List of Abstracts of QIRT 1998 (Lodz, Poland)

Quantitative infrared thermography in thermo-fluid-dynamics

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Abstract

Infrared (IR) thermography, due to its two-dimensionality and non-contact character, can be usefully employed in a vast variety of heat transfer industrial applications as well as research fields. The present work deals with measurements of temperature and/or convective heat transfer scanning radiometer applied to the *heated-thin-foil* technique. In more details, it is analysed the capability of the infrared system to study particular phenomena such as : the heat transfer in a static 180deg turn channel and heat transfer to air from a yawed circular cylinder.

Application of thermography for microelectronic design and modelling

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Abstract

This paper deals in with the particularities of infrared thermography in electronics or in other words with very small heat sources. This gives rise to very sharp temperature peaks and very rapid transient phenomena. For both of them, infrared thermography turns out to be a very effective measuring technique. At last some discussions about materials and combinations with modelling are presented. Fast thermal processes measurements in microelectronics are discussed using real-time image acquisition as well as so-called stroboscope method. Limits of using thermography for such investigations are outlined.

Statistics-based procedure for defect sizing and experimental evaluation of convection phenomena by using Video Pulsed Thermography

By F. CERNUSCHI[1], N. LUDWIG[2] and P. TERUZZI[2]

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Abstract

In the frame of defect sizing procedures using pulse thermography, the time evolution of the Full Width Half Maximum (FWHM) of the temperature difference between a defect region and a sound one was studied both theoretically and experimentally in the simple case of a circular sub-surface defect. A mismatch between experimental results and theoretical simulations has been found. Possible explanations of this disagreement have been analysed. Moreover an extension of a sizing procedure (applied to circular defects) to irregular shaped defects is presented.

Single-sided interferometric emir method for NDE of structures

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Abstract

Recent work at ONERA demonstrates the interest of using microwave interferometry associated with the EMIR (ElectroMagnetic-InfraRed) method in non destructive evaluation. Until now the method was based on the doubled-sided configuration which is not always applicable in industrial conditions. A single-sided new interferometric method is presented here which avoids this drawback.

Infrared thermographic detection and characterisation of impact damage in carbon fibre composites: results of the round robin test

By V.P. VAVILOV[1], D.P. ALOMOND[2], G. BUSSE[3], E. GRINZATO[4], J.-C. KRAPEZ[5] X. MALDAGUE[6], S. MARINETTI[4], W. PENG[2], V. SHIRAYEV[1] and D. WU[3]

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Abstract

Results of inspecting and impact damaged carbon fibre composite specimen are reported. Several physical test procedures and processing algorithms have been analysed within the framework of the international Round Robin Test. A statistical means for rating non-destructive testing techniques is proposed to convert original infrared images to defect maps that are of special interest for end-users. The potentials of the techniques for characterising shape and depth distribution of impact damage in carbon fibre composites are discussed, including comparison with ultrasonic C-scan results.

Mathematical model for simulation of defects under a material surface applied to thermographic measurements

By I. BORAS, S. SVAIC and A. GALOVIC

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Abstract

We present the mathematical model for simulation the heat conduction process in objects with buried defects. The model is based on the control volume numerical method. The simulation was carried out for defined start and boundary conditions on the model of known geometry and defects (cylindrical holes in different depths). The analysis was carried out in time and amplitude domain. The results of the thermographic measurments taken on the real model having the same

characteristic are given too. From the thermograms and numerical simulation the geometry of the defects is determined by means of the inverse procedure.

Detection of vertical surface cracks in unidirectional carbon fibre composites with an infrared line scanning technique

By J. VARIS, R. LEHTINIEMI and J. RANTALA

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Abstract

Crack detection in carbon-fibre-reinforced-composites was studied by using an infrared, line-scanner-based, nondestructive technique. In a unidirectional composite, 20mm long and 0.2mm wide artificial cuts were made to simulate vertical surface cracks. In order to estimate the detectability of the cracks, finite difference calculations were carried out. The numerical calculations estimated that surface cracks with depths down to 80μm were possible to be detected. In the experiments, the composite was heated with a radio frequency induction coil, and the surface temperature of the composite was monitored with the infrared line scanner. In the experiments, 160μm deep vertical surface cracks were observed.

