New Product Opportunity

Warming And Cooling Systems That Do Not Require Electricity

There are numerous heating and cooling applications that involve small amounts of heat gain or loss, where it is advantageous for reasons of safety, convenience, etc. to eliminate the need for electricity. One way that this can be accomplished is by using Phase Change Materials (PCMs). Examples of existing products that employ phase change technology include:

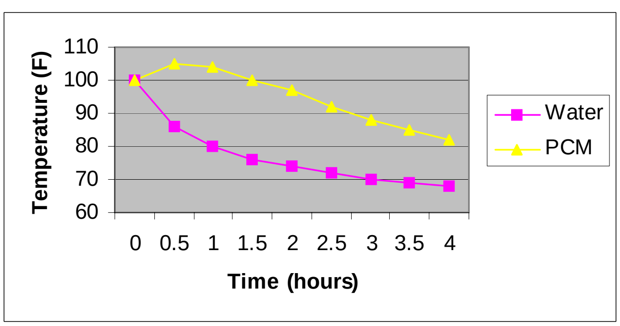
- *Hand Warmers* that are used by football fans, snow skiers, ice fishermen, etc.
- *Infant Heel Warmers* that are used to help maintain the body temperature of newborn infants.
- *Baby Bottle Warmers* that keep the milk warm prior to and during use.
- *Thermal Pads* (cold and warm) that are used in hospitals, nursing homes, etc. to raise or lower the body temperature of patients.
- *Carrying Containers* (cold or warm) for biomedical and biological materials.

PCMs utilize their latent heat of fusion to absorb, store, and release thermal energy during phase conversion between solid and liquid phases. Upon melting and freezing, a phase change material absorbs and releases substantially more energy, per unit weight, than a sensible heat storage material. The latent heat of fusion of many PCMs is substantial and can be used as either a heat source or a heat sink.

Of particular interest for many applications is the fact that PCMs release a large quantity of energy in the vicinity of their melting/freezing point (i.e. phase change temperature), but the equilibrium temperature of the substance remains the same. As a result, PCMs are essentially self regulating with respect to temperature and are able to maintain temperature within a very narrow range without the need for any type of external control.

In the example, shown in Figure 1, the temperature of 500 mL of solution, in two identical, non-insulated containers was monitored for 4 hours. One of the containers was filled with 100^{o} F water and the other container was filled with PCM that has been “activated”. The graph shows that the temperature of the water decreased quickly and reached ambient temperature in about 4 hours. The “activated” PCM reached a peak temperature of 105^{o} F after 30 minutes and remained warm for several hours.

Figure 1



There are several factors to consider in determining if a PCM is a viable option for your application. They include:

- Temperature – Materials with phase change temperatures from –28° F to 215° F are readily available.
- Cost - The cost of PCMs range from a few cents per pound to hundreds of dollars per pound.
- Safety – Some PCMs are very safe even for use in food contact or healthcare applications.
- Toxicity – Some PCMs are hazardous materials that may be difficult to use and can present disposal problems.
- Stability – Solutions that contain PCM are normally very stable (unlikely to spontaneously "activate") at low concentrations and considerably less stable at high concentrations.
- Reusability – Some products that contain PCMs are intended to be used only once and then discarded. Other products are "regenerated" and used over and over again.

One of the most commonly used PCMs is Sodium Acetate. Sodium Acetate is relatively inexpensive (about $2.50 per pound, at retail), non-toxic, and has a melting point (phase change temperature of 137° F). In a typical application, the Sodium Acetate is dissolved in hot (e.g. 180° F) water and then cooled to a temperature below the phase change temperature without allowing the PCM to crystallize, creating a super-cooled (or super-saturated) condition. The solution can then be "activated", when needed, to provide heat.

Most applications that employ Sodium Acetate involve concentrations between 1:1 and 2:1 (Sodium Acetate:water). The amount of heat generated depends on the concentration of Sodium Acetate and lower concentrations are inherently more stable and can be cooled to lower temperatures before they will spontaneously "activate". Higher concentrations produce more heat when they are "activated", but they are also more prone to spontaneous activation.

There are several different methods that are used to "activate" sodium Acetate solutions. Examples include: "seeding" the solution with Sodium Acetate crystals; creating nucleation sites by flexing a metal spring that is immersed in the solution; or rubbing glass or ceramic beads, that are immersed in the solution, together.

An important factor to consider in choosing an "activation" method is whether the product will be used only once, or if it will be "regenerated" and reused multiple times. For example, "seeding" the solution with Sodium Acetate crystals could be a good choice for a single use application, but it is probably not very practical for multi use applications, because the user would need to provide "fresh" seed-crystals each time the product is used.

One of the reasons that products that containing Sodium Acetate are so popular is because the phase change temperature is close to that of the temperature of the human body (e.g. 98.6° F). A 1:1 solution of Sodium Acetate and water, for example, will typically produce a peak temperature of about 105° F, which is nearly ideal for applications where the intended use involves maintaining body temperature in a cold environment or providing a slight increase in temperature for therapeutic purposes. Highly concentrated Sodium Acetate solutions can reach temperatures that approach the phase change temperature of Sodium Acetate (137° F), but they will never exceed that temperature because the Sodium Acetate re-dissolves at 137° F and moderates the reaction.