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CONSTRUCŢII. ARHITECTURĂ

THE MAIN CALCULATION PARAMETERS NEEDED TO OPTIMIZE THE THICKNESS OF THE HEAT INSULATION IN A COOLING ROOM OF THE PREMISES OF A COLD STORAGE SITUATED IN JASSY

BY

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The thickness of the heat insulation optimization imposes the introduction of following parameters:

a) Cooling degree–days, determinated in function of exterior air temperature and of the cooling rooms specific.

b) Exploitation index which depends on the correction coefficients and on the number of degree–days, installation efficiency and exploitation conditions for cooling rooms.

c) The invested capital pay-off factor, which takes in account the invested capital interest and liquidation for a certain period stipulated by in force legislation.

1. Introduction

For certain configurations of the shut-off and division devices of a particular building, one can determine the economical optimum thickness of the composing layers through analytical proceeding. The main calculation parameters needed to optimize the tickness of the heat insulation in a cooling room of the premises of a cold storage situated in Jassy are presented in what follows [1].

2. The Determination of the Temperatures Calculation

2.1. The Actual Temperature of the External Air

This temperature may be determined with relation:

$$t_e = t_{em} + cA_z, \quad [^\circ\mathrm{C}]. \tag{1}$$

The cold storages belong, through assimilation, to Ist category of buildings, where continuous operating processes, that cannot be disrupted, take place.

Accordingly, the degree of safety is 98%.

For the city of Jassy, the temperature in July and August is $t_{em} = 26°\mathrm{C}$ and, according to STAS 6648/2-82, $cA_z = 6°\mathrm{C}$, so that

$$t_c = t_{em} + cA_z = 32°\mathrm{C}.$$

2.2. The External Equivalent Temperatures Calculation

The external temperature may be calculated with relation:

$$t_s = t_e + \frac{A}{\alpha_e} I, \quad [°\mathrm{C}]. \tag{2}$$

2.3. The Overall Intensity of the Solar Radiation

Is calculated with relation:

$$I = a_1 a_2 I_D + I_d, \quad [\mathrm{W/m^2}]. \tag{3}$$

For certain building blocks the following situation may be encountered:

a) *South oriented wall*:

$$t_s = 32 + 52 \times 414 \times 10^{-3} = 53.5°\mathrm{C},$$

where: $A/\alpha_e = 52 \times 10^{-3}$ m^2.°C/W (cf. STAS 6648/1-82 for plastering) whith the built-up factors: $a_1 = 0.67$ (industrial platforms, in summer, STAS 6648/2-82); $a_2 = 1.00$ (altitude below 500 m, STAS 6648/2-82); $I_d = 394$ W/m^2 (vertical surface, S); $I_D = 734$ W/m^2 (horizontal surface).

Values I_d and I_D are in conformity with STAS 6648/2-82. Consequently:

$$I = 0.67 \times 1.00 \times 394 \times 147 = 414 \ \mathrm{W/m^2}.$$

b) *Terrace*:

$$I = 0.67 \times 1.00 \times 734 + 147 = 492 + 147 = 639 \ \mathrm{W/m^2},$$

so that:

$$t_s = 32 + 52 \times 639 \times 10^{-3} = 65°\mathrm{C}.$$

c) *SE, SW oriented wall*:

$$I = 0.67 \times 1.00 \times 514 + 147 = 491 \ \mathrm{W/m^2}$$

and

$$t_s = 32 + 52 \times 491 \times 10^{-3} = 57.5°\mathrm{C}.$$

d) *West, Est oriented wall*:

$$I = 0.67 \times 1.00 \times 575 + 1,103 = 1,488 \ \mathrm{W/m^2}$$

and

$$t_s = 32 + 52 \times 488 \times 10^{-3} = 57.4°\text{C}.$$

e) *NW, NE oriented wall*:

$$I = 0.67 \times 1.00 \times 402 + 80 = 349\ \text{W/m}^2$$

and

$$t_s = 32 + 52 \times 349 \times 10^{-3} = 50°\text{C}.$$

f) *N oriented wall*:

$$I = 0.67 \times 1.00 \times 52 + 53 = 88.5\ \text{W/m}^2$$

and

$$t_s = 32 + 52 \times 88.5 \times 10^{-3} = 36.6°\text{C}.$$

For a wall with various orientations, the values of the external equivalent calculation temperature are synthesized in Table 1.

