50

Magnetic Field Effects on Heat Transfer During Phase Change Transition in Temperature-Sensitive Magnetic Fluids

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Cold thermal energy storage (CTES) systems are often limited by the low thermal conductivity of conventional phase change materials (PCMs), restricting heat transfer during melting and solidification [1]. Ferrofluids, particularly temperature-sensitive magnetic fluids (TSMFs), offer a promising approach due to their coupled thermal and magnetic properties, enabling externally tunable heat transfer [2,3]. This study investigates the effects of magnetic field application and dilution on the transient heat transfer behavior of a water-based TSMF during solidification and melting. Experiments were conducted under field-free and applied uniform magnetic field conditions using diluted samples. Under field-free conditions, heat transfer is largely conduction-dominated, with dilution reducing temperature differences during solidification and enhancing heat flux and heat transfer coefficient (HTC) during melting. With magnetic field application, distinct changes in heat transfer behavior are observed. During solidification, variations in HTC evolution suggest that temperature-dependent magnetization may influence internal heat transport through magnetically induced body forces. Although bulk convection is limited, the observed trends are consistent with localized thermomagnetic effects. During melting, the magnetic field enhances the initial heat transfer rate, particularly at higher dilution ratios. Overall, heat transfer in TSMFs is governed by the combined effects of concentration-dependent properties and magnetic-field-induced forces, highlighting their potential for controllable thermal management in energy storage applications.

References

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