Non-Stationary Heat Conduction through Transparent Thermal Insulators

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Abstract **- This document refers to the non-stationary heat conduction through transparent thermal insulators. Non-stationary heat transfer means that temperature varies in time, in all points of the thermal field. Temporal and spatial distributions of the temperature inside of the sample are experimentally determined.**

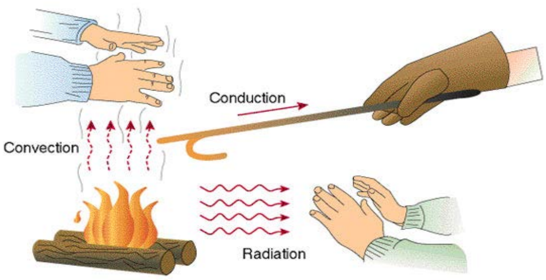
Keywords **- Transparent thermal insulators, non-stationary heat conduction, thermal field, coefficient of heat transfer over, coefficient of heat transfer through, coefficient of heat conduction**

Introduction

Each change of the body`s inner energy is called heat quantity. Energy transferred from/to a body is named heat quantity as well. This quantity is measured as temperature change. Heat is always transferred from the body which has higher temperature to the body with lower temperature, according to the second lawof thermodynamics.

There are three possibilities how the heat can be transferred, **picture 1**:

- conduction
- convection
- radiation



Picture 1. Heat transfer by conduction, convection and radiation [10]

1. Thermal field

Thermal field is a set of the temperatures in the specific points of interest at the specific time point:

$$t = f(x, y, z, \tau) \quad \text{................................ (1.1)}$$

Thermal field is non-stationary if the temperature changes itself during the observed time interval (equation 1.1). Field is called as stationary if the temperature does not change during the observed period (equation 1.2).

$$t = f(x, y, z) \quad \text{.................................. (1.2)}$$

Surface which is made of the points of interest which have exactly same temperature is called isothermal surface. Isothermal surfaces are equidistant, if the temperature difference between them is represented with constant value. Intersection of the isothermal surface and some plane is represented by isothermal line, which is shortly known as isotherm. Intersection of flat surface with the equidistant isothermal surfaces represents one whole family of the equidistantisotherms. Temperature distribution in space is given by (1.3):

$$\operatorname{grad} t = \frac{\partial t}{\partial x}\vec{i} + \frac{\partial t}{\partial y}\vec{j} + \frac{\partial t}{\partial z}\vec{k} = \nabla t \quad \text{....(1.4)}$$

$$\operatorname{grad} t = \vec{n} \cdot \frac{\partial t}{\partial n} \quad \text{............................(1.3)}$$

$$\nabla = \operatorname{grad} = \frac{\partial}{\partial x}\vec{i} + \frac{\partial}{\partial y}\vec{j} + \frac{\partial}{\partial z}\vec{k} \quad \text{...........(1.5)}$$

$\vec{n}$ is unit vector of the perpendicular line to the

isothermal plane.

$(\vec{i}, \vec{j}, \vec{k})$ are unit vectors of the Cartesian coordinate system. [1]

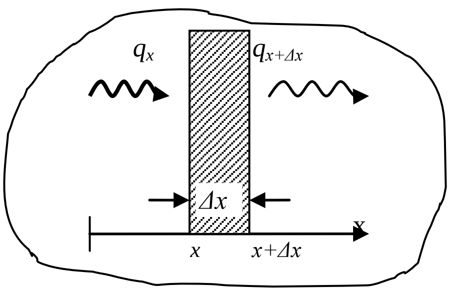
2. Heat transfer by conduction

In order to calculate thermal flux of the heat transferred by conduction, it is practical to use Fourier's law:

$$dQ = -\lambda \frac{dt}{dx} dS d\tau \qquad \text{.........................(2.1) [4]}$$

This law is very practical if we think about the heat transfer in one-dimensional direction. Fourier's law is applicable to the heat transfer,which is perpendicular to the plan parallel surface, as well as to the heat transfer through cylindrical and spherical bodies, but only if the heat transfer is radial and does not depend on azimuth and axial coordinates. [2], [7], [6].

