Development of an acclimatiezed chamber for IR based diagnostic research

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Abstract

Infrared thermography is widely applied to power systems in the power substations and in the overhead transmission lines condition monitoring, aiming at continuous operation and maintenance purposes. As applied in an outdoor environment, the themographyc inspection is influenced by a number of ambient variables such as wind, solar radiation, humidity, and so forth. A great challenge for the researchers consists in the development of methods to extract the influence of such ambient variables in order to get the most reliable diagnostic. Therefore, an acclimatiezed chamber was developed to simulate actual conditions, allowing for the development of methodologies in the laboratory for latter application in field. The purpose of the proposed paper is to present the principles that guided the development of the chamber, its automatization and to describe the tests that can automaticaly be conducted.

1. Introduction

There are a number of factors that can cause influence when conducting IR inspections in an uncovered environment, as in a power substation. Despite the IR inspection seems to be a simple task, the neglecting of some *factors of influence* can conduct to erroneous condition evaluation of the equipment under analysis.

Such factors of influence can be characterized as *procedural*, *physical* or *environmental factors*. The influence of Procedural factor is minimized when certified personnel is employed. This work is concerned with the technical and environmental influence factors. Figure 1 shows a typical scene of an IR inspection in a high-voltage substation. The main elements are the inspector, the thermal-camera, the equipment under analysis and the environment.
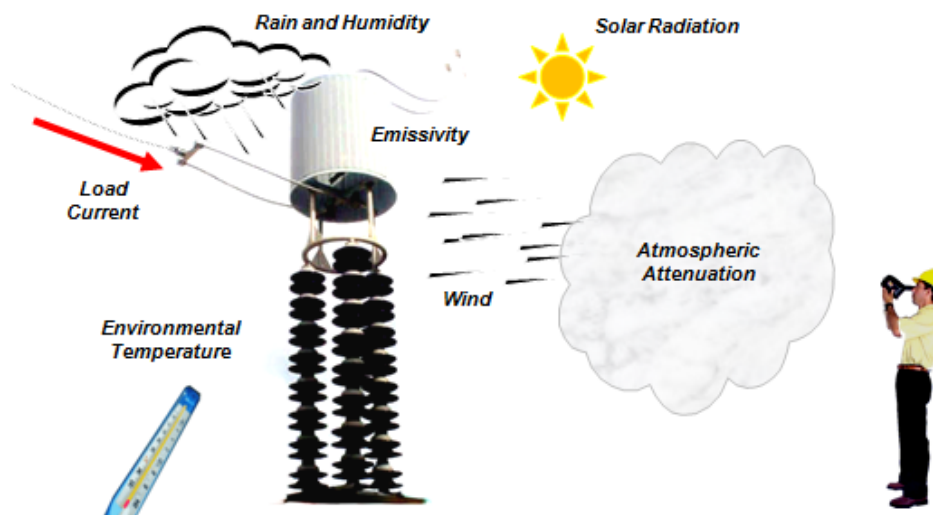

Fig. 1. *Procedural, technical and environmental sources of influence*

Procedural factor of influence can be minimized when certified personnel is employed [1]. Low target emissivity of the component under analysis, load current variation, small dimensions components at large distances are examples of *physical factors* of influence. In addition, for outdoor environments, there are other factors of influence such as solar radiation, atmospheric attenuation; wind velocity, temperature changes, rain and humidity are some of the environmental factors that turns the evaluation of an IR inspection in a difficult task.

2. Chamber components

In order to evaluate the extent of the influence of the aforementioned factors, an acclimatized chamber was developed to conduct tests in laboratory under controlled conditions.

