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Preliminary study of PTC use for human body heating dissipation mannequin*

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Abstract. *An important field of research for improving the efficiency of the Heating, Ventilation and Air Conditioning (HVAC) systems and for reducing the number of deaths occurred during the surgical procedures of the patients under effect of full anesthesy is the study of the human body heat loses mechanisms. A useful way to perform these studies is to manufacture a human body manikin which has maintained constant its surface temperature on a value close to real human body temperature. For heating the surface of the manikin can be used PTC (Positive Temperature Coefficient) thermistors mounted on the entire surface of the manikin. In this paper are presented preliminary results of the study performed on these devices, of the transient heating regime and the temperature stability.*

Key words: *PTC, thermistors, thermal mannequin, temperature stability*

1. Introduction

An important issue of the air conditioning systems is to ensure the indoor ambient quality for the best comfort of the users of these systems. Unfortunately there are two demands which are opposite: one is to comply with new air quality standards and the other is to save the energy. The main problem is to satisfy both of these by trying to optimise the systems which at the moment it seems they are not optimised enough. One of the main problems is the cooling of the rooms in hot season when the cold air supplied by the system is tumbling due to the gravitational forces causing the “cold”, “draft” and sore throat sensations to the people. This problem is caused by the poor quality of cooling and warm air mixture quality. On the other hand, the energy consumption seems to rise in the past decade mainly due to the hotter summers. A solution to these issues it seems to work on the optimisation of the design for the air recirculation terminal devices related to the ambient air.

It is seems that taking into account the convection air currents generated by the surrounding heat sources as human body will change dramatically the air flows

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configuration [1]. Unfortunately at the moment are considered the configuration of the air flows generated only by recirculation devices.

An important issue is to study the distribution of the air speed which is influenced by the heat sources, mainly the position of the peak values of the air speed [1]. Human body being an important heat source, has been developed a series of its models having various complexity used on the CFD type studies [2-4].

The thermal perception of the internal environment can be influenced by some specific parameters such as shape, size, metabolism, dressing level or physical activity [5].

Using a thermal mannequin for simulating the human body thermal behaviour [6-8] is a good solutions for validating experimentally the numerical models because the experiments involving human subjects are expensive, time consuming and difficult to be validated.

Has been developed a series of five low cost thermal mannequins prototypes made by Universitatea Tehnica de Construcții Bucuresti [10-13] team in the EQUATOR[9] project frame and we want to carry on further optimisations of better future prototypes. The main requirement for these mannequins is to have the real shape and size of an adult person, having its surface split in distinct areas, [7] each of them being maintained at a slightly different temperature from each other but close to the human body temperature [14].

A method for heating the surface of the mannequin is to mount Positive Temperature Coefficient (PTC) thermistors on the surface.

These thermistors have a self regulation temperature feature embedded which allow to maintain the mannequin surface on a controlled constant temperature. In this paper is presented a series of preliminary results of a study for evaluating the use of PTC for making thermal mannequins.

2. Experimental system setup

The block diagram for the experimental system made for testing the temperature stability and for measuring the consumed power is shown in the Figure 1. Each PTC thermistor which has been tested has been mounted on a square shape aluminium plate.