Let'sobserve thermal balance through thin layer, which is *Δx*thick according to the *x*–axison **picture 2.**



Picture 2. One dimensional heat transfer by conduction [1]

From the left side in thin layer, heat is transferred by conduction according to equation:

$$-\lambda S \frac{\partial t}{\partial x}|_x \qquad \text{...(2.2)}$$

On the right side of the layer, heat goes out as well by conduction according to the:

$$-\lambda S \frac{\partial t}{\partial x}|_{x+\Delta x} = -S(\lambda \frac{\partial t}{\partial x} + \frac{\partial}{\partial x}\left(\lambda \frac{\partial t}{\partial x}\right)dx) \qquad \text{........(2.3)}$$

In the layer which is *Δx* thick, it is possible that some extra heat is generated because of physical and chemical processes.

Generated heat is represented by:

$$q_V S dx \qquad \text{................................ (2.4)}$$

q_V - generated heat according to the volume in time units, q_V (W/m^3)
S -surface of the layer

In thin layer which is Δx thick, internal energy changes according to the:

$$\rho c S \frac{\partial t}{\partial \tau} dx \qquad \text{.......................... (2.5)}$$

c - specific thermal capacity of the material, c(J/(kgK))
ρ – specific density of the material, ρ(kg/m^3)

Thermal balance for thin layer is represented by:

$$-\lambda \frac{\partial t}{\partial x} + q_V S\, dx =$$
$$= \rho c S \frac{\partial t}{\partial \tau} dx - S\left[\lambda \frac{\partial t}{\partial x} + \frac{\partial}{\partial x}\left(\lambda \frac{\partial t}{\partial x}\right) d\,x\right] \qquad \text{........(2.6)}$$

If we proceed further, it is possible to obtain:

$$\frac{\partial}{\partial x}\left(\lambda \frac{\partial t}{\partial x}\right) + q_V = \rho c \frac{\partial t}{\partial \tau} \qquad \text{........................... (2.7)}$$

If we apply same procedure for the *y* and *z* direction as well, it is possible to obtain the following equation:

$$\frac{\partial}{\partial x}\left(\lambda \frac{\partial t}{\partial x}\right) + \frac{\partial}{\partial y}\left(\lambda \frac{\partial t}{\partial y}\right) + \frac{\partial}{\partial z}\left(\lambda \frac{\partial t}{\partial z}\right) + q_V = \rho c \frac{\partial t}{\partial \tau} \qquad \text{...(2.8)}$$

If we assume that λ is constant, follows:

$$\frac{\partial^2 t}{\partial x^2} + \frac{\partial^2 t}{\partial y^2} + \frac{\partial^2 t}{\partial z^2} + \frac{q_V}{\lambda} = \frac{1}{a}\frac{\partial t}{\partial \tau} \qquad \text{.... (2.9)}$$

and$a = \lambda/(\rho c)$, a(m^2/s)

a- represents velocity of temperature change for the body which conducts heat through itself [1]

3. Transparent thermal insulators

Transparent thermal insulators are materials which are transparent for sunlight, and very good thermal insulators at the same time.[3], [5]
Nylon and cellophane packed into poly-carbonic box can represent one type of the transparent thermal insulators [8].

Sample used for experimental measurements has dimensions: 50 cm × 50 cm × 11,2 cm. Sample is filled by nylon and cellophane. Its transparency coefficient is $\tau = 0{,}118$, or $\tau = 11{,}8$ %.
Thermal properties of transparent thermal insulator are examined using experimental thermal chamber, **picture3**, **picture4 andpicture 5**. [9]

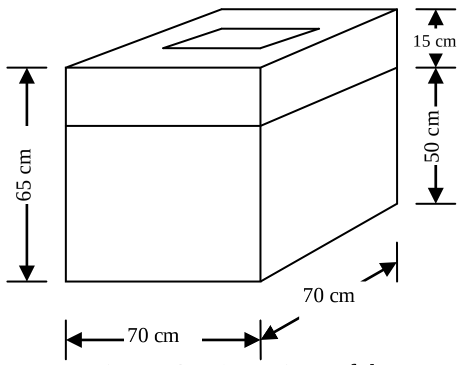
Experimental thermal chamber is made of Styrofoam which is 10 cm thick. Dimensions of the chamber are 70 cm × 70 cm × 65 cm. Inner opening has dimensions50 cm × 50 cm × 40 cm. On the thermal chamber, 10cm Styrofoam carrier is placed as well. This carrier has dimensions 70 cm × 70 cm × 15 cm. Inner opening has dimensions of 50 cm × 50 cm. [9]

