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Smart Technology in Spacesuits

Shelly Khanna, Amandeep Kaur
Fashon & Apparel Department, TIT&S College, MDU, Rohtak,
Haryana, India

Abstract—

The spacesuits are the mobile units to provide a comfortable stay to the astronauts away from the earth's atmosphere and its surface. They provide a microclimate to the space-flyers as a shield against the severe temperature variations of the space. The present paper highlights the use of smart technology in space suits to fulfil the functional requirements. In the future, astronauts might be wearing specially engineered garments that combine the life-preserving features of a spacesuit with augmented reality technology that could intuit the wearer's needs.

***Keywords—** spacesuits, astronauts, microclimate, smart technology, space-flyers.*

I. INTRODUCTION

The history of textile can be traced back to the age when human being tried to cover their body for safety and protection– even well before the production of fabric and other products started on machines **[1].** Today spacesuit is itself a wonderful application of smart textiles. While the primary objective of the space suit is to keep the astronaut safe, it is also critical that the suit does not prevent the astronaut from physically completing mission tasks. After safety, flexibility and mobility are perhaps the most important design considerations for suit engineers [**2**]. However, traditional gas-pressurized suits are inflexible. Gas pressurization causes stiffening of the soft suit materials, and changes in internal volume and pressure caused by deformation of the suit joints during movement forces the astronaut to expend energy every time when bends the suit away from its equilibrium position**[3-4].**

Mechanical counter-pressure (MCP) space suits have the ability to improve the mobility of astronauts as they conduct number of outer space activities. MCP suits, which differ from traditional (EMU) gas-pressurized space suits by applying surface pressure directly to the wearer using tight-fitting materials in place of pressurized gas, represent a fundamental change in space suit design. By altering the pressurization mechanism, MCP suits act as a conformal, vastly reducing the mass of the suit while simultaneously reducing the circumstance of the risk of suddenly failures due to puncture or depressurization. As a result, MCP suits represented a promising breakthrough technology for future exploration missions.

While MCP suits were first proposed over 40 years ago, challenges still existed to realize on air implementation. The underlying technologies required to provide uniform compression at sufficient pressures for space exploration that have not yet been perfected, and the challenge of donning and doffing such a suit remains unresolved. The most promising solution to both of these problems lies in active materials technology. Active materials, such as shape memory alloys (SMAs) and electro active polymers (EAPs) possess the ability to change shape when stimulated, and have been considered for application in everything from robotic actuators to self-expanding stents for human body implants. Integrating these technologies into a wearable garment could lead to smart textile capable of altering their compression characteristics upon command from a dedicated control mechanism **[5].** The technology uses phase change materials, which were first developed for use in space suits and gloves to protect astronauts from the bitter cold when working in space.

II. ART-E-FACTS OF SPACESUITS

Outer space is an extremely hostile place. If astronaut were to step outside a spacecraft onto a world with little or no atmosphere, such as the moon or mars, and not wearing a spacesuit, the following things would happen

- Astronaut would become unconscious within 15 second because there is no oxygen in the outer space.
- Astronaut's blood and body fluids would boil and then freeze because there is little or no air pressure.
- Astronaut's tissues (skin, heat, and other internal organs) would expand because of the boiling body fluids.
- Astronaut would face extreme changes in the outer space temperature.

  Sunlight: 248 Degree Fahrenheit /120 Degree Celsius.
  Shade: -148F/-100C.
- Astronaut would be exposed to various types of radiations such as cosmic rays and charged particles emitted from the sun.
- Astronaut could be hit by small micrometeoroids or orbiting debris from satellites or other spacecrafts.

So, to protect from these dangers, spacesuit must have

- Provide pressurized atmosphere.
- Breathable oxygen.
- Effective removal of carbon dioxide.
- Maintenance of a comfortable microclimate despite strenuous work and movement into and out of sunlit areas.
- Protection against micrometeoroids.
- Protection from cosmic radiations.
- Clear vision.
- Permitting the body and limb movements inside the spacesuit **[6].**

III. LATEST TECHNOLOGY IN SPACESUIT ASSEMBLY

A. EXTRA VEHICULAR MOBILITY UNIT (EMU)

These Special Suits have been designed to solve the problems faced by astronauts with earlier design of spacesuits for Mercury, Gemini and Apollo expeditions. The peculiar function of EMU is the internal gas-pressurization in the garment structure of the spacesuit

