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Implementation of Infrared Thermography in Power Utilities

Introduction

Infrared thermography is one of the more sophisticated NDT methods recently applied in detecting heat generating anomalies, and has become a major player to achieve reliability and quality for both mechanical and electrical equipments, through the implementation of Equipment Preventive Maintenance Programs, Heat is detected by an infrared camera. The camera translates heat to a visual image normally called a thermograph.

Infrared thermography is the science of acquisition and data analysis of thermal information from non-contact thermal imaging devices.

What is infrared?

Infrared energy is part of the electromagnetic spectrum and behaves similarly to visible light. It travels through space at the speed of light and can be reflected, refracted, absorbed, and emitted. Has a wavelength longer than that of visible light. Infrared is usually divided into 3 spectral regions: near, mid and far-infrared.

Where does infrared energy come from?

All objects emit infrared radiation as a function of their temperature. This means all objects emit infrared radiation. Infrared energy is generated by the vibration and rotation of atoms and molecules. The higher the temperature of an object, the more the motion and hence the more infrared energy is emitted. This is the energy detected by infrared cameras which detect thermal radiation only, not temperature. And the most important factor that affects radiation emitted form a target is its emissivity. Emissivity is the ability of a body to emit radiation. Each material has its own emissivity.

What is Infrared Thermography?

- Infrared Thermography is the technique for producing an image of invisible infrared light emitted by objects due to their thermal condition.
- An image produced by an infrared camera is called a thermogram or sometimes a thermograph.
- Therefore, Thermography allows one to make non-contact measurements of an object's temperature.

There are three things that make thermography so useful:-

It is non-contact – uses remote sensing.

- It keeps user out of danger when scanning live electrical components.
- Does not affect the target. (Non-destructive).
- Targets in high positions can be detected.

It is two-dimensional

- Comparison between the areas of the target is possible, that we can measure temperature in two points or a hundred points in the same target, and compare them.
- The image allows for excellent overview of the target, enabling find where problems are.

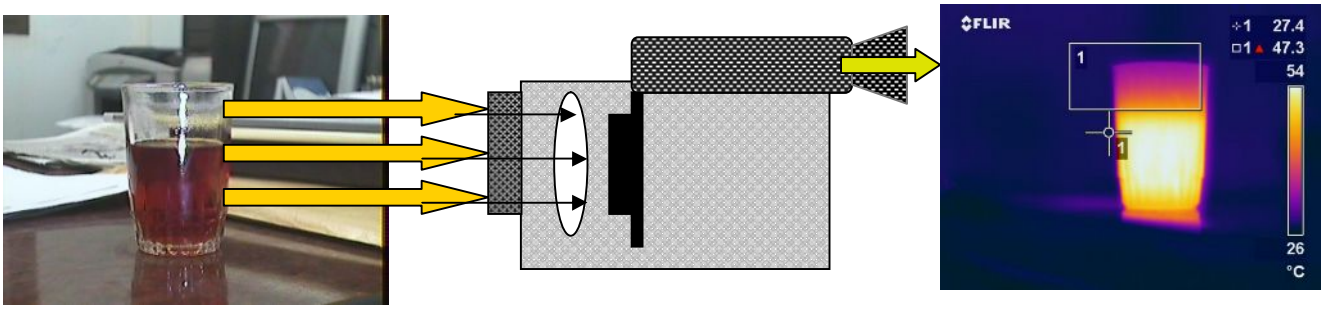
It is real time

- Real time imaging allows us to do very fast scanning of stationary targets with immediate results.
- The real time character of infrared thermography lets us capture very fast moving target

Method and Equipment

Camera Principles

The camera converts invisible infrared radiation into a visible image. It looks at the infrared radiation that is radiated from the target it is viewing. The infrared radiation passes through the lens, and it is focused on the detector, much like visual radiation on the film of a regular camera. (see fig.)



IR Camera Principle

An Infrared Image interpretation

The darker areas are those that radiate less thermal radiation, and that generally means those areas of the target are cooler. Brighter means the opposite – more radiation, and a warmer target. In the image below, we can tell that the car has been driven lately, because the wheels are warmer than the rest of the car. The motor is running or has recently been switched off, because the radiator is still warm.