Nde of frescoes by infrared thermography and lateral heating

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Abstract

The lateral heating procedure is applied to frescoes. A dedicated algorithm is proposed to reconstruct conventional thermograms and to identify detachments of the plaster and cracks. Then a map of defect location and extension is produced. Two numerical models have been implemented to simulate tests. A prototype equipment was also developed and applied both in laboratory and in situ.

Thermal analysis on internal and surface flaws by means of an infrared radiometer

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Abstract

Proven non-destructive tests have been widely used to detect invisible flaws. However, those methods are not remote sensing and cannot be applied in a severe environment. A thermal technique using the infrared radiometer is useful to detect the flaw, as is allows for remote sensing. In this paper, an abnormal radiation temperature distribution of the test piece was measured to detect the internal flaw by the infrared radiometer. The detection limit of the flaws was obtained experimentally and analysed numerically by means of analysis of the conductive heat flow around the flaw. The thermal image method represents thermal and detection behaviour of surface and internal flaws using the infrared radiometer.

Thermal nondestructive evaluation of copper products using an infrared line scanning technique

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[2]Nokia Research Center, P.O. Box 407, FIN-00045 NOKIA GROUP, Finland

Abstract

Defect detection in copper products was studied in laboratory conditions by using an infrared line scanning system. Finite difference calculations were carried out to estimate the surface temperature increase caused by delaminations. In the experiments, elongated delaminations, small voids, and air bubbles were found in the copper samples.

High-speed pulsed thermography of thin metallic coatings

By U. NETZELMANN and G. WALLE

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Abstract

A high-speed pulsed video thermographic system based on an infrared array camera was set up. For excitation, a flash lamp with controllable pulse duration was used. Metallic MCrAIY coatings on Nibase alloy with thicknesses in the range of 37 to 130 microns were studied. Delaminations at the interface of a 310μm thick copper layer on aluminium nitride ceramic could be observed. The thermal decay curves were modelled considering the measured the temporal profile of the excitation light. The results were verified by high-frequency ultrasound measurements at 50 to 80 MHz.

NDE of CFRP composites by transient thermography

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Abstract

Investigations are presented of factors that affect the transient thermography (TT) detectabilities of defects in carbon fibre reinforced plastic (CFRP) plates. The factors studied were: heating time and its optimisation; defect size, depth and severity; image processing. A quantitative comparison was made of TT and ultrasonic C-scan measures of defect size.

Moisture detection in walls trough measurement of temperature

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Abstract

Evaporation flux from wall surfaces can be estimated quantitatively by measuring the temperature which depends in a sensitive way on the evaporation rate. When the equilibrium condition is reached the temperature of surfaces where evaporation takes place is in fact directly correlated to the evaporation rate and it depends on several concomitant heat exchange processes. On the other hand starting from non-equilibrium initial condition the "dynamic" measurement of wall surface temperature as a function of time allows the evaluation of water content in the surface layers. In the Archaeometry laboratory of "Istituto di Fisica Generale Applicata" we performed some experiments on several plaster samples among the ones most traditionnaly used. We employed a climatic room where environmental parameters (temperature, RH, ventilation and irradiation) are controlled and cooling effects due to evaporation are investigated by thermography both in steady and unsteady conditions.

The rotating cement kiln 3D computer model oriented toward solving thermal nondestructive testing problems

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Abstract

The three-dimensional mathematical model of heat transfer in a rotating cement kiln is proposed. Both heat conduction and mass transfer phenomena are taken into account. It is assumed that, due to good mechanical mixing, clinker temperature is constant along both radial and azimuthal coordinates.

The numerical model is realised as a computer program that is used in solving an appropriate inverse heat transfer problem when inspecting insulation material loss in industrial cement kilns.

Thermal diffusivity estimation with averaged infrared thermography

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Abstract

Evaluation methods are proposed for thermal characterisation of layered systems by means of quantitative infrared measurements. Two thermal configurations are studied with an averaging procedure for two layer system. The principle of the estimation method is based on the use of Taylor series of the non-linear analytical transformation solutions to apply linear estimators to fit spectral distributions or time evolutions to experimental macroscopic temperature data. The advantage for potential industrial and laboratory applications is related to non-destructive thermal evaluation of delaminations in composite laminate and to thermophysical characterisation, i.e., diffusivity identification.