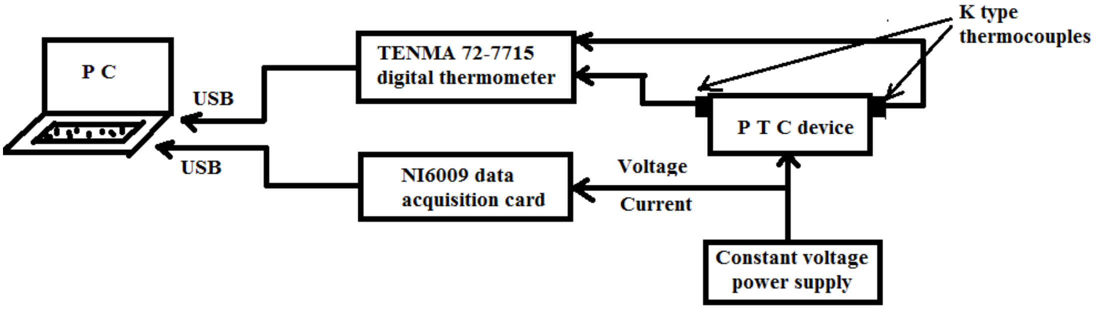

Figure 1. Block diagram of the measurement system

The power supply TENMA 72-10500, 30V/3A is applying a constant voltage to the PTC thermistor and to the first analogue input channel of the National Instruments NI6009 data acquisition card for measuring its value. The current intensity value which is flowing from the power supply thru PTC thermistor is measured using the second analogue channel of the same data acquisition card. On the same aluminium plate where is mounted the PTC device are attached two K type thermocouples connected to the TENMA 72-7115 digital thermometer for monitoring the temperature. Both data acquisition card and the digital thermometer are connected to the PC thru USB ports for data transfer.

Have been tested a number of PTC thermistors, HP03 1/04, HP03-1/08, HP05-1/22, HP06-2/22, HP06-2/13 made by DBK Technitherm Ltd and A60 B59060A0040A010 made by EPCOS (Figure 3)[16]

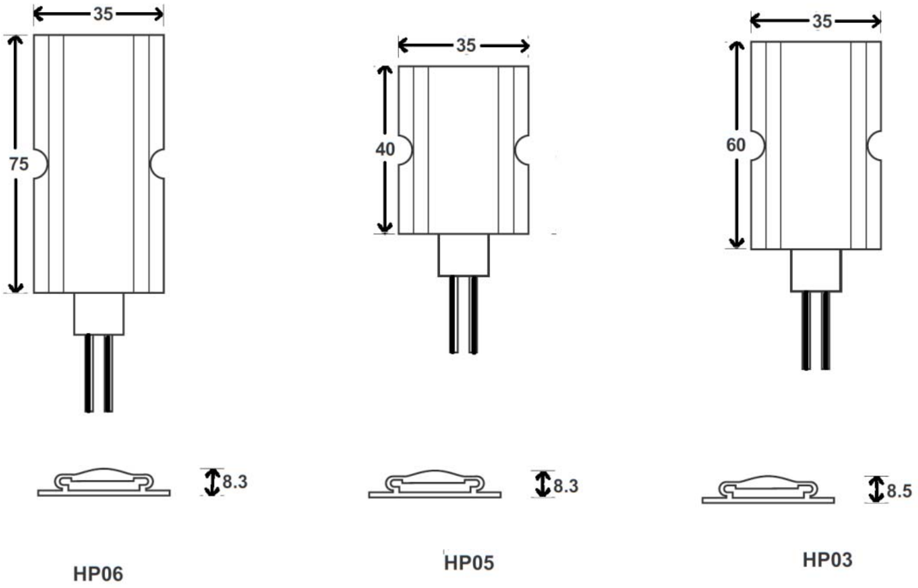

Figure 2. PTC dimensions produced by DBK Technitherm

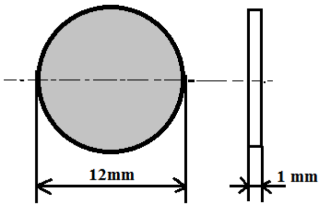

Figure 3. PTC dimensions of A60 B59060A0040A010 produced by EPCOS

Each of these thermistors have been mounted each on a 100 x 100mm square aluminium plate and 1.5mm thickness. The attaching mode of the HP03 – HP06 to the aluminium plate is shown in the Figure 4.