The chamber was designed to accommodate the component under test and to carry the same loading and environmental conditions observed in actual operation. Temperature is measured through both contact sensor and thermal-camera for comparison purposes. All the information is recorded using a data acquisition system and is ready for use in the analysis. Figure 2 shows a sketch and the main components of the developed chamber as described as follows.
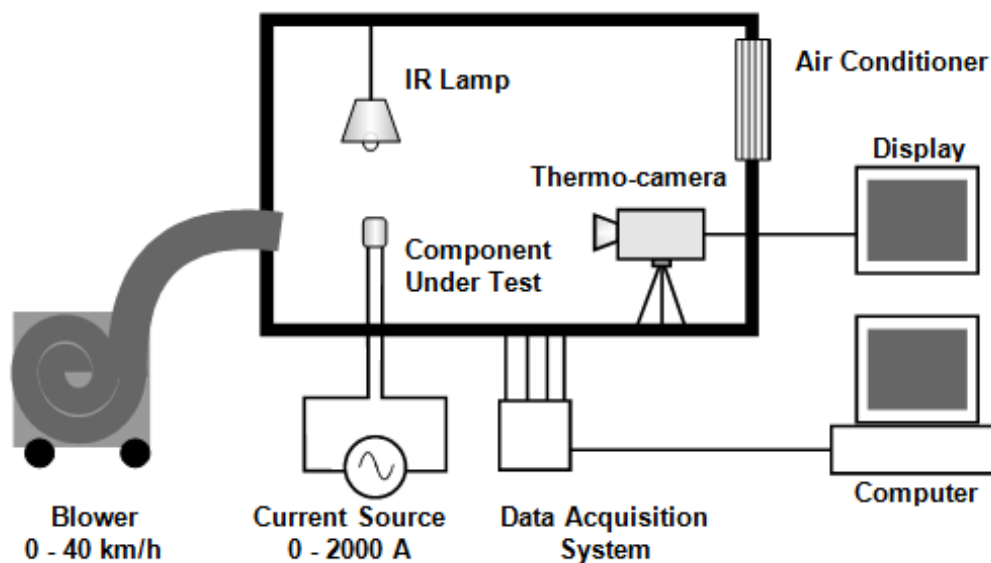

Fig. 2. *Sketch of the developed acclimatized chamber*

2.1. Air conditioning

In order to proceed with the ambient temperature simulations, an air conditioner device was installed. An electronic circuit was developed to provide the interface to the computer control system. The circuitry is based on transistors and relays with controlled by signals originated from the supervisory system. The control circuits are connected where the origininally selection key was used as a thermostat, as show in fig. 3. Therefore two circuits were installed, on for the heating function and other for the cooling function. The control system actuates at this cirtuit until the desired temperature is reached.

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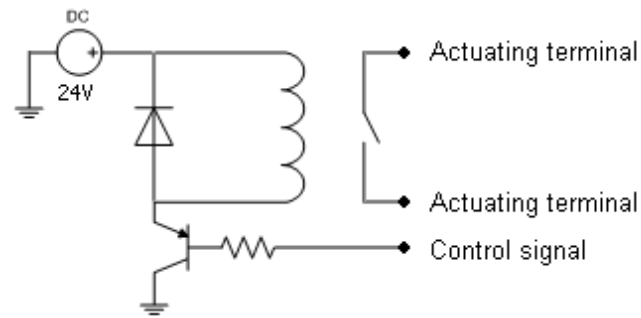
Fig. 3. *Air conditionned interface circuit*

2.2. Wind simulation

A centrifugal fan was used to simulate the wind. The wind speed is controlled by acting in the blower variable speed driven motor. The employed VSD has a reference voltage input ranging from 0 to 10V, which is related to the motor speed from zero to the rated speed. An analog output of the data acquisition system is used to produce the reference voltage. A hot-wire anemometer closes the loop control. Figure 4 depicts the blower (a) and the variable speed control (c).

(a)   (b)

Fig. 4. *Devices used for the wind simulation*

2.3. Other quantities simulation

The solar radiation is simulated using a dimmerized infrared bulb. The dimmer is also controled by the system using an analog output of the data acquisition system. Moisture is also simulated with the use of an ordinary hummidifier. Sensors of temperature, wind speed, and humidity are used to close the control loop. Figure 5 shows the employed wind speed sensor (a) and the humidity sensor (b).

