Climate chamber for a high temperature stability

Kühnel, Michael; Hilbrunner Falko; Fröhlich Thomas;
Ilmenau University of Technology (TU Ilmenau); Faculty of Mechanical Engineering
Institute of Process Measurement and Sensor Technology
PO Box 100565
98684 Ilmenau/ Germany

1. Introduction

A fair amount of measuring and testing tasks require stable environmental parameter such as temperature and relative humidity. A large number of different types of climate testing chambers are available for these applications. These devices based on the state of the art control the temperature and the humidity in the test volume by an influx of air reaching a temperature stability of $\Delta T_{time} \geq \pm 0.1$ K [1,2]. There are even more stringent requirements on the temperature stability in the field of research and development e.g. high precision force, weighing or interferential length measurement technology ($\Delta T_{time} \leq \pm 0.1$ K). At the same time additional requirements for static air and absence of vibration in the test volume do exist. Due to the technical principle described above devices based on the state of the art can not meet these demands.

2. Concept and Innovation

In contrast to the state of the art the panel temperature of the presented climate chamber is controlled. Thereto a fluid is passing through these panels. The temperature of the fluid is controlled by an external cryostat which is connected to the chamber using insulated flexible tubes. Due to this concept, the chamber and the cryostat can be placed spatially divided in different rooms. Hence there are no motors and pumps in the vicinity of the chamber. This allows a decoupling of the chamber from disturbances such as vibrations and electromagnetic fields. An exchange of the inner air is not possible when the chamber is sealed. Except some eventual free convection there is static air in the chamber. Compared to the state of the art a clear improvement of the temperature stability in the chamber is achieved by the following additional measures: The inner chamber is made of thick aluminium panels. Consequently, a high heat capacity, a high thermal inertia and a very good thermal conductivity of the inner chamber is achieved at the same time. Furthermore the chamber is insulated against the enviroment and covered by a cladding. The applied cryostat FP50-HL controls the fluid temperature with a maximum deviation of $\Delta T_{fluid} = \pm 0.01$ K [3]. A certain and constant rel. humidity inside the chamber can be set by the use of appropriate preconditioned silica gel inside the chamber.

3. Technical realisation

The principle of the climate chamber is shown in Fig.1. The base panel is made of 30 mm thick, the other panels of 15 mm thick aluminium plates. The aluminium panels are welded and thus sealed. Stainless steel coils with a rectangular cross section are pressed on to all except the base panel. The fluid in- and outlet is placed on the backside of the chamber as well as 6 sealed cable glands. Finally the whole chamber is covered by a 30 mm thick insulation layer and a cladding made from aluminium sheets. The chamber is divided diagonally into an lower and an upper section, see Fig. 2. The upper movable part can be tilted up. This ensures a very good access into the chamber and thus to the measurement setups inside, see Fig. 3. The gas springs facilitate opening and closing. A rubber seal is fixed to the upper part to ensure a propper sealing of the chamber. All parts such as gas springs or mounting feet are not attached directly to the chamber but with a plastic interlayer in between. Thus the inner chamber is insulated against temperature changes of these outer parts. The concept of the climate chamber was created at the Institute of Process Measurement and Sensor Technology (IPMS) at the TU Ilmenau, the construction and manufacturing was made by the Lieberherr AG [4] in close consultation with the IPMS.

