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HYPOTHESIS: A NEW ERA OF SPACE SUITS

Ashish Gothwal
E-mail: ashish16111985@gmail.com

ABSTRACT

Mechanical counter pressure (MCP) BioSuit concept (Electric alloy mesh, Thermal gel, and Electric gel suit) strategy required heat or electricity to impart pressure. It creates problems during fault in power source which may be vital in space. There is no description of how to make BioSuits radiation proof. The main limitations of MCP approach are the donning/doffing, lengthy pre-breathe and intra-vehicular adaptability. The gas-pressurized suits are bulky, heavy, leaky, and complex and require extra care and have low degree of mobility. My innovative idea on space suit design overcomes all these problems. It provides protection against vacuum, harmful radiations, micro meteor and extreme temperatures. The use of micro meteor detection system provides additional protection in open space. The inner layer of suit could be made from stretchable and porous fabric. The outer layer could be made from non-stretchable fabric (high quality leather as restraint layer). The high viscosity gel could be filled between these two layers to impart the mechanical counter pressure directly to the body. The porous structure allows the transfer of heat from body to the gel with anti-perspiration property and keeps the body cool during extra-vehicular activity (EVA). The gel can be filled through pneumatic valves by computer operated pneumatic pumps ensuring the uniform compression on whole body. A third layer of fabric, made of aerogel, could be incorporated on the restraint layer to provide thermal insulation. The nanoparticles coating used for radiation protection could be placed either between restraint layer and aerogel layer or onto the aerogel layer. This suit design would also provide the compression over the head by gel pressure which is not found in the existing space suits. The gel could be supplemented with antibiotic to avoid any contamination during planetary exploration. Use of Nitrogen scrubbers installed in the nose compartment of the helmet reduces the pre-breathing step before EVA.

Keywords: Space suit, Gel, Mechanical counter pressure, Mobility, Nanoparticles, Nitrogen scrubber, Micro meteor detection system.

INTRODUCTION

The space suit protects the astronauts from the lack of pressure in the space. At a world with little or no atmosphere, it is difficult to step outside a spacecraft without wearing a space suit because it may causes several complications which includes: boiling of blood and body fluids, expansion of body tissues, encounter temperature extremes, prone to harmful radiations, threats from micro meteors and man-made debris etc [1]. Due to the lack of atmospheric pressure and non availability of oxygen, humans carry their own environment to survive in the harsh environment of space. This could be possible with wearing a space suit which provides wearer a stable pressure, oxygen supply, regulation of temperature, ease in mobility, shielding from harmful radiations, protection from micro meteors and communication devices [1, 2].

Presently available space suits are very complex. The bulky structure of space suits resists mobility of astronaut causes high metabolic rate and reduces the efficiency and time period of extra-vehicular activity. NASA planned to explore the Mars surface by inhabited the humans on that planet [3]. The private organization also takes part in this effort and SpaceX has discussed their plans for Mars exploration [4]. In near future, space voyages for planetary exploration will be very costly. One basic requirement to this exploration is the need of highly efficient space suit than existing ones with greater degree of mobility and flexibility.

A revolutionary approach in space suit design is presented by BioSuit System. It acts as a second skin by providing mechanical counter pressure to the entire body [5]. According to Paul Webb, Mitchell Clapp and others, the performance of space suits can be enhanced by using MCP BioSuit approach. The MCP approach lowers the weight of space suit and improves the mobility, donning/doffing and cost of suit. The human body is pressurized by its own skin so that it behaves like pressure suit with extraordinary properties like high tensile strength, non permeable to gas and good ability of water retention [5]. Therefore, all these properties are exhibited by BioSuit.

The Martian space suit will be designed in reference to the environmental conditions encounter on the Mars surface. The environmental conditions that may occur on Martian surface includes low atmospheric pressure, low temperature, micro meteor threats, little gravity, Martian dust, sharp edges, human contamination and harmful radiations [6, 7]. The suit for Mars exploration should be highly advanced and robust in nature than currently used space suits for extravehicular activity [8, 9].

