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THERMO-PHYSICAL ANALYSISOFTHE ACCUMULATION OFHEAT INTHEAIROFTHEENVIRONMENTANDON THE WALLS OFA CLOSEDENVIRONMENT

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ABSTRACT
Often in various literatures we see thermal balance taking into account the expenditure on the accumulation only heat of space air or only heat accumulation on the walls of the closed environment. In the paper will analyze some thermal parameters such as: inside temperature of the air ambient, spend accumulated heat to heat the closed environment and that which accumulated on the walls, as well as the corresponding time constants. The purpose of this paper is to analyze the thermo-physical environment limits to the possibility of negligence in a thermal balance equation) the accumulated heat in the air of the environment orb) accumulated heat in the walls of the environment.

Key words: temperature, thermal balance, the accumulation of heat.

1. INTRODUCTION
The Equation of thermal balance for a local presents the heat capacity of the heater that needed to compensate the heat that lost into the accumulation wall [1], in interior ambient air of a local and from interior ambient to exterior via heat transmission of local wall (fig.1), respectively [2]:

$$P=Q_A+Q_T=Q_{Aa}+Q_{AM}+Q_T \qquad (1)$$

But usually encountered in the literature specific accumulation of heat in the air and into the walls:

- For space with large volume:

$$P=Q_{Aa}+Q_T \qquad (2)$$

- For space with small volume:

$$P=Q_{AM}+Q_T \qquad (3)$$

Where:

P, W – Thermal capacity of the heater;
Q_{Aa}, Q_{AM}, W – Accumulation heat capacity in the interior ambient air and in the wall of a local;
Q_T, W – Heat thermal capacity that transmitted via the wall from interior to exterior ambient air;

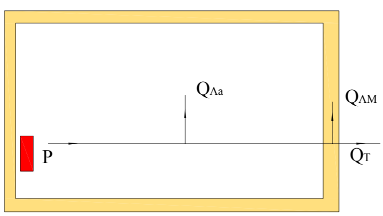

Figure 1. Heater thermal capacity and heat losses

2. THERMAL PARAMETERS OF INTERIOR AMBIENT AIR AND WALL OF A CLOSED SPACE

Interior temperature of a local ambient air by total accumulation constant:

$$t_b = \left(\frac{P}{kF} + t_j\right)\left(1 - e^{-\tau/T}\right) + t_0 e^{-\tau/T} \text{, in } {}^0\text{C;} \tag{4}$$

The equations are the same as eq. (4) for special cases when we have accumulation of heat in the air or just in the walls, replacing the equation $T=T_a$ or $T=T_m$.

Where:

Total accumulation constant:

$$T = T_a + T_m \text{, in s;} \tag{5}$$

Air accumulation constant:

$$T_a = \frac{c_a \rho_a V_a}{kF} \text{, in s;} \tag{6}$$

Wall accumulation constant:

$$T_M = \frac{c_m \rho_m V_m}{kF}\frac{Z}{2} \text{, in s;} \tag{7}$$

Non-dimensional constant:

$$Z = 1 + \frac{k}{\alpha_j} - \frac{k}{\alpha_b}, \quad / ; \tag{8}$$

In continuity of this paper there are analyzed the thermal parameters which influenced in thermal equilibrium of the heater and the interior temperature of a closed space. In view of the exposed model in the equations (1) (2) and (3) there are ensued these analytical expressions in function of heater thermal capacity:

Average temperature of the wall:

$$t_m = \frac{t_1 + t_2}{2} \text{, in } {}^0\text{C;} \tag{9}$$

Transmission heat losses via the wall [3]:

$$Q_T = F \cdot k\left(t_b - t_j\right) \text{, in W;} \tag{10}$$

Total heat accumulation in air and in walls:

$$Q = P - Q_T = Q_{Aa} + Q_{AM} \text{, in W;} \tag{11}$$

Accumulation heat in interior ambient air:

$$Q_{Aa} = c_a \rho_a V_a \frac{dt_b}{d\tau} \text{, in W;} \tag{12}$$

Accumulation heat in the wall [4]:

$$Q_{AM} = c_m \rho_m V_m \frac{Z}{2}\frac{dt_b}{d\tau} \text{, in W;} \tag{13}$$

Where:

$$\frac{dt_b}{d\tau} = \left(\frac{P}{kF} + t_j - t_0\right)\left(\frac{e^{-\tau/T}}{T}\right) \tag{14}$$