Recent development in thermoelastic stress analysis

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Abstract

Thermoelastic stress analysis (TSA) is one of the methods in experimental mechanics used for qualitative and quantitative estimation of the stress state on the surface of cyclically loaded structures which can be either models or actual structures in their operating environment. In this paper critical remarks are given on two different theoretical approaches to derive the main TSA equation of isotropic materials. The main TSA equation of generally anisotropic and orthotropic materials is also shown. Furthermore, the influence of temperature on thermomechanical features of the materials is investigated. By comparing several construction and model materials it is

shown that makrolon is the most suitable material for model making in the thermoelastic stress analysis.

Thermoelastic and thermoplastic effects during loading and unloading of an austenitic steel

By E. A. PIECZYSKA, S. P. GADAJ and W. K. NOWACKI

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Abstract

The effects of thermomechanical coupling occurring in metal during consecutive tensile tests were examined. The relations between temperature and stress and strain changes were investigated both in elastic and plastic ranges. The change of the character of the sample temperature was applied as a criterion for the limit between the elastic and plastic regime. The thermomechanical coupling effects were interpreted in terms of the material microstructure evolution. The thermal effects concomitant with the thermoelastic unloading were evaluated.

Temperature evolution during simple shear test of steel

By S. P. GADAJ, W. K. NOWACKI and E. A. PIECZYSKA

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Abstract

Investigation of the simple plane shear of stainless steel and constructional steel was carried out. The stress-strain curves and the distributions of infrared radiation for various shear rates have been monitored. Temperature changes occurred in the sheared paths. This temperature raised due both to the increase of the deformation and to the rate of shear. The asymmetry of the thermal distribution of the shear paths related to the macroscopic shear bands was observed. Finally the results were compared with the results of numerical simulation of this kind of material deformed in adiabatic condition.

Optical and thermal restoration applied to thermo-elastic stress analysis by IR thermography

By S. OFFERMANN, C. BISSIEUX and J. L. BEAUDOIN

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Abstract

The resolution of stress analysis by means of infrared thermography is limited by the optical performance of the IR imaging equipment and by heat diffusion within the sample. The optical low-pass filtering is characterised by 1D and 2D transfer functions, while the 2D heat diffusion is modelled by a Bessel function. Iterative procedures are used for the restoration of both the optically smoothed contrasts and the thermally attenuated spatial gradients. The technique has been tested in some academic experiments, and then applied to stress maps of actual industrial parts.

Analysis of stress influence on thermal diffusivity by photothermal infrared thermography

By H. PRON, J. F. HENRY, S. OFFERMANN, C. BISSIEUX and J. L. BEAUDOIN

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Abstract

An infrared thermography equipment is used to measure the temperature rise at the surface of a steel bar, simultaneously submitted to the irradiation of a modulated laser beam and to a static uniaxial mechanical stress. The camera measures the radial temperature profiles across the laser

beam, in order to point out the influence of stresses on the local thermal properties. Since this influence remains rather weak, a careful identification of the properties is to be undertaken.

Investigation of metal deformation using thermography

By W. OLIFERUK

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Abstract

Three applications of thermography are presented to investigate metal deformation. All of them are based on monitoring the temperature distribution on a metal surface during its deformation. The first application is the determination of the onset of plastic deformation on a macroscopic scale, based on the thermomechanical coupling. The second involves the use of thermography to monitor the evolution of the plastic zone and to predict the location of the necking in the sample under test. Third, thermography is used to determine the energy balance during the uniaxial tensile deformation of austenitic steel.

Thermovision method in stress analysis of textile materials

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Abstract

This paper presents measurements of strength of textile products with thermography monitoring. Temperature and load during elongation up to break are measured for various materials, such as yarns, woven or knitted fabrics. A correlation has been found between the temperature at the place of break and elongation and tensile strength.

