Applied Energy xxx (2011) xxx–xxx

Contents lists available at ScienceDirect

Applied Energy

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

Application of infrared thermography for the determination of the overall heat transfer coefficient (*U*-Value) in building envelopes

Paris A. Fokaides [a], Soteris A. Kalogirou [b,*]

[a] University of Cyprus, Department of Civil and Environmental Engineering, Cyprus
[b] Cyprus University of Technology, Department of Mechanical Engineering and Materials Science and Engineering, Cyprus

ARTICLE INFO

Article history:
Received 9 January 2011
Received in revised form 24 April 2011
Accepted 6 May 2011
Available online xxxx

Keywords:
Infrared (IR) thermography
Overall heat transfer coefficient (*U*-Value)
Sensitivity analysis
Thermal emissivity
Reflected temperature

ABSTRACT

Infrared (IR) thermography constitutes a reliable measurement method for the determination of spatially resolved surface temperature distributions. IR thermography may be used for several research problems, applications, and measurement environments with a variety of physical arrangements. In this work the results of the determination of the overall heat transfer coefficient (*U*-Value) with the use of IR thermography for building envelopes are presented. The obtained *U*-Values are validated by means of measurements performed with the use of a thermohygrometer for two seasons (summer and winter), as well as with the notional results provided by the relevant EN standard. Issues related to the applicability of the method due to the non-steady heat transfer phenomena observed at building shells are also discussed. A more precise validation of the proposed technique was also performed with the use of heat flux meters. The percentage absolute deviation between the notional and the measured *U*-Values for IR thermography is found to be in an acceptable level, in the range of 10–20%. Finally, a sensitivity analysis is conducted in order to define the most important parameters which may have a significant influence on the measurement accuracy.

1. Introduction

The use of infrared (IR) thermography has increased dramatically throughout the world over the past few years. This technique is employed for the measurement of surface characteristics for a variety of research investigations involving all possible heat transfer phenomena. The method is especially important and useful because it gives spatially resolved surface temperature distributions non-intrusively, even when large gradients of surface temperature are present [1]. IR thermography can be used in building envelopes to detect heat losses, missing or damaged thermal insulation in walls and roofs, thermal bridges, air leakages and sources of moisture. IR thermography can also be employed in building diagnostics for the determination of the thermo physical properties of building envelopes. Currently, this application is becoming more important, as the knowledge of the *U*-Value is a precondition for the classification of the energy performance of existing buildings [2]. This information may not be in some cases accessible or available, especially in the case of old buildings or in member states of the European Union where the regulatory authorities did not kept detailed building records at the time of construction. Therefore, the question to answer is how reliable is the implementation of IR thermography for the determination of the *U*-Value of building shells.

The discussion on the applicability of the IR thermography for building diagnostics has been held since this technique was widely commercialized at the early 90s. One of the most important questions to answer is whether this technique may provide reliable quantitative measurements, or if the extend of this application is limited to qualitative results. Another issue which is also under discussion, especially in the case of building thermography is the non-steady character of the heat transfer in building envelopes and the interpretation of an instantaneous thermogram under non-steady conditions.

The main areas for using IR thermography in building diagnostics are presented in detail by Balaras and Argiriou [3]. In particular, representative examples of building envelopes, mechanical and electrical systems inspection in audited office buildings are presented to demonstrate common problems and data interpretation. In this study, it is suggested that building IR thermography on external building elements should be performed either at night or during a cloudy day. This was found to be important in order to avoid the problem of temperature increase which occurs as a result of the incident solar radiation, and the impact from the absorbed solar energy, which presents a time lag of a few hours. Additionally in this work it is pointed out that measurements

* Corresponding author. Address: Cyprus University of Technology, Department of Mechanical Engineering and Material Sciences and Engineering, P. O. Box 50329, Limassol 3603, Cyprus. Tel.: +357 2500 2621.
E-mail addresses: fokaides@ucy.ac.cy (P.A. Fokaides), soteris.kalogirou@cut.ac.cy (S.A. Kalogirou).

0306-2619/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.apenergy.2011.05.014