EVALUATION OF STEADY-STATE OPERATION OF ENVIRONMENTAL CLIMATIC CHAMBER MEASURING TEMPERATURE AND RELATIVE HUMIDITY

Iska Kolaveri Spahiu[548]
Dhurata Premti[549]
Floran Vila[550]
Anisa Dhroso[551]

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Abstract: *This study reports measurements conducted with a climatic chamber as a technical device that enables the selection, at a closed volume, of specific temperature and humidity values in the air. The main scope was to study the stability, in order to have an efficient chamber that could reach a steady state during operation, in high accuracy.*

Key words: *Experimental chamber, temperature, relative humidity.*

1. INTRODUCTION

The calibration of a climatic chamber is very important to determine the deviation of the climatologically characteristics of the air temperature and relative humidity in specific parts of chamber volume that are selected for use. Climate chamber that we used for our measurements is model DY110 - 62672. Other aspects such as the inhomogeneity of the internal environment and a steady state through measurements are often necessary to characterize the climatic environment, as well as the possible effects of the test material placed on it. We investigate the most suitable spatial position to place our temperature sensor or relative humidity sensor (about 5 cm from each direction). Temperature uniformity is related to the total thermal load and the amount of circulating air inside the chamber. During the investigation we focus also on identifying quantitatively and qualitatively the parameters contributing to the transient situation.

2. GENERAL DISCRIPTION OF CLIMATIC CHAMBER

Climatic chamber is a technical device allowing selectively specified air temperature and/or relative humidity values to be realized in a closed volume in a working space. The chamber structure is made up of carbon steel sections and panels protected by painting with powdered polyester resin especially chosen for its excellent resistance to abrasion and atmospheric agents. The calibration of a climatic chamber serves to determine the deviation of the climatological characteristics of air temperature and relative humidity in those parts of the chamber volume which are provided for use or in individual points of the chamber volume from the values displayed by the indicators of the chamber. The calibration result is valid only for the volume spanned by the measuring points.

[548] General Directorate of Metrology of Albania, Autostrada Tr-Dr, km8, Kashar, Tirane, Albania
[549] University of Tirana, Faculty of Natural Sciences, Bulevardi Zog I, Tirane, Albania
[550] Academy of Sciences of Albania, Shëtitorja Murat Toptani, Tiranë, Albania
[551] University of Tirana, Faculty of Natural Sciences, Bulevardi Zog I, Tirane, Albania

3. THE CHARACTERISTICS OF THE CLIMATIC CHAMBER

The volume of the chamber is 112 liter, with useful internal dimensions (54.8x46x44.7cm). The range of humidity 10% to 98% and the range of temperature: -40°C to 180°C. During the increasing temperature process, the maximum variation speed is approximately 3°C/min .

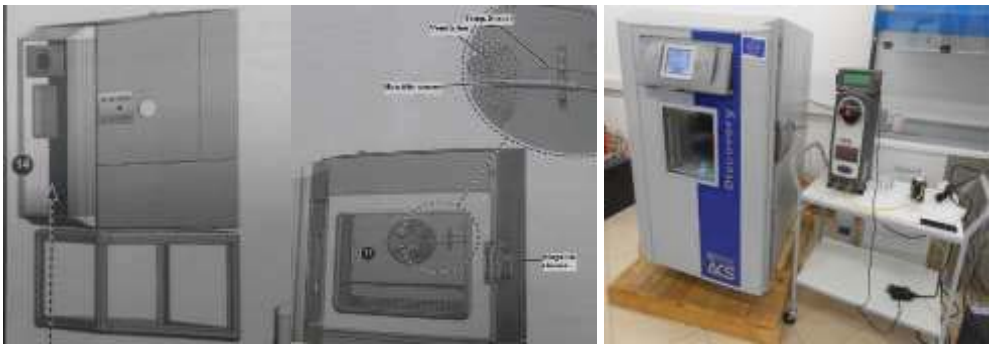

Figure 1. The design of the climatic chamber and the sensor placed inside it.