(a)   (b)

Fig. 5. *Some of the employed sensors*

2.4. Control system

It was decided to use an of the shelf plataform (LabView®) to implement the computer based control system. A data acquisition box with both analog and digital inputs and outputs, integrated with data acquisition software, was employed in the developed chamber. The software was carefully configured to read the inputs and proceed with the outputs in order to control the chamber environment and establish a desired ambient condition. While acting on the control elements, readings of the sensors were used to close the loop control. Figures 6 and 7 depict wind speed and ambient temperature schedules.
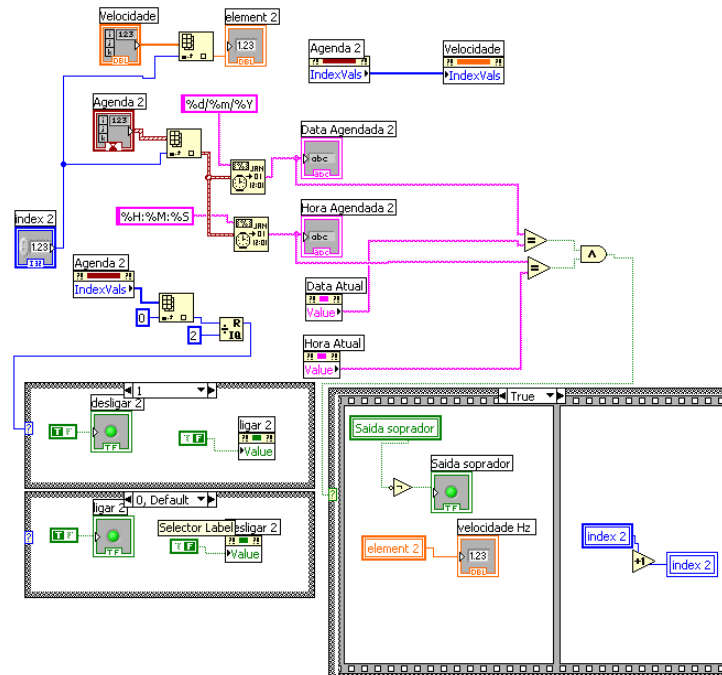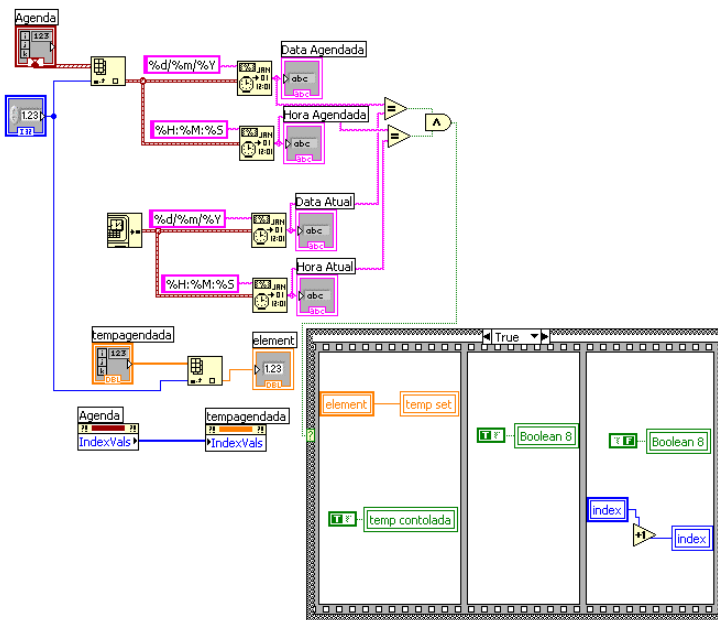

