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DROPWISE CONDENSATION IN MICROGRAVITY: DROPLET REMOVAL BY A SHEARING AIRFLOW

Abstract

Dropwise condensation (DWC) is a superior mode of heat transfer compared to the usual filmwise condensation (FWC). This is important for the environmental control and life support system (ECLSS) in space vehicles. Also, DWC can be found in other applications related to reduced gravity environments, such as thermal management systems for satellites, power management systems, and wastewater treatment for manned space platforms. The high HTC seen in systems with DWC also means that these systems can be miniaturized, making them lighter. This is essential for space application—an area in which one of the goals for system design is the minimization of a system's weight. However, the condensation phenomenon at the liquid–vapor interface in microgravity (i.e., space applications) is not well understood. Therefore, it is necessary to understand humid air condensation in a microgravity environment. Understanding the shedding of droplets from a surface is a critical part of the dropwise condensation process for improving heat transfer. Because gravity as a droplet removal technique is not available in space, the use of airflow to shed droplets is considered for condensing heat exchangers in environmental control and life support systems. Surface coatings affect drop adhesion, and here four different surfaces (PMMA, PS, PTFE, and SHS) and various droplet sizes (80, 60, and 40 L) were used to understand the above phenomenon. It was found that the critical velocity to shed a droplet in microgravity was up to 8 percent lower than that in normal gravity. Also, the effect of the droplet size was investigated for both microgravity and normal gravity; the shedding velocity was lower for microgravity, and it decreased as droplet size increased. Increasing hydrophobicity of the coating, decreased critical velocity for shedding. Finally, the droplet was found to detach from superhydrophobic surfaces in microgravity. The detachment of droplets from the substrate will hamper the condensation process that can produce a larger fresh area; also, detachment of droplets and entrainment in airflow, counters the concept of removing moisture from the air in a dehumidification process.