The main drawbacks of gas-pressurized space suits are the weight balance and flexibility. There is a good safety record for gas-pressurized suits, but they are rigid, movement is difficult due to stiff balloons, threat of abrasion or micro meteor puncture that may causes the early EVA termination. There is a successive improvement in the space suit designs over the past 40 years with some drawbacks. They are bulky, leaky, expensive, less safe, heavy and requires pre-breathe steps. Innovative design in space suit development is considered essential for performing complex physical tasks due to extreme conditions on Mars surface [10].

BIOSUIT APPROACH

The concept behind BioSuit is generally based on the pressure applied on the astronaut in different way that the body feels counter-pressure by skintight suit. The skintight suit showed greater advantages over gas-pressurized suits in terms of high degree of mobility that is not possible with a gas-pressurized suit. The idea of mechanical counter-pressure by skintight suit was first introduced by Physiologist Dr. Paul Webb in the late sixties and made a prototype on this idea in early seventies.

MATERIALS USED FOR BIOSUIT SYSTEM

There are three different concepts used for the space suit design are as follows [11, 12]:- i) Electric alloy mesh suit concept utilizes voltage to generate mechanical counter pressure by shape memory alloy, ii) Thermal gel suit concept utilizes temperature to generate mechanical counter pressure by polymer gel, iii) Electric gel suit concept utilizes the similar property of thermal gel suit but there is no thermal gel is used i.e., electrical gel.

Mars is existed farther from the sun. Its surface temperature is lower than earth. The maximum temperature and minimum temperature of Mars surface are 20 °C and -120 °C respectively. The mars atmosphere is rich in carbon dioxide so that materials used for space suits must have non-permeable and non-degradable property for carbon dioxide [12, 13]. Thermal, mechanical and chemical protections are provided by PBZO (Polyphenylene benzobioxazole), PTFE (Polytetrafluoroethylene), Nylon 6, 6 and PVDC (Polyvinyldiene chloride). These polymers are used to develop Martian suits.

LIMITATIONS OF BIOSUIT APPROACH

MCP BioSuits concept (Electric alloy mesh, Thermal gel, Electric gel suit) strategy required heat or electricity to impart pressure. It creates problems during fault in power source which may be vital in space. The MCP suits show significant problems in developing an effective suit with donning/doffing ease and applying a uniform compression over entire body.

MAIN PROBLEMS RELATED TO THE EXISTING SPACE SUITS

There are several problems associated with space suit which includes:-

1) Cooling of astronaut's body while wearing the space suit.
2) Designing of much efficient helmets.
3) Protection of space suit from micro meteors to avoid damage to suit.
4) Protection of astronaut from harmful radiations.

To overcome these problems I proposed simple and effective ideas to design space suits with freedom of movement while wearing this. This space suit design may also lower the risk of damage of space suits by micro meteors present in the space and provide protection against harmful radiations.

MY SPACE SUIT DESIGN

The space suit with three layers (inner stretchable perforated layer, middle high quality leather restraint layer & outer aerogel thermal insulation layer) of fabric would be tailored in such a way that the adequate pressure could be exerted on the body of astronaut by the suit and easy to wear in zero gravity. After wearing the space suit, the required pressure is achieved by filling the gap between two layers with high viscosity gel. This would impart the required pressure on the body.

Idea that solves problem 1:-

The design of space suit may contain three layers of fabric in which gel could be filled in the empty space between inner and middle layers. The gel used for this purpose would be highly viscous. The inner layer of the fabric would remain perforated through which heat generated by the astronaut's body would be taken up by the gel. Therefore, it would cool the body of astronaut by avoiding sweating. This idea may also protect the astronauts from micro meteors which I discuss later in the section 3.

