Infrared Thermography and their Application

Anamika Paul, Department of Mechanical Engineering,
Galgotias University, Yamuna Expressway Greater Noida, Uttar Pradesh

***ABSTRACT:**Modern thermography is based on an infrared camera's ability to monitor the heat generated by the body's surface, detect any surface variations of radiation temperature, and it transforms into an image, called a thermo-gram.IR thermography is now seen as an extremely useful instrument. The military uses the thermal imaging devices to track, recognize and distinguish enemy people, equipment and buildings.Infrared thermography is used to quantify and analyse the physiological and pathological functions related to the body's thermal homeostasis and temperature.Analysis of streams of infrared video thermography resulted in valuable knowledge about the micro vascular (arteriolar) role of the skin and vital organs when exposed during surgery.Infrared thermography provides useful information when determining the suitability of an organ for transplantation based on quantifiable parameters of the role and viability of the tissue.Infrared thermography is a new, non-destructive method of measuring redeveloped and non-renovated buildings examined. Infrared cameras have a way of calculating temperature in both the inside and the outside of building constructions.Infrared thermography has been shown to be useful for insulation inspection, to identify sources of air leakage and heat loss, to find the exact location of heating tubes or to discover the reasons why mold, moisture is increasing in a particular area, and to detect hidden characteristics, degradations of building structures in conservation fields as well.*

***KEYWORDS:**Infrared Thermography,Kirchhoff's Law, Non-Destructive Evaluation, Planck's Law Stefan–Boltzmann Law, Thermal Imaging System,Thermal Detector Structure, Video Thermography.*

INTRODUCTION

Thermo graphic images using parts of the structure drawbacks associated with thermal characteristics can be easily established to discover the causes and suggest remedy.The prospect of the total measured surface temperature field facility being reported contactless and remotely provides great advantages compared with the traditional structure analysis. The program is equally useful on current buildings, secured facilities and new facilities.Infrared thermography (IRT) is used in an ever wider number of fields of application and for many different purposes; indeed, any process based on temperature may benefit from the use of an infrared system[1].An infrared imaging system should be considered an important aid for diagnostic and preventive purposes, for understanding complex fluid dynamics phenomena, or for determining material characteristics and procedures that may help enhance product design and manufacturing.Infrared thermography can follow a product's entire life as it can be used to manage the production process to determine the final product quality in a non-destructive manner and to track the in-service part.The first use of infrared thermography as a non-destructive research technique dates back to the early last century but has only recently been accepted by standardized techniques[2].IRT suffered from perplexities and incomprehension mostly due to difficulties in the thermogram interpretation.Infrared thermography is a mature technique which is becoming increasingly attractive in a growing number of fields of use.This has also led to a proliferation of infrared devices that differ in weight, size, shape, efficiency, and cost to meet a multitude of user's desires in a wide variety of applications.Infrared imaging systems can now be customized to different requirements and can be used for process management and maintenance planning without production delays and with consequent savings in energy.IRT is a valuable resource for the non-destructive assessment of architectural structures and artworks, since it is capable of identifying much of the causes of deterioration of artworks and buildings of historical and civil interest[3].

THERMAL IMAGING SYSTEM

The thermal imaging device produces an image of the scene electronically. The image can be converted to pseudo colour or false colour where hot areas are marked by reds and cold objects by blues.The brightness when viewed in black-and-white indicates hotter objects. When printed on the electronic image it is a thermogram. A thermogram is simply a thermal energy chart in which shades of gray or colours reflect different radiant energy levels.Back to black-and-white conversion does not have the initial gray scale[4]. Figure 1 shows the thermogram and visible image.

