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Infrared thermography and geophysical techniques in cultural heritage conservation

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Abstract
Infrared thermography is a powerful tool of nondestructive evaluation, but it has some limitations when dealing with deep and low thermal resistance defects. This is the case of thick walls of historic buildings and buried anthropic remains, which are important tasks of the cultural heritage field. Thus, it is evident the need of relatively high-depth inspection techniques such as the geophysical ones. The main purpose of this study was to characterize the overlapping zone from low-to-high depth with infrared thermography and geophysical methods. The investigation was carried out on two-component structures including a plaster layer over a support of marble, brick, or tuff with plaster detachments intentionally created. Results prove that an integrated use of the two techniques allows for detailed evaluation of architectonic structures and provides information about the related causes of degradation.

Keywords
Infrared Thermography, Geophysical Methods, Nondestructive Evaluation, Cultural Heritage

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Rating floor heating and cooling panels using a thermograph robot

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Abstract
Energy, exergy, environment, and comfort advantages of panel heating and cooling systems in green buildings are especially important for hybrid HVAC (Heating Ventilating and Air-conditioning) systems, which co-locate radiant floor panels with forced-air convection systems. In spite of their advantages, implementation of hybrid HVAC systems is difficult, because there are no empirical data concerning their rating and design. This situation complicates the boundary conditions used for CFD (Computational Fluid Dynamics) techniques and makes it necessary to test panels under actual operating conditions in hybrid HVAC environment to generate proper data. A new method was developed to accurately determine the floor panel heat flux using thermographic data gathered by a specially designed robotic device and a new measurement procedure. Steady-state surface temperatures of each incremental floor area in a virtual grid are measured using a mini IR camera mounted on the robot, which also measures all indoor enclosure surface temperatures and the air temperature. Collected data are processed by a novel algorithm to calculate the total heat flux and the thermal efficiency of the floor panel. The same method may also be used to detect leaks in hydronic panels or hot spots in electric panel mats before their failure.

Keywords
Thermograph Robot, Radiant Panels, Hybrid HVAC Systems, Quantitative Thermogrammetry, Thermal Image Processing

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Defect detection by pulse compression in frequency modulated thermal wave imaging

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Abstract
A new, quantitative, whole field, non-contact and non-destructive technique for sub-surface defect detection is presented based on frequency modulated thermal wave imaging (FMTWI). Electro-thermal modeling and MATLAB-SIMULINK simulation has been carried out for the proposed technique. Experimental results of frequency modulated thermal wave imaging are reported, and defect detection by a correlation approach demonstrated

Keywords
Thermal Wave, Electro-Thermal Modeling, Frequency Modulation, Matched Filter, pulse compression, correlation

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Thermal vision system for protective coat coverage inspection

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Abstract
The Subsurface dynamic thermographic procedure has been applied in a wide range of industries, yet; the static applications are still limited to Predictive Plant Maintenance PPM qualitative routines. This work is concerned with the development of a quantitative static thermographic application, which is intended to evaluate the coverage of automotive protective coat applied on steel substrates. This developed system is an automated replacement for subjective inspection procedures, in contrast to currently applied methods, provides repeatable and precise detection. An in-house static image analysis code is developed for acquired thermograms processing.

Keywords
Coat overage inspection, Thin paint, Self-referencing and Thermal mismatch

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Ultrasound excited thermography - Advances due to frequency modulated elastic waves

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Abstract
Ultrasound excited thermography allows for defect selective imaging using thermal waves that are generated by elastic waves. The mechanism involved is local friction or hysteresis which turns a dynamically loaded defect into a heat source which is identified by a thermography system. If the excitation frequency matches to a resonance of the vibrating system, temperature patterns can occur that are caused by standing elastic waves.

These undesirable patterns can affect the detection of damage in a negative way. We describe a technique how the defect detectability of ultrasound activated thermography can be improved. With the objective of a preferably diffuse distributed sonic field we applied frequency modulated ultrasound to the material. That way the standing waves can be eliminated or reduced so that the detectability is significantly improved.