Idea that solves problem 2:-

Many researches are carried out to find the ways through which much better helmets can be designed. Here I propose an idea that can be used as an alternate for the designing of space suit helmets. The radiation proof gas masks can be used for this purpose (refer to figure 1). These types of helmets with some modification in present design would protect the astronauts from external atmosphere.

Idea that solves problem 3:-

The problem of suit damage always persists during space walk. I have an idea for this problem. As I discussed before in the section 1, the astronaut's suit could be protected from puncture damage by using the gel. The gel used for this purpose must have the property of sealant which immediately seals the puncture made by micro meteors and also avoid the loosing of pressure exerted on the body. There would be other technique used in collaboration with above said approach. The use of sensor technology which detects the path of incoming micro meteors and send signal to the computer and then computer operating the thruster packed at the back of the astronaut change the position and keep away the astronaut from the path of incoming micro meteors. If by chance any micro meteors escape from the sensor surveillance and hit the suit, it would stop by the layer of highly viscous gel present in between the two layers of space suit and this gel seals the puncture made by the micro meteors.

Micro meteor sensing system

This system could be deployed in the space that probes the path of incoming micro meteor. The backpack of astronaut's carries receiver and thruster. The receiver is connected to the computer present in the space vehicle which collects information from sensing system and gives command to the receiver installed in the backpack to operate thrusters. The backpack also contains sensors which check the nearby surrounding for any hurdle and avoid collision. The astronaut would move in the safe direction where there is no risk of collision with hard and sharp object.

Idea that solves problem 4:-

On Earth, the living organisms are protected from harmful radiations by the shield provided by magnetic field of the Earth. But in space there is no such kind of shield is present to protect the astronauts from the radiations. In space, astronauts are more prone to radiations. To avoid the radiation damage, I proposed an idea here. In this idea, a mixture of silver nanoparticles, magnetic nanoparticles, lead nanoparticles and SPF 100 agent can be used in the form of paste for coating. This coating would protects the astronauts from harmful radiations because silver is used as control rods in the nuclear reactor to absorb excess neutrons, magnetic nanoparticles act as a shield of magnetic field against cosmic rays similar to earth's magnetic field, lead nanoparticles protects against the X-rays and gamma rays and SPF 100 agent gives protection against UV rays [14].

NOTE- The idea 3 & 4 may also be used for the protection of International space station from micro meteors and harmful radiations.

In this space suit design, I am aiming to exert mechanical counter pressure on the body by using elastic property of fabric with high viscosity gel. The suit designed in section (see figure 1, 3 & 4) which supports the different parts of body according to their need. It would be flexible. The helmet of the space suit provides greater mobility of neck (see figure 1 & 2) due to its unique design.

The design of my space suit would be superior than others existing suits in terms of its cost effectiveness, greater mobility, ease in donning/doffing and light weight which will help in partial gravity of planetary exploration which is not possible with existing space suits. The gel could be used for the body compression and to impart the mechanical counter pressure directly to the body. The inner layer of space suit design has stretchable and porous fabric. The middle layer could be made from non-stretchable fabric (high quality leather) and act as restraint layer. The high viscosity gel could be filled between these two layers of fabric. The porous structure allows the transfer of heat from body to the gel with anti-perspiration property and keeps the body cool during EVA. No liquid cooling garment would be needed. The gel can be filled through pneumatic valves present on the suit by computer operated pneumatic pumps ensuring the uniform compression on whole body. A third layer of fabric, made of aerogel, could be incorporated on the restraint layer to provide thermal insulation. The nanoparticles coating (to protect the astronauts from harmful radiations as mentioned in space suit design idea 4) could be placed either between restraint layer and aerogel layer or on the aerogel layer according to their performance where these are more effective. An aerogel filled canister or aerogel fabric bandage could also be used in case of micro meteor damage which retain the thermal insulation over sealing nick (a gap is produced in insulation layer after collision but seal due to gel). The suit would be dust-proof due to minimum seals and bearing joints which reduces the risk of dust damage and reduce inspection time and cleaning task. The front zipper could be covered with flap to minimize these risks and also provide easy donning/doffing tasks. My suit design would also provide the compression over the head by gel pressure which is not found in the existing space suits. Hemispheric protection is provided by moon but restricts the exploration program on the other hemispheric region and the surface above head (i.e. sky) is prone to harmful radiations and micro meteor threats. But my space suit design gives full protection at any hemispheric region. The gel could be supplemented with antibiotic/antimicrobial agents to avoid any contamination during planetary exploration. In my helmet design, nose and eye compartment are pressurized rather than whole head in the existing space suit helmets. This may avoid the helmet fogged by air expired from nose because the eye and nose compartment are separate and provide clear vision. A tear in gas-pressurized space suit or loss of power to maintain MCP suits in compression causes low pressure but in my design a tear in suit could be sealed itself by the sealant property of gel and retain the optimum compression as compared to rest of the body. Use of Nitrogen scrubbers installed in the nose compartment of the helmet reduces the pre-breathing step before EVA. The astronaut can inhale Nitrogen free air in the environment of spacecraft/habitat while wearing the helmet.

