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Solar blind pyrometric temperature measurement on pressurized volumetric power tower receivers

by Markus Pfänder, Marc Röger, Peter Heller

German Aerospace Center (DLR),, Institute for Technical Thermodynamics,
Apartado 39, E-04200 Tabernas, Spain

Abstract

The operation of solar thermal high temperature receivers requires an accurate knowledge of the temperature distribution on critical parts of the receiver. However, concentrated solar radiation makes it difficult to determine the temperature on irradiated surfaces. Contact thermometry is not appropriate for the use under concentrated solar radiation and also pyrometry fails when external light sources interfere significantly. To avoid distortion of the temperature reading, the measurement has to be performed in a spectral range where the emitted thermal radiation exceeds the reflected solar radiation by a multiple. The measurement in solar blind spectral regions of atmospheric absorption bands offers one possible solution of filtering the solar radiance from the measurement signal. Along with the intensity of the incoming solar radiation and the absorber emittance, the bi-directional reflection properties and the temperature of the object determine the required selectivity of the spectral filter. In atmospheric absorption bands, the influence of the atmospheric absorption on the measurement signal cannot be neglected even for small path length. The paper describes the methods of solar blind pyrometric temperature measurement on solar thermal high temperature receivers and shows the possibilities and limitations of accounting for the atmospheric absorption with models based on radiation transfer calculations. Finally, experimental results recorded with an infrared mirror scanner especially designed for the measurement on a pressurized volumetric receiver are presented and compared to thermocouple readings and results of a thermodynamic model of the receiver.

Keywords

solar blind, solar thermal, high temperature, atmospheric absorption, radiative transfer, HITRAN

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Quantitative inspection of non-planar composite specimens by pulsed phase thermography

by Clemente Ibarra-Castanedo*, Nicolas P. Avdelidis, Ermanno G. Grinzato, Paolo G. Bison*, Sergio Marinetti**, Liu Chen*, Marc Genest*, Xavier Maldague***

* Computer Vision and Systems Laboratory , Department of Electrical and Computer Engineering
Université Laval, Quebec City (Quebec) G1K7P4, Canada.

** Istituto per le Tecnologie della Costruzione - Consiglio Nazionale delle Ricerche (ITC-CNR),
Corso Stati Uniti, 4-35127, Padova, Italy.

Abstract

In pulsed phase thermography (PPT), amplitude and phase delay signatures are available following data acquisition; carried out in a similar way as in classical pulsed thermography, by applying a transformation algorithm such as the Fourier transform (FT) on thermal profiles. An extended review on PPT theory, including a new inversion technique for depth retrieval by correlating the depth with the blind frequency fb (frequency at which a defect produces enough phase contrast to be detected), has already been proposed confirming PPT's capabilities as a practical inversion technique. In this work, planar and non-planar CFRP composites were evaluated by quantitative PPT. Experimental results showed that, for the geometries studied here, surface shape has little impact on depth inversion results.

Keywords
Pulsed phase thermography, complex shape, composites, CFRP.

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Airborne laser IR thermographic system for detecting gas leaks from underground pipelines

by Oleg V. Ershov*, Alexey G. Klimov*, Vladimir P. Vavilov**

*Pergam Engineering, Olminskogo St., 3A, Moscow, Russia
ershov@pergam.ru
**Institute of Introscopy, Savinykh St., 7, Tomsk , Russia

Abstract
An airborne laser IR thermographic system intended for remote gas detection is described. The system involves three channels of which one is active and two are passive. The active channel includes a 15 mW tunable laser diode illuminating the ground surface with 1 ms pulses of IR radiation at the wavelength of 1650 nm. The system sensitivity by the laser channel is about 100 ppm*m at 100 m (by methane). The two passive channels allow visualizing the ground surface in both the visual and mid-IR wavelength. The system has passed on-flight testing in cooperation with some Russian gas transportation companies.

Keywords
laser, infrared thermography, gas leak detection, airborne system

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Enhancement of open-crack detection in flying-spot photothermal non-destructive testing using physical effect identification

by Pierre-Yves Joubert*, Sébastien Hermosilla-Lara, Dominique Placko*, François Lepoutre***, Marc Piriou****

* SATIE UMR CNRS 8029, , Ecole Normale Supérieure de Cachan,
61, avenue du Président Wilson, 94235 Cachan cedex, France