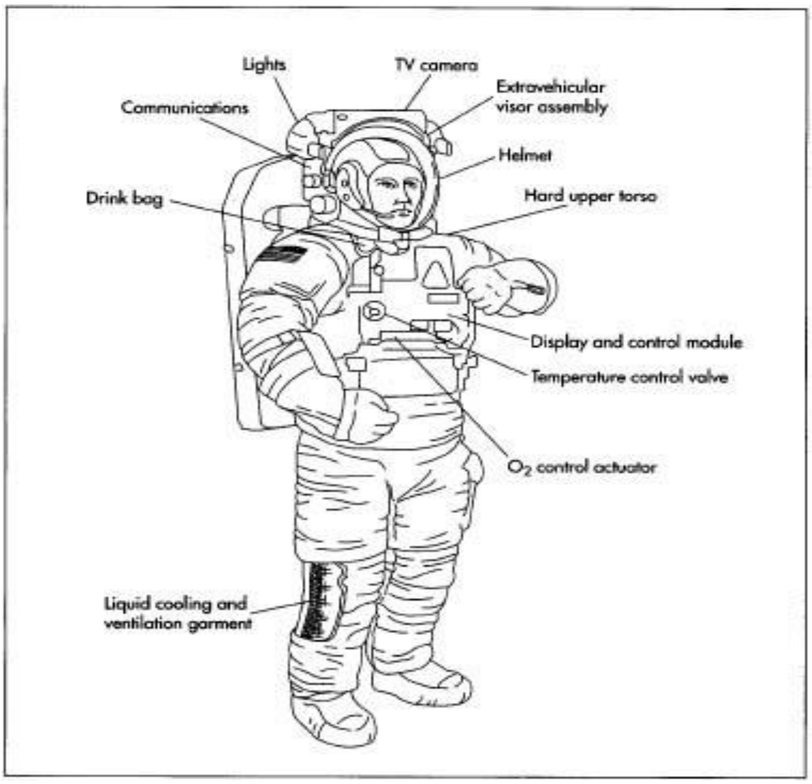

Fig 1 EMU (extra vehicular Mobility Unit). Source: www. Ssoar.org

1) *Some facts related to EMU*

- Weight = 280lb (127 kg) on earth.
- Thickness = 3/16 in (0.48Cm), 14 layers.
- Atmosphere = 4.3lb/Sq. inch (0.29 atm.) of pure oxygen.
- Volume = 4.4 to 5.54 Cu.feet (0.125 to 0.53 Cu meter) without astronaut.

2) *Composite layers of the EMU* - It consists of 14 layers of structure to perform number of functions such as thermal resistance, vapor absorption and impact resistance layers. First layer is made up of knitted structure from Nylon tricot that is lined. Over the first layer, second layer of spandex material fabric tubing is laced. Third layer is a urethane-coated nylon fabric layer called the pressure bladder layer. Over which a pressure-restraining layer made up of Dacron is laced. These two layers are employed to felicitate the astronaut from pressure balancing both internal and external pressures. Above these two layers, a thin liner of nylon coated with Neoprene is placed, followed by a series of seven layers, thermal micrometeoroid garment of aluminized Mylar laminated with Dacron. These seven layers are thermally insulated, protecting the astronaut from heat phenomenon and providing impact

resistance against meteoroids. The ortho-fabrics or outer layer of spacesuit, which is exposed to various radiations, is made up of a blend of Gore-tex, Kevlar and Nomex materials coated with Phase change material on surface and gloves to protect astronauts from the bitter cold when working in space **[1,6]**.

3) Other parts of the EMU are.