Compared performances of four algorithms used for modulation thermography

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Abstract

A theoretical analysis is presented about the performances of a series of four different algorithms for modulation thermography: standard lock-in method, 4-bucket method, variance method and least-squares method. The precision on the amplitude and on the phase lag is evaluated versus the number of integrated images, depending on the input noise level, on the actual signal amplitude and on the quantisation level.

Progress in ultrasound lockin thermography

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Abstract

Ultrasound lockin thermography (ULT) is based on thermal wave imaging as a local response to periodical heat deposition. The substantial difference as compared to photothermal imaging and optical lockin thermography (OLT) is that the heat source generating a thermal wave is provided by the defect itself due to the attenuation of amplitude modulated ultrasound. While friction effects heat results in the emission of long ranging thermal waves from defects. This way one has a dark field method to display defects in various materials even in the presence of complicated structures related with intact samples.

Detection of loose rivets in aeroplane components using lockin thermography

By TH. ZWESCHPER[1], D. WU[2] and G. BUSSE[1]

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Abstract

Lockin thermography with its capability to monitor modulated heat flow in large areas (several m^2) within a few minutes is applied to the rapid and remote inspection of aircraft structural components.

While some of our earlier work was devoted to the detection of subsurface structures and defects such as impact damages, delaminations, and hidden corrosion areas, we investigate in this paper how well the method is applicable to monitor the tightness of mechanical joints such as screws, rivets, and bolts.

Pulsed phase thermography of Aluminum laminates: neural network investigation

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Abstract

In this paper, a brief review of Pulsed Phase Thermography (PPT) principles are recalled followed by investigations of a neural network applied to quantitative depth discrimination in PPT in the case of aluminum specimens. The paper includes theory and experimental investigations.

Broadening IR applications through using spectral filters

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Abstract

Some materials we look at with an infrared camera can appear "transparent", so we actually see through them rather than looking at them. In such cases, you end up measuring the temperature of objects behind the target you intended to measure, rather than the target itself. Examples of these types of materials include glass, plastics and many gasses. Other applications involve situations where we need to see through a semi-transparent material or gas to get at the object of interest. Examples of this type of situation include looking through furnace gasses or through a glass or plastic package to see what's going on inside. Knowing the spectral characteristics of the material and selecting the proper filter-IR camera combination can solve many difficult measurement situations.

The infrared camera must have the capability of utilizing specific infrared filters to tune the IR system for viewing and measuring objects involving IR transparent materials. Understanding which filter to use and its limitations is critical to getting good results and making proper decisions from the data.

True temperature measurement of electronics through infrared transparent materials

By R. LEHTINIEMI, C.-M FAGER and J. RANTALA

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Abstract

The applications of thermography in electronics have increased considerably during the last years, simultaneously with more and more emerging thermal design problems. However, most

often the infrared cameras have been utilized only for verification of thermal design of already built printed circuit boards in free air, which seldom is their natural environment of use. In this work, possibility to perform true temperature measurements of electronics located inside an enclosure with assist of infrared transparent materials is studied.

Amplitude sensitive modulation-thermography the new way of moisture measurement in building materials

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Abstract

Most damages in buildings, particularly in old buildings, are a direct or indirect consequence of moisture. The causes can be leakages in compartments of the building, perigee or that areas of facades are exposed to driving rain. In addition the building structures contain salts in most cases which become mobile in moist materials and cause again indirect damages. Even after having taken measures of dewatering these damages can be still effective.

For a diagnosis of a moisture damage including the determination of its cause and the damage rate, it is necessary to measure the moisture in those building compartments. Effective measures of reconstruction make sense only after a through analysis of the damage. An analysis technique is demanded for detecting damages which is non-destructive, remote sensing and highly selective with respect to moisture and which should be able to locate large areas with excessive moisture. Unfortunately, for practical applications such a device for detecting moisture, fulfilling all the conditions mentioned above, is still not available on the market.

IR microscope measurement of the plasma spreading in thyristors

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Abstract

Plasma spreading and development of conductive path during turn-on process in today's high-current thyristors, is one of the main limits to the use of these power devices in high-speed

applications. There are a few methods of measurement of dynamic parameters in thyristors. Recombination radiation caused by the current in the semiconductor is measured with the use of a contactless IR method. We propose to use an IR microscope with the detector of the recombination radiation in silicon (? ˜ 1.14μm).