The elastic fills work in the similar way as bellows-like structure works in the existing EMU's (refer to figure 5). It could be far better than mechanical bearing joints. Elastic fills at joints could provide required compression on the joints with ease in mobility. The role of elastic fill is just like bellows-like molded rubber at the shoulder, elbows, hips and knee joints. When our joints are in relaxing position, their covered area is less than when in bending position. The bending position feels stretch while we bend our knees or arms. Same conditions are provided by using the elastic fills. Donning/doffing of my suit design would be as simple as to get on and off our daily wearing clothes. The eyes compartment could be pressurized when we wear the helmet in the spacecraft environment/habitat. The amount of air trapped in the eye compartment could be enough for compression until it is not leaked. The use of zipper with flap in the upper torso and lower torso could reduce the donning/doffing time. Pre-filled gel space suits can be used as reserves where no computer-operated pneumatic pumps are available. My suit design combines the property of pressurized suit with MCP approach and takes it to the next level. It works even in the absence of cabin pressure so behaves as EVA and IVA suits. The existing EMU's contains eleven layers and have more weight and are not suited for planetary exploration. The high numbers of layers hinder the flexibility. My space suit design could be made of only three layers (inner perforated stretchable layer, middle high quality leather for restraint layer and outer aerogel for insulation layer) of fabric which increase its flexibility and lower its cost and weight. My suit design provides greater balance of weight by using unique shape of portable life support system (figure not shown). The design of portable life support system would be similar to human life jacket because it only contains oxygen tanks for respiration. Due to its unique design, it gives greater degree of balance and has low weight which is not possible with existing portable life support system.

CONCLUSION

The humans are adapted to the atmospheric pressure (1 g) on the earth. But when humans go into the space, there is no external pressure that exerts force on the body to remain it in its normal state. Due to the lack of pressure in the space, human fluid comes out from the body just like happens with a fountain pen in space. To avoid these situations space suits are designed to protect astronauts. Many researches are carried out to design suits which are more efficient in outer space. But the existing space suit designs have several drawbacks. For future space missions, especially Mars exploration, there is a need of advanced space suit which performs all the vital tasks to help astronauts keep alive. This is not possible with the use of gas-pressurized suits which limit the astronaut's ability. Whole body MCP skintight suits show the greater potential of being used in the planetary exploration programs as well as in space voyages. Ease in donning/doffing, require lengthy pre-breathe periods and intra-vehicular activity are critical for MCP approach. All these requirements are overcome in my space suit design which provides an excellent regime for future space exploration programs. At present, this innovative design is an idea and need to be proved. The steps used for the space suit design are well documented in the literature. When these steps arranged in the unintuitive way, a new space suit design will be obtained that facilitates the broad advantages and value to space technology and industry. This hypothesis is experimentally radical and if proved, this will led to the new age of space suits.

