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Effects of Lattice Geometry and Magnetic Field on Phase Change Behavior of Water-Based Temperature-sensitive Magnetic Fluids

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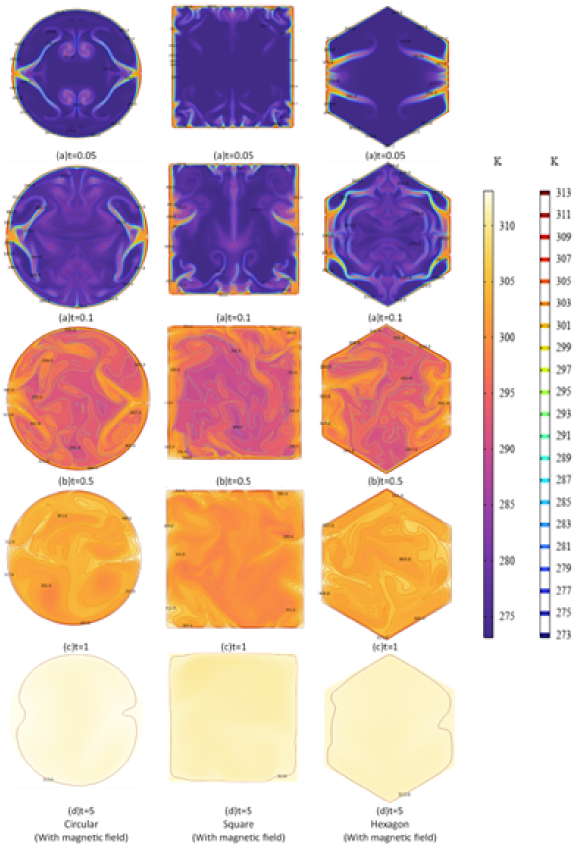

Figure 1:

This study investigates the solid–liquid phase change behavior of a temperature-sensitive water-based magnetic fluid (TC3030W) confined in lattice structures, focusing on the combined effects of geometry and applied magnetic fields on heat transfer. Experimental analyses were conducted under Helmholtz and solenoid magnetic field configurations, complemented by finite element simulations using COMSOL Multiphysics to simulate the magneto-thermo-fluidic behavior. Under Helmholtz magnetic fields, phase change behavior exhibits strong geometry dependence, with the square lattice showing the fastest melting (354 ± 4.68 s) and the circular lattice the shortest solidification time (381 ± 5.41 s), indicating distinct optimization pathways.

Under a solenoid magnetic field, the circular lattice demonstrates the highest enhancement, reducing phase change times relative to purified water by up to 8.8% in melting and 7.0% in solidification at 40 mT, driven by thermomagnetic convection. Numerical results indicate convection-enhanced heat transfer under a uniform magnetic field, driven by thermomagnetic effects shown in Figure 1. These findings highlight the combined role of lattice geometry and magnetic-field-induced convection in governing phase change performance.

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