Natural Refrigeration System Design

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Introduction: Evaporative cooling is a natural process observed in daily life, governed by evaporation physics. Leveraging this natural phenomena, Natural cooling devices can be designed as an alternative to active systems. Passive Natural refrigerators are inexpensive, portable and operates without electricity. Phase change multiphysics modelling methodology is used to design novel evaporative coolers with improved performance.

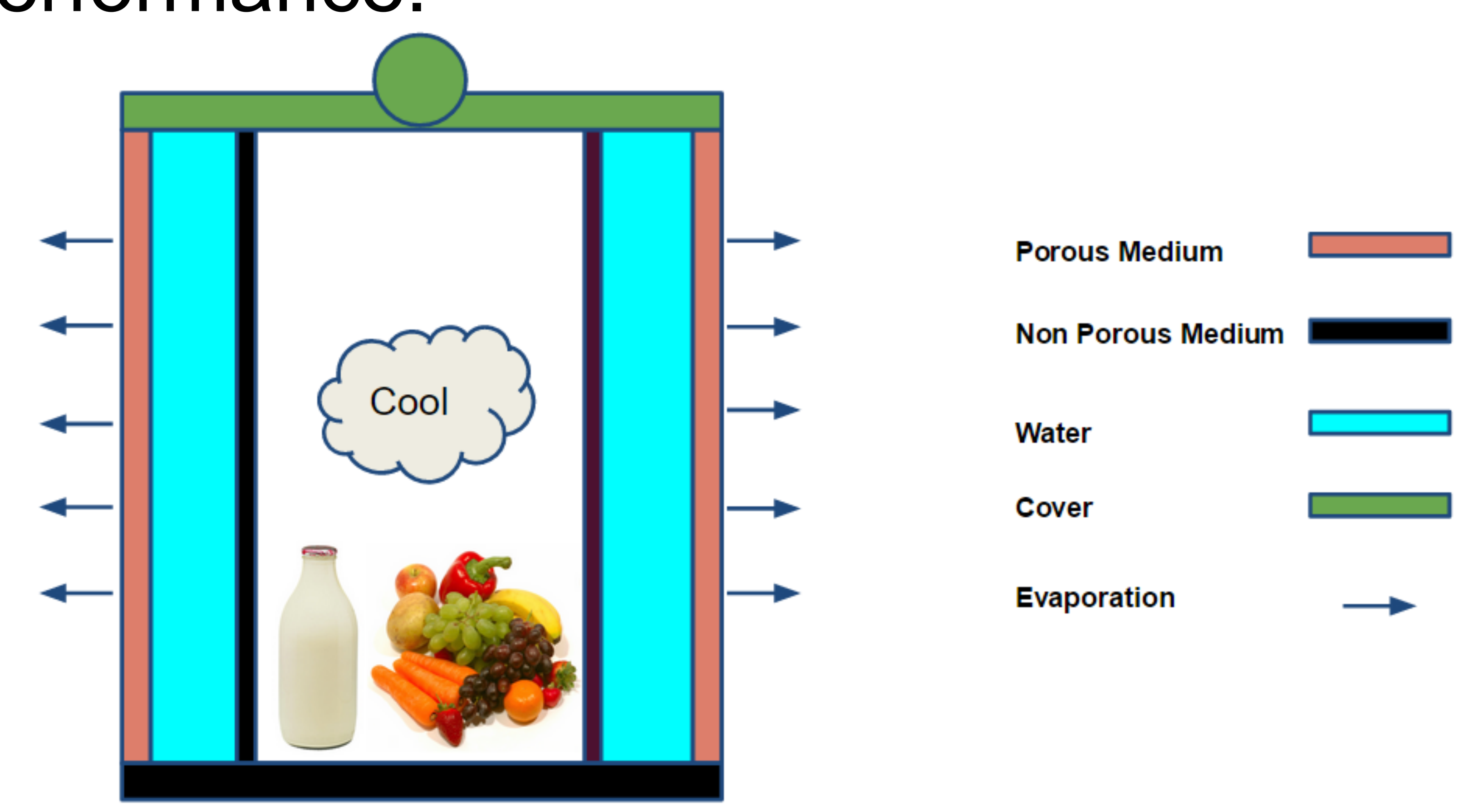

Figure 1. Working principle of Natural Refrigerator.

Computational Methods: A coupled Multiphysics CAE Simulation model for evaporative cooling is developed using COMSOL 5.1. A time dependent Heat Transfer model coupled with Turbulence & Transport model is used to evaluate and compare the performance of evaporative coolers.