Experimental thermal chamber and sample carrier are protected with the aluminum foil, from the outer side with the plastic foil as well. Aluminum foil is used for thermal insulation, and to reflect light and heat. Plastic foil improves thermal insulation and mechanical protection of the thermal chamber. Inside the experimental thermal chamber, 3 electrical bulbs are placed, with power values of 15 W, 25 W and 25 W,as well as two electrical fans, **picture 5.** [9]

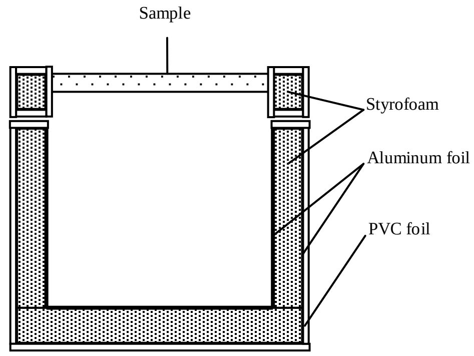
Electrical bulbs represent sources of the thermal and light radiation. Combining bulbs, it is possible to simulate different source powers, such are15 W, 40 W, 50 W and 65 W. Electrical fans with the power of 1,68 W are connected serially. Fans are used in order to simulate natural circulation of air inside the chamber. Temperatures are measured using 12-channel digital thermometer PCE-T 1200 at 10 specific representative points, using thermic wires, **picture 6.**[9]

During the experimental measurements, 112 mm thick sample is used. This sample is placed horizontally. Beneath the sample two electrical bulbs are placed,P = 2 × 25 W = 50 W.Intensity of heat radiation through surface of the transparent thermal insulator is $I = 200\ W/m^2$. [9]

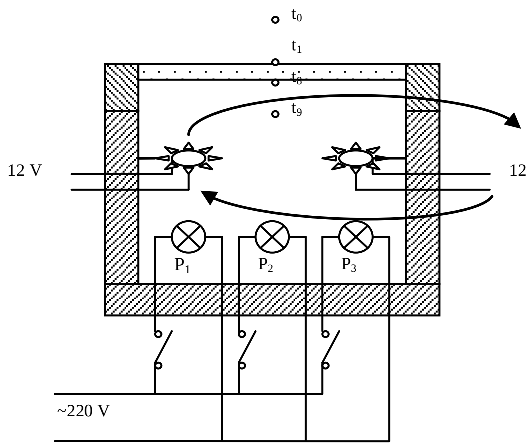
Initial temperatures in all representative points were equal to the temperature of the outer air. At the initial moment of measurements, heat source is started as well,measurements are made each 5 minutes and lastedtotally 200 minutes. [9]



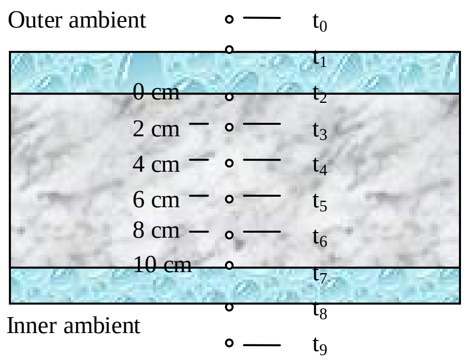
Picture 3. Dimensions of the thermal chamber [9]



Picture 4. Thermal insulation of thermal chamber [9]



Picture 5. Electrical schematics [9]



Picture 6. Representative points on sample [9]

4. Results of the experimental measurements

Results of the experimental measurements are given in **table T-1**, graphical results are presented on **picture7**. In**table T-2**thermal values of the sample are defined.

