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Analysis of Clothing Air Gap in a Protective Suit According to the Body Postures ⋆

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Abstract

In dangerous working environments such as a Chemical, Biological and Radiological (CBR) exercise, a protective suit plays an important role to increase work efficiency as well as prevent fatal damages. Air gaps entrapped in protective suit play an especially important role in heat transfer. The distribution and size of air gaps depends on body motions. The study developed 8 representative body motions (stretching, walking, crawling, crouching, twisting, climbing and reaching, moving weights and lateral bending) of CBR exercises of which 2∼4 static body postures per each motion were derived. 3D body scan was conducted on one male participant for the postures listed. Scanning was performed on both nude and dressed bodies to measure the distribution and size of air gaps between human body and clothing. As a result, curves and volume of the air gaps varied with the different postures. The results serve as the basic data to improve protective performance of current protective suit.

Keywords: Body Posture; 3D Body Scanning; Protective Suit; Air Gaps Layer; Air Gaps Volume

1 Introduction

Protective suits are essential battle equipments to ensure individual's right to live against chemical, biological, and radiological (CBR) agents and to sustain fighting powers in warfare. Thus

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it is mightily important to predict and improve the performance of protective suit's ability to minimize damage.

Fundamental to improving CBR protective suit is to prevent vapor and particulate agent penetration. The protective suit has to minimize the air flow of opening areas like collar and cuffs or pants which are vulnerable to external contaminants. For measuring the stability and performance of protective suits, it is necessary to simulate the air movement carrying chemical, biological, and radiological agent. However previous studies testing the performance of protective suits have mostly focused only on a limited number of positions [7] either on one side (upper or lower) [2] or in fixed positions [9, 10]. Most of the studies used 3D scanning to focus on nude bodies [1, 3-6, 8] because body scanners are originally developed with the purpose of collecting body data. Therefore, research about a whole body measurement in a diversity of motions in protective suit is insufficient now.

The purpose of this study is to derive representative body motions for CBR exercises and identify static postures for each of the representative body motions, to take three-dimensional (3D) air gaps figures to measure the air gaps between human body and clothing, and to get the curve of significant opening area has extracted to predict the air flow. The three-dimensional air gaps figures also can be used to measure the distribution and volume of air gaps between the human body and clothing using a three-dimensional body scanning technique.

2 Method

In this study, we first selected the representative body motions referred to in the Man In Simulant Test (MIST) videos, next we carried out the 3D body scanning to extract 3D Air Gaps and Curves of the Opening Area, and the last step was to calculate each volume of the body segmentation.

3D body scanning was performed for the nude and the dressed to measure the distribution and size of air gaps between the human body and clothing. Hamamastu BL full-body scanner (Hamamastu Photonics, Japan), and Rapidform 2006 (3D Systems, Inc., Korea) were used to analyze and transshape the 3D shapes. This scanning - experiment had been carried out from August 2012 to December 2013 in the 3D body scanning laboratory which was developed by Clothing Ergonomics Laboratory, Seoul National University.

The subject is one male participant who is 20 years, height 172.5 cm, weight 75 kg, fits to '4 size' (average among 1∼6 size) CBR protective suit, '265 mm' military boots, 'middle size' gloves, and 'large size' rubber overshoes.

Each postures were scanned both the nude and the dressed, the nude scan was performed wearing specially designed for keep the silhouette of the human body intactly without distortion, and the dressed scan was performed wearing underclothes, military boots, gloves, and all CBR protective suit (top and bottoms protective clothing, rubber gloves, rubber overshoes) developed by Agency for Defense Development, Korea.

2.1 The Selection of Representative Body Motions

Body motions referred to Man In Simulant Test (MIST) videos of National Fire Protection Association (NFPA), and Textile Protection and Comfort Center (TPACC) of NC State University.