- Gloves
- Arms
- Helmet
- In-suit Drink Bag
- Primary Life Support Sub-system(PLSS)
- Secondary Oxygen Pack (SOP) **[6].**

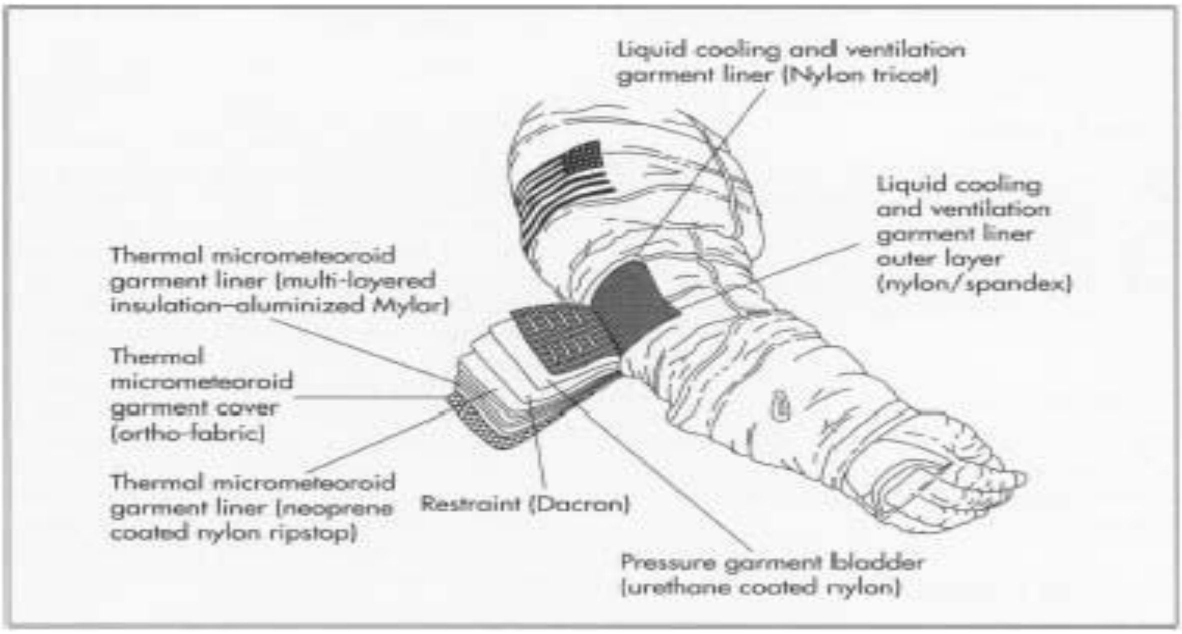

Fig 2. Composition of EVU. Source: htpp://manavalan.files.wordpress.com

B. CREW CONTROLS

Currently, astronauts control the cooling and pressure systems of their EVA suits using a set of controls mounted on the chest. The pushbuttons and sliders are mechanical switches that must be large enough for an astronaut's gloved hand to access. Using Smart Fabrics, controls could be integrated seamlessly into any location on the EVA outer garment and conductive textiles could replace the traditional wiring. This would reduce the EMU's mass and potentially make the controls more accessible [**9**]**.**

Fig 3. Crew control device

C. CUFF CHECKLIST

The current checklist is merely a set of laminated cards that the astronaut flips through to find a particular task **[10]**. A cuff checklist is used to remind the astronaut of the tasks that are to be performed on the current extravehicular activity, and may contain diagrams and procedure steps.

D. HEALTH MONITORING

One of the major scientific objectives is to understand how much longer exposure to the space environment affects the human body. Additionally, the challenges of treating illness in space make it even more critical for astronauts to monitor their own health and identify potential health problems early in their critical work positions **[11].** A special long term medical survey is designed and developed to be comfortably worn by the space- flyers for up to 24 hours. The Long Term Medical Survey System (LTMS) is a lightweight, safe, reliable and easy-use medical measurement system monitors astronauts' health during surface operations activities. LTMS meets medical safety standards and is easily wearable by anyone and performs the monitoring & recording of ECG, respiration rate, pulse rate, core body temperature, blood pressure, activity/posture and weight and body composition **[12].** It has three body contacts with no gel and cableless electrodes in the upper wear (shirt/ Tshirt).

.Fig 4. Long term Medical survey

E. WEARABLE CONTROL AND FEEDBACK

Smart Fabrics could enable astronauts to remotely communicate, control, and receive feedback from systems they would otherwise need to physically approach. Using flexible electronics integrated into the clothing of the astronauts, they could have continuous access to critical functions, science experiments, or simple conveniences. In darkness or low visibility, the astronaut would still be able to locate critical controls if they were attached to his or her clothing.