Thermal capacity coefficient [5]:

$$C_a = m_a \cdot c_a \text{;} \tag{15}$$

$$C_M = m_M \cdot c_M \text{, inJ/K.} \tag{16}$$

Where are:

k, W/(m^{2}K) – total coefficient heat transmission; F, m^2 – total area of the wall surfaces of a local; V_h, m^3 – interior volume of a local; V_j, m^3 – exterior volume of a local; δ, m – thickness of the wall; α_b, α_j, W/(m^{2}K) – interior and exterior heat convection coefficient; ρ_a; ρ_M, kg/m^3 – density of air and density of wall; c_a; c_M, J/(kgK) – air mand wall specific heat capacity; t_0, ^{0}C

– interior temperature at the eginning moment; t_j, ^0C – exterior temperature; m_a; m_M, kg – mass of air and mass of wall; τ, s - time.

3. THERMO-PHYSICAL ANALYSISOFTHE ACCUMULATION OFHEAT INTHEAIROFTHEENVIRONMENTANDON THE WALLS OFA CLOSEDENVIRONMENT

In view of upon expressions, by means of the simulations respectively the diagrams that are presented in continuity, it is analyzed the interior temperature and the other thermal parameters for a modeling local. This local, with the walls of the brick composition, has these characteristics: width a=6m, length b=6m, and height c=5m; thickness of the wall δ_M=0.3m; heater capacity P=10000, 11000..100000 W; Conduction coefficient λ=0,7W/(mK), convection coefficients α_b=8W/(m^{2}K); α_j=25W/(m^{2}K); density of the wall ρ_M=1850kg/m^3; specific heat of the wall c_M=920J/(kgK); density of the air ρ_a=1,2kg/m3; specific heat of the air c_a=1005 J/(kgK); air conduction coefficient λ_a=0,02W/(mK); total area of the wall surfaces $A_h=[2a(h+\delta_M)+2ab+2b(h+\delta_M)]$; interior volume of local $V_h=a\cdot b\cdot h$, m^3; exterior volume of local $V_j=(a+2\delta_M)(b+2\delta_M)(h+2\delta_M)]$, m3; beginning temperature: t_0=10^{0}C; exterior temperature t_j=-15^{0}C; the time where the parameters are analyzed τ=0,100,...,1000000s. P_1=5000W.

In the table below are shown 5 - cases of volume air closed space.

V_h=1000 m^3	V_h=2000 m^3	V_h=3000 m^3	V_h=4000 m^3	V_h=5000 m^3
V_j=1191 m^3	V_j=2315 m^3	V_j=3438 m^3	V_j=4562 m^3	V_j=5685 m^3
V_M=183.6 m^3	V_M=305.4 m^3	V_M=427.2 m^3	V_M=549 m^3	V_M=670.8 m^3
A_h=612 m^2	A_h=1018 m^2	A_h=1424 m^2	A_h=1830 m^2	A_h=2236 m^2
k=1.685 W/(m^{2}K)	k=1.685 W/(m^{2}K)	k=1.685 W/(m^{2}K)	k=1.685 W/(m^{2}K)	k=1.685 W/(m^{2}K)
q_0=0.866 W/(m^{3}K)	q_0=0.741 W/(m^{3}K)	q_0=0.698 W/(m^{3}K)	q_0=0.676 W/(m^{3}K)	q_0=0.663 W/(m^{3}K)
Z=0.857	Z=0.857	Z=0.857	Z=0.857	Z=0.857
$C_a=1.206\cdot10^6$ J/K $C_M=3.125\cdot10^8$ J/K	$C_a=2.412\cdot10^6$ J/K $C_M=5.198\cdot10^8$ J/K	$C_a=3.618\cdot10^6$ J/K $C_M=7.271\cdot10^8$ J/K	$C_a=4.824\cdot10^6$ J/K $C_M=9.344\cdot10^8$ J/K	$C_a=6.03\cdot10^6$ J/K $C_M=1.142\cdot10^9$J/K
$T_a=1.17\cdot10^3$ s $T_m=1.298\cdot10^5$ s	$T_a=1.406\cdot10^3$ s $T_m=1.298\cdot10^5$ s	$T_a=1.508\cdot10^3$ s $T_m=1.298\cdot10^5$ s	$T_a=1.565\cdot10^3$ s $T_m=1.298\cdot10^5$ s	$T_a=1.601\cdot10^3$ s $T_m=1.298\cdot10^5$ s
T_m/T_a=111.003	T_m/T_a=92.321	T_m/T_a=86.094	T_m/T_a=82.98	T_m/T_a=81.112
$t_{bmax}(P_1)$=33.494 ^{0}C	$t_{bmax}(P_1)$=14.154 ^{0}C	$t_{bmax}(P_1)$=5.842 ^{0}C	$t_{bmax}(P_1)$=1.218 ^{0}C	$t_{bmax}(P_1)$=−1.727^{0}C
$\tau a=2.882\cdot10^3$ s $\tau m=3.199\cdot10^5$ s	$\tau a=1.028\cdot10^3$ s $\tau m=9.49\cdot10^4$ s	$\tau a=1.104\cdot10^3$ s $\tau m=9.504\cdot10^4$ s	$\tau a=2.315\cdot10^3$ s $\tau m=1.921\cdot10^5$ s	$\tau a=2.831\cdot10^3$ s $\tau m=2.297\cdot10^5$ s