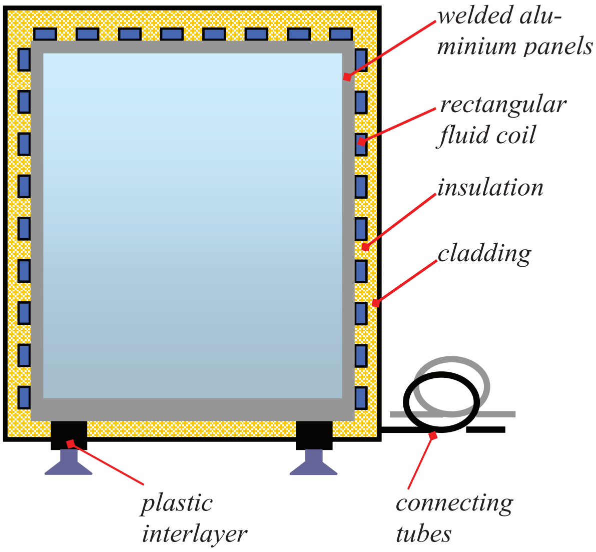

Fig. 1: cross sectional view of Climate Chamber

Fig. 3: opened climate chamber containing a measurement setup

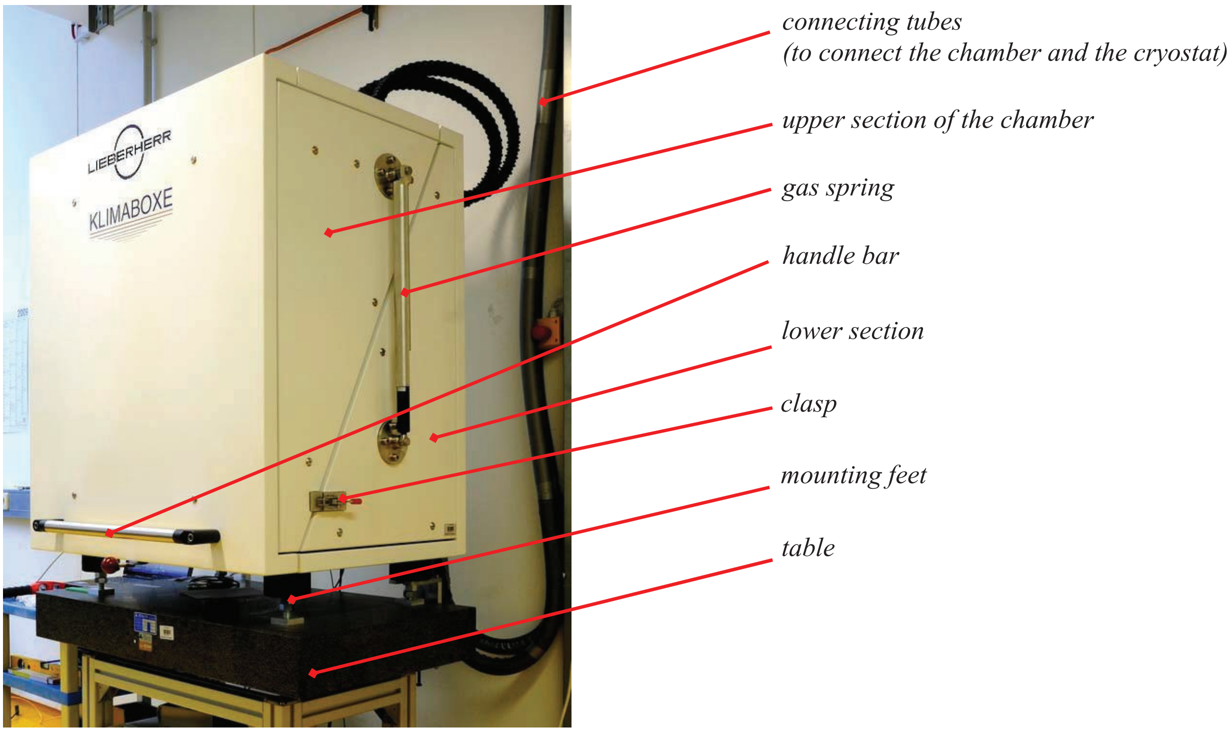

Fig. 2: climate chamber with additional transport frame

4. Results

To determine the temperature stability (ΔT_{time}) and distribution ($\Delta T_{spatial}$) in the inner chamber eight Pt_{1000}- thermometer were fixed in the centre of each of the 8 panels (one on each panel). Furthermore a Pt_{100}-thermometer was installed in the centre of the box to measure the air temperature. Before that the 8 Pt 1000 thermometer were calibrated on a common plate. The maximum temperature deviations among those 8 Pt_{1000} were determined to be $\Delta T_{Pt1\text{-}8} < 0.01$ K. The measurements of the chamber performance were carried out in a range of $10°C < T_{Chamber} < 40°C$. During all investigations the temperature of the lab in which the chamber is placed was controlled ($T_{Lab} = 23 \pm 1°C$). The cryostat is placed in a non air conditioned room besides the lab and is connected to the chamber using two 5 m long insulated tubes. In the given range the maximum temperature gradient in the chamber was measured to be $\Delta T_{spatial} = \pm 1K$. Leaving the base panel out of consideration the gradient is only $\Delta T_{spatial} < \pm 0.3K$. This is due to the absence of fluid coils on the base panel. The stability of the temperature within 7 days was measured at $T_{chamber} = 20°C$. At the mentioned boundary conditions the temperature stability of all 9 measurement points is $\Delta T_{time} < 0.01K$, see Fig. 4 for the temperature of the rear panel and the air in the centre of the chamber. Both the low and the high frequency disturbances are correlated with the temperature of the lab. The heating and the cooling rate of the chamber were measured to be 0.25 K/min respectively 0.18 K/min [5]. The determined values are compared to two commercially available chambers, see Tab. 1.