F. MECHANICAL COUNTER-PRESSURE (MCP) SPACE SUITS

Mechanical counter-pressure (MCP) space suits have the potential to improve the mobility of astronauts as they conduct planetary exploration activities. MCP suits differ from traditional (EMU) gas-pressurized space suits by applying surface pressure to the wearer using tight-fitting materials rather than pressurized gas. An active MCP suit can relax or tighten as necessary, independently on all areas of the body (except the head). With the advancement of shape-changing materials, an active suit may be produced with electro-active polymer fibres integrated circumferentially into the elastic weave, or shape memory alloy bands aligned in the longitudinal directional. A small, light and flexible suit based on active MCP elastics could be worn for all extravehicular operations, but also during launch and entry. **[10].**

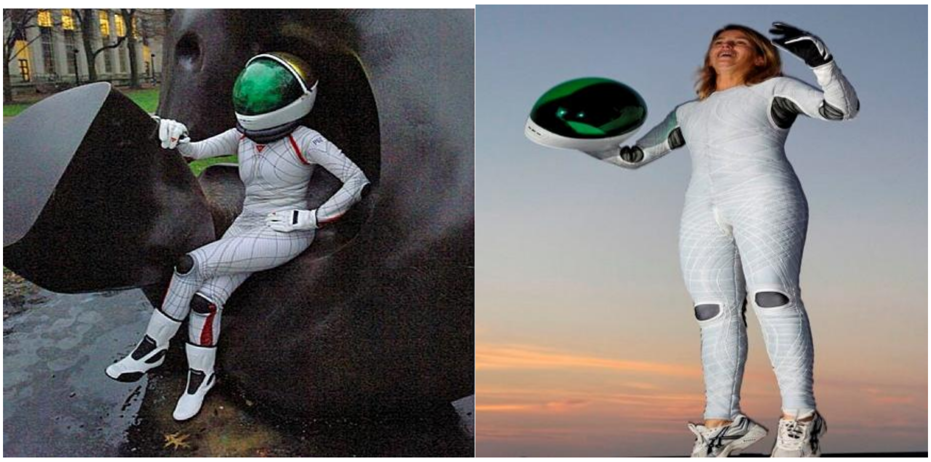

Fig 5. MCP Suits

G. SMART SPACESUIT TECHNOLOGY

The spacesuit textiles to behave smartly it must have a sensor, an actuator (for active smart textiles) and a controller unit (for very smart textiles). These components may be active materials, such as shape memory alloys (SMAs) and electro active polymers (EAPs) possess the ability to change shape when stimulated, fiber optics, phase change materials, thermo chromic dyes, miniaturized electronic items etc, these are incorporated and coated onto different parts of the spacesuit to improve its functionality [5]. At a designated high temperature, PCMs are provided with an ability to absorb and hold heat to produce a cooling effect. At a designated low temperature, PCMs release their stored heat to produce a warming effect in a localised area. On the other, SMAs are used for the actuators in the control system of spacesuits.

IV. SCOPE OF SMARTER TECHNOLOGY IN SPACESUITS

The future Spacesuits are perceived to perform self repairing of holes, generate electricity and inactivate germs. The spacesuit would be self-healing because its innermost layer, which provides the spacesuits with an airtight seal, is filled with a thick polymer gel. The rubber-like gel is sandwiched between two thin layers of polyurethane so that if a hole forms in these layers, the gel oozes from surrounding areas to plug it. If the suit piercing with a larger hole is there, the material would immediately alert the astronaut of the hole's location. That is because the material contains a layer that is crisscrossed with current-carrying wires. Large punctures would break circuits in the damaged area, allowing built-in sensors to alert a central computer. The suit would even be able to provide its own power for those sensors using flexible solar cells that would be sewn into the outermost layer. The material also keeps microbes at bay using layers of silver-coated polyester. It slowly releases silver ions, which kill bacteria. And layers of polyethylene would also protect astronauts because polyethylene contains a lot of hydrogen, which is a good radiation blocker.

V. CONCLUSIONS

The smart technology has got the potential area of applications in one of the most tedious and complicated state-of-the-art hi-technical stream. The use of miniature microprocessor based intelligent technology can be designed and developed for the future space technology inclusive of spacesuits and spacecrafts. The advent of the technology is on the route of extensive exploitation for the Lunar and Martian expeditions to make the astronaut’s stay in the outer space worth spending.

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