IR CAMERA AND PYROMETER USED FOR WOODWORKING CONTROL

By M. KASTEK[1], H. MADURA[1], H. POLAKOWSKI[1] and W. SOKOLOWSKI[2]

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Abstract

Similarly to metal cutting machines, also wood cutting machines can be also equipped with automatic devices for determination of tools conditions. This paper presents one of the methods used for determination of limits of woodworking parameters or admissible wear of blades of cutting tools. The paper includes results of measurements of woodworking process continue measurement of a surface temperature by means of an IR camera and a pyrometer.

Modelling of infrared imaging for 3-D objects

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Abstract

Infrared emission of a 3-D object has been modelled using Faceted Thermal Target Model (FTTM) - fast and user-friendly software based on the geometrical ray-tracing. The methodology of preparation of the faceted target models using CAD software was described. The model takes into account spectral characteristics of the imaging chain (including thermal scanner). The obtained results of simulations for 3-D object have been presented.

A critical analysis and possible modifications of two analytical models for defects sizing using Video Pulse Thermography

By F. CERNUSCHI[1], N. LUDWIG[2], P. TERUZZI[2] and G. BOTTAZZI[3]

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[3]Università degli Studi di Milano, Dipartimento di Fisica, Via Celoria, 16 20133 Milano Italy

Abstract

Two models describing the surface thermal contrast of a sample (containing a sub-surface defect) during a pulse thermography experiment are compared. For both models, multiple reverberations have been taken into account and the effect of the plane wave approximation in treating heat pulse reflections has been analysed by the introduction in the models of a suitable "diaphragm". Moreover for one model an extension to different defects has been proposed. Finally a defect sizing algorithm has been theoretically studied.

Experimental characterisation of the convective heat transfer in a vortex - wall interaction

By P. REULET, M. MARCHAND and P. MILLAN

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Abstract

The development of turbulence models and wall laws for the numerical simulation of flows in complex geometries requires a detailed experimental analysis of turbulence and of the phenomena that appear in turbulent boundary layers. There is a strong need to develop new measurement systems allowing the determination of unsteady wall heat transfer coefficients.

In order to improve the knowledge of the unsteady phenomena occurring in perturbed boundary layers, a fundamental study is conducted on the interaction of a single vortex with a flat plate. An experimental methodology using a specific thermal sensor whose surface temperature is

measured by an infrared thermography system is presented. It allows the characterisation of the unsteady convective heat transfer coefficient whose evolution is compared with the fluctuations of the wall friction coefficient, calculated from velocity profiles measured by laser Doppler velocimetry.

Quantitative infrared thermography in fire tests

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Abstract

The classification of fire resistant occurs with the aid of the results of fire tests. The criteria for the classification are determined in european standards. The use of infrared thermography not only for qualitative observation but also for quantitative measurement during fire tests of glasses and glazings makes it possible to check the demands of national or international standards as ISO 3009 and forthcoming EN 1364 more exactly.

An FT-IR based instrument for measuring infrared diffuse reflectance

By L. FRANCOU and P. HERVE

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Abstract

The determination of the reflectance for directional irradiation of diffusely reflecting sample is important to improve the knowledge of thermal exchanges. It appears necessary to have some complete reflectivity measurements. Thus an infrared scattering instrument has been build and we have done measurements on several samples. The incidence angles range from 10° to 80°. The use of a Fourier Transform spectrometer permits measurements in the 650 cm-1-8000 cm-1 wavenumber range (1.5µm-15µm) and the maximal spectral resolution is 0.125cm-1. The instrument was tested on an alumina sample at room temperature. The wavenumber range is 1300 cm-1-8000 cm-1.

Surface and volume effects in thermal signatures of buried mines: experiment and modelling

By P. PREGOWSKI[1], W. SWIDERSKI[2] and R. T. WALCZAK[3]

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Abstract

This paper presents models, software and results both experiment and based on simulations. Results of the estimations clarified and quantitatively confirmed the strong influence of moisture gradients and density level of the soil for thermal decomposition on the surface. These multiplicative structural noises caused by surface and subsurface irregularities are the main source of false alarms even in case of mines buried in sand. Better understanding of this phenomenon should help in elaborating more effective prediction and detection procedures of IRT applications.

