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FACTORS INFLUENCED ON HEAT GAINS AND HEAT LOSSES IN BUILDINGS

The paper presents the results of investigations on building's heat gains and heat losses. The heat balance conditions in selected buildings were observed. The factors, which influence heat gains and heat losses in analysed building were identified. The changes of value of these quantities on the influence of individual factors were estimated.

Introduction. As far as heat gains are concerned, a factor that positively influences heat balance of the building is solar radiation. Both radiation duration and radiation rate are limited. About 80% of the total insolation concerns spring and summer months [1]. During the heating season an average sum of total solar radiation amounts to 1.44 kWh/m^2/24 hrs. Some heat gains result from the existence of additional heat sources connected with the utilisation of building. The gains come from people staying in the building, electrical and gas equipment as well as lighting.

Heat losses in a building result from heat penetration through external and internal partitions as well as from heating up the air exchanged in the ventilation process. Heat lost on penetration has been up till now the highest value in the annual loss account. With low thermal insulation of partitions it amounted to 80%. The observed and predicted increase of thermal insulation of external coating of buildings causes high dependence of heat losses on the ventilation needs. Heat lost on ventilation with air-tight enclosures amounts to 70–80%. Wind is a significant factor intensifying losses. At the speed of 3 m/s heat losses increase 2%, and with 6 m/s exceed by 25% the value of losses as compared to the windless weather. The shape and location of a building has a considerable influence on the whirl and wind velocity. The shape of the building determines as well its energy properties. Precipitation causing dampness of partitions and deterioration of their thermal insulation increases heat losses.

Subject of investigations. Research was conducted in a dozen or so single- family one- or two-storey buildings, built in traditional technology. Two buildings had a complete basement, but only one basement was heated. One building had a partial basement. The buildings were situated with minimal glazing facing north and maximal – south.

Fig. 1. One of the analysed building's

The analysis of heat balance copmonent's. It was determined: window's surface Po, wall's surface Ps, heating surface Pu, cooling partition's surface, heating cubic capatity V, shape's coefficient A/V, glazing's surface Po/Ps, window's surface/heating surface Po/Pu, window's surface/heating cubic capacity Po/V, air change's quantity to ventilation, person's quantity, heat losses and heat gains. The results are shown in Table 1.-3. ($\bar{x}$) it's arithmetic mean, (*H*) it's harmonic mean and (*s*) it's standard deviation.

Table I

Building's parameters

Statistical Indexes	Po	Ps	Pu	V	Po/Ps	Po/Pu	Po/V	A/V
	m^2			m^3	%			m^{-1}
$\bar{x}$	39.6	199.3	231.1	581.9	20.2	17.3	6.9	-
H	-	-	-	-	-	-	-	0.9
S	11.3	57.8	36.2	110.1	3.7	5.0	1.8	0.1

Table II

Air change's quantity to ventilation and person's quantity

Statistical Indexes	Air change's quantity to ventilation	Person's quantity
$\bar{x}$	1.1	5.9
S	0.4	1.4

Table III

Heat gaines and heat losses

Statistical Indexes	Heat gaines		Heat losses	
	kWh/rok	GJ/rok	kWh/rok	GJ/rok
H	26 140.0	92.9	34 646.3	124.8
S	6 192.4	17.9	7 555.1	24.1

Analysing fluctuations of the values of heat gains in the general heat balance of given buildings the influence of the the heated cubic capacity, surface of transparent partitions as well as the number of people inhabiting the given buildings was examined. Similarly, only the relations for the factors for which the correlation coefficients remained at the level 0.5 – 1 were presented. For the rest of determined factors the correlation coefficients were below 0.2. The given relations are illustrated by figures 2-6.

