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A SIMPLIFIED CALCULATION PROCEDURE TO DETERMINE THE ECONOMICALLY OPTIMAL SOLUTION OF THE HEAT INSULATION FOR SHUT-OFF AND DIVISION DEVICES IN COOLING FACILITIES

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The assessement of the economic efficiency of installation of a building implies its sizing from adequate materials, the appraisal of each variant and the final selection of the optimal one through multicriteria, representing the solution to obtain the minimum yearly cost per unit of insulation's surface.

1. Introduction

For certain configurations of the shut-off and division devices of a particular building, one can determine the economically optimum thickness of the composing layers through analytical calculation.

2. Determination of the Economically Optimal Resistance to Heat Permeability and of the Optimal Thickness of the Insulating Layer (Using the Unicriterion Methods of Optimization)

For the insulating layer (the external and internal structural members) the economically optimal thickness is given by relations:

$$R_{\text{iz}}^{\text{opt}} = \sqrt{\frac{(t_s - t_i)r_i c_i + (t_{sm} - t_i)N i_{ex} c_{ex}}{r_{\text{iz}}\lambda_{\text{iz}}c_{\text{iz}}}}, \quad [\text{m}^2.^\circ\text{C/W}]; \tag{1}$$

a) for external structural members (walls, ceiling-roogs);

$$d_{\text{iz}}^{\text{opt}} = \sqrt{\frac{(t_s - t_i)r_i c_i + G_r i_{ex} c_{ex}}{r_{\text{iz}}\lambda_{\text{iz}}c_{\text{iz}}}}\lambda_{\text{iz}}, \quad [\text{m}]; \tag{2}$$

$$d_{\text{iz}}^{\text{opt}} = \sqrt{\frac{(t_s - t_i)r_i c_i + (t_{sm} - t_i)N i_{ex} c_{ex}}{r_{\text{iz}}\lambda_{\text{iz}}c_{\text{iz}}}}\lambda_{\text{iz}}, \quad [\text{m}] \tag{3}$$

– for external structural parts (walls, ceiling non-heated floors), where: t_s is the outside equivalent calculation temperature (the temperature of sunny weather), [°C]; t_{sm} – the average outside equivalent calculation temperature (the average tempure for a cooling room, [°C]; t_i – the inside calculation temperature for a cooling room, [°C]; t_{am} – the inside temperature of adjoining rooms, [°C]; N – the number of cooling days expressed in seconds (during a year).

There are also considered: i_{ex} – the utilization factor (wich brings the necessary correction depending on the actual conditions of utilization); c_{ex} – the specific exploitation/utilization cost, [lei/W s]; R_{iz} – the resistance to thermal/heat permeability of the heat insulating layer, [m^2.°C/W]; t_{am} – the adjoining room inside temperature in case of inner parts: walls, ceilings, [°C], with $t_{am} > t_i$; c_i – the specific cost of investment regarding the freezing plant, [lei/W]; r_i – the capital recovery factor depending on the average annual interest rate and on the freezing plant redemption as well as on the repair expenses; G_r – the number of degree.days of cooling, [°C.s]; d_{iz} – the thickness of the heat-insulation, [m]; r_{iz} – the capital recovery factor depending on the average annual interest and on the capital redemption for heat insulation as well as on the repair expenses; c_{iz} – the specific cost of heat insulation, [lei/m^3].

When analysing the last relations, one can conclude that, in the case of a building situated in a certain town/village and fitted out with a proper freezing plant, all parameters that are included in these relations (except the coduction of heat coefficient, λ_{iz}, and the particular expenses for the insulation, c_{iz}) can be considered the same for a certain shut-off device with $t_s - t_i$ and $t_{sm} - t_i$ constants (for outside elements) or, $t_{am} - t_i = \text{const.}$ (for inside elements), wich leads to the conclusion that an overall constant, C, for each case considerated, can be established as it follows [1]:

a) for outside elements (walls, roof-celings):

$$C_e = \sqrt{\frac{(t_s - t_i)r_i c_i + G_r i_{ex} c_{ex}}{r_{\text{iz}}}}, \quad \left[\frac{°\text{C}^{1/2} \cdot \text{lei}^{1/2}}{\text{W}^{1/2}}\right]; \tag{4}$$

b) for inside elements (walls, celings, non-heated floors):

$$C_i = \sqrt{\frac{(t_{am} - t_i)r_i c_i + G_r i_{ex} c_{ex}}{r_{\text{iz}}}}, \quad \left[\frac{°\text{C}^{1/2} \cdot \text{lei}^{1/2}}{\text{W}^{1/2}}\right]. \tag{5}$$

3. A Simplified Calculation Procedure to Determine the Economically Optimal Solution for Shut-off and Division Devices in Cooling Facilities. Determination of the Thermo-economic Efficiency of Insulation

Relations (2) and (3) can also be written depending on the element, namely:

$$d_{\text{iz}}^{\text{opt}} = \frac{C\lambda_{\text{iz}}}{\sqrt{\lambda_{\text{iz}} c_{\text{iz}}}} = C\sqrt{\frac{\lambda_{\text{iz}}}{c_{\text{iz}}}}, \quad [\text{m}]. \tag{7}$$

Utilizing the notation:

$$E_t^{\mathrm{opt}} = \sqrt{\frac{\lambda_{\mathrm{iz}}}{c_{\mathrm{iz}}}}, \quad \left[\frac{{}^{\circ}\mathrm{C}^{1/2} \cdot \mathrm{lei}^{1/2}}{\mathrm{W}^{1/2}}\right], \tag{7}$$

relation (6) can be written:

$$d_{\mathrm{iz}}^{\mathrm{opt}} = C E_t^{\mathrm{opt}}, \quad [\mathrm{m}]. \tag{8}$$

where E_t^{opt} is the thermo-economic efficiency of insulation defined by relation (7).

4. Conclusion

In conclusion, for a given building, equipped with a freezing plant, the value of constant C can be worked out and then it will be determined, for each shut-off device, the optimal thickness of the the termal insulation, taking into account the conduction of heat coefficient and the cost of material.

A choice of the optimal thermo-insulation material would be offered, in our case, by the thermo-economic efficiency, E_t^{opt}, of insulation. The calculations will be made for a particular structure of the shut-off device and will require several types of thermal insulations.

So, the assessement of the economic efficiency of insulations implies its sizing from several adequate materials, the appraisal of each variant and the final selection of the optimal one, through multicriteria, which represents the solution to obtain the minimum yearly cost per unit (m^2-thermo-insulation).

By comparing the results, the heat insulation will be chosen so that the yearly cost and the required thikness be minimum [1].

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METODĂ SIMPLIFICATĂ DE CALCUL PENTRU DETERMINAREA SOLUŢIEI OPTIME DE IZOLARE TERMICĂ LA ELEMENTELE DE ÎNCHIDERE ALE SPAŢIILOR CU TEMPERATURI SCĂZUTE

(Rezumat)

Literatura de specialitate prezintă, în special, relaţii de calcul privind optimizarea izolaţiei termice pentru clădirile echipate cu instalaţii de încălzire, care, prin modul de abordare şi de cuprindere a parametrilor nu pot fi aplicate în totalitate pentru calculul de optimizare a izolaţiilor frigorifice.

Se evidenţiază o metodă simplificată de calcul a termoizolaţiilor pentru frigorifere care, prin introducerea noţiuni de *eficienţă termoeconomică*, dă posibilitatea determinării grosimii optime a stratului termoizolator.