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Author: Mr. Jeffrey Steiner
University of Connecticut, United States

Prof. Ramesh Malla
University of Connecticut, United States

STUDY OF PREFABRICATED COMPOSITE LAYER AS A TEMPERATURE AND IMPACT SHIELD FOR LUNAR HABITATS

Abstract

The next logical step in the advancement of manned space exploration is a return to the Moon for an extended period of time. The Moon presents a plethora of opportunities for testing advancements in technologies related to spaceflight and extraterrestrial habitation, as well as the ability to act as a low-gravity origin point for further human exploration throughout the solar system. The establishment of a long-term human footprint on the Moon is dependent on the ability of the space industry to overcome the challenges that will be presented during future attempts to inhabit the lunar surface. The lunar environment presents a multitude of technical challenges to be overcome that are not restricted to: a hard vacuum, lack of substantial atmosphere, susceptibility to multiple forms of dangerous cosmic radiation, potential for micrometeoroid impacts at hypervelocity, and a broad range of temperature extremes. The construction of a resilient lunar habitat requires a design that addresses all of these technical challenges in a cost-effective manner.

The focus of this study is the analysis of a proposed lunar habitat to assess its ability to resist temperature extremes and impact forces. In order to resist these environmental hazards, a prefabricated composite shield layer comprised of Kevlar fabric, ultra-high molecular weight polyethylene, open-cell aluminum foam, and vacuum insulation panels are implemented in the design. While many proposals for In-Situ Resource Utilization(ISRU) have been put forward in recent years, the first habitats on the Moon will most likely have to be manufactured as multiple parts on Earth and assembled on the lunar surface. As the lunar infrastructure is developed, ISRU techniques for manufacturing and construction will become more viable. The thermal analysis in this paper utilizes the thermodynamic equation of heat conduction and radiation to produce a depth-dependent temperature gradient from the habitat exterior to the interior that changes continuously with time during the lunar diurnal cycle. The impact analysis is able to determine the dynamic response and effectiveness of the habitat shielding layer to resist micrometeorite and launch debris impact. The results of this study should be useful to determine the potential implementation/use of prefabricated composite structures for the initial lunar base.