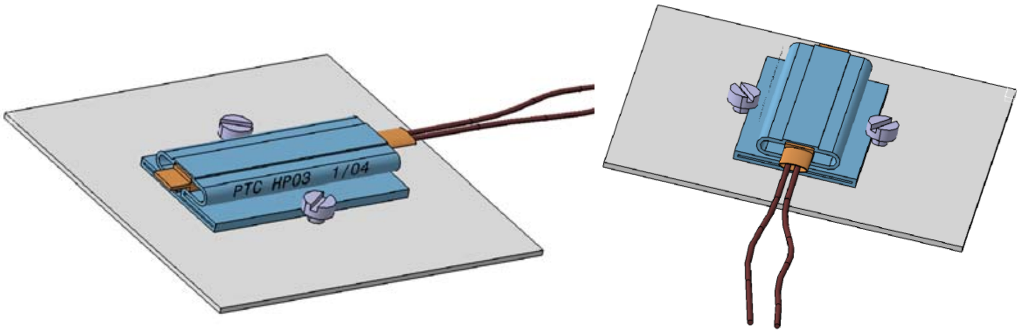

Figure 4. HP03 thermistor attached to the aluminium plate

For the purpose of monitoring the temperature, have been attached to the aluminium plate, two K type thermocouples which are connected to TENMA 72-7715 thermometer.

The A60 B59060A0040A010 PTC thermistor having a shape of a disk without any terminals as it appears in Figure 3, is requiring a system for attaching it to the aluminium plate and for electrical connections. This system is made by a smaller rectangular plate which is pressing the PTC against the aluminium plate using two screws (Figure 4).

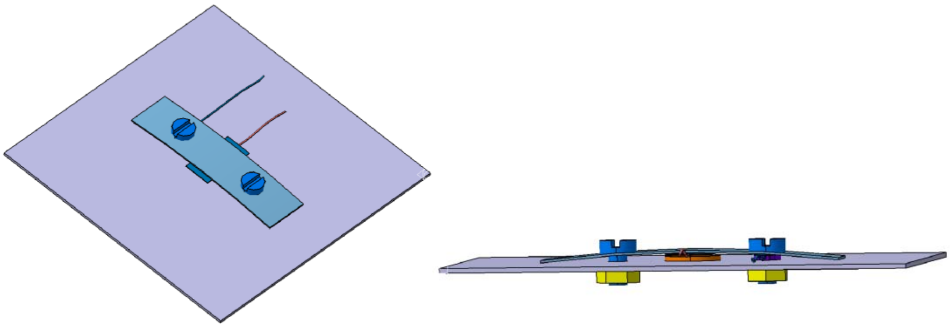

Figure 4. A60 B59060A0040 thermistor attachment system to the aluminium plate

The main element of the electrical circuit diagram of the PTC thermistors testing system is the NI 6009 data acquisition card which is measuring simultaneously the applied voltage and the electrical current which is flowing thru the PTC thermistor (Figure 5). In this way can be monitored continuously the consumed power of the device.

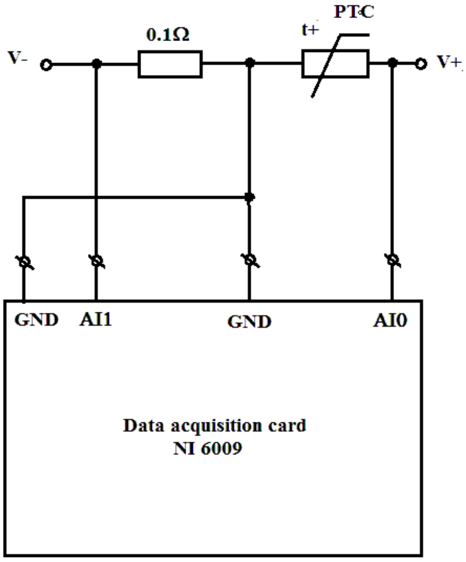

Figure 5. Circuit diagram for PTC testing

Applied voltage to the thermistor is measured by AI0 channel from the data acquisition card which is set in the range of 0 – 10V and the current intensity (I) is measured by using a 0.1Ω resistor connected in series with the PTC device. The dropping voltage on this resistor is offering the information about the electrical current intensity which is passing thru it. This voltage (U) is measured by AI1 channel of the data acquisition card and the measurement range is set in 0 – 1V range. Knowing the value of the resistor, the current intensity is calculated by:

$$I = U / 0.1 \tag{2.1}$$

Knowing the applied voltage and the current intensity can be easily calculated the power (P) consumed by the PTC thermistor:

$$P = U \cdot I \tag{2.2}$$

These calculations are done in a Labview code which is controlling system data acquisition and storage.