IR thermography application in studying phenomena in warm extrusion tooling

By A. KOCANDA[1], P. CZYZEWSKI[1], K. KITA[1] and P. PREGOWSKI[2]

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Abstract

Temperature of warm extrusion tools has been measured by means of both thermocouples as well as thermographic camera. A series of workpieces was extruded and changes in temperature during production were continuously recorded. Experimental results were compared with results of numerical simulation of heat exchange by means of FEM. An influence of temperature

variations on physical and mechanical properties of tool steels was taken into account in the analysis of tool behaviour.

IR trend analysis for HV/MV equipment diagnostics

By M. FLORKOWSKI and Z. KORENDO

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Abstract

In this paper the problem of varying load/ambient compensation is considered. The concrete application area is the trend analysis for HV/MV disconnectors condition assessment. As neither the direct temperature comparison nor thermograms subtraction is possible a new approach is proposed. A set of characteristic invariant factors with a rule-based reasoning algorithm are defined as a patent pending method for diagnosing possible defect development. The proposed approach allows for both trending and defect localisation. An experimental example demonstrates the feasibillity of the proposed approach.

Intraoperative thermal coronary angiography - correlation between internal mammary artery (IMA) free flow and thermographic measurement during coronary grafting

By M. KACZMAREK[1], A. NOWAKOWSKI[1], J. SIEBERT and J. ROGOWSKI[2]

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[2]Cardiac Surgery Department, Medical University of Gdansk, Gdansk, Poland

Abstract

In this paper the intraoperative thermoangiographic evaluation of the patency and flow in the internal mammary artery (IMA) anastomosed to the anterior descending branch of the left coronary artery (LAD) is presented.

30 patients were operated due to ischemic heart disease, using cardiopulmonary bypass technique. LIMA was anastomosed to the left anterior descending (LAD) branch in all cases, additional venous grafts were applied in 29 cases. Thermographic evaluation was performed in the rewarming phase of the operation, when all grafts were anastomosed to coronary arteries.

After the peripheral coronary anastomoses are completed, IMA clamp is released. The inflow of warm blood into the previously cooled area creates appropriate temperature gradient for thermographic recording. This warranted very good imaging quality of the heart and coronary arteries. Even small branches could be visualised using this system.

Detailed investigation of aerothermal behaviour of confined impinging jet

By J.-M. BUCHLIN and M. LAPERCHES

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Abstract

The detailed distribution of the convective heat transfer coefficient in the vicinity of the impingement of a vertical turbulent circular air jet on a horizontal flat plate is inferred from temperature measurements performed by quantitative infrared thermography. Steady-state experiments are conducted with the heated-thin-foil method. PIV measurements performed by seeding the air jet with smoke and illuminating the section of interest by a YAG laser sheet support the interpretation of the IR results. The effect of the jet Reynolds number ranging from 20000 to 70000, the normalised stand-off distance with values as small as 0.1 and the presence of a roofing on the thermal exchange coefficient is emphasized. It is shown that two heat-transfer peaks can develop in the impingement region. Their magnitude and position change with the stand-off distance and are well correlated to the flow features.

Thermography for polymers film blowing

By P. G. BERARDI[1], G. CUCCURULLO[1] and L. DI MAIO[2]

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[2]Departement of Chemical and Food Engineering, University of Salerno, 84084 Fisciano, Italy

Abstract

Polymer temperature distribution in film blowing was investigated by means of an IR thermography system sensing in the window between 2 an 5µm. Since in this band polymers behave as selective emmiters, the emission and reflection of the radiation are bulk and surface phenomena. Thus, a preliminary study on the film radiative behaviour is presented in order to characterise the thermography readout on semitransparent sheets. Then, experiments on film

blowing extrusions have been performed with polypropylene on a pilot plant in order to measure the on-line film temperature distribution for different working conditions.

