCM SavE® FS-21

PCM SavE® FS-29

Insulated Cradle



Thermal Energy Storage Device for Healthcare

By Samit Jain

Managing Director

Pluss Advanced Technologies Pvt. Ltd., Gurgaon

Introduction

Thermal energy storage systems based on Phase Change Materials (PCMs) have traditionally found applications in the air conditioning and refrigeration industry with the focus on reducing energy requirement. Recently, PCMs have been used for developing products in the healthcare industry that are affordable for the masses in the developing world. Treatment of newborn babies suffering from birth asphyxia is one such area where PCMs have brought down treatment costs dramatically and have made treatment possible even in remote areas.

Birth Asphyxia

Perinatal asphyxia, neonatal asphyxia, or birth asphyxia is the medical condition resulting from deprivation of oxygen to the newborn that lasts long enough to cause physical damage, especially to the brain. Hypoxic Ischemic Encephalopathy (HIE) associated with acute perinatal asphyxia in the term or near term newborns causes a neurological syndrome that can develop in a newborn after a period of birth asphyxia. HIE is one of the most common causes of neurological complications resulting in

chronic handicapping conditions, the most common of which is cerebral palsy.

The Impact of Perinatal Asphyxia

Neonatal mortality accounts for two thirds of infant mortality in India and other developing countries. Birth asphyxia is the second largest cause of deaths among infants in the first month of birth. It accounts for 10% of the overall infants dying under the age of 5 and approximately 20% of neonatal deaths. The developing countries including Africa, Indian sub-continent

About the Author

Samit Jain holds an M.Sc. (Hons.) in Physics and a Bachelor's (Hons.) in Electrical and Electronics Engineering, both from BITS, Pilani. He also holds an M.S. in Electrical Engineering from the University of Hawai'i, USA. He started his career with Tata Elxsi and subsequently worked at Hawai'i and Los Angeles in the area of network communications before returning to India. He has been with Pluss Polymers (now renamed Pluss Advanced Technologies Pvt. Ltd.) since 2003, and is currently the Managing Director. He is a specialist in thermal energy storage projects, particularly using PCMs. Samit is passionate about the environment, and is a co-founder and trustee of Advit Foundation.

continued on page 56

continued from page 54

and South East Asia account for the majority of deaths due to perinatal asphyxia. According to the WHO global health survey, approximately 683,000 babies died because of birth asphyxia in 2012 globally. Developing countries account for more than 95% of these deaths and India leads the chart with around 150,000 deaths.

The Treatment

Therapeutic hypothermia induced by cooling the newborn's internal body temperature to 33.5°C and maintaining the temperature between 33°C and 34°C for 72 hours has been proven to be the only medical intervention which reduces the risk of death or major disability and increases the rate of normal survival at the age of 18 months among newborns suffering from birth asphyxia.

The Problem

Although cooling has proven to be beneficial for perinatal asphyxia, the standard cooling equipment available in the market is very expensive, costing approximately Rs. 15-20 lakh (\$25,000-\$35,000). Most of the hospitals in India or other developing countries cannot afford it. Several low cost methods have been tried, the most popular being the use of ice packs to cool the baby. Ice packs have the disadvantage of having to be changed quite often, leading to very high manual supervision. In addition, due to the very low surface temperature of ice (0°C), it does not give the precise temperature control of 33-34°C and induces a lot of shivering with increased risk of subcutaneous fat necrosis.

The medical fraternity knows the treatment, but they do not have anything that is affordable as well as efficient to conduct the therapeutic hypothermia treatment.

PCM Based Neonatal Cooling Device

PCMs have been used to develop an affordable and easy to use passive cooling device for newborns suffering from birth asphyxia. To ensure precise temperature control, a cascaded system of PCMs is used. Cascaded system is a technology that employs two or more PCMs with different melting points. By engineering the melting points, thicknesses, conductivities and placement of the involved layers, a 'quasi-automated' cooling system is created, which, while being completely passive, gives the precise temperature control of 33-34°C required as per the treatment protocol.

The device has four major components (please see title picture):

Insulated Cradle

This is a roto-molded plastic structure that serves as a framework for placing all the other components and provides insulation to the PCM, helping it last longer.

29°PCM

This forms the bottom layer of the device. Three units of 29° PCMs are placed at the bottom of Insulated Cradle. 29° PCM in solid state passively extracts heat from the neonate's body which is at 37°C, thereby inducing and sustaining hypothermia.

21° PCM

This is the second layer of the device. It is used in conjunction with 29° PCM to quickly bring the temperature of the neonate down to 33°C. It is subsequently removed and 29° PCM takes over to sustain the temperature for longer hours.

Conduction Mattress

The conduction mattress is a gel based bed, which provides a smooth surface for the baby to lie on and improves heat transfer between the baby and the PCM.



Figure 1: A neonatal cooling device in use

Advantages of PCM Based Neonatal Cooling Device

PCM based cooling device is affordable and costs just 1/10th of the existing equipment available in the market. It has made treatment possible even in the remotest areas of the country. Moreover, all the PCMs are reusable and hence there is no maintenance cost for the customer. The device does not require any electricity when in use and therefore reduces any chance of accident. It is very simple to use. No intimidating wires and circuits for the nurses and doctors.

Conclusion

PCM based neonatal cooling device is one example of how PCMs can play a role in healthcare. A few products have come up in India in the last 3 years, like a PCM based infant warmer developed to keep the baby warm for 4-6 hours without any constant source of electricity, and a PCM based neonatal cooling device. The highlights of both the products have been ease of use, non-electronic nature, affordability and the ability to be used in remote areas. Both the products are currently designed for child care, but the medical fraternity is now finding use for such PCM based products in other fields like therapeutic pads, cooling the brain during cardiac arrest, precise and appropriate temperature control for medicines, pharmaceuticals and biological products and as a blood warmer. It has opened up a completely new dimension for PCM based thermal energy storage systems. ❁