Table 1
External Equivalent Temperatures Calculation

Orientation	N	NE, NW	E, W	SE, SW	S
t_s, [°C]	36.6	50	57.4	57.5	53.5

2.4. The Average External Equivalent Temperatures Calculation

If the calculations are made based on I_{Dm}, I_{dm} values, according to STAS 6648/2-82, it results for a wall with different orientations

$$t_{sm} = t_{em} + \frac{A}{\alpha_e} I_m,\ [°\text{C}],$$

where I_m is the average intensity of solar radiations, [W/m^2].

The values of the obtained temperatures are synthesized in Table 2.

Table 2
External Equivalent Temperatures Calculation

Orientation	N	NE, NW	E, W	SE, SW	S
t_s, [°C]	35.2	36.8	42.7	43.0	42.2

For a terrace, $t_{sm} = 43.6°\text{C}$. In conclusion, within the relations for optimization, t_S and t_{Sm} will be taken into account as determined.

2.5. The Calculation of the Inside Air Temperature

This temperature is adopted depending on the situation of the cooling room and on the technological needs of ware preserving and storing; this temperature has roughly the following values:

a) cooling rooms for storing the consumer goods at constant temperatures higher than the freezing point of water:

$$t_i = -2°...+5°\text{C}, \text{ (temperature } t_i \text{ is maintained constant);}$$

b) cooling room or cooling tunels (refrigeration) to cool up the goods from the environment temperature up to the storage temperature:

$$\text{up to } t_i = -10°\text{C}, \text{ (temperature } t_i \text{ is variable);}$$

c) deep-freezing rooms for goods storage at deep-freezing points:

$$t_i = -18°...-30°\text{C}, \text{ (temperature } t_i \text{ is constant);}$$

d) deep-freezing rooms and freezing tunnels for cooling, deep-freezing and overcooling of the goods stored at deep-freezing:

$$t_i, \text{ ranging between the environment temperature and } -40°\text{C};$$

temperature t_i is variable;

e) cooling rooms for storing vegetables and fruits:

$$t_i = 2°...10°\text{C};$$

f) rooms for technical units (refrigerating unit, electric switch and power supply plant, rooms for accumulators, deposits and garages for tramways, trolleybuses, automobiles, repair (workshops, etc.):

$$t_i = 2°...10°\text{C}.$$

2.6. The Number of Cooling Days

This number is assessed depending on the destination of the cooling rooms and on the temporary or continuous operating process.

By analysing the average values of the equivalent calculation temperatures of the outside within a year, three dinstinct periods emerged normaly:

a) April 15...October 15 (warm period), $N = 183$ days;

b) October 15...November 30 and March 31...April 15 (transition period), $N = 76$ days;

c) November 30...March 1 (cold period), $N = 106$ days.

The number of cooling days, N, [s], are assessed depending on the temporary or continuous operating process.

The number of degrees for cold days will be determined for each period separately.

In order to establish the correct number of degrees for cold days, the weather data related to the local climate will be used.

According to STAS 6648/1-2/82 for Jassy, a safety degree of July, the average outside calculation temperature, t_{sm} (the average temperature of sunny weather), is given in STAS 6648/2-82, for various orientations of vertical shut-off devices and for horizontal surfaces so that they verify the value $t_{em} = 27° \pm 1°C$. In case of other months, necessary corrections are needed. By calculating the average value for the oeriod April 15...October 15, the values for t_{Sm}^{per} presented in Table 3, are obtained.