The investigation of actual evapotranspiration with the use of thermography

By P. BARANOWSKI, W. MAZUREK and R. T. WALCZAK

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Abstract

In the study actual evapotranspiration was calculated from the energy balance equation in which the radiation temperature of plant cover is a component of sensible heat flux expressing the transport of heat energy from evaporating surface to the atmosphere. High differences in the course of sensible and latent heat fluxes for the lysimeters with different soil moisture levels were noticed. Daily courses of potential evapotranspiration calculated with different methods were compared with actual evapotranspiration under comfort soil water conditions. The hourly values of actual evapotranspiration in lysimeters with comfortable water conditions better follow the evapotranspiration calculated according to the Penman-Monteith and Kimberly-Penman formulae.

Convective heat transfer to a jet in cross-flow

By G. CARDONE, C. MEOLA and G. M. CARLOMAGNO

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Abstract

An experimental investigation is made to measure convective heat transfer coefficients over a plate due to the combined effects of a wind tunnel stream and a jet perpendicularly injected into the cross flow. Tests are carried out for varying the stream velocity and the velocity ratio of the jet to the stream. The turbulence level of the free stream is also varied by means of a turbulence promoter. An infrared scanning radiometer applied to the *heated thin-foil* technique is employed. Data is reduced in dimensionless form in terms of the Nusselt number *Nu*, based on the nozzle

exit diameter, or better the ratio Nu/Nu_0 where $\underline{Nu_0}$ is the Nusselt number relative to the undisturbed plate.

Modelling of conjugate heat transfer in microelectronics with variable fluid and substrate parameters

By B. WIECEK

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Abstract

2-D model of heat dissipation in hybrid microelectronic circuits with temperature dependent fluid and substrate parameters is presented in this paper. Natural convection and radiation are included. For natural convection the boundary layer approach is proposed for the as the ceramic substrate vertically mounted with heat source on it. The main result shows the significance of using varying parameters in electronics where the temperature does not exceed the level of 500K.

Uncooled IRFPA developments review

By J.L. TISSOT, F. ROTHAN, C. VEDEL, M. VILAIN and J.J. YON

LETI/CEA.G-DOPT-38054 GRENOBLE Cedex 9 - FRANCE

Abstract

Today, large number of uncooled infrared detector developments are under progress due to the availability of silicon technology that enables realization of low cost 2D IR arrays. Development of such a structure involves a lot of trade-offs between the different parameters which characterize these detectors:

- infrared flux absorption,
- measurement of the temperature increase due to the incoming infrared flux absorption,
- thermal insulation between detector and readout circuit,
- readout of thermometer temperature variation.

These trade-offs explain the number of different approaches that are under worldwide development. We present a rapid survey of the state of the art through these developments. LETI/LIR has chosen resistive amorphous silicon as thermometer for his uncooled microbolometer development. After a first phase dedicated to the acquisition of the most important detector parameters in order to help the modeling and the technological development,

an IRCMOS laboratory model (256 x 64 with a pitch of 50 μm) was realized and characterized. It was shown that NETD of 80 mK at f/1.25 Hz and 300 K background can be obtained with high thermal insulation (1.2 10^7 K/W).

Some problems in application of integrated radiation thermopile sensor

By A. MARINCIC[1] and R. TMUSIC[2]

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Abstract

In this paper some problems that arise in application of integrated radiation thermopile sensor Heimann TPS 535, incorporated in module TPMF2, in application that measures temperature of movable heating plates, that are used in food processing industry, were investigated. Series of experiments of cooling of a previously heated body were performed and linearization of integrated radiation thermopile sensor output voltage was accomplished within ± 1.5°C. Thermographic verification was carried out, in order to optimize characteristics of described system application.

Optimization of the photothermal camera for crack detection

By J.-C. KRAPEZ[1], L. LEGRANDJACQUES[2], F. LEPOUTRE[1] and D.L. BALAGEAS[1]

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Abstract

We present recent advances about the application of the photothermal camera for the detection of cracks on metallic surfaces of industrial quality. We describe a normalization procedure designed to clean the photothermal images of the optical noise and thereby to increase the propability of detection of the cracks. A theoretical analysis about the spatial resolution of the photothermal camera is finally exposed.

