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FEM Modeling of Thermal Conductivity of Phase Change Material

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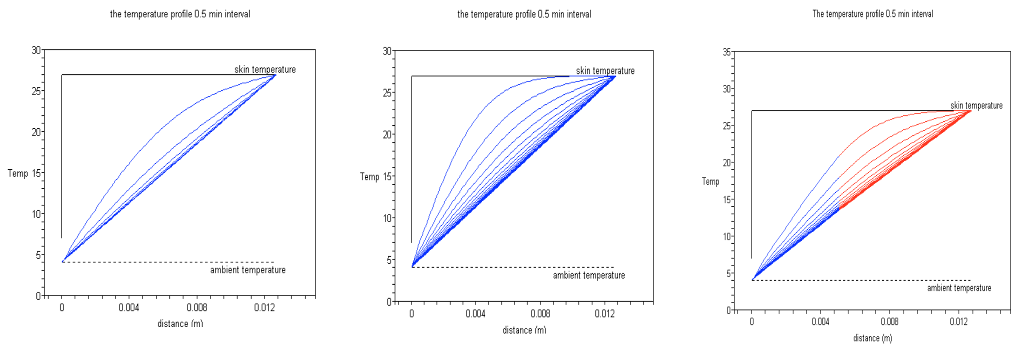
A Phase Change Material (PCM) is a type of polymer substance encapsulated in microscopic balls of heat-resistant plastic. When these encapsulated balls of PCM are coated onto a garment, they increase the thermal capacitance of the garment, by utilising the latent heat release or absorption during the phase change of the PCM.

Each PCM has its own designated fusion temperature. If a PCM-enhanced-garment is stored in a temperature higher than the fusion temperature of the PCM, the polymer substance encapsulated in the microscopic balls is in liquid state. After being exposed to a temperature lower than its fusion temperature, the state of PCM in the garment will change from liquid to solid. During the phase change process, the PCM releases heat to the garment, which consequently keeps the wearer warmer much longer. This process can be reversed, in which case, the heat is absorbed, thus keeps wearers cooler over an extended period.

In this project, we adopted the mathematical model proposed by Gear et al. We implemented the model into the Finite Element algorithm based on Galerkin weak formulation, with 2nd order shape functions. We then started to develop the Finite Element Analysis (FEA) codes for modeling of the thermal conductivity of PCMs, using MAPLE.

The results for the transient heat transfer in the three types of garments are shown in Figure 1.



(a) (b) (c)

Figure 1. Transient thermal profiles of (a) Thinsulate; (b) PCM without phase change (c) composite of Thinsulate and PCM without phase change.

The results in Figure 1 show that the temperature profile for the garment made from Thinsulate approaches the steady state the fastest, while PCM is the slowest. It is also important to compare the heat fluxes at the skin boundary for these three garments, because the heat flux profile indicates how soon the diver could feel the effect of the cool water.

It is expected that PCM with phase change will provide even longer thermal protection than that without phase change. We are currently in the 3rd stage of our program, *i.e.* we are developing the FEA codes for transient heat transfer in a PCM with phase change. The final objective of the project is to predict the optimal combination of the Thinsulate and PCM that would give wearers the best protection.

Kim Ngoc received an ICE-EM Vacation Scholarship in December 2005.
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I found that the project very interesting. I would like to thank ICE-EM for the opportunity to undertake the Vacation Scholarship to research my project. It was also a good chance for me to join in the BDI (Big Day In) to communicate with other students and share our research experience.

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