Table T-1[9]

Time (min.)	t_0(°C)	t_1(°C)	t_2(°C)	t_3(°C)	t_4(°C)	t_5(°C)	t_6(°C)	t_7(°C)	t_8(°C)	t_9(°C)
0	25,4	25,4	25,6	25,6	25,5	25,5	25,4	25,4	25,3	25,3
5	25,7	25,7	26,0	26,2	26,5	27,1	28,6	34,8	41,4	36,3
10	25,9	26,3	27,1	27,2	28,2	29,8	33,1	41,4	47,7	43,9
15	26,0	26,9	28,2	28,6	30,2	32,6	37,1	46,2	51,4	48,5
20	26,1	27,3	29,2	29,7	31,9	34,9	40,1	49,2	54,6	51,4
25	26,4	28,0	30,5	31,4	34,2	37,8	43,8	52,9	57,5	55,0
30	26,5	28,6	31,7	33,0	36,3	40,4	46,9	56,0	60,1	57,6
35	27,0	29,1	32,9	34,7	38,5	43,1	50,2	59,6	62,9	60,5
40	27,1	29,4	33,9	35,9	40,3	45,2	52,8	61,8	65,2	62,8
45	27,0	29,9	34,8	37,2	42,0	47,3	55,3	64,2	67,4	64,9
50	27,1	30,1	35,3	37,9	43,1	48,6	56,8	65,7	68,7	66,3
55	27,3	30,4	36,0	38,8	44,3	50,0	58,5	67,4	70,3	67,6
60	27,3	30,7	36,6	39,7	45,4	51,3	60,0	69,0	71,8	69,0
65	26,9	30,9	37,1	40,4	46,3	52,4	61,4	70,3	72,9	70,1
70	27,1	31,1	37,5	41,0	47,1	53,4	62,5	71,5	73,9	71,2
75	27,0	31,4	38,0	41,5	47,9	54,2	63,5	72,5	75,0	72,2
80	27,2	31,3	38,3	42,0	48,4	54,9	64,3	73,4	75,8	73,0
85	27,1	31,5	38,5	42,4	49,0	55,6	65,1	74,2	76,6	73,9
90	27,4	31,6	38,8	42,7	49,6	56,3	65,9	75,1	77,2	74,8
95	27,0	31,7	39,0	43,1	49,9	56,6	66,4	75,6	77,8	74,9
100	27,1	31,8	39,3	43,4	50,3	57,1	66,9	76,1	78,6	75,2
105	27,3	31,9	39,5	43,7	50,7	57,6	67,5	76,7	78,8	75,9
110	27,5	32,0	39,6	43,9	51,0	57,9	67,9	77,1	79,2	76,3
115	27,2	32,0	39,8	44,2	51,3	58,3	68,4	77,7	79,9	76,5
120	27,0	32,1	40,0	44,4	51,6	58,6	68,7	78,1	80,2	77,0
125	27,1	32,1	40,1	44,5	51,9	59,0	69,1	78,4	80,5	77,6
130	27,2	32,2	40,2	44,7	52,1	59,2	69,4	78,8	81,0	77,7
135	27,2	32,3	40,3	44,8	52,2	59,4	69,6	78,9	81,1	77,9
140	27,5	32,3	40,4	45,0	52,4	59,5	69,8	79,1	81,2	78,0
145	27,2	32,3	40,4	45,0	52,5	59,7	70,0	79,4	81,6	78,2
150	27,1	32,4	40,5	45,1	52,7	59,8	70,1	79,7	81,8	78,5
155	27,0	32,2	40,5	45,2	52,7	60,0	70,4	79,8	81,7	78,7
160	27,2	32,3	40,5	45,2	52,8	60,1	70,5	80,0	82,0	78,7
165	26,7	32,2	40,5	45,3	52,9	60,2	70,6	80,1	82,3	78,8
170	27,0	32,2	40,5	45,3	52,9	60,2	70,7	80,2	82,4	78,8
175	27,2	32,3	40,6	45,3	53,0	60,3	70,7	80,3	82,5	79,0
180	27,1	32,4	40,6	45,4	53,1	60,4	70,9	80,4	82,6	78,9
185	27,0	32,1	40,5	45,4	53,1	60,4	70,9	80,4	82,4	79,2
190	27,2	32,2	40,5	45,3	53,1	60,4	71,0	80,5	82,7	79,0
195	27,2	32,4	40,6	45,4	53,2	60,5	71,0	80,6	82,9	79,2
200	26,8	32,3	40,6	45,4	53,2	60,6	71,2	80,7	82,7	79,3

