

Supplemental Information

S1: Simplification of body core temperature, Eq.14a:

The solutions presented in this paper all contain transient terms which can be simplified if $\alpha_i t < 1$ by expanding the exponential function in a power series

$$1 - e^{-\alpha t} \approx 1 - \left\{ 1 - \alpha t + \frac{1}{2}(\alpha t)^2 - \dots \right\} = \alpha t + O(\alpha^2 t^2)$$

In the example considered in this paper we find $\alpha_1 = 8.2 \cdot 10^{-6} \text{ s}^{-1}$ and $\alpha_2 = 5.1 \cdot 10^{-4} \text{ s}^{-1}$ which corresponds to times of 34 and 0.5 hour, respectively. Assuming $Q_3=0$ and expanding only the first transient then yields

$$T_1^{Q+r} \cong \beta Q_1' t + \frac{(1-\beta)Q_1'}{\alpha_2} [1 - e^{-\alpha_2 t}] \quad \text{Eq. S1}$$

The effect of the second transient however is small since here $\beta = 0.994$. By expanding both transient terms we can see that the Q_3 terms cancel, resulting in

$$T_1^{Q+r} \cong Q_1' t \quad \text{Eq. S2}$$

S2: Continuation after a change in boundary conditions

After an event at t_k (like a change in boundary condition or the end of melting)

$$T_1(t > t_k) = T_1(t_k) - A_1[1 - e^{-\alpha_1(t-t_k)}] - A_2[1 - e^{-\alpha_1(t-t_k)}] \quad \text{Eq. S3}$$

and similarly for T_3 . Note that this also requires an update of the temperatures in the A_i and B_i terms.

S3: Human body with PCM and no radiation:

Fully enclosed protective clothing such as chemical, biological or firefighter garment systems are an example of a situation in which the internally produced metabolic heat cannot escape and in such situations often PCM cooling elements are enclosed within the garment to temporary improve thermal comfort. In absence of radiation the solutions for T_1 and T_3 as given in Eqs.12–15 largely simplify and become

$$\begin{aligned} T_1^{no \text{ rad}} &= T_1^0 - (1-\beta)(T_1^0 - T_3^0)[1 - e^{-\alpha_0 t}] \\ T_3^{no \text{ rad}} &= T_3^0 + \beta(T_1^0 - T_3^0)[1 - e^{-\alpha_0 t}] \\ T_1^{Q, no \text{ rad}} &= [\beta Q_1' + (1-\beta)Q_3']t + \frac{1-\beta}{\alpha_0} (Q_1' - Q_3')[1 - e^{-\alpha_0 t}] \\ T_3^{Q, no \text{ rad}} &= [\beta Q_1' + (1-\beta)Q_3']t - \frac{\beta}{\alpha_0} (Q_1' - Q_3')[1 - e^{-\alpha_0 t}] \end{aligned}$$

where β now reduces to $h_3/(h_1+h_3)$ and $\alpha_0 = h_1+h_3$ as before.

The heat flux at interface 1 is proportional to the T_1-T_3 temperature difference. Using the equations above this then becomes

$$T_1 - T_3 = (T_1^0 - T_3^0)e^{-\alpha_0 t} + \frac{Q_1' - Q_3'}{\alpha_0} [1 - e^{-\alpha_0 t}] \quad \text{Eq. S4}$$

S4: Hotplate without radiation:

The most direct experimental evidence about the possible cooling power and duration of a PCM cooling element can be obtained by blocking the cooling capacity which is lost by radiation during a hotplate experiment. Experimentally this is done by carefully insulating the PCM outer surface. The transient and melting stage solutions for the cooling power then become

$$P_{hp} = \frac{A}{R_2^{eff}} (T_1^{hp} - T_3^0) e^{-h_3 t} \quad t < t_1, \quad \text{phase 1} \quad \text{Eq. S5}$$

$$P_{hp} = \frac{A}{R_2^{eff}} (T_1^{hp} - T_3^m) \quad t_1 < t < t_2, \quad \text{PCM melting} \quad \text{Eq. S6}$$

$$P_{hp} = \frac{A}{R_2^{eff}} (T_1^{hp} - T_3^m) e^{-h_3 (t-t_2)} \quad t > t_2, \quad \text{phase 3} \quad \text{Eq. S7}$$

Thus from such an experiment the contact resistance R_2^{eff} can be determined from the melting plateau and the parameter h_3 is obtained from the phase 3 transient. By comparing this with a hotplate experiment with radiation, we can also obtain parameter h_4 (see Eq.20).