Applications

The applications of thermography that have been discovered over the years are numerous and divers. The most common applications we intended in this paper that is condition monitoring in mechanical and electrical equipments electrical power utilities.

Condition Based Maintenance

Infrared thermography is used for condition monitoring, CM, to optimize maintenance and keep production running smoothly and safely, at the lowest possible cost.

Condition Monitoring

- Electrical.
- Mechanical, friction, heat losses.
- Tanks and vessels.
- Fluid flow problems.

Medical and veterinary

The non-invasiveness of thermography makes it very useful and completely harmless in medical applications. An animal cannot tell you where it hurts, so for the veterinarian, thermography is a valuable tool.

Quality Control and Process Monitoring

Infrared cameras are becoming more and more common in factories, for quality control and continuous measurement of temperature in the production process.

Non-destructive testing

Infrared thermography is a technique that is used to nondestructively inspect parts for the presence of subsurface defects. The technique normally consists of applying heat to one surface of the part and observing the thermal response, using heat-sensing devices such as infrared cameras, as the part cools. Internal defects such as voids modify the thermal response and produce local hot or cold spots on the specimen surface.

Infrared thermography in Power Utilities

Historic Overview

Infrared thermography was introduced in Sudan in the year 2003 by the National Electricity Corporation (NEC), A team of 13 engineers were subjected to infrared thermography level I training course in Sudan, conducted by Infrared Training Center (itc), Sweden. The engineers were recognized as level I thermographers. In the year 2006, eight engineer were level II certified from the same training center

Most of the defects or faults in electric power generation, transmission, or distribution are heat generating, and some of them are of a catastrophic nature, for both, personnel and equipment. Taking the National Electricity Corporation (Sudan) as a case study applying thermography, we got four examples that illustrate how thermography was the key player to detect major faults that could have caused a quite big loss.

The standard followed is : ASTM E1934-99a(2005)e1 Standard Guide for Examining Electrical and Mechanical Equipment with Infrared Thermography

Example (1)

Detection of Heat Loss due to bad Thermal insulation

Fig. (a) Shows a visual image of a 30MW-steam turbine (Khartoum North Thermal Power Station-Sudan KNPS) where we can see the thermal insulation covering the turbine cylinder and the main steam inlet pipes to turbine, with temperature 480°C, and pressure of 60 bars. Fig (b) shows the infrared image of the same turbine, and we can clearly see the bright areas that indicate the heat leakage from the weak points of the insulation. This leakage may lead to temperature drop, and consequently thermal stresses which have fetal effect on the turbine cylinder.

Fig (1-a) Visual image of turbine No.2

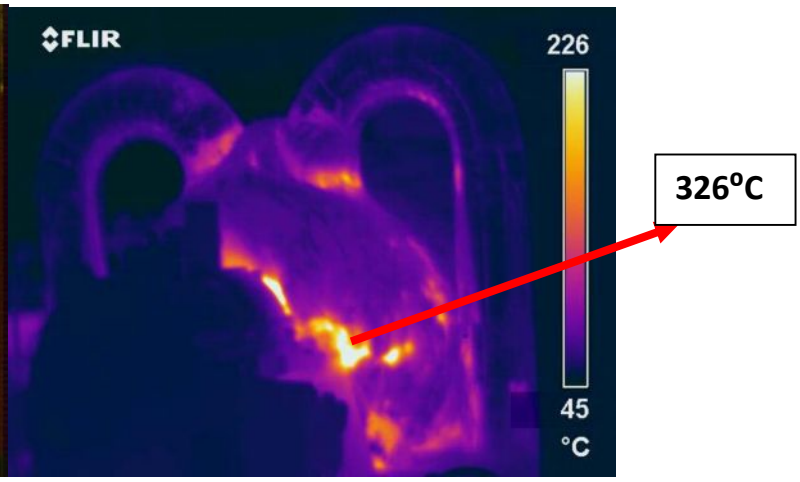


Fig. (1-b) Thermal image of turbine No.