Fig. 6. *Wind speed schedule*

Fig. 7. *Ambient temperature schedule*

## 2.4. Chamber final appearance

The final aspect of the chamber is depicted in Fig. 8. With that is possible to simulate differente operating envirionmental conditions, allowoing for developing mathmatical models to understand the influence of ambient variables of influence.
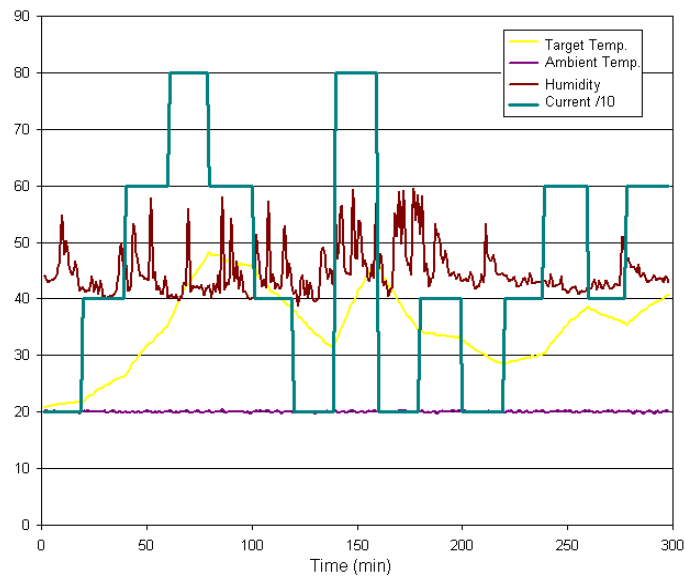

Fig. 8. *Developed acclimatized chamber*

3. Some simulations results

The front page of the control software is presented in Fig. 9. On that page is possible to control manualy (setting up the dials) or automatically (defining reference values) all the devices related to the acclimatized chamber. In addition, some graphic information on the variables is presented.
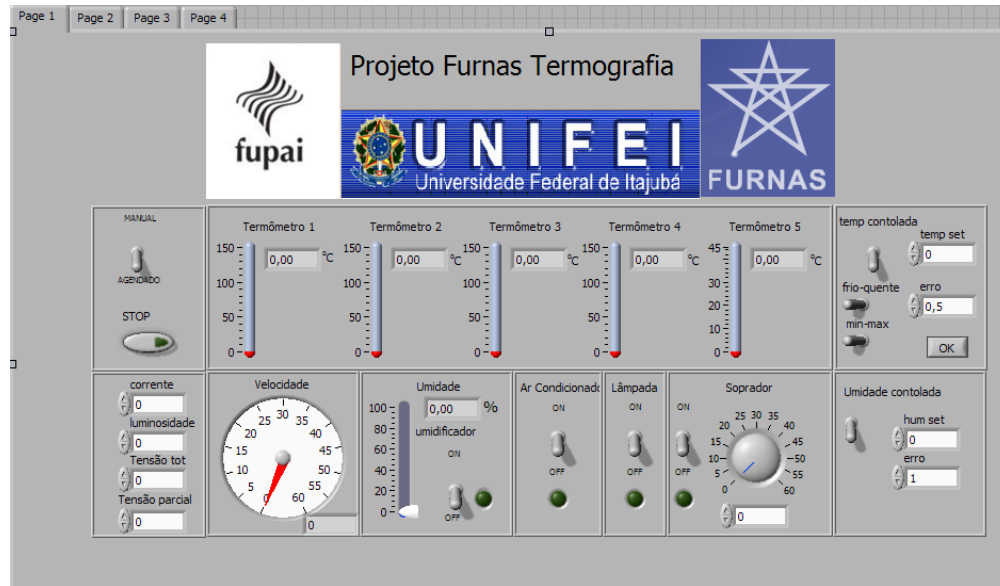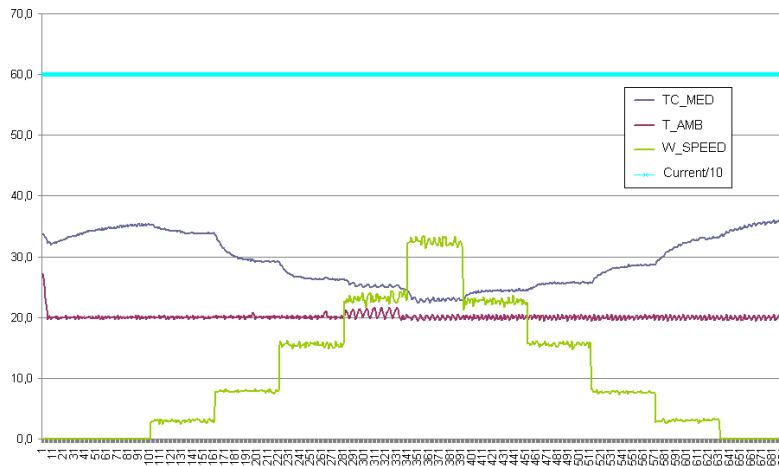