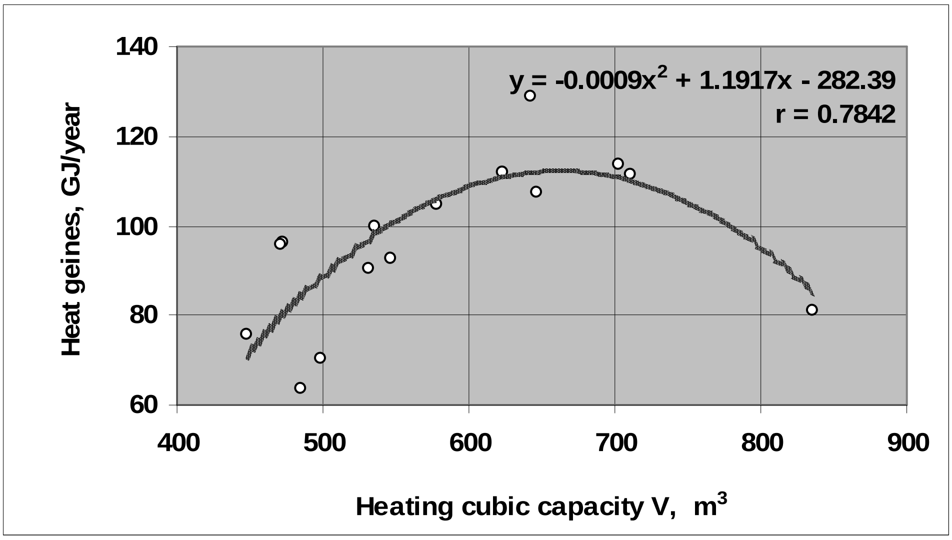

Fig. 2. The V influence on heating gains

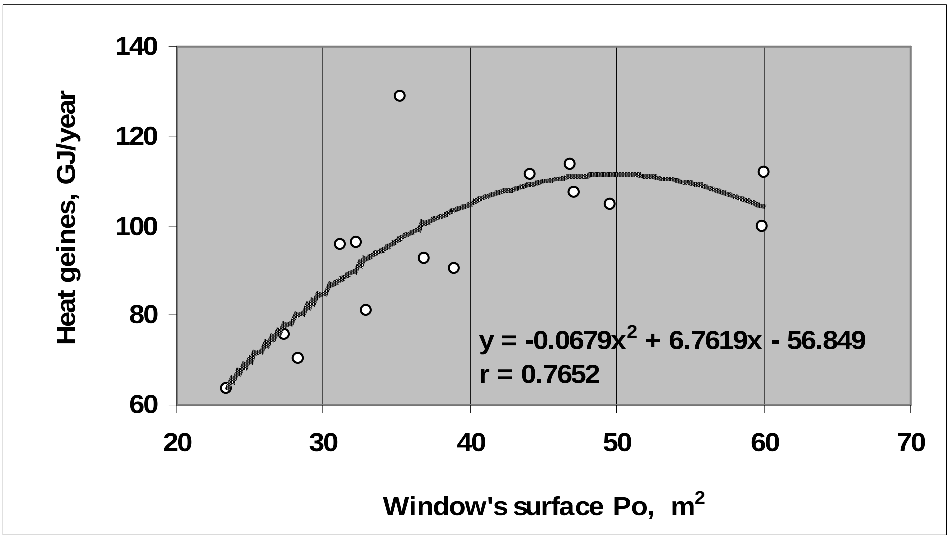

Fig. 3. The Po influence on heating gains

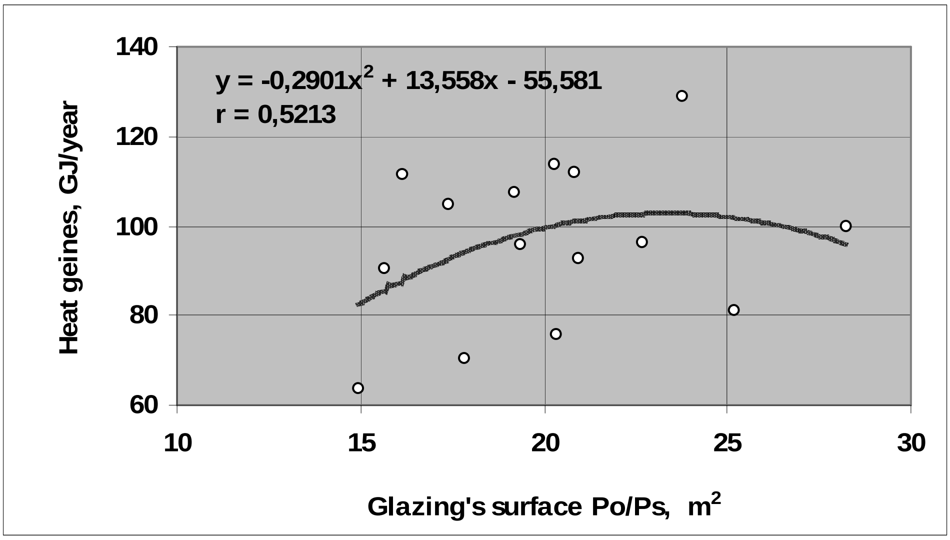

Fig. 4. The Po/Ps influence on heating gains

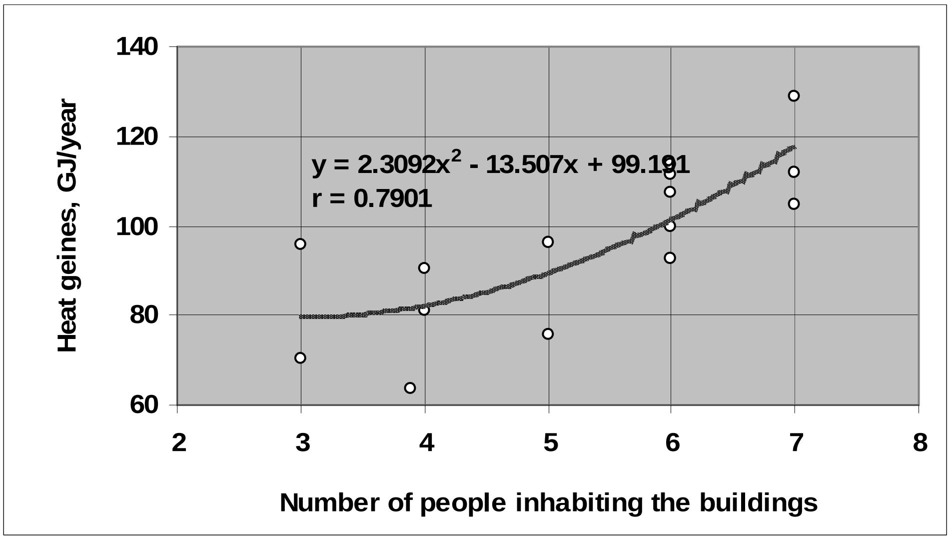

Fig. 5. The number of people inhabiting the buildings influence on heating gains

Undoubtedly, a significant influence on the generated value of heat gains obtained from solar radiation is related to the appropriate location of the building in relation to the directions of the world, depending on a degree of elevation glazing. This influence was analysed gradually turning the building every 45^{o} in relation to the original location of elevation with the lowest glazing in the northern direction and to the elevation with the highest glazing in the southern direction.

The results of the analysis are presented in figure 6.

