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A Review on Errors Caused in Infrared Thermography Measurements

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Abstract- Infrared thermography in its process uses thermal imager to detect radiation and then further converting it to get object temperature and temperature distribution. The results of thermography measurement get affected by various parameters say emissivity, ambient temperature, atmospheric temperature, transmittance, relative humidity, distance and view factor between object and sensor. Parameters such as emissivity, ambient temperature, transmittance, relative humidity, distance between object and sensor are user specified to the measurement software. The present work focuses on review of errors caused in infrared thermography measurements.

Keywords- Error, infrared thermography, measurements.

I. INTRODUCTION

Infrared thermal imaging is widely used for measuring Temperature measurement, heat flux monitoring, machine condition, fluid system monitoring etc. In its process it uses thermal imager to detect radiation and then further converting it to get object temperature and temperature distribution. The results from measurement contain error and sources of these errors may be from different physical and atmospheric factors.

Infrared thermography is the process of using a thermal imager to detect radiation (heat) coming from an object, converting it to temperature and displaying an image of the temperature distribution. Images of the detected temperature distribution are called thermograms, and they make it possible to see heat-producing objects invisible to the naked eye. It's widely-used in predictive maintenance and condition monitoring.

Since all objects above absolute zero (-459.67 degrees Fahrenheit) give off thermal infrared energy, thermal imagers can easily detect and display infrared wavelengths regardless of ambient light. A common example of this is using night-vision goggles to detect objects in the dark. Infrared thermography is commonly used in a variety of industries and applications.

The primary goal of infrared thermography is to confirm machinery is running normally and to detect abnormal heat patterns within a machine, indicating inefficiency and defects.

Inspecting mechanical equipment using infrared thermography is a big advantage for asset managers tasked with condition monitoring. Even though infrared imagers are simple to use, interpreting the data they produce can be a bit more challenging to break down. It's important not only to have a working knowledge of how infrared imagers work, but also baseline knowledge of radiometry and heat transfer processes.

II. TYPES OF INFRARED THERMOMETERS

An infrared thermometer in its most basic form consists of a lens that focuses the infrared thermal radiation onto a detector, which turns the radiant energy into a color-coded signal.

Infrared thermometers are designed to measure temperature from a distance, preventing the need for contact with the object being measured. Today, there are a variety of infrared thermometer configurations for specific applications. Following is a look at three of the most common types of infrared thermometers.

1. Spot infrared thermometers:
Also known as a pyrometer, a spot infrared thermometer resembles a handheld radar gun and is used to detect and measure the temperature at a specific spot on a surface.

2. Infrared thermal-imaging cameras:
A thermal-imaging camera is an advanced type of radiation thermometer used for measuring temperature at multiple points across a large area and creating two-dimensional thermographic images.

Thermal-imaging cameras are considerably more software- and hardware-based than a spot thermometer. Most cameras display real-time images and can be hooked up to specialized software for deeper evaluation, accuracy and report generation. Modern thermal-imaging cameras are handheld.

III. INFRARED THERMOGRAPHY ASSESSMENT CRITERIA

When using infrared thermography as a tool for condition monitoring, it's recommended you establish severity criteria. Severity criteria can be presented in two forms: general categories identifying temperature levels or specific categories of machines or components. Severity criteria develop over time with an accumulation of data. It's best practice to develop severity criteria specific to each category of equipment based on the equipment's design, operation, installation, maintenance characteristics, criticality and failure modes.

Establishing severity criteria on individual machines or components is based on a number of factors, including temperature rise vs. historical data, determining the rate of deterioration and time to failure, how critical the machine or component is to the overall process, safety, etc. Rises in temperature for critical machines, mechanical components, bearings, electrical supply and more are common applications used by thermographers to classify temperature severity or mechanical abnormalities.

IV. INFRARED THERMOGRAPHY AND PREVENTIVE MAINTENANCE

Infrared thermography is a highly recommended preventive maintenance tool in nearly all industries. You won't find another tool that gives you such accurate, real-time data without disrupting the process flow from shutting down your systems.

Working infrared thermography into your regularly scheduled maintenance procedures is a great way to catch abnormalities in components and machines quickly. Using baseline thermography on new equipment or after repairing equipment will provide a set of thermal images to compare all other tests against and lets you more easily troubleshoot future issues.

V. LITERATURE REVIEW

Infrared thermography was first used for purposes other than civil construction. Its principles were discovered by accident while scientist William Herchel wastrying to solve an astronomical problem, in the 1800's (Barr, 1961). Over the years, the technique was improved foruse in several sectors (Lucchi, 2018).

In1830, Melloni, an Italian investigator, discovered that NaCl, in natural crystals large enough to be transformed into lenses and prisms, became the main infrared until the 1930's, the era of synthetic crystal (Flir, 2017). The first quantum detector was developed between 1870 and 1920 based on the interactions between the radiations, increasing the precision and considerably reducing the response time (Smith et al., 1958). The thermography was greatly improved during World War II, showing the importance of the technology especially at night. The propagation of the infrared images in the construction sector occurred in the 2000's, with the use of barium-strontium titanate and microbolometer (Lucchi, 2018). In the last years, its use has increased dramatically, mainly in restoration, building construction, and survey works (Kylili et al., 2014; Bianchi et al., 2014).