t_0(°C) –air temperature of the outer ambient

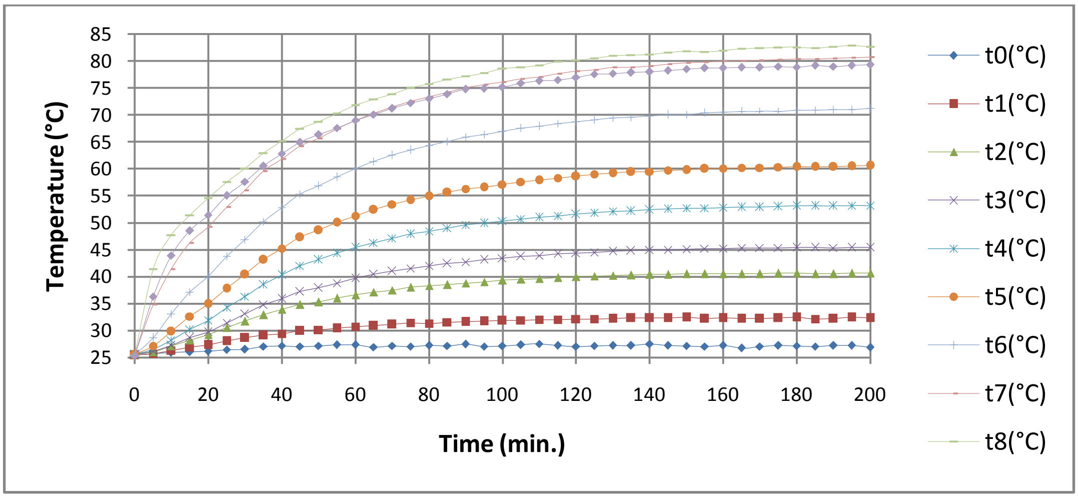
t_1(°C) –temperature on outer surface of the sample

t_2(°C) –temperature on inner surface ofthe sample´souter panel

t_3(°C) –temperature inside of the sample, at the distance of 2cm from the outer panel

t_4(°C) –temperature inside of the sample, at the distance of 4cm from the outer panel

t_5(°C) – temperature inside of the sample, at the distance of 6cm from the outer panel
t_6(°C) –temperature inside of the sample, at the distance of 8cm from the outer panel
t_7(°C) –temperature on inner surface of the sample´s inner panel
t_8(°C) –temperature on outer surface of the sample´s inner panel
t_9(°C) –air temperature inside of the thermal chamber



Picture 7.Graphical representation of the temperatures in representative points at specific time moment[9]

According to**table T-1**some specific thermal values are given in**table T-2**.

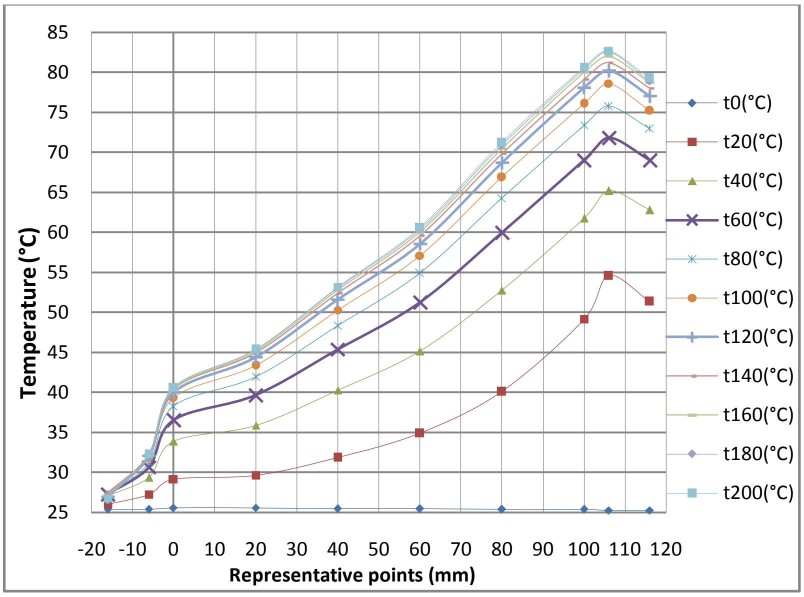
Table T-2[9], [8]

