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A Review

Burgeoning trend of smart clothing: an overview on military use

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■ **ABSTRACT :** Smart outfit's development started in military field and still remains a main field. Clothing is the first layer of protection and forms an important protective layer in military operation while combats and environmental hazards. Extended Cold weather clothing ensemble, High Altitude Pulmonary Oedema chambers, Anti-G suits, Flame retardant overalls, Submarine Escape Sets, Chemical warfare protection ensemble, liquid cooled garment for protection against hyperthermia etc., are fabricated from variety of technical textiles having special material properties. Technical and smart textiles are used worldwide to provide protection from the hazards of battlefield to the military and paramilitary forces, as 'man behind the machine' is the most important entity in a war theatre. The design of smart cloth is crucial to obtain the best results. This review focuses a collective account of harsh military environment faced by war fighters during War and Peacetime and desired smart textiles to lower the wear and tear due to harsh surroundings and battle menaces.

■ **KEY WORDS:** Smart clothing, Technical textiles, Harsh military environment, Phase change materials, Aerogels, Liquid cooled garment, Submarine escape set, Flame retardant fabrics

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Textiles for military uniforms face a very complex set of encounters. They need to provide protection, durability and comfort in a wide range of hostile environments. The smart textiles will sense, react, and adapt themselves to the environmental conditions. Now-a-days the new wearable technologies fit in advanced functions such as monitoring mechanical, environmental, physiological parameters in an ecological and in non-intrusive line of attack. The smart clothing allows the monitoring of the vital signs like heart rate, breathing rate, temperature, emotional factors like HRV-Heart Rate Variability, EDA-Electro Dermal Activity related to fatigue, stress and effort. These are the topmost level of smart textiles.

The soldier of the future is most likely going to be the central character in the practical application of wearable technology (*http://www.armytechnology.com*). In fact, the first idea to put embedded sensors into garments given birth in the military field by Dr. Sundaresan Jayaraman, researcher team at Georgia Institute of Technology. The wearable T-shirt won the best invention of the Millennium (Fall, 1998) and TIME

named it as one of the best inventions in 2001 (*http://www.mse.gatech.edu*). The intelligent garment is washable smart shirt based on the wearable 2.0 is intended to monitor the heart rate activity and body acceleration. Strain measure textile sensors are used to investigate breathing parameters. Mechanically, the sensors elongate into relation with body motion structures. The device will be supported by mobile app which is designed forgathering and supervising data related to 3D accelerations (Anterior-Posterior, Medio-Lateral and Vertical) and the ECG potential in real-time. In battlefield environments, soldiers may be in an unusual state of behaviour, such as a rapid march, a high-altitude jump, and injury (*https://www.researchgate.net*). A BTS can operate in parallel with other detection systems and can provide more accurate body status information for medical units or the command center. Smart expedients for the military, irrespective of whether it is a robot on the battlefield or human, as an independent sensing node or as an intelligent exoskeleton that can be used to cross the boundaries of a soldier's ability, need soldiers to provide multi-dimensional input to the system (*https://blog.peigenesis.com*).

Military traits of smart textiles:

Protection against injury, Wound detection, Health and stress monitoring, Kinetic sensors measure things like steps, pressure, acceleration, GPS location and direction. These sensors direct stress and injury generate electricity and offer tactical coordination between ground troops and their command centers, full-body bullet proof armour, 360 degree cameras with built-in in night vision and a powered exoskeleton (*https://www.livescience.com*).

When soldiers fall wounded on battlefields, their smart uniforms instantly report the location of gunshot wounds or even detect traces of nuclear, biological or chemical attacks in blood and sweat. This intellectual clothing possibly will make a lifesaving difference in medical care and give commanders a sense of battles unfolding as casualties mount. The smart uniforms would include medical sensors built into the fabric to monitor the health of team. Such garments would not only detect where wounds occurred and how deep they go, but also report a fallen soldier's location with GPS coordinates and pass along other critical information for battlefield medics. Smart clothing fibres might even "estimate the depth of penetration" from bullets or shrapnel and how they affect surrounding organs. Sensors could also detect specific "biomarkers" in human blood, saliva, sweat or urine that reveal the presence of chemical or biological weapons, radiation from nuclear weapons or even traces of explosives left by a roadside bomb (Tharion and Kaushik, 2006).

Health status monitor:

In the notion of avoidance and alert by, William J. Tharion who scrutinized 27 soldiers with the WPSM system (Warfighter Physiological Status Monitoring) (Kumar, 2012). This system consists of a Vital Sign Detection System (VSDS) which measures heart rate, respiration rate, body motion and body position, a fluid intake monitor (FIM) a sleep watch that estimates sleep through actigraphy, a skin temperature patch and a health hub that hosts the WPSM sensor network and algorithms such as determining life sign status or estimation of thermal injury to the Soldier. Kumar (2012) and Hock-Beng Lim *et al.* (2010), with a project funded by Defence Research Organization (DRDO), developed a novel uniform referred to as Teleintimation Garment. The goal of the project is to develop a garment to monitor vital parameters and bullet penetration in soldiers and analyse the data through software, named Soldier's Status monitor, to alert the military unit. To monitor the health status of soldiers (Oxygen saturation, temperature, acceleration, EEG, EKG, Heart rate and blood flow), Hock Beng Lim *et al.* (2010) (*http://neurogadget.com*) created an advanced helmet were they integrate a Body Sensor Network embedded within a neck pad, headband and chin-neck pad. The Defence Department's National Center for Telehealth and Technology, for example, offers a mobile App, called BioZen that can provide sophisticated biofeedback on heart rate, respiratory rate, skin temperature and other factors, though it requires the user to buy compatible medical sensors separately (*http://www.army.mil*). Caravalho (http://*www.forbes.com*) suggested 2025 as a possible date by which soldiers could be using body sensors reported in literature findings and here summarized.

Smart clothing has become a key component in the creation of new military uniforms, designed to improve the health of the soldier while providing added battlefield insight.

Vitality fabrication through smart clothing:

Scientists at The Princeton University have generated a square of a flexible silicone material, inserted using a ribbon of piezoelectric material named as PZT that generates voltage that can be used to produce electrical current. This can be converted back into mechanical movement. Solar energy could help us. In terms of energy, Development and Engineering Center (CERDEC) is developing a wearable solar panel that can be integrated in the uniform (*http://www.armytechnology.com*). As well, a start-up called Power Walk M-series (*http://www.3ders.org*) developed a bionic power product composed of a knee brace. With a device on each leg the walking soldier generated an average of 12 watts of electricity.

For the proof of identity of friendly soldiers in action and in the battle fields and during stress conditions, the Institute for Soldier Nanotechnologies (ISN) is working in the direction of entwining fibre-optics, which holds signal that could be identified from end to end through a laser. Once shined upon the uniform, it will transfer a friendly signal to the user's own uniform, recognising the suspected soldier as friend. The absenteeism of return signal will promptly detect opposition (*http://www.buffalo. edu*) Development and Engineering Centre, which develops field and combat clothing, chem-bio protection, body-armour systems, gloves, hats and helmet covers, are now experimenting, making garments with new textiles and 3D printing (*http://www.armytechnology.com*).

Conclusion:

Most of the innovations are been nurtured in the labs, at present moment there is no smart clothing uniform is readily available in the market. The Army Natick Soldier research center is searching to make garments with new textiles and 3D printers. New applications and materials have been developed with the aim to have devices that can monitor the subjects for longer time and harvest self-energy or solar energy. The next step will be the integration of the existing wearable technologies in usable smart clothing and bring them from the lab to the field, which high efficiency and productivity.

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