4. OBSERVATIONS DURING THE MEASUREMENTS

During this study are used some reference sensors. The measurements are made in different days, in accordance with chamber characteristics. During the measurements was noticed the deviations of air temperature and the humidity inside the chamber, as a result of inhomogeneity system. Technical means (thermal insulation, air circulation, radiation shields, etc.) are used to minimize the temporal and spatial inhomogeneity of air temperature and air humidity as well as the deviations of the air temperatures and humidities prevailing in the useful volume from the nominal values.

Iska Kolaveri Spahiu

Graduated in 2009 from the University of Natural Sciences of Tirana, Albania, in Physics, Master degree in Physics.
Since 2011 works in General Directorate of Metrology of Albania, in Temperature and Humidity fields. From January 2017 to September 2017 was researcher in Gestworking place Czech Metrology Institute, Prague, Czech Republic, part of EMPIR project no. "15RPT03, Expansion of European research capabilities in Humidity measurements (HUMEA)"

The lack of homogeneity or in-homogeneity, Stability of the chamber during 30 min, are necessary to characterize the climatic chamber, as well as the possible effects of the test material placed on it. A measuring location is the spatial position (i.e. approx. 5 cm max. in each dimension). Other measurements are done in only one center position.

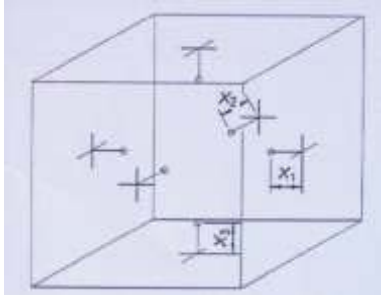

Figure 2. An example for the locations of Temperature sensors inside the chamber

5. MODELING AND SIMULATION OF WALL TEMPERATURE BASED ON HEAT TRANSFER CALCULATION

The wall temperature is a state variable that only changes when there is a heat flow in or out of the wall. The heat flows are only possible by conduction and the heat flow on the input side is modeled as:

$$Q_i = \alpha_i S_{murit} (T_{in.} - T_{murit}) \quad (1)$$

$$S_{murit} = L \cdot H \quad (2)$$

Where:
-wall width L, height H and thickness d
-insulation thickness on input side $d_{ins,i}$ *and output side* $d_{ins,o}$
-thermal conductivity of wall material K *and insulation material* K_{ins}
-heat transfer coefficient α
-volumetric specific heat capacity of wall material c_V *and insulation* $c_{V,ins}$
Also Some other formulas are used, in base simulation program: POLYMATH[3]

In this study, are done measurements in different points of Relative Humidity, but on this paper is presented only for one point, medium point of RH%.