3. Experimental method

For studying the behaviour of each PTC device regarding temperature stability, has been applied a constant voltage during each test having the value in the range between 4.5 – 8.5V using 1V step. For each value of the voltage has been measured every second the current intensity and plate temperature variation in time for 30 minutes.

This time interval of 30 minutes has been chosen for allowing the system to reach thermal equilibrium.

The data acquisition rate of 1 measurement/second has been proved to be fast enough for sensing the fastest temperature and current intensity variation for the studied system.

For preventing any significant external perturbation from the environmental conditions such as air draughts, the system has been shielded and the ambient temperature has been maintained to 23^0C.

4. Results and discussions

After analysing all the experimental results has been selected those from two PTC thermistors: A60 B59060A0040A010 and HP03 1/04 which seems to have the best characteristics such as the temperature stability for this voltage range applied.

By applying a constant voltage to the PTC device will produce a flowing current thru it which will heat the device quickly at beginning producing a rapid temperature rise which will have as result dropping of the current intensity.

This current intensity variation for A60 B59060A0040A010 thermistor is shown in the figure 6 and for HP03 1/04 is presented in figure 7.

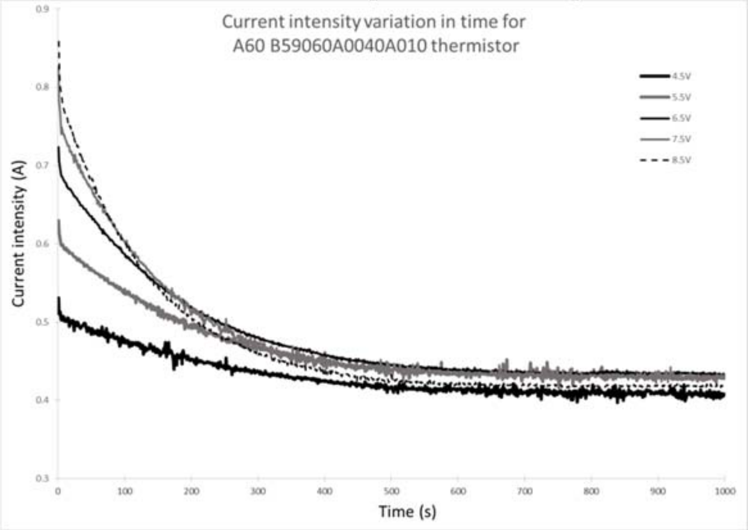

Figure 6. Current intensity variation for A60 B59060A0040A010 thermistor

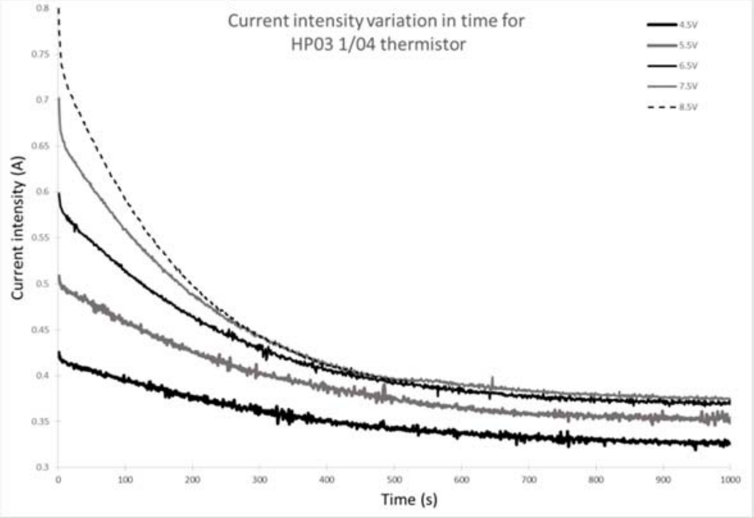

Figure 7. Current intensity variation for HP03 1/04 thermistor

The applied voltage being constant, the variation of the current intensity is caused by the variation of the resistance of the PTC device, which is rising quickly at the beginning and slower after.

