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Author: Mr. Nikhil Vadhavkar
Massachusetts Institute of Technology (MIT), United States, nvadhavk@mit.edu

LIGHTER, ADAPTIVE THERMAL SUBSYSTEM FOR LIFE SUPPORT DURING MARS EXTRAVEHICULAR ACTIVITY (EVA) PLANETARY EXPLORATION

Abstract

The Mars environment presents a number of challenges to the current extravehicular activity (EVA) architecture. The Martian gravity of 0.38 g is more than twice that of lunar gravity, resulting in more stringent mass requirements for the spacesuit and portable life support system (PLSS). The Martian atmospheric pressure of 7 mmHg (0.933 kPa, 0.135 psi), combined with seasonal temperature swings and forced convection, place an increased burden on the PLSS to maintain comfortable working conditions for a surface explorer. The current PLSS utilizes a liquid cooling and ventilation garment (LCVG) and sublimator for heat rejection. NASA is developing system- and component-level upgrades to improve upon the International Space Station (ISS) Extravehicular Mobility Unit (EMU) PLSS. However, the open-loop venting of water and mass of the heat rejection subsystem are not directly addressed, as these efforts are not specific to Martian exploration. We propose a new paradigm for thermal control during EVA that leverages the mechanical counter pressure (MCP) BioSuitTM currently in development at MIT. In addition to the mobility advantages gained from MCP, the BioSuitTM takes advantage of the interaction between the suit and the environment. We present a trade study of insulation and heat rejection concepts for incorporation into an advanced planetary spacesuit system, including variable insulation geometry,electrochromics, and radiative heat rejection. The novel thermal model simulates various EVA profiles on Mars at polar and equatorial perihelion and aphelion. We conclude that variable insulation will reduce the requirement for active heat rejection, making the PLSS simpler and lighter. Active heating elements utilizing next-generation battery technology can augment insulation and provide a fast response to deal with changing environmental conditions during an EVA. An advanced suit PLSS for Mars should not require an LCVG and evaporator, thereby closing one consumables loop and making the PLSS significantly lighter.