** FRAMATOME-ANP, NDE Technical Center, Industrial Site Saint-Marcel,
B.P.13, 71380 Saint Marcel, France

***ONERA, DMSE, 29, avenue de la Division Leclerc - BP72 , 92322 Châtillon, France

Abstract
This paper considers the images provided by a photothermal camera (flying-spot camera) dedicated to open-crack detection. In this type of active thermography, both thermal and optical effects contribute to the elaboration of photothermal images. Here the thermal effect is relative to the presence of open-cracks and the optical effects are due to surface conditions. In the case of open-cracks detection, the optical effects induce high magnitude perturbation signals, possibly masking the presence of open-cracks. In this contribution a signal processing method is proposed in order to identify both thermal and optical effects separately. The method lies uses multiple principal component analysis combined with a continuous wavelet transform. It is used to enhance the open-crack detection for the inspection of an industrial mock-up showing open-cracks and various surface

conditions. The enhancement of the detection performance is characterized thanks to Receiver Operating Characteristic curves. The proposed method shows high detection performances and could be extended to a classification scheme..

Keywords
open-crack detection, photothermal imaging, principal component analysis, wavelet analysis, physical effect identification, receiver operating characteristic curves.

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Numerical modelling of thermoelasticity and plasticity in fatigue-loaded low carbon steels

by T. Ummenhofer, J. Medgenberg

Technical University Carolo-Wilhelmina Braunschweig, Institut fuer Bauwerkserhaltung und Tragwerk
Pockelsstrasse 3, 38106 Braunschweig, Germany

Abstract
Cyclic plasticity has been found to be an early and characteristic aspect of fatigue damage accumulation during high cycle fatigue tests of low carbon steels. Microscopic pictures of a fatigue loaded specimen reveal the extensive development of persistent slip bands due to cyclic plasticity. A finite element model including thermoelastic and thermoplastic effects is presented, which can be used for the characterization of the TSA signal under non-adiabatic conditions. Numerical studies were performed regarding a possible detection of localized cyclic plasticity in low carbon steels by lock-in thermography. The results indicate small temperature variations due to cyclic plasticity at the second harmonic of the loading frequency. Thermographic detection with high spatial resolution seems possible and eventually can be applied to hot-spot assessment and new prediction methods for fatigue-loaded structures.

Keywords
fatigue damage, cyclic plasticity, thermography, high cycle fatigue, thermoelastic strain analysis, TSA

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Near infrared thermography with silicon FPA – Comparison to MWIR and LWIR thermography

by Yann Rotrou*, Thierry Sentenac*, Yannick Le Maoult*, Pierre Magnan, Jean Farré****

*Centre de Recherche sur les Outillages, les Matériaux et les Procédés (CROMeP)
Ecole des Mines d'Albi, route de Teillet, 81000 Albi, France

**Laboratoire de Conception d'Imageurs Matriciels Intégrés (CIMI)
SUPAERO, 10, avenue Edouard Belin, 31055 Toulouse, France

Abstract
An ideal thermographic camera could be defined as an uncooled system with high spatial and thermal resolutions featuring a video frame rate, and a short calibration process. In this paper a measurement system based on Silicon FPA operating in the Near Infrared spectral band ($0.7 - 1.1$ µm) is proposed. This system offers an excellent spatial resolution, a low cost and compactness. With a specific radiometric model, this system can accurately measure temperatures, in a broad temperature range, from 400 up to 1000°C. A comparison with two commercial infrared cameras is performed between 400 and 700°C.

Keywords
silicon FPA, thermography, radiometric model

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Processing of temperature field in chemical microreactors with infrared thermography

by Christophe Pradere*, Mathieu Joanicot*, Jean-Christophe Batsale *, Jean Toutain , Christophe Gourdon*****

* LoF, FRE 2771, 178 avenue du Docteur Schweitzer, 33608 Pessac, France

** TREFLE- ENSAM, Esplanade des Arts et Métiers, 33405 Talence cedex, France

*** LGC, UMR 5503, , BP 1301, 5 rue Paulin Talabot, 31106 Toulouse Cedex 1, France

Abstract
This work is devoted to the first analysis of temperature fields related to chemical microfluidic reactors. The heat transport around and inside a microchannel is both convective and diffusive with spatial distribution of source terms and strong conductive effects in the channel surrounding. With simplified assumptions, it is shown that Infrared thermography and processing methods of the temperature frames allow to estimate important fields for the chemical engineers, such as the heating source distribution of the chemical reaction along the channel. A validation experiment of a temperature field processing method is proposed with Joule effect as calibrated source term and non reactive fluids. From such previous experiment, a Peclet field is estimated and used in a further step in order to study an acid-base flow configuration.

Keywords
Chemical microreactors, Microfluidic, Inverse Methods, Temperature field processing, MEMS, Microsystems