All these following figures - diagrams are calculated in function of heater thermal capacity P and of time τ

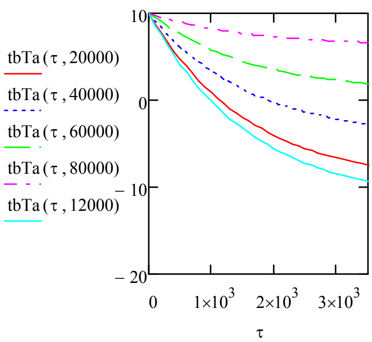

Figure 2. Interior temperature of a local ambient in function of heat accumulation in the air for P=20000, 40000...120000

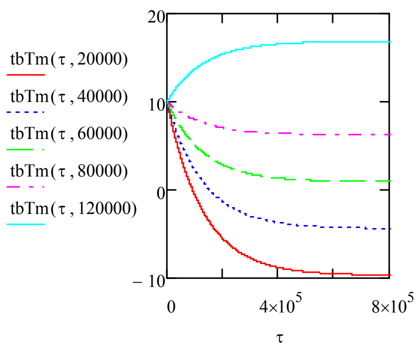

Figure 3. Interior temperature of a local ambient in function of heat accumulation in the wall for P=20000, 40000...120000

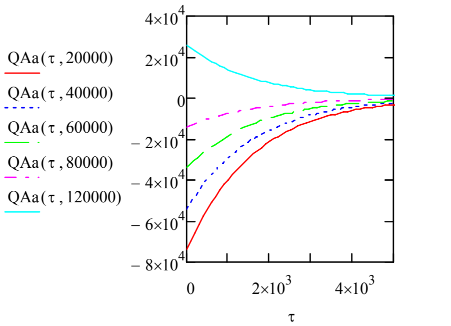

Figure 4. Accumulation heat in ambient air for P=20000, 40000...120000

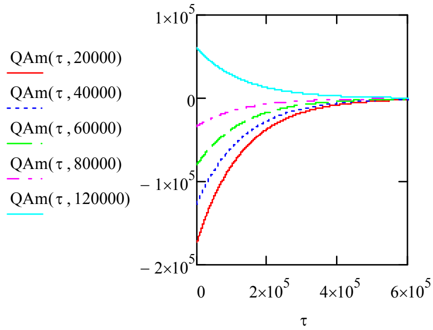

Figure 5. Accumulation heat in the wall for P=20000, 40000...120000

All these upon diagrams are calculated in function of heater thermal capacity P and of time τ

4 CONCLUSION

Mathematical Model upon exposed describes the interior temperature and the others thermal parameters in view of the influence of heater thermal capacity and accumulation heat. From upon formulas achieved results about: q_0, $W/(m^3K)$; k,$W/(m^2K)$; Z, (/); Q_{Am}/Q_{Aa}. The upon diagrams shown the changing of interior temperature, average wall temperature, air and wall accumulation heat capacity, heat transmition capacity and rapport between total accumulation heat and heat transmitted via the wall, in function of heater thermal capacity and of time. From results and the schemes it is shown that after e determined time achieves the steady state of thermal parameters. However, it is important to note that by the increase of volume of enclosed space grows the need for heating indoor air, but also increases the accumulated heat in the walls. This indicates cases that, for low-volume spaces preferred to consider the accumulation of heat in the walls, for medium volume spaces preferred to consider the accumulation of heat in the air and on the walls, while for large spaces to consider only the heat accumulation in the air (meaning internal thermal insulation or and the external thermal insulation).Taking in considerate the accumulation heat in air and in the wall achieves the exactness and genuineness about the practical results, and also to secure the control for heating system, to regulate the process circle respectively to stabilize the state parameters. All of this leads to processes automatization and to optimalizate the managing of equipments, installations and systems respectively to save the energy.

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