Example (2)

Detection of High Pressure Steam Leakage

Fig. (2-a) shows a visual image of high pressure seal steam inlet to turbine No. 3 KNPS. The case was; unknown source of steam leakage within the area, nobody can see it since it is dry superheated steam; one can just feel it and hear the terrible noise. It is unsafe to run the unit with this situation. There will be a high consumption of steam, and the area around the turbine will be extremely hot.

Fig (2-b) shows the IR image of the same area. In this image the source of the steam leakage was obviously seen

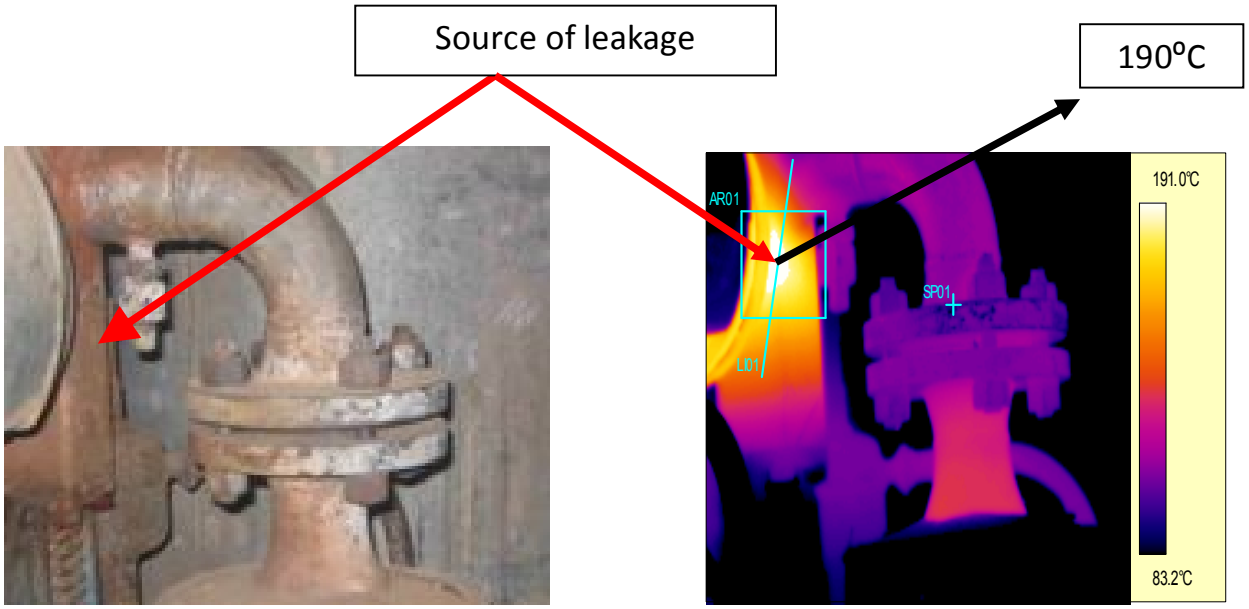


Fig (2-a) Visual image **Fig (2-b) IR image**

Turbine No. 3 – KNPS (60 MW)

Example (3)

Leaking Valves

In this example, we see two IR images for two different steam valves, having the same size and the same type. They are both in the closed position. In the left IR image, it is clear from the bright area, that the steam is enclosed in the upstream of the valve, where spot 1 reads 185°C, while spot 2, in the downstream of the valve, in the dark area, reads only 61.9°C, so the result is that the valve is holding,

In the right IR image, although the valve is in the closed position, but still there is a steam leaking from the upstream of the valve to the downstream. There is a slight difference in readings between spot 1 and spot 2. So one can confidently judge that the valve is leaking.

