19. TEMPERATURE CONTROL WITH PHASE CHANGE MATERIALS

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Abstract. Temperature control is a very suitable application because there you can take advantage of the high capacity of PCMs in a small temperature range. In the case of transport boxes, PCM modules to keep the internal temperature constant within a few degrees for a long time have already penetrated the market. Further applications that are currently under development or in a first stage of market introduction are textiles and clothes, electronic equipment, medical applications, cooling of newborns, catering and even a laptop that includes PCM!

Keywords: PCM, temperature control, applications

19.1. Introduction

Phase Change Materials offer the possibility of thermal protection due to their high thermal inertia. This protection could be used against heat and against cold, during transport or during storage. Protection for food, beverages, pharmaceutical products, blood derivatives, electronic circuits, cooked food, biomedical products, and many others, is possible. Here some of these applications are presented, especially looking for the ones that are already in the market and that emphasize the potential of Phase Change Materials.

An application already in the market is the temperature control utilizing PCM for transportation of pharmaceutical goods or other temperature sensitive goods. Also in the market is the utilization of PCM for cooling or heating of the human body, since it has been demonstrated both for personal comfort and for medical therapy. Passive cooling of buildings and of telecom cabinets are examples of widespread applications.

H. Ö. Paksoy (ed.), Thermal Energy Storage for Sustainable Energy Consumption, 315–321.

19.2. Strategy

When talking about temperature control, what do we mean? An example from everyday life is the storage of frozen food like pizza, ice cream, vegetables or others. In many cases, the package indicates the maximum storage time depending on the temperature of storage. If the food is not kept below a certain temperature it often has to be eaten at the day of purchase.

Let us think that a temperature sensitive good is inside a well insulated box. To stabilize the temperature at the desired value, the thermal mass of the interior is strongly increased by adding PCM with suitable melting point and mass. Everybody has done this before when adding ice packs to a picnic basket.

19.3. Containers for Any Kind of Temperature Sensitive Goods

The best known application of PCMs for transport or conservation of materials at a constant temperature are containers with removal parts containing a PCM (usually water, nowadays many other products) that must be kept in the refrigerator before use, and that keep a low temperature in the container for a period of time (Figure 161).

Some companies only commercialize the PCM pads (Figure 162). Such pads can be used to keep products warm (the pad must be conditioned in an oven and/or microwave oven) or cold (conditioning is done in the refrigerator) during shipment.

Figure 161. Rigid encapsulator (picture from Va-Q-tec)

Figure 162. Soft encapsulator (picture from Climator)

PCM transport boxes have also been adopted in vacuum boxes to improve their performance (Figure 163).

19.4. Containers for Beverages

One application that has been commercialized is the so-called "isothermal water bottle" especially developed for cycling, but that could be used by any other sporting person. It is a double wall bottle, with ALCAL® being the PCM. The bottle has capacity for about 0.5 l, and it has to be held in the refrigerator for the PCM to solidify and then the bottle will keep the beverage cold.

This concept could be used in many other products, such as isothermal maintenance of fresh drinks (isothermal container for champagne, cava, wine, etc) and warm drinks (soups, tea, coffee, etc).

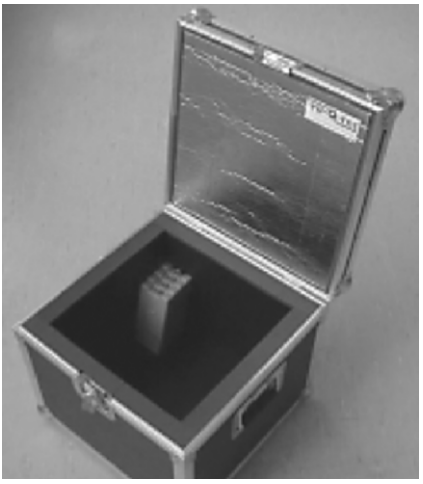

Figure 163. Transport box (picture from Va-Q-tec)

19.5. Containers for Food

In many catering applications, cooked meals are produced in one point and have to be transported to another place where they are eaten. Some examples are transport of cheese, salads, frozen deserts, confectionery, or fish. PCMs containers could also be used to avoid breaking the cold chain during transportation of precooked meals, foie-gras, smoked salmon, milk derivates, ice-cream, and many others.