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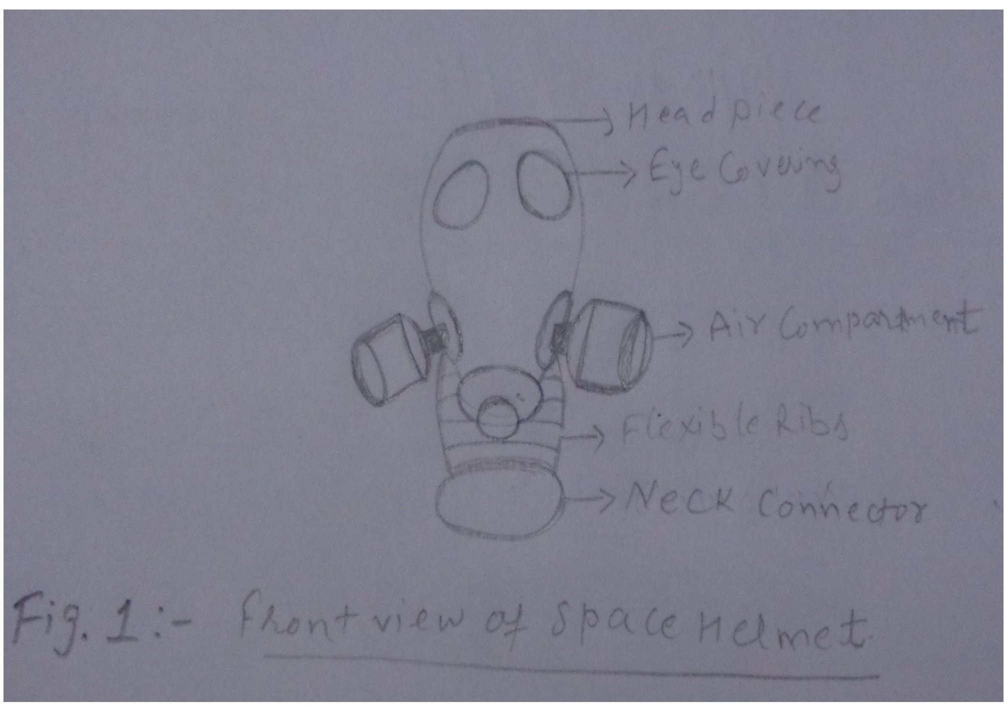

Fig. 1:- Front view of Space Helmet

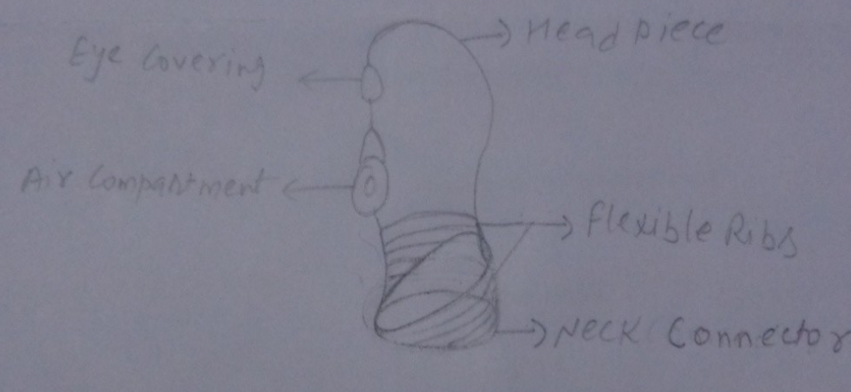

Fig. 2:- Side view of Space helmet.