The time variation of the resistance for A60 B59060A0040A010 thermistor is presented in the figure 8 and for HP03 1/04 in figure 9.

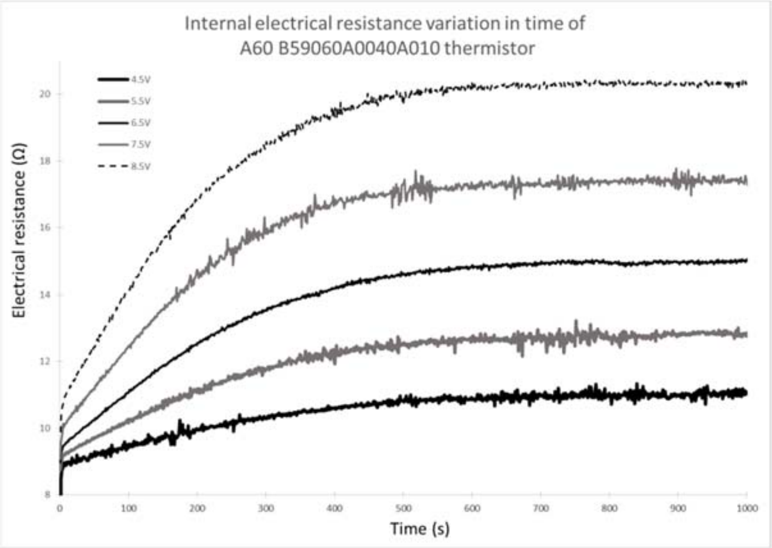

Figure 8. Variation of the internal electrical resistance of A60 B59060A0040A010 thermistor

For both thermistors, the internal electrical resistance is rising significantly in the first 5 minutes and then the rise slope is lowering in time becomes nearly constant after 15 minutes.

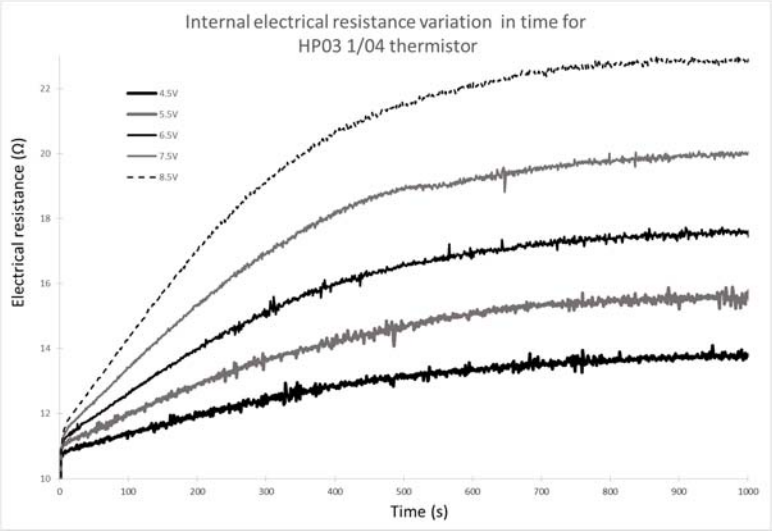

Figure 9. Variation of the electrical internal resistance of HP03 1/04 thermistor

The stability of the current intensity and of the electrical internal resistance after 15 minutes has as result a stability of the temperature which can been seen in the figures 10 and 11.