Spatially resolved measurement of the spectral emissivity of high-temperature components by multi-channel thermography

By G. WALLE, N. MEYENDORF, T. VETTERLEIN, U. NETZELMANN, D. BECKER and H. BRUNS

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Abstract

A non-contact pyrometric and thermographic technique for fast measurement of the temperature and emissivity at temperatures up to 1700°C was developed. Thermographic images were acquired in five spectral bands. A teaching algorithm was implemented. The system was tested on SiC and $MoSi_2$ samples.

Infrared pyrometer for temperature measurement of objects, emissivity of which depends on wavelength and time

By Z. BIELECKI[1], K. CHRZANOWSKI[1], R. MATYSZKIEL[3], T. PIATKOWSKI[1] and M. SZULIM[2]

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Abstract

The multiband MBP 98A pyrometer for non-contact temperature measurement of objects with unknown and wavelength-dependent emissivity has been presented in this paper. The pyrometer was designed using single thermoelectrically cooled PbS detector of spectral band of 1-2.5 μm and 8 narrow-band optical filters. It enables temperature measurement of objects at temperature within a range of 500°C-1200°C and a speed of 75 Hz. It can be used for controlling various industrial-technological processes as well as in research works for testing of classic singleband pyrometers in temperature measurement of objects whose emissivity depends on the wavelength and time.

Multichannel thermography systems for real-time and transient thermal process application

By B. WIECEK and S. ZWOLENIK

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Abstract

This paper presents the architecture, software and applications of high-speed, multichannell thermal and visual computer systems based on PCI (Peripheral Component Interconnect) and PCMCIA standards. The presented solutions are general and can be applied both for various cameras and computer systems. The new image processing algorithms were implemented to ensure more precise temperature measurements, e.g.: 2D perspective transformation, directional emissivity correction, bicubic interpolation, etc.

Directional emissivity correction by photogrammetric 3D object reconstruction

By P. SAWICKI[1], R. STEIN[2] and B. WIECEK[2]

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Abstract

In this paper, the detailed algorithm for directional emissivity correction by 3D object reconstruction is presented. The method is based on photogrammetric Direct Linear Transformation (DLT) with numerical improvements to achieve better convergence. The results of DLT solution are used to correct the directional emissivity and introduce the distance dependent transmission of ambient. Presented algorithm was practically tested in multichannel video-thermal system with one thermal and four optical channels. The algorithm is useful in various applications, e.g.: in industrial photogrammetric monitoring, optical metrology, robotics.

Fast scanning pyrometer for temperature measurements of car wheels

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Abstract

The paper presents design and technical parameters of fast infrared pyrometer the measuring head of which can be shifted in relation to a measured object. Spectral range of the pyrometer operation is within 8-12 μm. Measurements control and data registration are performed using adequate software. The pyrometer was used for measurement of temperature of moving car wheels.

Black silicon as secondary standard of the black body

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[2]Institute of Technical Physics, University Kassel, Germany

Abstract

One of the important problems in thermography of microsystems is scaling of the infrared radiation in very small areas. We describe an application of dry etched silicon surface, so called black silicon as the secondary standard of the black body in the Far Field Thermography (FFT). In our experiments the black silicon surface topography is studied with Scanning Electron Microscopy (SEM) and Atomic Force Microscope (AFM). Sample preparation is discussed also. Dependence of emission coefficient on temperature is studied in the wide temperature range and is compared with traditional black body model.

A comparative study of advanced frequency-domain coding techniques in compression of infrared line-scan images

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Abstract

A comparative study of transform coding techniques in data compression of IRLS (InfraRed Line-Scanner) images is described in this paper. In performance evaluation of block transform and wavelet image coders, we first carefully formed two sets of "good" basis functions: 4 types of generalized overlapped block transform (LOT) and 3 types of biorthonormal discrete wavelets transform (DWT). We fond by extensive computer simulation on IRLS representative test-images, type and order of transform in the most efficient scalar quantized-entropy coder in each set for compression ratio from10:1 to 50:1, based on objective and subjective quality measures of decoded test images. Finally, in performance comparison of the most efficient generalized block transform and wavelet coder we found that biorthogonal Doubechies DWT based coder outperforms standard DCT and optimized LOT coders. Additionally, DWT coder gives possibility for further research on spatial image segmentation and terrain/altitude adaptive IRLS image coding.