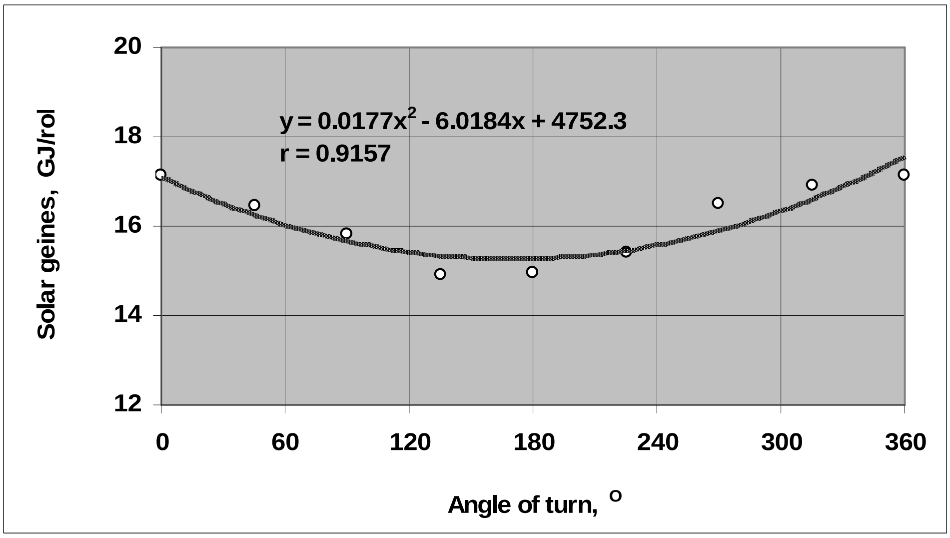

Fig. 6. The cardinal points building's location influence on solar gains

Solar gains in the given buildings remained at the level 16.1 GJ/year with the standard deviation equalling 0.9 GJ/year.

Analysing fluctuations of the values of heat losses in the general heat balance of given buildings the influence of the cooling partition's surface A, the heated cubic capacity V, the shape's coefficient A/V, the surface of transparent partitions Po, wall surface Ps, glazing's surface Po/Ps as well as the air change's quantity to ventilation in given buildings was examined. Fig. 7-13 illustrate the formation of values related to heat losses in given buildings depending on the selected factors.

Regression equations correlations and coefficients were determined. Similarly, only dependencies for the factors for which correlation coefficients remained at the level about 0.5 to 1 were presented. For the rest of determined factors the correlation coefficients were below 0.3.