Governing Equations:-

$$-n.(-k\nabla T) = H_{vap} n.(-D\nabla c+uc)$$

$$c_{vap} = P_{sat} / R_g T$$

H_{vap} = Latent heat of Vaporisation.

P_{sat} = Saturation Pressure

R_g = Gas Constant

Results: Simulation results shows the temperature distribution for evaporation cooling in both designs. Natural cooling shows potential to lower the temperature by about 50°C from the initial conditions. The corrugated design shows further lowering of temperature around 14%. Temperature difference of 10°C is obtained for large evaporative surface area compared to standard surface area.

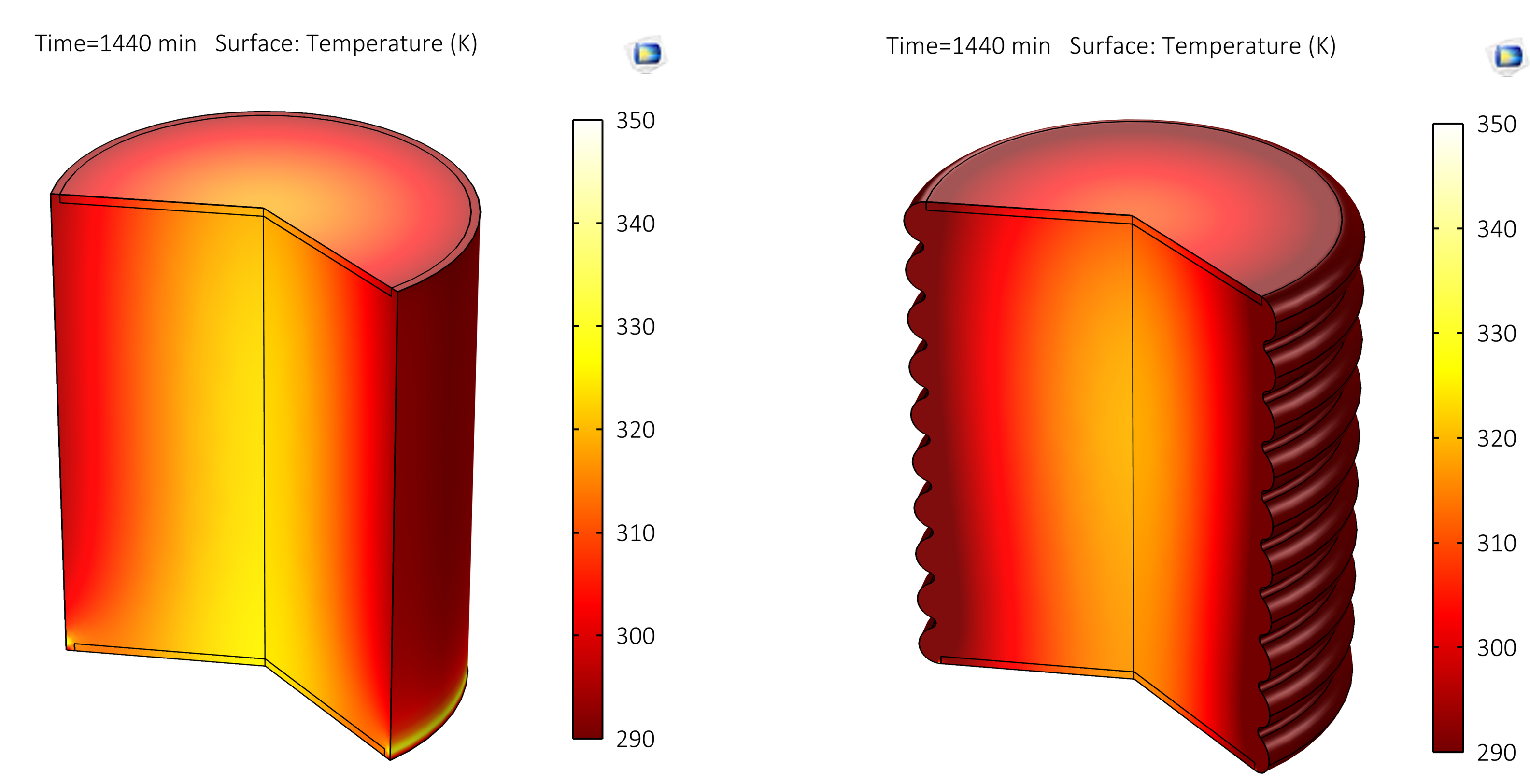

Figure 2. Cooling performance comparison.