Table 3

The Average Equivalent Temperature (April 15...October 15)

t_{Sm}, [°C]	Vertical surface								Horizontal surface
April 15... October 15	NE	E	SE	S	SW	W	NW	N	39.4
	30.4	33.4	33.4	32.4	33.4	33.4	30.4	28.4	

By calculating the ratio $t_{sm}^{\text{per}}/t_{sm}^{\text{July}}$ it results a corrective coefficient $y_1 = 0.87$ for vertical surfaces and $y_2 = 0.89$ for horizontal ones.

Making use of relation:

$$G_r = (t_{em} - t_i)N, \ [°\text{C.s}],$$

it can be calculated, for example, the number of degree-days for cooling the rooms up to 0°C, the result being summarized in Table 4.

Table 4

The Number of Degree-Days for Cooling Rooms up to 0°C

	Vertical surface								Horizontal surface
	NE	E	SE	S	SW	W	NW	N	
No. degree-days	45.03	50.52	50.52	48.69	50.52	50.52	45.03	41.37	61.50
No. degree-sec$\times 10^6$	389.059	436.493	436.49	420.68	436.493	436.493	420.68	357.437	531.360

From the weather data for the city of Jassy, differences can be noticed between the value t_{sm} indicated in STAS 6648/2-82 and the one determined through measurements, which calls for the necessary correction; the average value of this correction is:

$$y_2 = 0.75 \text{ for vertical and horizontal surfaces.}$$

3. The Calculation of Thermotechnical Parameters

a) $m = 1$ is the thermal bulk coefficient;

b) λ_{it} is the conduction of heat coefficient of heat insulation, adopted accordingly to STAS 6472/3-1997 or is determined experimentally in specialized laboratories.

c) i_{ex} represents the operating value, which is given by relation:

$$i_{\text{ex}} = \frac{ey}{\eta_f}. \tag{6}$$

d) e is adopted depending on the average cooling temperature in operation, different from that taken into consideration in design calculations, from the storage factor, the functional disruption and the specific needs of the stored wares.

e) y is built-up factor of the number of degree-days determinated with relation:

$$y = y_1 y_2 y_3, \tag{7}$$

where $y_1 = 0.87$ – for vertical surfaces; $y_1 = 0.89$ – for horizontal surfaces; $y_2 = 0.75$ – for vertical and horizontal surfaces; $y_3 = 0.95$ – the factor which depends on the different conditions of utilization of the building; η_f is the overall efficiency of the refrigerating unit.

4. The Calculations of the Economic Parameters

The capital must pay-off in a number of years (n) at a certain interest, [%], so that:

$$r_i = \frac{(1+i)^n t}{(1+i)^n - 1}. \tag{8}$$

The interest, i, depends on the mode of financing the construction (a_i) and, the refrigerating unit, a_i; the pay-off duration is longer for building blocks (50 years) as compared to the additional facilities (10...15 years). The repair size is taken over from current practice for similar situations; it is recommanded that $a_{ri} = 0.02$.

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PRINCIPALII PARAMETRI DE CALCUL PENTRU OPTIMIZAREA GROSIMII IZOLAŢIEI TERMICE LA O ÎNCĂPERE RĂCITĂ DIN INCINTA UNUI DEPOZIT FRIGORIFIC

(Rezumat)

Optimizarea grosimii izolaţiilor presupune introducerea următorilor parametri:

a) Grade-zile răcire, calculate în funcţie de temperatura aerului exterior şi de specificul încăperilor răcite.

b) Indice de exploatare, factor care depinde de coeficienţii de corecţie ai numărului de grade-zile, randamantul instalaţiei şi condiţiile de exploatare pentru camerele frigorifice.

c) Factor de reproducere a capitalului investit, care are în vedere dobânda şi amortizarea capitalului investit pentru o anumită perioadă prevăzută de legislaţia în vigoare.