Fig. 9. *Developed acclimatized chamber*

Figure 10 presents the results of a test where the driving current was scheduled to increase 200 Amps in steps of 20 minutes. In that picture, the target (a connector) temperature, ambient temperature, humidity, and current are depicted.
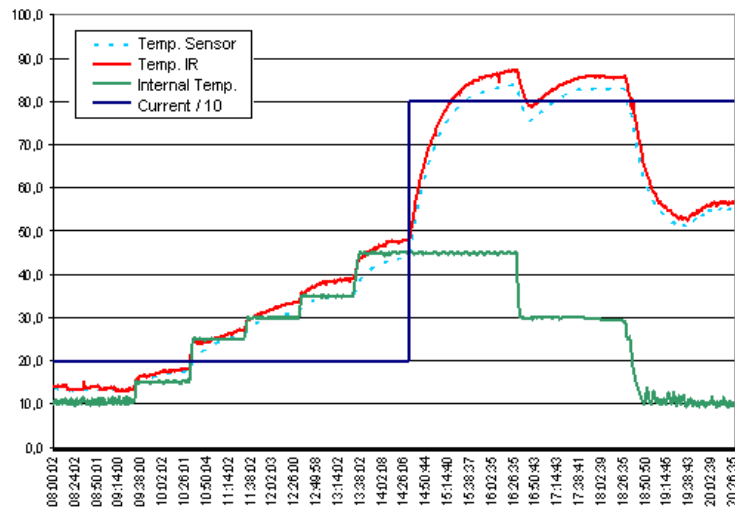

Fig. 10. *Developed acclimatized chamber*

Figure 11 and 12 presents two different simulations. The first demonstrates the influence of the wind speed over the target temperature. In that simulation the wind speed was scheduled to vary 2 km/h in steps of 1 hour, being the target heated at a constant current of 600 (A). Ambient temperature was set do stay constant at 20 (°C).

Fig. 11. *Developed acclimatized chamber*

It can be observed the variation of the temperature with the wind speed. Of course, a time constant should be accounted for. A different simulation is depicted in Fig. 12 where the ambiente temperature over the target temperature is analysed. In this case the humidity is kept in the 40-60% range, the current is established at 600 (A), and solar radiation and wind speed were set at zero. Ambient temperature was scheduled to vary 15 (°C) in steps of 2 hours. After some time, the current is elevated to a much higher value and the ambient temperature is changed to a lower level.

Fig. 12. *Developed acclimatized chamber*

This kind of test is interesting to understand the dynamics of the target temperature as a function of the ambient temperature.

CONCLUSIONS

There is a strong need on the development of analysis tools regarding in field thermographic surveys. The development of an acclimatized chamber described in this paper tries to contribute in such direction. It was shown how important data can be obtained by applying specific tests, allowing for the development of mathmatical models to better understand and correct the influence of ambient temperature over data obtained through thermographic surveys.

ACKNOWLEDGMENT

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