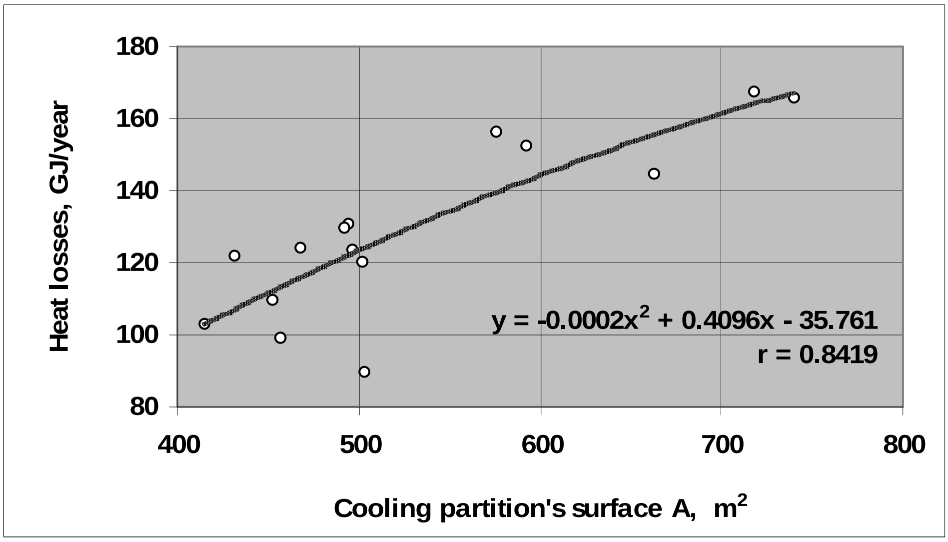

Fig. 7. The A influence on heat losses

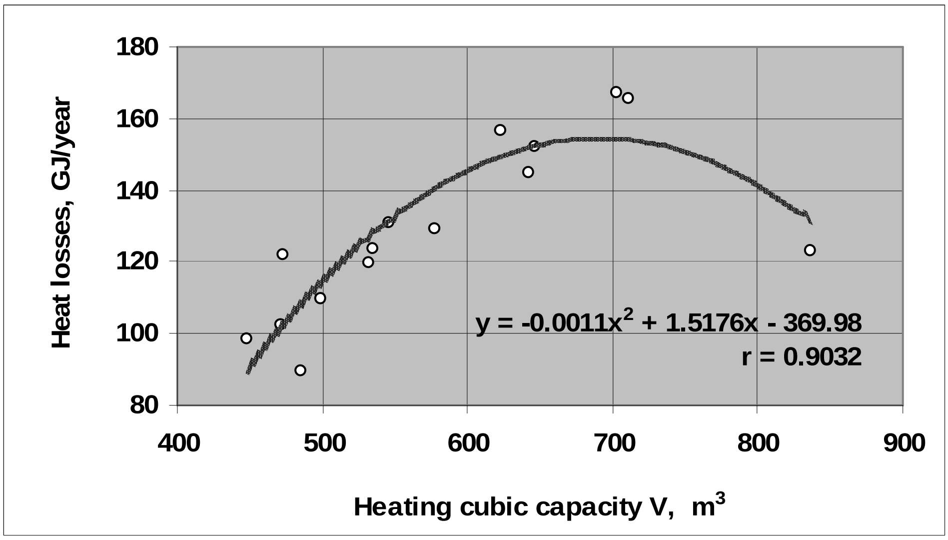

Fig. 8. The V influence on heat losses

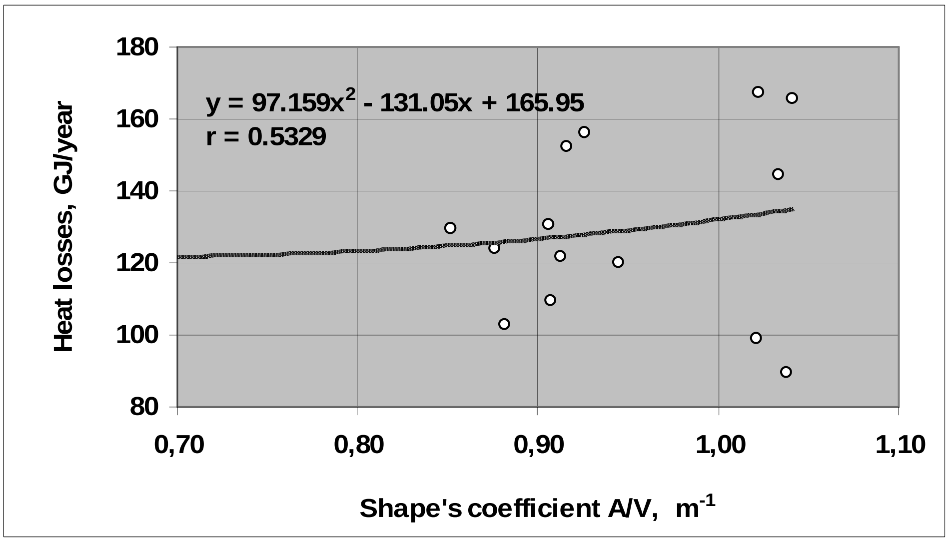

Fig. 9. The A/V influence on heat losses

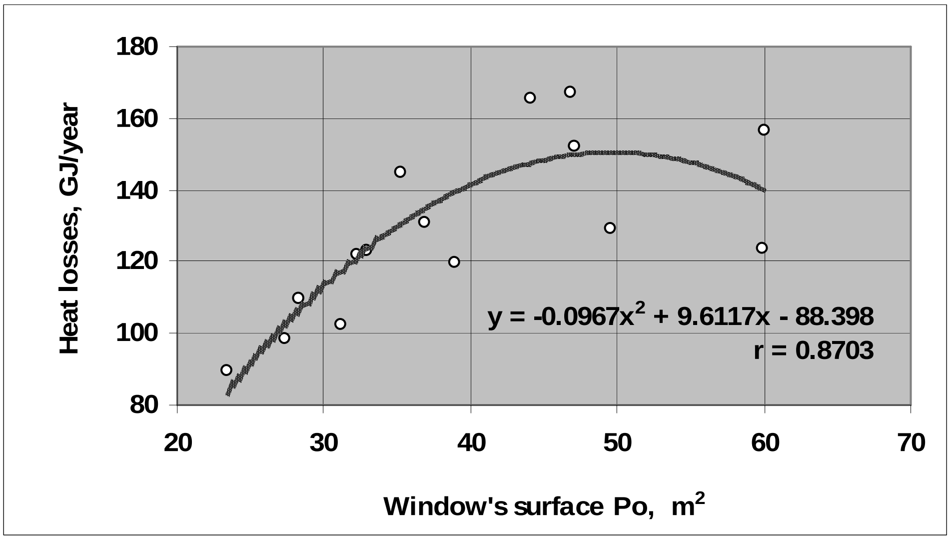

Fig. 10. The Po influence on heat losses

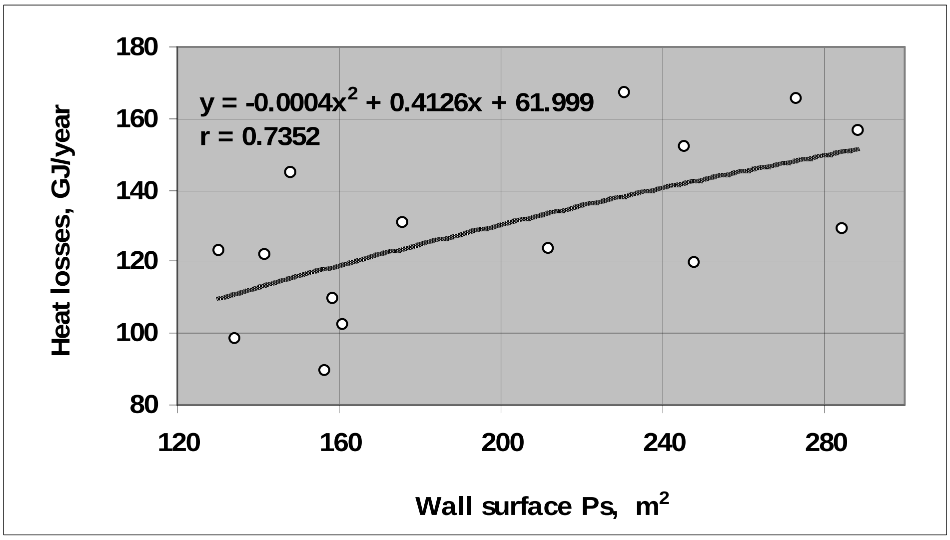

Fig. 11. The Ps influence on heat losses

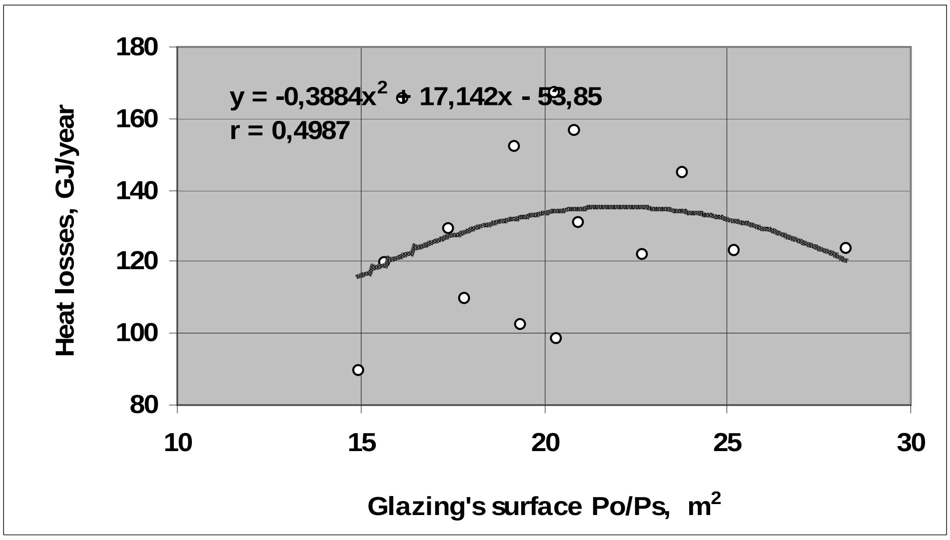

Fig. 12. The Po/Ps influence on heat losses

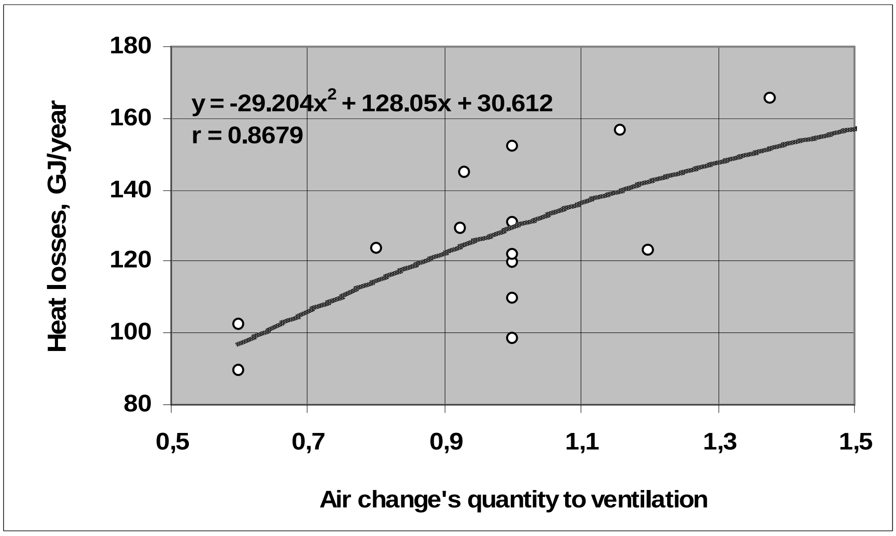

Fig. 13. The air change's quantity to ventilation influence on heat losses

Conclusions.

– A factor which has a beneficial influence on heat balance is solar radiation, which is on the side of heat gains. For the sake of analysis the influence of solar radiation on heat gains it is more beneficial to use the wall surface area. In this case the changes in glazing by 13% influenced the changes in heat gains.