No.	Physical parameter	Value of the parameter
1.	Maximal air temperature inthermal chamber	t_{3k} = 79,3 °C
2.	Maximal temperature on the surface between sample and chamber	t_{2k} = 82,7 °C
3.	Maximal temperature on the surface of the sample which is facingouter ambient	t_{1k} = 32,3 °C
4.	Air temperature in outer ambient	t_0 = 26,8 °C
5.	Temperature difference between maximal air temperature in thermal chamber and maximal temperature on the surface between the sample and chamber	Δt_i = -3,4 °C
6.	Temperature difference between maximal temperatures on the sample surfaces	Δt_u = 50,4 °C
7.	Temperature difference between maximal temperature on the sample´s outer surface and air temperature of the outer ambient	Δt_e = 5,5 °C
8.	Coefficient of the heat conduction from heat chamber to the surface of the sample	α_i = -58,82 W/m^{2}K
9.	Coefficient of the heat conduction through sample	k_u = 3,97 W/m^{2}K
10.	Coefficient of heat conduction	λ_u = 0,445 W/(mK)
10.	Coefficient of heat conduction between sample´s outer surface and the air in outer ambient	α_e = 36,36 W/m^{2}K
11.	Resistance to the heat conduction between chamber´s inner air and the sample´s inner surface	R_i = -0,017 m^2K/W
12.	Resistance to the heat conduction through sample	R_u = 0,252 m^{2}K/W
13.	Resistance to the heat transfer from the sample surface to the air in outer ambient	R_e = 0,028 m^{2}K/W
14.	Resistance to the heat conduction from heat chamber to the air in outer ambient	R = 0,263 m^2K/W

In **table T-3** are presented temperatures which are measured in time intervals of 20 minutes. Results of the experimental measurements from **table T-3** are given on **picture 8**.
From the graph it is possible to conclude that temperature exponentially increases, if we observe transparent thermal insulator from outer ambient (surface of the sample facing outer ambient) to the thermal chamber (surface of the sample facing thermal chamber.)

Table T-3[9]

i	*d*(mm)	t_0(°C)	t_{20}(°C)	t_{40}(°C)	t_{60}(°C)	t_{80}(°C)	t_{100}(°C)	t_{120}(°C)	t_{140}(°C)	t_{160}(°C)	t_{180}(°C)	t_{200}(°C)
0	-16	25,4	26,1	27,1	27,3	27,2	27,1	27,0	27,5	27,2	27,1	26,8
1	-6	25,4	27,3	29,4	30,7	31,3	31,8	32,1	32,3	32,3	32,4	32,3
2	0	25,6	29,2	33,9	36,6	38,3	39,3	40,0	40,4	40,5	40,6	40,6
3	20	25,6	29,7	35,9	39,7	42,0	43,4	44,4	45,0	45,2	45,4	45,4
4	40	25,5	31,9	40,3	45,4	48,4	50,3	51,6	52,4	52,8	53,1	53,2
5	60	25,5	34,9	45,2	51,3	54,9	57,1	58,6	59,5	60,1	60,4	60,6
6	80	25,4	40,1	52,8	60,0	64,3	66,9	68,7	69,8	70,5	70,9	71,2
7	100	25,4	49,2	61,8	69,0	73,4	76,1	78,1	79,1	80,0	80,4	80,7
8	106	25,3	54,6	65,2	71,8	75,8	78,6	80,2	81,2	82,0	82,6	82,7
9	116	25,3	51,4	62,8	69,0	73,0	75,2	77,0	78,0	78,7	78,9	79,3



Picture 8. Graphical representation of the temperatures in points of interest each 20 minutes[9]

After temperature stabilization in the points of interest, special parameters are presented through **table T-4**. Maximal temperature interval Δt_i, of the *i*-th representative point, is equal to the difference of the temperatures which are obtained at the end, τ = 200 min., and at the beginning of the measurement. (τ = 0 min.). [9]

