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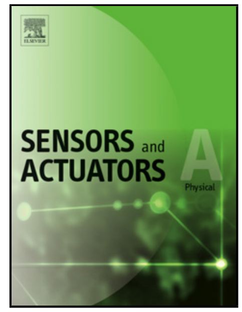

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Authors: Hayriye Gidik, Daniel Dupont, Gauthier Bedek

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Development of a radiative heat fluxmeter with a textile substrate

Hayriye Gidik[a,*] hayriye.gidik@yncrea.fr, Daniel Dupont[a], Gauthier Bedek[b]

[a]UCLille, HEI, GEMTEX, F-59046 Lille, France
[b]UPTEX, 59336 Tourcoing, France

Abstract

This study presents the development of a textile radiative heat fluxmeter (TRHF) which was designed by weaving technology. The first part of this work focuses on a textile heat fluxmeter (THF) which was developed with the principle of a gradient heat fluxmeter. In order to transform this THF to a TRHF, a polymer with different graphite concentrations was applied on one of the faces of the THF by using coating technology. In applying graphite, the incident electromagnetic radiation absorption can be increased. Thus, the second part presents the principle and the specific design of the TRHF. Since the previous work gave satisfactory results for polyester/cotton (70/30 PES/CO) material and satin 5 weaving structure, PES/CO/Sa was used as textile substrate for the radiative heat fluxmeter [1]. Five different graphite concentrations, i.e. 5%, 10%, 20%, 30%, and 40%, were compared for electromagnetic radiation absorbency in order to identify the most appropriate ones to produce the TRHF. Two of these concentrations were chosen, i.e. 20% and 30%, due to their higher absorbency. Thus, three THFs with different graphite concentrations, i.e. 0%, 20%, 30%, were developed and their performances were compared with a reference radiative heat fluxmeter for sensitivity. The TRHF with 30% of graphite has higher performance than the other THFs and its sensitivity is slightly higher than the reference one.

Keywords: Radiative heat fluxmeter, smart textile, thermoelectricity, heat transfer, firefighter

1. Introduction

Thermal comfort is the key factor to be considered in clothing design, and furthermore an important factor for protective clothing systems for firefighters working in hot environments [2]. Firefighters' protective clothing protects the human body against high radiation heat flux, flashover conditions, and puncture-abrasion hazards [3]. Although flashover situations in which the firefighter is surrounded by the fire are highly feared, such situations are rather rare. Firefighters normally do not fight the fire from the inside but rather from the outside of the flaming environment and the heat exposure is mostly due to radiation [4].

Thermal environments are divided into three categories, such as (i) routine, corresponding to a common intervention for firefighters characterized by low radiant heat flux from 0.42 to 1.26 $kW.m^{-2}$ and air temperatures in the range of 10 - 60°C, (ii) hazardous, representing an intervention in the presence of high radiant heat flux from 1.26 to 8.37 $kW.m^{-2}$ and air temperatures in the range of 60 - 300°C, and (iii) emergency, corresponding to extreme conditions from 8.37 to 125.6 $kW.m^{-2}$ and air temperatures in the range of 300 - 1000°C [5]. The most burn injuries sustained by firefighters occur in thermal environments with low radiation level (classified as routine or hazardous conditions), as a result of prolonged exposure [6].

Our previous studies proposed a textile heat fluxmeter (THF) as a physiological status monitoring system (PSM). It can detect, analyze and monitor the heat and mass transfers with minimum disturbance due to its porous structure. In addition to this, its flexibility can be taken as an advantage for being compatible with complex surfaces. In using this THF, early symptoms of heat illness can be detected and necessary interventions can be taken before injury occurs [1, 7]. In this study, we are interested in transforming this THF to a TRHF with regard to measuring radiative heat flux. Thus, the first part of this study gives a brief description about the THF and the second part focuses on the principle and the specific design of the TRHF with results and discussion.

2. Textile heat fluxmeter (THF)

2.1. Principle of a gradient heat fluxmeter