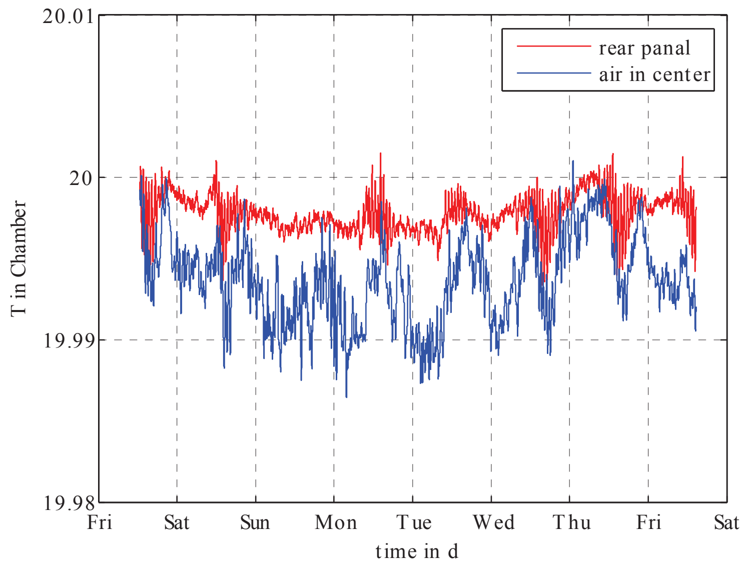

Fig. 4: long term stability of the temperature of the rear panel (red) and the air in the centre (blue)

	Weiss [1] **WK 111- 600**	**Feutron** [2] **600**	**TU Ilmenau** **Lieberherr AG**
Dimensions **h** x **w** x **d** in mm	950x800x800	860x720x620	900x780x560
$\mathbf{T_{chamber}}$ in K	-5..+90	-75/-40/+5 .. +100/+180	-50..+200* [3] +10 ..+40**
$\mathbf{\Delta T_{time}}$ in K	±0.1 .. ±0.3	±0.2 .. ±0.5	< ±0.01
$\mathbf{\Delta T_{spatial}}$ in K	±0.5 .. ±1	-	±0.3 .. ±1
Heating rate in K/min	0.5***	3	> 0.25***
Cooling rate in K/min	0.2***	3	> 0.18***
humidity control	yes	yes	static

Tab. 1: comparison to commercial products, *theoretical attainable, **tested, ***as per IEC 60068-3-5 [5]

5. Conclusions

Compared to devices based on the state of the art the temperature stability of the presented climate chamber is ten times better. Despite non circulating air the spatial temperature gradient is roughly on the same level. The gradient as well as the heating and the cooling rate could be further improved by applying fluid coils on the base panel as well. A key advantage of the chamber arises due to the spatially divided arrangement of the climate chamber and the cryostat. Due to the absence of motors, magnetic valves or any other electromechanical parts the chamber is decoupled from disturbances such as vibrations and electromagnetic fields.

6. Literature

[1] www.wut.com; Weiss Umwelttechnik GmbH

[2] www.feutron.de; Feutron Klimasimulation GmbH

[3] www.julabo.de; Labortechnik GmbH

[4] www.lieberherr.com; Lieberherr AG, Swiss

[5] IEC 60068-3-5; Confirmation of the performance of temperature chambers