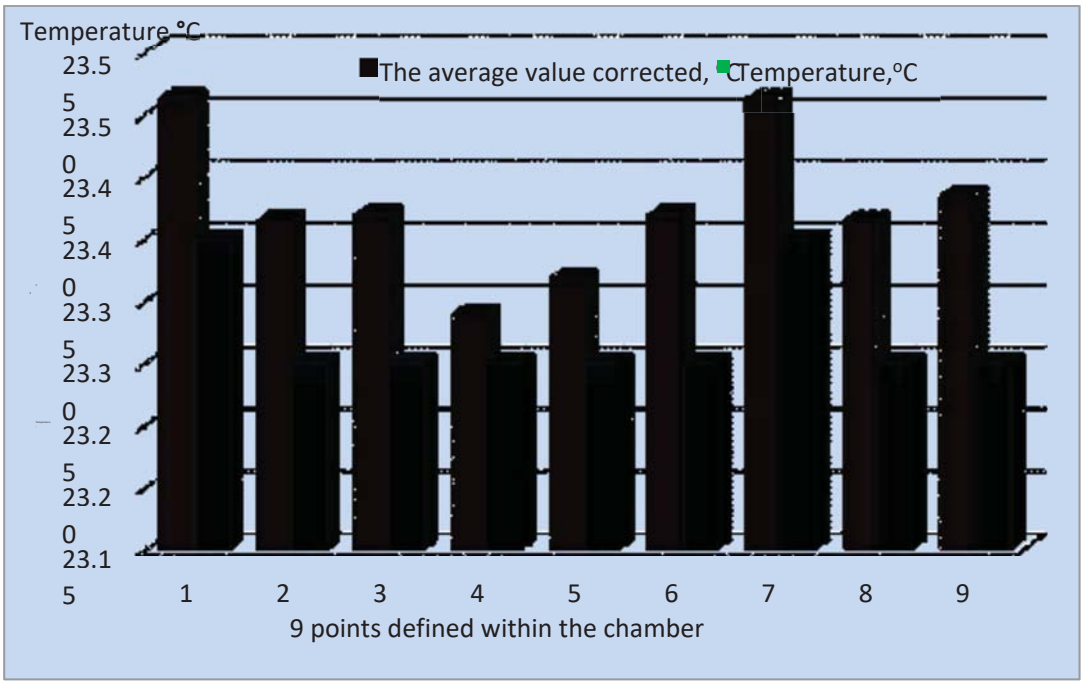

Figure 3. The difference of corrected average of temperature values in the specified volume of the climatic chamber at 50% relative humidity.

Dhurata Premti
Part the staff working at University of Tirana, Department of Industrial Chemistry. The Department of Industrial Chemistry at the Faculty of Natural Sciences, University of Tirana, is the only Department of all other public and private Universities departments that specializes in teaching and research in the field of organic, inorganic, engineering, chemical technology chemical, food technology and microbiology.

6. CALCULATION OF THE UNCERTAINTY

In 50% of relative humidity, are performed the calculations of the some components that are added in the uncertainty budget for temperature, as shown in the table below.

Quantity	Description	Distribution	Uncertainty
$\delta T_{inhomogenity}$	Correction of inhomogeneity	rectangular	495 mK
$\delta T_{instability}$	Correction of instability	rectangular	356 mK
$\delta T_{radiation}$	Correction of radiation effect	rectangular	584 mK
δT_{load}	Correction of loading effect	rectangular	98 mK

In 50% of relative humidity, are performed the calculations of the some components that are added in the uncertainty budget for humidity, as shown in the table below.

Quantity	Description	Distribution	Uncertainty
$\delta h_{inhomogenity}$	Correction of inhomogeneity for rh%	rectangular	1.9 %
$\delta h_{instability}$	Correction of instability for rh%	rectangular	1.4 %
δh_{load}	Correction of loading effect for rh%	rectangular	0.45 %

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[1] EURAMET Calibration Guide *cg-20, Version 02 (11/2010), Calibration of climatic chamber.*

[2] DKD-R 5-7: *Calibration of Climatic Chambers (2004)*

[3] Base simulation program: POLYMATH http://www.learncheme.com/student-resources/polymath

[4] EURAMET Calibration Guide *no 20, Version 5.0 (09/2017), Guidelines on the Calibration of Temperature and/or Humidity Controlled Enclosures.*

[5] IEC 60068 series on environmental testing, in particular: IEC 60068-3-6 – Environmental Testing – Part 3-6: (2001) BS EN 60068 -3-6(2002), *Confirmation of the Performance of Temperature/Humidity Chambers.*

Floran Vila
Decorations and Awards:
Order Naim Frashëri, Kl. III, (Presidium of the People's Assembly of RPSSH, Tirana, Albania, 1979)
Honor Award, (Balkan Physical Union, BPU 9, Istanbul, Turkey, 2015)
Professional experience from 1964
1994 – ongoing: Professor, Department of Physics, FSHN, UT
2008 – ongoing: Academician, Academy of Sciences of Albania

***Anisa Dhroso** is a lecturer at the Department of Industrial Chemistry, Faculty of Natural Sciences, University of Tirana since 2007. She graduated from this Department in 2006. In 2009 she completed her postgraduate studies in Food Engineering. In 2015 she received the Doctor of Science degree, in the direction of Technology and Food Microbiology, Food Safety Assessment and Quality. She has participated in a number of academic activities at national and international level.*