This system will consist of three layers, as shown above in Figure 1. The outermost layer consisting of tufted fibers is composed of poly(3,4-ethylenedioxythiophene (PEDOT), which blocks the lunar environment from direct contact with the EGA. The tufting process creates a dense array of durable bundles of fiber to block regolith penetration at the micron scale. These fibers are designed to carry a charge themselves, thereby extending the electrostatic field and decreasing the rate of dust accumulation. With electrostatic charge reaching above the fabric of the suit, joints and seals will require minimal cleaning as regolith adhesion is greatly reduced. If the fibers become saturated with dust, it will not cause the system to fail and occasional brushing of the fibers will provide sufficient cleaning to improve the longevity of the system.

The outermost layer of longer electrostatic fibers is accompanied by shorter catching fibers arranged in a single row along the seal abutting edge. These strands are shown in Figure 1 to the right proximally. This catching row is composed of high surface area angular fibers designed to entrap infiltrating dust, commercially used in woodshop filters. During donning and doffing, regolith particles will be shaken loose, potentially side-stepping our charged solution. Any regolith particles that land along the seal abutting edge of the TEST-RAD solution will be caught by this row of star-shaped fibers.

The middle layer consists of a conductive metal mesh. This serves as a medium for the electrostatic charge to pass through, as well as providing the necessary structure for fiber tufting. The mesh being used is woven stainless steel with holes of either .9 mm, 1 mm, or 2.5 mm (the most effective size will be determined during testing). This mesh is one of two major components of the EGA, with the other being a static electricity generator connected to the power supply of the life support system. The static electricity generator will be integrated to provide electrostatic charge to the various TEST-RAD systems which require it. At the initiation of the moonwalk the life support system is activated, causing an electrostatic charge to be generated and thus the repulsion of regolith from sensitive areas. One concern of the Artemis mission, and longer duration EVAs, is the variation in regolith charge depending on whether it is lunar day or lunar night. The system is effective in either of these situations, as the electrostatic field generated by TEST-RAD is great enough to repel dust particles independent of regolith polarity. This concept has been proved by the NASA Electrostatics and Surface Physics Laboratory and TEST-RAD will be developed to reproduce a similar level of success (Calle et al., 2008).

The third and final layer provides a connection point between the system and the suit. This is achieved through the use of local charge reducing fabrics located directly underneath the EGA mesh. This creates a physical barrier between the suit and the charge coming from the static generator. TEST-RAD, in essence, separates the harsh lunar environment from sensitive areas of the suit through the use of electrostatics and tufted fibers. The purpose of this last layer separates the charge from direct interaction with the suit. This creates a system whereby dust is blocked by the electrostatics, and the electrostatics are blocked by an insulating layer. As a result, the harmful, sharp regolith never reaches the suit.

Importance

The TEST-RAD system will improve the safety of astronauts on extended moonwalks through the deflection of regolith. Specifically, it aims to optimize the durability and functionality of key sections of the suit, such as joints, bearings, and seals. It will also lessen the amount of free regolith in habitation modules as dust particles are actively repelled from the fabric. Lastly, it should decrease the time needed for overall suit cleaning which should help the crew focus on much more significant tasks.

Christoffersen et al. recommends a limitation on the use of woven fabrics as they have a tendency to induce frictional regolith damage (2009). This wear, if continued over greater duration missions and longer EVA times, could cause catastrophic damage to the pressure suit. TEST-RAD does not use woven fabric; instead, the system employs a tufted design to account for fine regolith that will interact with the fabric. The outermost fibers being packed at such a high density (coupled with electrostatic forces) prevents the penetration of regolith onto the exterior fabric. Therefore the system eliminates the risk in damage to sensitive areas of the EVA suit, likewise causing the risk of catastrophic failure due to dust abrasion to drop dramatically. Overall, extra protection and reduction of risk will greatly extend the life of Artemis generation spacesuits.

Astronauts from Apollo Era Missions noted mild lung discomfort due to inhaled regolith particles which were brought into habitable areas (James and Kahn-Mayberry, 2011). The system aims to decrease the amount of airborne regolith in two primary ways. The first is through the aforementioned repulsion of lunar dust, because the less particles on the suit, the less particles that make it into habitable space. The second involves soil that has penetrated past the electrostatic layer. This minimal amount of dust is taken up by the irregularly shaped filtration fibers and blocked in from escaping. This solves the problem of airborne particles significantly as dust adhered to seals and bearings does not unattach from the suit. Instead it remains trapped underneath the electrostatic layer, bound by filtration media, unable to affect astronauts' respiratory health and comfort.

Cleaning time is another area TEST-RAD is designed to improve over the Apollo Missions. During previous moonwalks, astronauts used brushes to remove large pieces of regolith from afflicted spacesuit areas. However, this was somewhat inefficient as there were still particles stuck in the woven parts of the suit (Christoffersen et al., 2009). This process was also highly time consuming for crew members. TEST-RAD leads to faster and more effective cleaning due to decreased regolith adhesion. Due to less dust in seals and bearings directly