Keywords
Ultrasound excitation, burst phase evaluation, frequency modulation

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Infrared surface temperature measurements for long pulse operation, and real time feed-back control in Tore-Supra, an actively cooled Tokamak

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Abstract
Tore-Supra is a Tokamak (I_p=1.5MA, B_t=4T) aiming at doing researches in the field of controlled nuclear fusion. It has been constructed with a steady-state magnetic field using super-conducting magnets and water-cooled plasma facing components for high performances long pulse plasma discharges. When not actively cooled, plasma-facing components can only accumulate a limited amount of energy since the temperature increase continuously (T~sqrt(time)) during the discharge until radiation cooling is equal to the incoming heat flux (T>1800K). Such an environment is found in the most today Tokamaks. In the present paper we report the recent results of Tore-Supra, especially the design of the new generation of infrared endoscopes to measure the surface temperature of the plasma facing components. The Tore-Supra system is described in details, the new JET infrared thermography system is presented and some insight of the ITER set of visible/infrared endoscope is given.

Keywords
Nuclear Fusion, Tokamak, Infrared Thermography, Endoscope, Actively cooled, Calibration, Data acquisition, Interlock, Feedback, Safety.

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Performance of FPA IR cameras and their improvement by time, space and frequency data processing. Part I – Intrinsic characterization of the thermographic system

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Abstract
The characterization of focal plane array infrared cameras is more complex and time consuming than it was for single detector cameras. In the present study, the calibration of two cameras of the same type shows that: i) there is no noticeable difference between the performance of the two cameras, ii) due to the shape variability of the histogram of the pixel individual Noise Equivalent Temperature Difference (NETD), considering just the image mean NETD is not sufficient to characterize the thermographic system. Numerous calibrations have been performed quantifying the improvements of the thermal resolution by time, space and frequency (lock-in) processing.

Keywords
FPA camera, data processing, lock-in thermography, NETD

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Direct infrared measurements of phased array near-field and far-field antenna patterns

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Abstract

A thermal imaging technique has been developed to measure electromagnetic (EM) fields. This technique is applied in this paper to measure the EM fields radiated by large phased array radar antennas and to determine the near-field distributions and the far-field antenna pattern. This thermal technique is based on infrared (IR) measurements of the heating patterns produced in a thin, lossy detector screen made from a carbon loaded polyimide film placed in the plane over which the field is to be measured. The temperature rise in the screen material is related to the intensity of the field incident on the screen. An experimental calibration table was developed at NIST/Boulder to convert the temperature rise at any point on the screen into an equivalent incident radiated field strength. This thermal imaging technique has the advantages of accuracy, simplicity, speed, and portability over existing hard-wired probe methods and produces a 2D picture of the near field or the far field. These IR measurements, therefore, can be performed on-site at the remote location of the antenna in-the-field to produce an image of the radiating field of the array, which can be used to determine the overall radiation characteristics of the array, i.e., the radiation pattern of the combined array elements (gain and beam-width) and the condition of the electronic switching circuits (phase shifters and attenuators). Therefore, the overall “state of health” of the array and the need for repair can be determined in-the-field using the IR technique to avoid the expensive and time consuming alternative of dismantling the array and shipping it to a maintenance depot for testing, calibration, and repair on a standard, planar, near-field antenna test range. In this paper, the IR technique is tested in a controlled environment to determine the feasibility of using the IR images as an array diagnostic tool i) to measure the radiated field of large phased array radar antennas (near-field or far-field patterns in a transverse plane parallel to the plane of the array), ii) to measure the transition of the field from the near field to the far field (in an axial plane perpendicular to the plane of the array), and iii) to test the switching of the array from a scan mode to a target tracking mode.

Keywords

phased array radar antennas, infrared, thermograms, near- field antenna distributions, far-field antenna patterns, array diagnostics