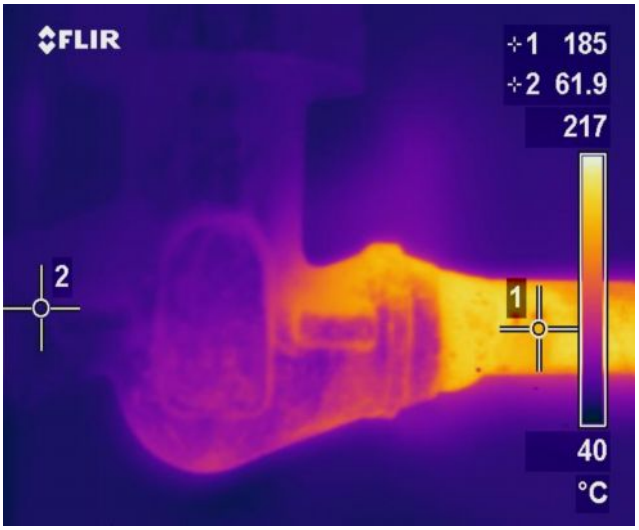


Fig (3-a)

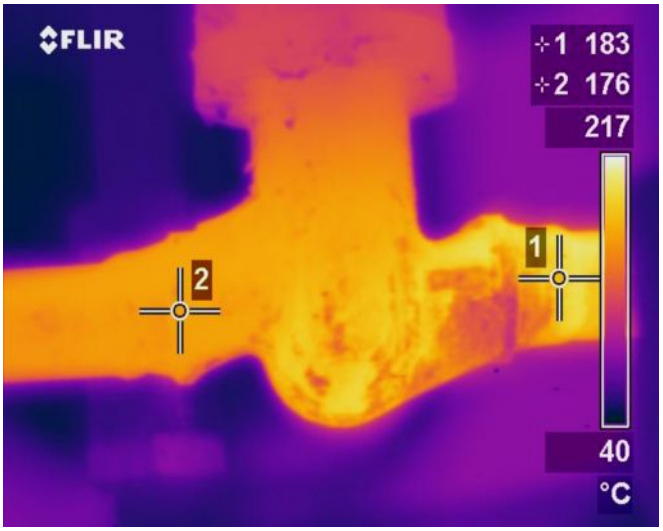


Fig (3-b)

Visual image of the valve

Example (4)

Transformer cooling oil circulation

Not always thermography searching for hot spots or hot areas, sometimes cold areas becomes fetal problems. Transformers are usually cooled by natural circulation of the cooling oil inside fins; the fins are arranged in groups, each group acts as a radiator and located around the core of the transformer. The IR image of fig.(4) shows a 110/33 KV transformer in a substation in Khartoum North, we see that the upper part of the transformer is bright, while the lower part is dark, and that is due to temperature of the oil. From the IR image we see that one of the radiators seems to be cold, and this may affect cooling efficiency, so winding temperature will rapidly increase causing damage in the transformer. A report was raised to maintenance people, who found that