Table T-4 [9], [8]

i	t_{ip}(°C)	t_{ik}(°C)	Δt_i (°C)	t_{is}(°C)	τ_{is} (min.)	μ_i(1/min.)
0	25,4	26,8	1,4	26,1	20,00	0,03465
1	25,4	32,3	6,9	28,8	32,50	0,02132
2	25,6	40,6	15,0	33,1	36,00	0,01925
3	25,6	45,4	19,8	35,5	38,33	0,01808
4	25,5	53,2	27,7	39,4	39,25	0,01765
5	25,5	60,6	35,1	43,1	34,91	0,01985
6	25,4	71,2	45,8	48,3	32,12	0,02158
7	25,4	80,7	55,3	53,1	25,75	0,02691
8	25,3	82,7	57,4	54,0	19,06	0,03636
9	25,3	79,3	54,0	52,3	21,25	0,03261

5. Analysis of the measurements results

According to the graph which is presented on**picture7**, temperature graphs at specific representative points are defined through functions:

$$t_i = t_o + \Delta T_i (1 - e^{-\mu_i \tau}) \quad \text{.............................(5.1)}$$

i–order number of the representative point,
i =0, 1, 2, ..., 8, 9
τ *- specific time moment*
t_i *-current temperature in i-th representative point*
t_0 *-temperature in outer ambient*
ΔT_i *-difference between maximal temperature in i-th representative point and outer ambient*
Δt_i *- current difference between maximal temperature in i-th representative point and outer ambient*
μ_i *-timecoefficient for i-th representative point*

$$\mu_i = \frac{\ln 2}{\tau_{is}} = \frac{0{,}693}{\tau_{is}} \quad \text{...................................(5.2)}$$

τ_{is} presents time during which the following temperature is reached:

$$t_i = t_0 + \frac{\Delta T_i}{2} \quad \text{...(5.3)}$$

τ_{is} is defined directly from graph.

Temperature in all representative points tends to:

$$t_i = t_0 + \Delta T_i \quad \text{...(5.4)}$$

Current temperature values in specific representative points according to the depth (distance from the sample´s surface) of the transparent thermal insulator, at the specific time moments are given in **table T-4**and graphically presented on**picture 8**. Between representative points 2 and 7 of the sample,exactly the space between 0 mm to 100 mm is filled with the material which is point of observation.

In these specific points of interest, maximal temperature difference can be obtained as:

$$\Delta T_i = \Delta t_2 e^{\delta_i x_i} \quad \text{..................................(5.5)}$$

i= 2, 3, ..., 7, 0 cm $\le x_i \le$10 cm

i = 2, x_2 = 0 cm
i = 3, x_3 = 2 cm
i = 4, x_4 = 4 cm
i = 5, x_5 = 6 cm
i= 6, x_6 = 8 cm
i = 7, x_7 = 10 cm

$$e^{\delta_i x_i} = \frac{\Delta T_i}{\Delta t_2} \quad \text{....................................(5.6)}$$

$$\delta_i = \frac{1}{x_i} \ln \frac{\Delta T_i}{\Delta t_2} \quad \text{..................................(5.7)}$$

$$\delta_7 = \frac{1}{d} \ln \frac{\Delta T_7}{\Delta t_2} \quad \text{..................................(5.8)}$$

$$\delta_7 = \frac{1}{10cm} \ln \frac{53{,}9°C_7}{13{,}8°C} = \frac{1{,}39}{10cm} = 0{,}136 \frac{1}{cm} \quad \text{.......(5.9)}$$

Using (5.5) in (5.1), follows:

$$t_i = t_o + \Delta t_2 e^{\delta x_i} (1 - e^{-\mu_i \tau_n}) \quad \text{.....................(5.10)}$$

n = 0 min, 20 min, ..., 180 min, 200 min

For points of interest between sample surfaces, follows:

$$t(x_i, \tau_n) = t_0 + \Delta t_2 (0{,}200) e^{\delta_7 x_i} \quad \text{..............(5.11)}$$

$$t(x_2, \tau_{200}) = 26{,}8\ °C + 13{,}8\ °C = 25{,}6\ °C + 15\ °C = 40{,}6\ °C \quad \text{(Exp. 40,6 °C)}$$

$$t(x_3, \tau_{200}) = 26{,}8\ °C + 13{,}8\ °C \cdot e^{0{,}136 \cdot 2} = 25{,}6\ °C + 13{,}8\ °C \cdot 1{,}31 = 44{,}9\ °C \quad \text{(Exp. 45,4 °C)}$$

