Applied Thermal Engineering 36 (2012) 32–38

Contents lists available at SciVerse ScienceDirect

Applied Thermal Engineering

journal homepage: www.elsevier.com/locate/apthermeng

Feasibility of perspiration based infrared Camouflage

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ARTICLE INFO

Article history:
Received 27 September 2011
Accepted 1 December 2011
Available online 8 December 2011

Keywords:
Infrared camouflage
Sweat evaporation
Cloth prototype
Sensible and latent heat transfer

ABSTRACT

Infrared camouflage without resorting to existing and often burdensome technologies is clearly attractive. In this paper, we explored a new approach to potentially achieve the infrared camouflage by facilitating the latent heat transfer while controlling the sensible heat transfer of the human body. A multilayer structure of the corresponding camouflage cloth prototype with specific functions for each layer is proposed here (layer I to layer IV, from the body skin to the outside, respectively). Since the requirements for cloth infrared camouflage at steady state are much stricter than at transient period, a steady state model for this prototype is developed to test its feasibility. The influences of related key parameters, including the porosity and the thickness for each layer are discussed using the model. The results show that a satisfactory infrared camouflage may be accomplished using all the layers proposed under specified structural conditions. In order to achieve the best effect of camouflage, for example, when the environment temperature is 296.15 K with 30% relative humidity, we further discovered that (1) the porosities of layer I and layer II should be lower as 5%, but those of layer III and layer IV should be relatively higher (85% and 90%, respectively); and (2) the thickness of the second layer should be greater enough to 1.5 cm, but the thickness of layer IV must be sufficiently thin at 0.1 cm. In summary, our proposed prototype provides a promising design for the uniform that can be used to suppress the probability of infrared detection.

1. Introduction

Infrared camouflage for the human body has been attracting the attention of many researchers for long time and several such technologies have been developed. These infrared camouflage technologies, according to the Stefan–Boltzmann's law describing the phenomena of infrared radiation and detection [1–3], can be divided into such three categories as changing the infrared transmission characteristics of the atmosphere, controlling the emissivity of the external surface and adjusting the surface temperature of the target.

In changing the infrared transmission characteristics of the atmosphere, infrared aerosols were used to form a suspension system, where a large amount of small solid or liquid particles produced by the smoke agents were dispersed in the atmosphere. These particles will either emit more intense infrared rays than both the target and the surroundings so as to dominate the detection image, or absorb, reflect or scatter infrared rays to attenuate the infrared radiation of the target [4,5]. However, camouflage achieved in this way merely lasts for a short time, and thus is only suitable for temporary use.

Coating materials with lower emissivity have been widely used in controlling the external surface emissivity of the target. It is reported that metals, oxidized metals and certain semiconductors are the three main types of materials with lower emissivity [1,6,7], and have been utilized to produce infrared camouflage films and fibers [8–12]. However, there are still some inherent limitations for such infrared camouflage materials. For instance, their performance stability and durability need to be improved, and most of them are not permeable and comfortable enough for clothing purpose. Another infrared camouflage method in this category is called the "infrared deformation technology" [13,14], achieved by varying the emissivity of different parts of the target so as to destroy the entirety of the thermal images. Obviously, it is only effective when applied to close-in targets, not to ones at a distance.

In terms of adjusting the surface temperature of a target, some heat insulation or storage materials have been developed to reduce the temperature difference between the target and the surroundings, rendering the target less visible to infrared devices. Among them, the most typical and widely used are the phase change materials (PCMs), capable of absorbing or releasing the latent heat via phase transformation so as to moderate the temperature change. For instance, Mckinney et al. [15] reported that paraffinic hydrocarbons are generally the most effective PCMs with longer life

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doi:10.1016/j.applthermaleng.2011.12.001