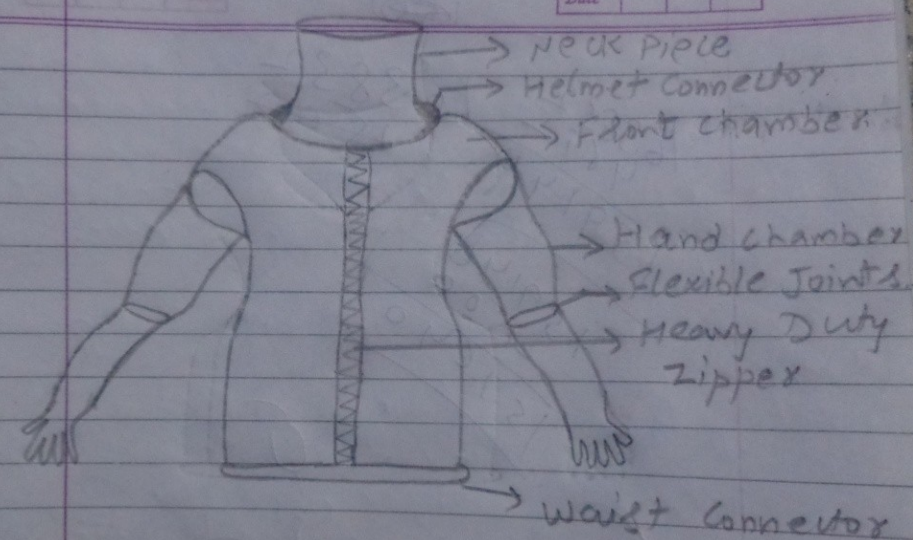

Fig. 3:- Front view of upper Torso.

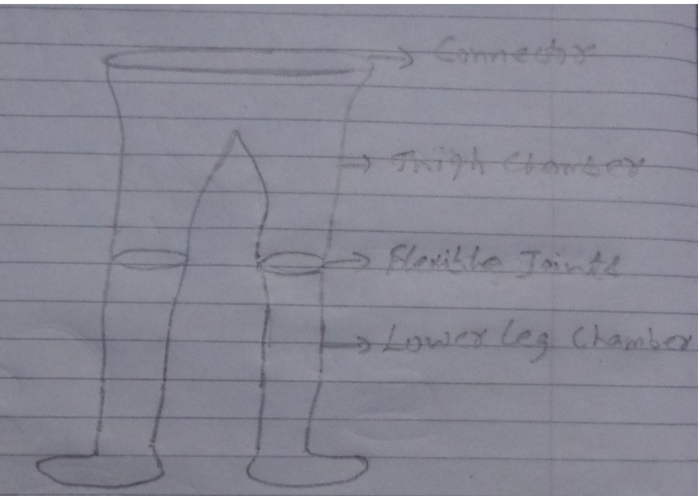

Fig.4:→ Front view of Lower Torso

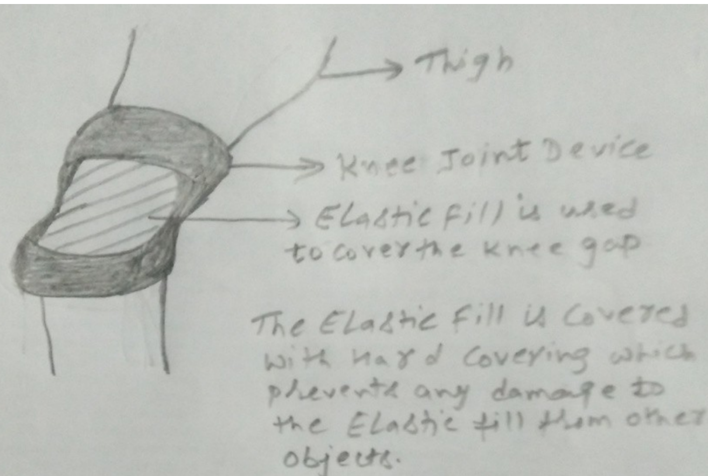

Fig.5 – Flexible device used for easily bending of arms & legs joints.