$$t(x_4, \tau_{200}) = 26{,}8\ °C + 15\ °C \cdot e^{0{,}136 \cdot 4} = 26{,}8\ °C + 13{,}8\ °C \cdot 1{,}72 = 50{,}5\ °C \quad \text{(Exp. 53,2 °C)}$$

$$t(x_5, \tau_{200}) = 26{,}8\ °C + 13{,}8\ °Ce^{0{,}136 \cdot 6} = 26{,}8\ °C + 13{,}8\ °C \cdot 2{,}26 = 58{,}0\ °C \quad \text{(Exp. 60,6 °C)}$$

$$t(x_6, \tau_{200}) = 26{,}8\ °C + 13{,}8\ °Ce^{0{,}136 8} = 25{,}6\ °C + 13{,}8\ °C \cdot 2{,}97 = 67{,}8\ °C \quad \text{(Exp. 71,2 °C)}$$

$$t(x_7, \tau_{200}) = 26{,}8\ °C + 13{,}8\ °C \cdot e^{0{,}136 \cdot 10} = 26{,}8\ °C + 13{,}8\ °C \cdot 3{,}90 = 80{,}6\ °C \quad \text{(Exp. 80,7 °C)}$$

Generally for any point, according to the depth of the sample, at any moment it is possible to obtain:

$$t(x,\tau)=t_0+\Delta t(0,\tau)e^{\delta x}(1-e^{-\mu\tau}) \quad ....(5.12)$$

$$\frac{\partial t}{\partial x}=\delta\Delta t(0,\tau)e^{\delta x}(1-e^{-\mu\tau}) \quad ....(5.13)$$

$$\frac{\partial^2 t}{\partial x^2}=\delta^2\Delta t(0,\tau)e^{\delta x}(1-e^{-\mu\tau}) \quad ....(5.14)$$

$$\frac{\partial t}{\partial \tau}=\lambda\Delta t(0,\tau)e^{\delta x}e^{-\mu\tau} \quad ....(5.15)$$

$$\frac{\partial^2 t}{\partial x^2}=\frac{1}{a}\frac{\partial t}{\partial \tau} \quad ....(5.16)$$

$$\delta^2\Delta t(0,\tau)e^{\delta x}(1-e^{-\mu\tau})=\frac{1}{a}\lambda\Delta t(0,\tau)e^{\delta x}e^{-\mu\tau} \quad ..(5.17)$$

$$a=\frac{\mu}{\delta^2}\frac{e^{-\lambda\tau}}{1-e^{-\lambda\tau}} \quad ....(5.18)$$

$$a=\frac{\mu}{\delta^2}\frac{1}{e^{\lambda\tau}-1} \quad ....(5.19)$$

Coefficient of temperature conduction is time variable function:

$$a_7=\frac{0{,}0269\frac{1}{\mathrm{min}}}{\left(0{,}136\frac{1}{\mathrm{cm}}\right)^2}\cdot\frac{1}{e^{\lambda\tau}-1}=$$

$$=\frac{2{,}42\cdot 10^{-6}\frac{\mathrm{m}^2}{\mathrm{s}}}{e^{\lambda\tau}-1} \quad ....(5.20)$$

After 25,75 minutes (**table T-4**),coefficient of temperature conduction is:

$$a=2{,}42\cdot 10^{-6}\frac{m^2}{s} \quad ....(5.21)$$

At initial moment, $\tau = 0$, $a \to \infty$
When the stationary temperature conduction is reached, $\tau\to\infty$, $a\to 0$ [9]

6. Conclusion

Using experimental measurements in the points of interest of the transparent thermal insulator, it is concluded that temperatures are changing exponentially in all representative points. Heat conduction is at the very first moment non-stationary, but with the time becomes stationary.
Measurement results are expressed through tables and graphs as well. Current temperatures in accordance to the depth of the sample are presented on graph.
Due to the graph it is possible to conclude that temperatures in points of interest are decreasing exponentially, if we observe thermal insulators from inner side (side facing thermal chamber) to the outer side (side facing outer ambient).
Graphical representation of the temperatures in accordance to time is given through family of the graphs. From the graphs some special relations for the temperatures in the points of interest are defined.
Function which describes temperature in any point of thermal insulator at any time moment is obtained.
After the derivation of this function, according to the depth of the sample (distance from the surface of the sample), thermal insulator´s conduction coefficientis specified.

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