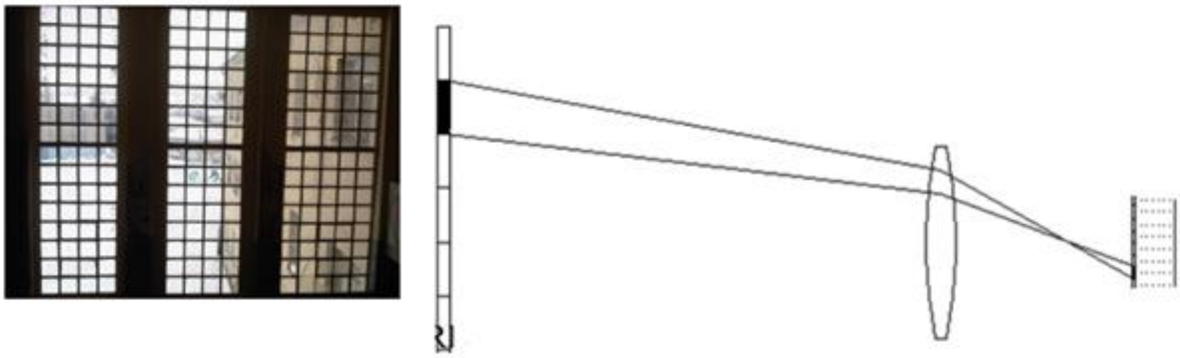

Fig.1: Thermogram and Visible Image

THERMAL DETECTOR STRUCTURE

Detectors calculate the temperature rise by the thermally insulated portion due to the IR radiation absorption. For this reason, thermal detectors are composed mainly of an infrared absorber embedded with a thermometer item in close contact with it.The portion of the thermometer senses incoming temperature rises caused by IR and transforms it into an electric signal. The most common detection mechanism is the resistive bolometer whose resistance varies with temperature, but other mechanisms such as pyro electric effect, thermoelectric junction, conductivity to the P-N junction or mechanical deflection caused by thermal stress may be used.A two-dimensional array of detectors, an Integrated Reading Circuit (ROIC) is typically designed to calculate the resistance of each bolometer and to format the results into a single video imaging data stream[5].Due to the close association between thermal insulation and sensitivity, the high-performance uncooled IR detector must be worked under vacuum-usually 10-2 Torr in a special box supplied with an infrared window.In the practice of thermal comfort in buildings a significant part of overall energy consumption. Infrared thermograph has proven to be an extremely useful tool for visualizing heat loss through the building elements of the potential for research to improve energy efficiency in buildings.Buildings thermal imaging and subsequent expert analysis will detect design defects and focus efforts on rehabilitating the optimum improvement of energy efficient building systems. Figure 2 shows the structure of thermal detector and ULIS ceramic package.