– Directing the elevation with the maximal transparent partitions towards north causes about a 15% drop in gains from solar radiation.

– Another factor that lowers the gains from radiation is shading the elevation.

– The amount of heat lost through partitions mainly depends on their surface area, heat-insulating properties and the temperature difference.

– For the sake of energy management a bigger density of the building's solid is advantageous, however a shape factor has a direct and more significant influence on heat consumption than exclusively on its losses. A more significant relation was obtained for the analysis of the influence of the surface of cooling partitions.

– Increasing in a certain bracket the insulation thickness influences to a small extent the percentage increase of capital spending, however after having reached a certain value further increase of insulation thickness does not result in the noticeable economic effects, but it becomes a source of construction problems.

– Analysing the heat losses it is more beneficial to use only the window surface, and not the elevation glazing. In the first case a clear correlation was noticed, while the changes in elevation glazing influenced the changes in heat losses only in 7%. Excessive size of transparent surface area is to a larger extent a source of increased heat losses than the factor generating considerable gains. In summer however it causes the overheating of rooms and the loss of thermal comfort.

– Keeping the required parameter values of microclimate, and especially of temperature, also influences the heat losses. Lowering the temperature from 20 ^{o}C to 18 ^{o}C causes the heat drop by about 8.5 %[2].

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