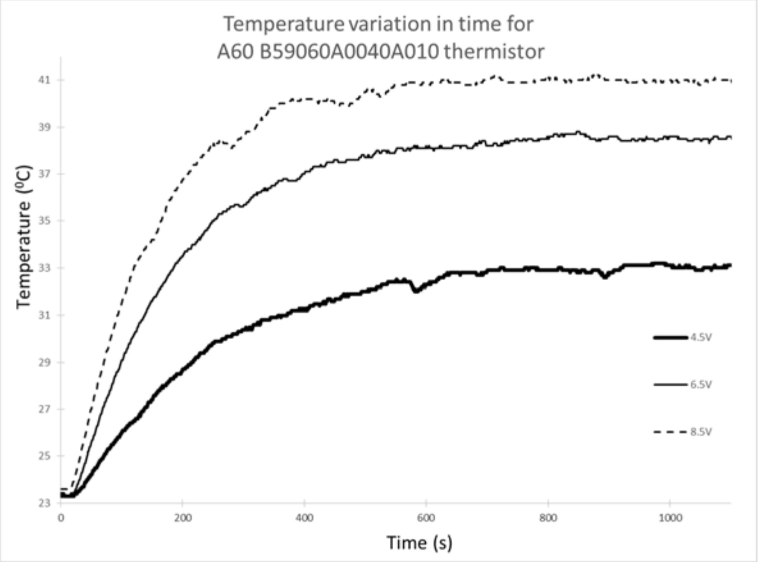

Figure 10. Temperature variation for A60 B59060A0040A010

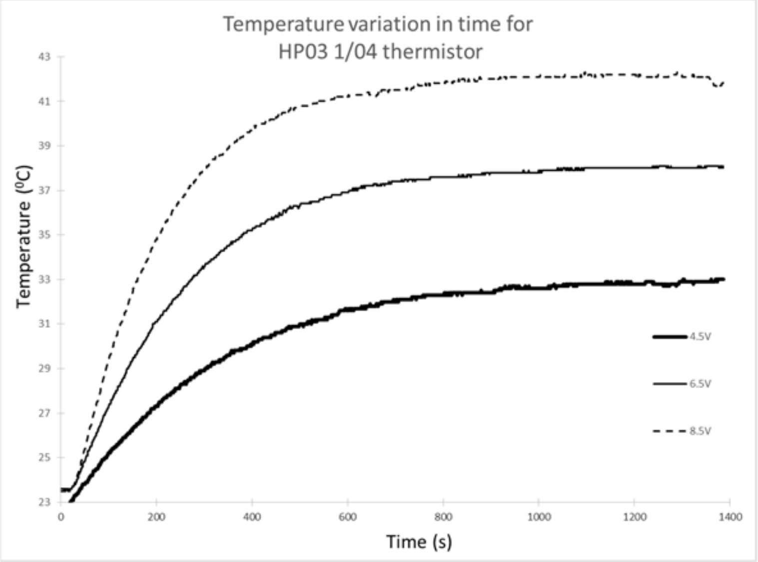

Figure 11. Temperature variation for HP03 1/04

All results shown above reveal a clear correlation between variations of the internal electrical resistance, current and temperature. Any change of temperature of the thermistor will have as results a change of its electrical resistance causing a variation of the intensity of current. For each characteristics, the power supply voltage has been maintained constant.

5. Future directions of development

One of the useful direction for improving using the PTC device as heating element for mannequin will be to try to reduce the relaxation time of the thermistor.

This is necessary to reach quicker the equilibrium temperature and to improve the temperature stability in time. This could be done by connecting this type of thermistor into a higher complexity circuit, where the applied voltage will be controlled by another devices during transient processes, maintaining it constant only during the thermal equilibrium.

6. Conclusions

The preliminary studies presented in this paper was performed for evaluation the use of the PTC devices for heating the thermal mannequin surface. The advantage of this devices is the low cost and simplicity of installing and using them. They require only to be mounted of the mannequin's surface and be supplied by a constant voltage power supply.

They present an intrinsic self regulating temperature feature when they are powered from a constant voltage power supply.

Their current temperature stability added with the possibility of improving it by connecting them in a higher performance circuits recommend the PTC thermistors as an excellent component for maintaining constant temperature of the external surface of the thermal mannequins.

Acknowledgements

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