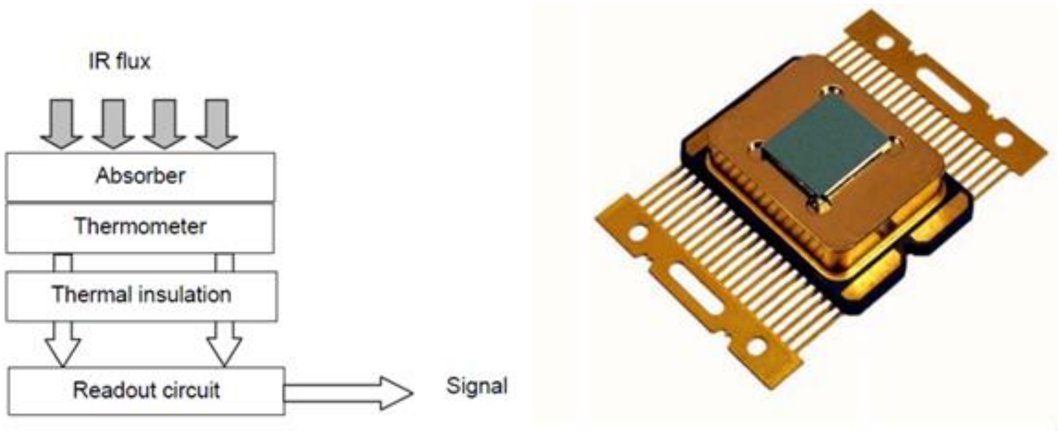

Fig.2: Structure of Thermal Detector and ULIS Ceramic Package

APPLICATIONS OF IR THERMOGRAPHY IN NON-DESTRUCTIVE EVALUATION OF STRUCTURAL SYSTEMS

During the time of the measurement, the thermo graphic scanning device will determine and display the distribution of temperature based on IR radiations emitted from an object's heated surface without any physical contact between the measuring equipment and the surface examined. As a consequence, in various shades of colours or a gray scale, a thermal two-dimensional representation of the object is obtained[6].The measuring test theory is based on the assumption that every substance continuously absorbs energy (electromagnetic radiation) in relation to its temperature on the surface. This energy depends on the spectral properties (emissivity, reflection), thermal properties (conductivity, heat transmitting capability of the material itself, real heat, thermal diffusivity) and other physical properties of the material.Through using solar radiation, the static (passive) thermography technique is accomplished to capture the thermal images without applying an external heating or cooling system and under normal environmental conditions. The calculated temperatures are determined by three factors: surface shape, weather conditions, and system of climate.The surface structure defines different insulating abilities and different thermal conductivity values; the lower thermal conductivity is determined by air voids and low density areas. The surface condition has a profound effect on the emissivity of the surface higher rough surface values and lower smooth surface values.The weather system that surrounds the earth solar radiation, cloud cover, air temperature, wind speed, earth moisture affects the validity of the representation of images.During the natural cooling cycle, images may be taken at night, when the solar radiation is no longer present. In the thermo graphic picture areas most variations will be observed displaying cooler temperatures than the adjacent areas[7].A daylight study will display reversed effects-higher temperature levels will be seen in the affected areas. This technique is often used when measuring wide areas, offering a low cost source of heat and contributing to an even distribution on the surface being studied.An external source of irradiation (IR), dynamic (active) thermography is often used to analyse the inside of a house. In the dynamic periodic way lockin thermography or in the dynamic single-shot way pulse thermography, the energy is transmitted into the target.Heat penetrates the object being studied, and the distribution of surface temperature depends on the material's thermal properties and on its inner layers. In homogeneities, defects in the surface of the material being studied can be observed during the cooling-down cycle in observable temperature variations disturbing the heat flux in the local region of the earth[8]. Figure 3 shows the pulse phase thermography.

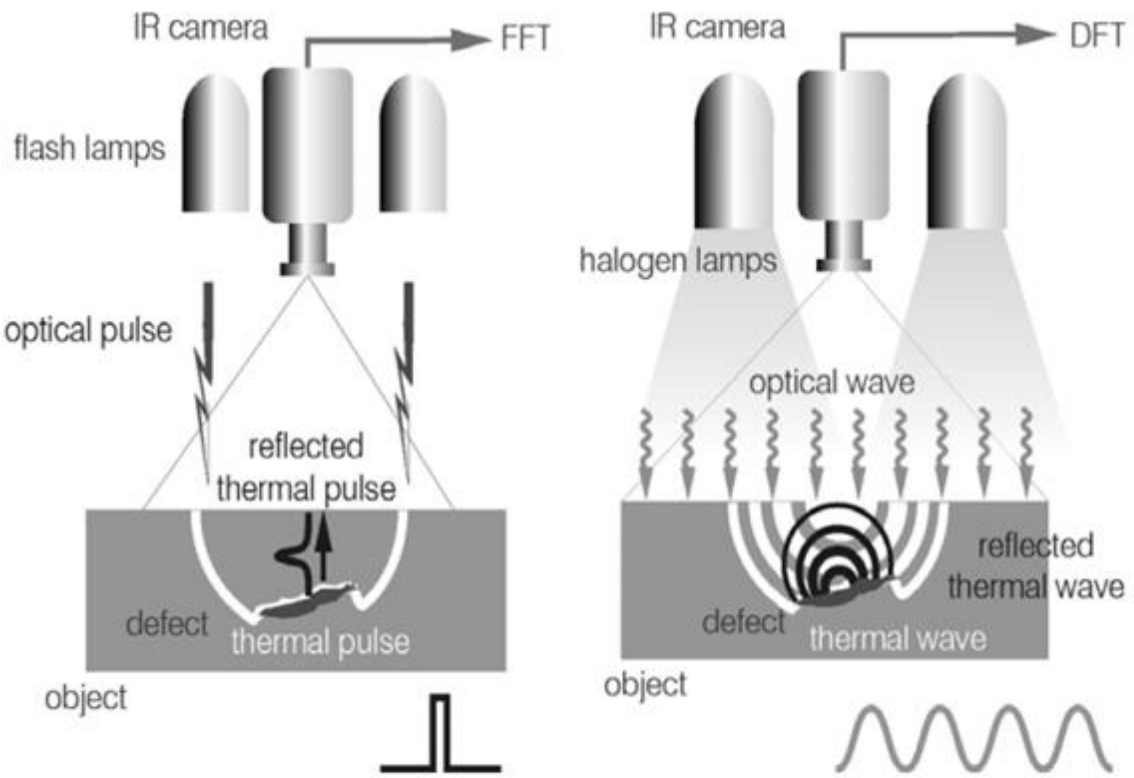

Fig.3: Pulse Phase Thermography

INFRARED VIDEO THERMOGRAPHY AS A TOUCHLESS POLYGRAPH METHOD FOR PSYCHOPHYSIOLGICAL STRESS DETECTION

Infrared imaging and image processing are implemented around as an effective method for the detection of deception by demonstrating its ability to identify facial stress patterns at a distance. Infrared imaging will track the breathing process, based on the difference in temperature between the exhaled air and the ambient room temperature.The large arteries is pass near the skin surface (external carotid artery, temporal artery, etc.), cardiac pulse wave may also be tracked by infrared thermography.Replacing conventional polygraph testing with non-contact infrared video thermograph recordings and their multifaceted examination allows for monitoring vast numbers of people for possible signs of their deceptive behaviour[9].