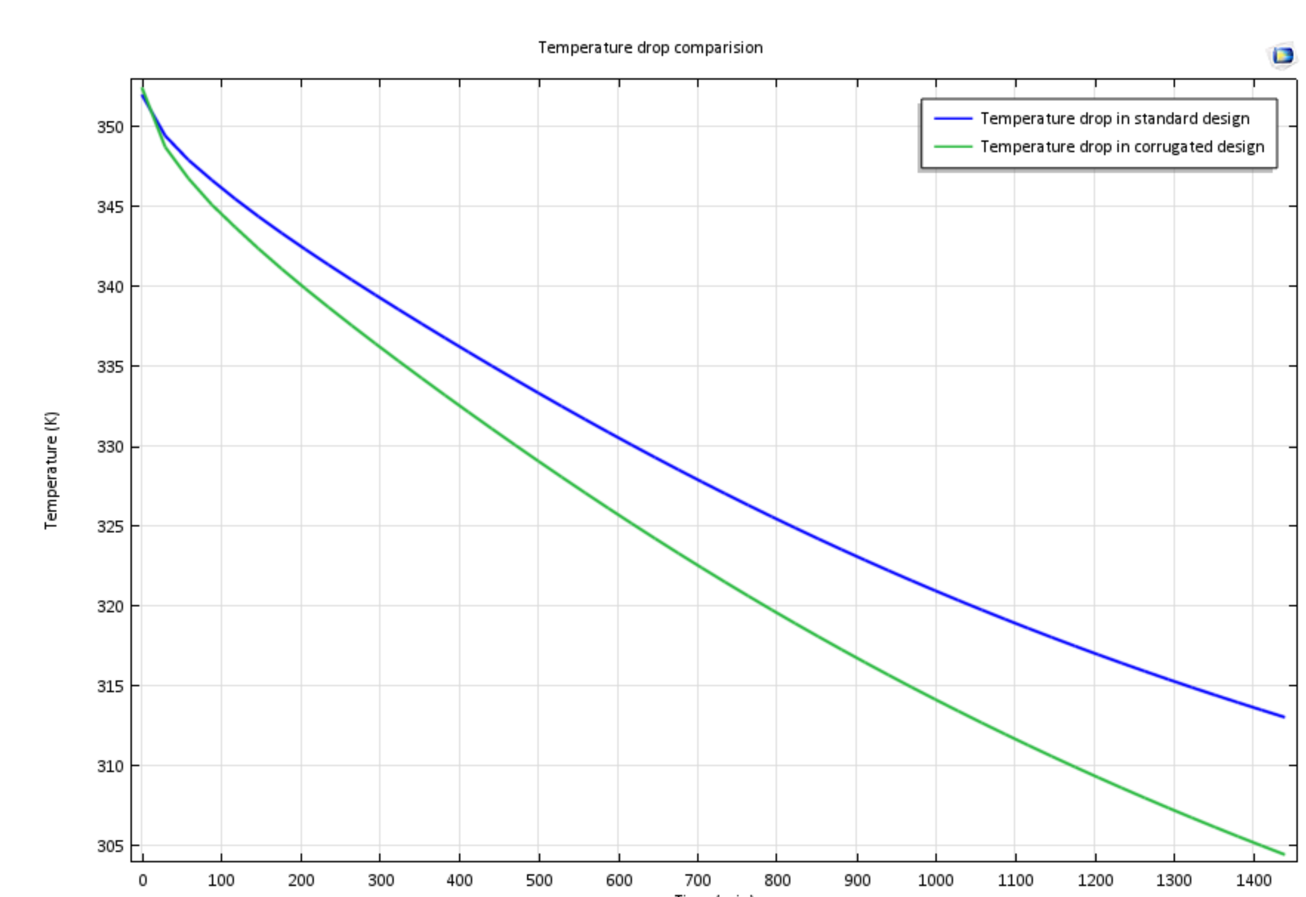

Figure 3. Temperature drop comparison.

Conclusions: The phase change physics model helped to optimise the evaporator design for efficient performance. The corrugated evaporative surface demonstrated additional 14% reduction in temperature compared to standard design. This multiphysics modelling methodology can be used to optimise evaporative cooling based low cost products with superior performance.

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