One example of such an application that has already been comerzialized are pizza-heaters. The use of a container with PCM with the right melting temperature allows multiplying by three the length of time the food is kept above 65 °C.

The same concept could be used for food distribution in hospitals, schools, etc, or in devices to heat up feeding bottles, and other food containers.

Other developments are a container for hot food transportation at controlled temperature between 70 °C and 85 °C, and a container for ice-creams to be held below −8 °C.

19.6. Medical Applications

The transportation of blood and its by-products is very critical with respect to temperature. Some products need to be transported between 20 and 24 °C, others between 2 and 6 °C, and others between –30 and –26 °C. A container was designed and produced to allow the transport of such blood products between the hospital and the transportation vehicle (which is already conditioned at the right temperature), and between the vehicle and the final destination.

Another medical application are hot or cold pads to treat local pain in the body (Figures 164 and 165).

One more application for medical purposes is a mattress for operating tables, which can be use to avoid the decrease of the body temperature during

Figure 164. Hot cushion for medical purposes, (picture from Rubitherm)

Figure 165. Rubitherm cold product for cooling therapy

long operations, or during operations of burned people. The mattress would be heated up electrically before its use (the PCM would be with a melting temperature of about 37 °C), and it would release the heat during the operation. This application is being tested as a prototype.

A new product being developed currently is a mattress to treat hypoxia (lack of oxygen) in newborn babies. It is known that reducing the body temperature of the new born has a positive effect; therefore they are treated with cold towels, medicine, chilled rooms to keep the temperature. This treatment could be substituted by the treatment with a PCM mattress, thereby optimizing and prolonging the temperature regulating effect.

Heat can be a problem for professional athletes both in training and at competition. Heat can also be a problem for other people like elderly people, people with some diseases and children. If the body-temperature can be reduced most people would feel more comfortable, perform better, be able to keep concentrate better and for a longer time and the risks of dehydration and fatigue is reduced. New products to address this problem were developed, such as wrist-cooler, a neck-cooler, a cap and a vest (Figure 166). All these

Figure 166. Wrist-cooler, neck-cooler, cap and vest with PCM for thermal protection (pictures from Climator)

Figure 167. Left, PVC packet with TEAP PCM; center, top view of Battery Jacket; right, side view of Battery Jacket

products are being used by more and more athletes and professional workers in extreme conditions.

19.7. Electronic Devices

This is one of the most developed and commercialized applications of PCMs. For example, a protection for electronic devices from heating up by solar isolation when installed outdoors has been studied. A PCM developed to change phase at 35 °C would absorb solar radiation during day, and thereby prevent the electronic device to reach certain security temperature. The heat would be released during the night, allowing the cycling performance of the PCM. Nowadays, France Telecom has a prototype which is being tested.

Many telecommunication equipments must be located outdoors and powered by batteries. The company TEAP, together with Power Conversion Products and MJM-Engineering, has developed a battery jacket that minimizes the effects of peak heat loads in the day (Figure 167). The use of TEAP TH29 allows the heat loads to be absorbed in the daytime and released during night.

A passive cooling system for communications equipment has been developed by Climator AB, starting with a collaboration with Ericsson Telecom. This work lead to the production of ClimSel Cooling Systems that nowadays have been in operation for several years, with 100% function and no

Figure 168. PCM pad for laptops (picture from Climator)

maintenance needs. This system has been installed in other sites and applications, with similar good results.

Another problem studied and solved with PCM products is the overheating of laptop computers. One of the possible alternative methods to the used the noisy traditional fans is to add a PCM pad under the computer chassis (Figure 168). When the temperature of the computer chassis rises to the melting point of the PCM, the temperature of the computer will be kept close to this temperature.

Finally, we can report that a shelter for telecommunications with over 300 kg of PCM for thermal protection is commercialized in India.