In addition, it is important to note that the use of this technique has been associated with a reduction in size equipment, cost reduction and resolution improvements, sensitivity and accuracy, operability and portability (Meola, 2012). The use has grown considerably over the last 15 years, mainly for civil engineering and restoration of historic buildings, thus facilitating a diffusion of European legislation not only for energy efficiency but also for energy auditing of buildings (Lucchi, 2018). However, evenafter 30 years since the beginning of its use, it has not yet been extensively exploited (Grinzato et al., 2002; Albatici and Tonelli, 2010).

Several researchers have applied infrared thermography techniques for various uses(Bagavathiappan et al., 2013) such as emissivity measurement and determination of global heat transfer coefficient, thus demonstrating a positive potential (Porras-Amores et al., 2013). O'Grady (2017a) brings important information in his research: about 40% of the energy consumed in Europe comes from buildings. The previous study on thermal behavior of walls avoids errors in the construction phase. Once built, its on-site verification enables to find possible pathologies and/or design deficiencies that lead to a reduction in its thermal performance.

Robinson et al. (2017) aimed to study a simple and low-cost method to estimate the effective thermal diffusivity in structural walls of buildings. For this, they used infrared thermography as an experimental and low-cost method to calculate the thermal diffusivity of the concrete wall under controlled conditions. The greatest difficulty found in this work was the control of heat loss through the lateral limits of the section, being calculated in situ, since in controlled environment, the lateral limits were isolated.

This inexpensive experiment combined with a mathematical model resulted in a concrete diffusivity of 7.2 m2/s ± 0.27m2/s, which is sufficiently precise. For this experiment the lateral limits were isolated, but it was concluded that there is a great loss of heat for these limits.

Danielsky and Fröling (2015) investigated quantitative methodology to analyze the thermal performance of building envelope in a non-stationary state condition, including two phases. They did experiments with wood wall exposed to external conditions to calculate the coefficient of heat transfer by convection; the value of

2.63 W/ (m2K) was found. The external parameters used were wind speed, humidity, and snowfall. In addition, the heat flow through the wall was assumed to obtain stable state condition only sparsely and for short periods. HFM and infrared thermography were used for the calculation of both the heat transfer coefficient and conductivity. The results of 4% and 3%, respectively for the conductivity and the global transfer coefficient, were found compatible with differences between the methods, suggesting that the thermography method is more accurate.

Donatelli et al. (2016) used active thermography for two prototype walls under controlled environmental conditions and calculated the thermal transmittance in situ, comparing with the thermal transmittance calculated by a computer program. The results showed that the temperature measurements on software (FEA) are identical to those of a real wall, and that the procedure allows the measurement of temperature in prototype walls throughout the year without climatic interference.

O'Grady et al. (2017a) elaborated a study with an efficient, non-destructive method, based on an outside infrared thermographic survey, to determine the performance of the thermal bridge. For this, they compared the values of the thermal properties, mainly of the thermal transmittance, obtained by the quantitative infrared thermography, with the values of a hot box.

A computer program was used to adjust the results. The thermal transmittance of these 2 methods with 3 different wind speeds was calculated and compared. For the thermal transmittance, the external convective coefficient was determined using the Jürges approximation and the Nusselt number.

The results of this study demonstrated the suitability of both approaches for calculating the value of thermal transmittance; however, the Jürges approach is less time consuming. Infrared thermography is an effective tool for the determination of thermal transmittance.

O'Grady et al. (2017b) propose the use of non-invasive and easy-to-use method to provide quantitative measurements often actual thermal performance in the thermal bridge. They studied thermal properties and used quantitative infrared thermography in addition to an experimental program designed to quantify the thermal bridges and tested in a calibrated and controlled hot box.

They used the calculation of the thermal transmittance and the temperature variation. Three samples were taken, sample 1had the highest value found: 0.441 W/(mK) by hot box and 0.436 W/(mK) by thermography. It can be concluded that after being tested in the laboratory and presenting excellent results for the external conditions, the observations will be a challenge for the precision of the measurements by the infrared thermography.

VI. CONCLUSION

The method has a great applicability in the identification of air leak points. These of active or passive thermography will generate different results. The active technique shows air leaks clearly. External stimuli aid in detection of air leaks, which may be highlighted as advantageous in the use of infrared thermography.

Among the uncertainties identified were (1) the difficulties in the longer processing time of the transient analysis, which requires unique equipment, and (2) the interpretation of the graph data and pressure versus temperature histograms. For future research, the comparison between the thermal images of passive infrared thermography and the active one in a quantitative approach would be very useful.

The advantages found in thermal bridges are simple and effective evaluations of their effect in the thermal energy behavior. Simplicity in the geometry of the building contributes to measured and calculated values. Given the uncertainty of energy consumption in the configuration with thermal bridges, the singular error due to the analysis of each thermal bridge must be taken into account.

The incidence factor often thermal bridge, analytically defined, depends on the internal temperature of both the air and the wall for the infrared thermographic camera to read. Among the applications on thermal bridges identified through the measurements, it should be highlighted the possibility of making interventions to improve the insulation. In addition, it is a useful method to analyze, refine and validate specially designed3D simulation tools for the evaluation of energy performance in buildings, since they can evaluate thermal fields of internal and external walls.

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