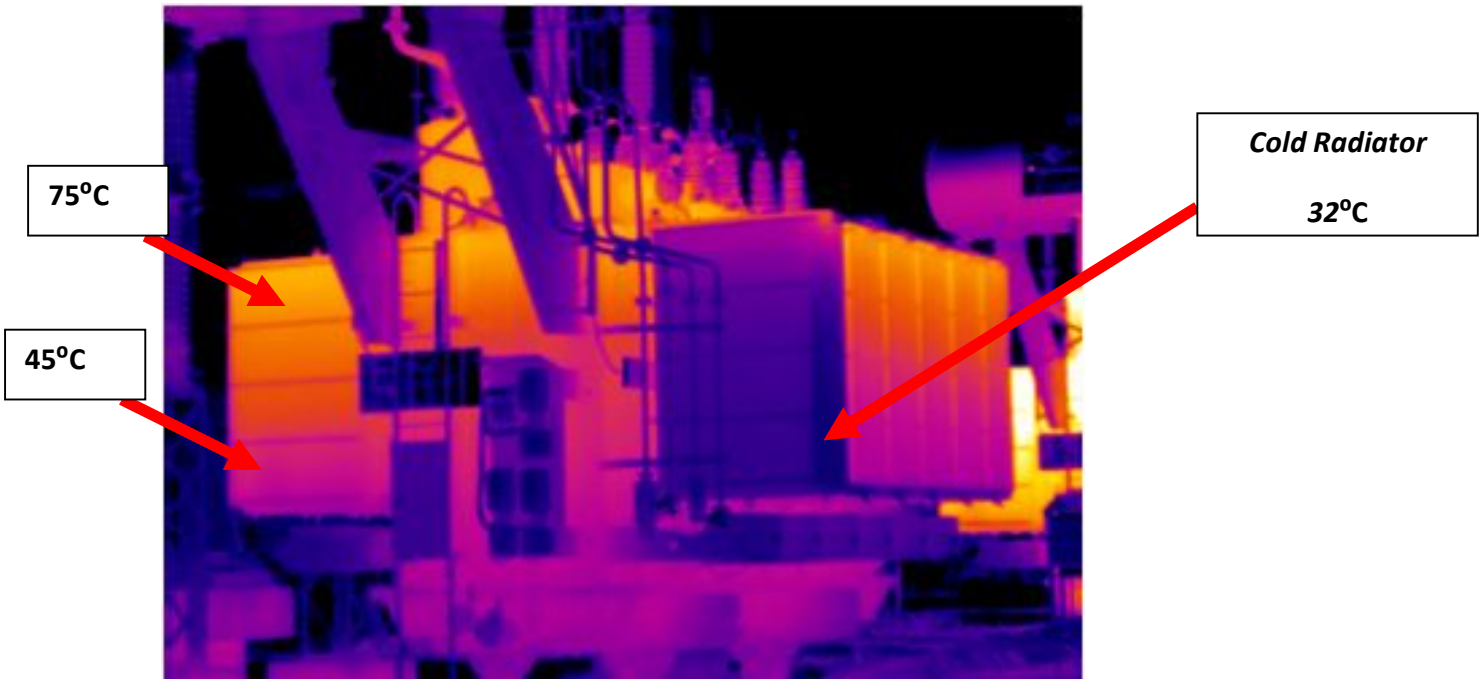
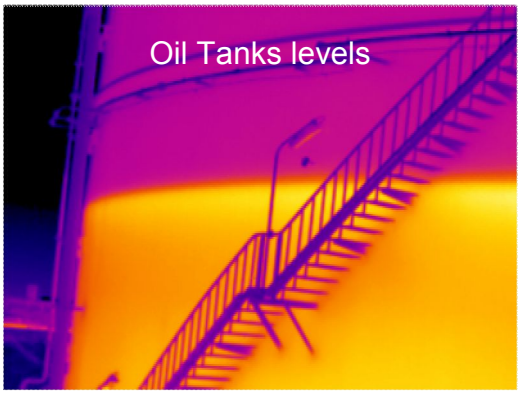
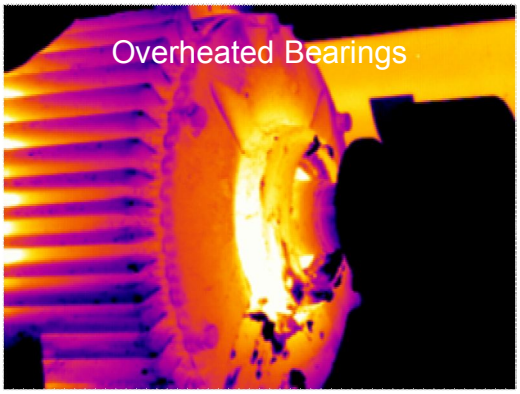


Fig (4)

Some IR images of Mech. & Elec. Application.



Oil Tanks Level



Overheated Bearing

Electrical Applications

High voltage substations

Preventive Maintenance Program

A scheduled program was prepared in MS-Project for each power Station, mainly the thermal ones, and all equipments were included in the program to be periodically monitored. Faulty images are reported and sent to maintenance department in each power station to take actions.

Reports:

After doing the scanning with the camera, all the data are uploaded to computer whereas special software can automatically generate a report for all images, each image in a separate page. The report contains all the parameters concerning the scanned part.

Reference:

Thermography Level 1, Course Manual. By:

Infrared Training Center (itc). FLIR Systems AB, Stockholm

Note: All IR images in this paper were taken using

- Flir SC 3000 IR Camera.
- Flir P 65 IR Camera.

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