IR THERMOGRAPHY FUNDAMENTAL OPERATING PRINCIPLES

The thermography is based on the emission of artefacts but the IR thermography functional theory agrees with three basic radiation laws:

*Kirchhoff's Law of Thermal Radiation:*The relationship between emission and energy absorption meaning that a body that absorbs also emits according to this definition, the emission coefficient ε, is introduced in equation as the ratio of emissivity E, of the real body to emissivity E_z, of the black body at the same temperature ε =E / E_s. The emission coefficient (ε) is non-dimensional taking values from 0 to 1 and depending on the body's wavelength, temperature, and surface texture.

*Planck's Law of Radiation:*the specific spectral radiation I' emanating from the idealized black body,

$$I'(\lambda,T) = \frac{2\pi hc^2}{\lambda^5} \cdot \frac{1}{e^{hc/\lambda kT} - 1},$$

Where: λ is the wavelength, T – the absolute temperature, h – the PlanckConstant and c – the speed of light. If the specific spectral radiation I is plotted over the wavelength λ, as a function of temperature, typical Planck curves will result.The maximum curve changes with the temperature to a smaller wavelength in accordance with the Wien displacement law, where λ = b / T is the maximum wavelength, T is the absolute black body temperature, and b is the proportionality constant called the Wien displacement constant equal to 2.8977685(51) − 10−3 mK (Mohr, 2008).

Stefan–Boltzmann Law: The emission of the surface over all wavelengths, incorporated the Planck law and discovered that the radiant power, I, [W / m2], increases with the fourth temperature power, I = T 4, where σ = 5.67 W / m^2 K^4[10].

INFRARED THERMOGRAPHY APPLICATIONS

Infrared thermography is developed as a useful clinical medicine diagnostic tool particularly in body shell assessment. The biophysical and biochemical basis for the use of cellular energy and the molecular origin of normal metabolic rate in mammals have been well studied. Thermo graphic representation of the infrared image has a sound scientific basis. Circulatory and/or inflammatory disorders and diseases have a major effect on some body regions thermal homeostasis, which is readily available for infrared thermography assessment.Rheumatoid arthritis is characterized by repeated joint inflammatory processes, followed by hyperthermia of the surfaces of the skin that cover the joints. Infrared thermography offers objective, quantifiable, reproducible measures of the strength and extent of the joint involvement[11].The therapeutic effectiveness of various treatment strategies to minimize the severity of an inflammatory cycle can be measured objectively and quantitatively, and contrasted by infrared imaging. This offers an alternative to the semi- quantitative scoring schemes currently in use.Disease of Raynaud is characterized by a sudden, irregular, painful vasospasm of the digital arteries of the finger, caused by cold or emotional stress. The intensity of the disease can be quantified by infrared imaging, and successive attacks can be compared.Because of the variation in the underlying disease mechanisms, it is also possible to distinguish the primary and secondary types of Raynaud's syndrome by infrared imaging, which offers useful information for further diagnostic procedures and individualized disease treatment and also has prognostic value[12].

CONCLUSION

The main aim of non-destructive thermo graphic testing technique is to provide knowledge by examining the real properties of existing buildings to determine surface irregularities cracks, voids, etc.Thermal anomalies, voids, air leakage, intrusion of moisture and the structure of buildings create numerous superficial temperature models with characteristic shapes in a thermal picture.The high temperature variations on the thermal images are also indicative of structural changes, structural defects, lack of insulation, corrosion (cracks), and sources of air leakage, heat loss, and moisture.The infrared measurement provides a detailed picture of the building envelope thermal security level and describes the week zones shielded from direct contact with the eyes.For the practice of thermal comfort for buildings a significant part of overall energy consumption. Infrared thermographhave proven to be an extremely useful tool for visualizing heat loss through the building elements and the potential for work to improve energy efficiency in buildings.Buildings thermal imaging and subsequent expert analysis will detect design defects and focus efforts on rehabilitating the optimum improvement of energy efficient construction systems.

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