Microgravity Effects on Vapor Compression Cycle Performance for Cold Food Storage with Oil-Free Compression

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ABSTRACT:

NASA and private space organizations are working towards the goal of colonizing the moon and mars. To establish a thriving human colony on a celestial body other than Earth, robust and efficient life support systems need to be developed. Currently, astronauts only have access to shelf stable foods in space which do not maintain high nutritional value beyond one-to-three years. A refrigeration device that can operate in zero gravity is necessary to store nutritional food for longer durations. A vapor compression cycle (VCC) was designed and built that leveraged the use of a liquid resilient, oil-free scroll compressor to increase robustness and reliability of a refrigeration system for long duration space flight in microgravity. The oil-free operation of the compressor allowed the VCC to operate in microgravity due to the mitigation of oil management in typical refrigeration compressors. The VCC was designed to cool a cabinet to -20 C that can fit within the space constraints of two EXPRESS racks on the International Space Station (ISS). A fabricated refrigeration unit was flight tested on a parabolic flight that simulates microgravity for 20 second periods. Four parabolic zero gravity flights were utilized to validate that the VCC can operate in microgravity and investigate its effect on the performance of the oil-free refrigerator. The impact of microgravity on the steady-state operation of the VCC was investigated during the first microgravity flight day. A pull-down of the cabinet temperature was performed during the third microgravity flight day. From the first and third flight tests, valuable insight of how the VCC operates in microgravity was established. Conclusions can be drawn about the increase in evaporator capacity in microgravity and rate of change of cabinet return temperatures due to the lack of buoyancy forces. Limitations of calculating performance metrics of the VCC are explored due to space constraints of the physical refrigeration unit which reduced the amount of instrumentation that could be utilized. Different applications for the VCC are explored; food storage system, space conditioning for a lunar habitat, or thermal management devices for spacecrafts.