RESEARCH ABOUT THE INFLUENCE OF INTERNAL HEAT GAINS ON ENERGY PERFORMANCE EVALUATION OF INDUSTRIAL BUILDINGS

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Abstract: This paper attempts to demonstrate how the internal heat gains influence the energy performance of industrial buildings. In order to achieve this, the paper considers a concrete case of a production hall. The energy performance of this buiding is calculated by taken into account three variants: the first one – a reference variant, the second one- a version that does not account for heat gains related to the production process and the third one - normal operating conditions. The calculation methodology is the one related to Romanian regulations in force, using the simplifying assumptions of these regulations.

Keywords: energy performance of the building, internal heat gains, annual heat demand, energy need for cooling

1. INTRODUCTION

The industrial sector has the largest share of the Romanian total electricity consumption, respectively 56.1%. Also, according to the document submitted to public review, Romania's Energy Strategy, thermal energy consumption in Romanian industrial sector in 2008 was 323,490 thousand t.o.e. from 1795,490 thousand t.o.e., so 18% of the final consumption of thermal energy. In 2013, the thermal energy consumption in the industrial sector was accounted for 258,660 thousand t.o.e. from 1415,670 thousand t.o.e., which represent 18.27% [1].
For a long period of time, the main focus of the industry has been to increase productivity but, the new sustainable development policy involves reducing CO2 emissions. This can be achieved by increasing energy efficiency, by default through intelligent use of electricity and heat in industrial processes and of buildings in which these processes are carried out [2]. The energy used for the thermal comfort of the buildings in the industrial sector is an important component of energy consumption, so it is important to know how it is influenced by different factors.
In the monthly calculation method from the national norm MC001/2, in accordance with EU norm ISO 13790, the heat demand of the building, Q_h, is defined for each calculation period [3]:

$$Q_h = Q_L - \eta * Q_g, \text{ [J]} \tag{1}$$

where Q_L is the heat loss of the building (J), η the utilisation factor of heat gains and Q_g the total heat gains, including solar and internal heat gains (J). The annual heat demand is the sum over all the months with a positive heat demand.
The utilisation factor of heat gains, η, is a mitigation factor of heat contributions provided to compensate for additional thermal losses that occur when heat gains exceed the calculated heat loss.
In the same way, is defined the energy need for space cooling for each calculation period (month or season) which is calculated, according to ISO 13790 [4]:

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$$Q_c=Q_g-\eta_C*Q_L, \text{ [J]} \tag{2}$$

where Q_c is the building energy need for cooling (J), Q_L the total heat transfer for the cooling mode, Q_g the total heat sources for the cooling mode, (J) and η_c the dimensionless utilisation factor for heat losses.

The internal heat sources include [4]:

- metabolic heat from occupants and dissipated heat from appliances;
- dissipated heat from lighting devices;
- heat dissipated from or absorbed by hot and mains water and sewage systems;
- heat dissipated from or absorbed by heating, cooling and ventilation systems;
- heat from processes.

Industrial halls are very simple constructions with relatively loose requirements in heating and cooling, but with high internal heat gains. A lot of research papers suggested that there is a significant energy saving potential with some changes in the process load, the occupancy pattern and the using of the daylight. [5], [6], [8]. The aim of this paper is to demonstrate how the internal heat gains influence the energy performance of industrial buildings.

2. CASE STUDY

The studied building is a prefab building with a structure made from pillars and beams, galvanized cold profiled rafters 2KB500-5 mm. The elements of the external building envelope are:

- The exterior walls, made of coated wall-cladindding boxes with glass wool layer insulation with 80 mm tickness and pre-painted trapezoid-profiled steel sheets 0,6 mm tickness, hot — galvanized;
- The sectional aluminium doors;
- The non – walk roof terrace, made of pre-painted trapezoid –profiled steel sheets, tickness 0,6 mm, hot-galvanized with glass wool layer – 80 mm insulation thickness ;
- Light shafts of polycarbonate 5 mm tickness with translucide termoisolation;
- Ground plate is made of concrete fine leveled and finished with epoxy based paint.

The building has no special items shading facades. For thermal comfort the building was equiped with four Rooftops York D1G120, each with a nominal cooling capacity of Qc = 34,7KW and a nominal gas heating output capacity of Qh = 56,5KW.

Table 1. Constructive features of the building

No.	Building	Height H_{med} [m]	Built area A_c [m^2]	Usable area A_u [m^2]	Volume V [m^3]	Inside temperature, in winter $\Theta ij,w$ [˚C]	Inside temperature, in summer $\Theta ij,s$ [˚C]
1	Industrial hall	4,92	1736,00	1694,70	8343,87	18,00	25,00

In table 2 are shown thermal characteristics of the elements of the building envelope: areas of building envelope components S_j, [m^2], and adjusted thermal resistances R_j', [m^2*K/W], where j- is a component of the hall envelope. The adjusted thermal resistance is calculated considering the effect of the thermal bridges.

Table 2. Thermal features of the elements of the building envelope

Element of building envelope	S_j [m²]	R_j' [m²*K/W]
Exterior Walls	837,35	1,54
Exterior Doors	64,53	2,13
Ground plate	1694,70	3,06
Non -walk roof teracce	1481,87	2,05
Light shafts	267,41	0,46

The thermal resistance of the entire exterior envelope is calculated using the following formula [7]:

$$R' = \frac{\sum_j S_j}{\sum_j S_j \times R'_j} = 1{,}788, \text{ [m²*K/W]} \tag{3}$$

Internal heat gains
The industrial hall is equiped with a lot of special machines like injection molding machines, deburring machines and welding machines. It examines three variants, respectively:
Variant 1. It is taken into consideration the conventional norm SR 13790 - 2008 where the value of internal heat gains per unit of square is a = 3,01 W/m^2.
Variant 2. The heat gains from the equipment used in the production process are not considered, only the heat gains from occupants and lighting are considered. In this case, the value of heat gains per unit of square is a = 8,02 W/m^2.
Variant 3. Normal operating conditions with continuous operation mode (3 shifts in 24 hours), with 40 people and heat gain from the lighting considered. The internal heat gains per unit of square of the equipments used in production process are shown in table 3:

Table 3. Heat flow rates from the internal sources in variant 3

Parameter	U.M.	Value
Heat flow rates from equipments	W	46600
Number of occupants		40
Heat flow rate from an occupant, according EN ISO 13790	W/occupant	130
Total flow rate from all occupants	W	5200
Lighting	W	10496
B Coefficient, according EN ISO 13790		0,8
Heat flow rate from lighting	W	8396,80
Sum of heat flow rate from internal heat sources	W	60196,80
Useful area	m^2	1694,70
Internal heat gains pers units of square, *a*	W/m^2	35,521

3. RESULTS

The energy performance of the industrial hall is calculated according to the method used by the Romanian norms Mc 001, which is comparable to the method of EN ISO 13790 and consequently, in accordance with the EU regulations. In table 4 are shown the principal indicators of energy performance calculated for the analyzed industrial hall.

Table 4. Performance indicators

Legend	Indicator	U.M.	Variant 1	Variant 2	Variant 3
Bulding energy rating	N	-	89,26	90,97	93,47
Internal heat gains	a	W/m^2	3,01	8,02	35,52
Energy use for heating	q_{inc}	kWh/m^2per year	237,28	201,93	79,66
Energy use for hot water	i_{acm}	kWh/m^2 per year	2,77	2,77	2,77
Energy use for lighting	w_{il}	kWh/m^2 per year	21,48	21,48	21,48
Energy use for ventilation	q_v	kWh/m^2per year	9,47	8,36	8,36
Energy use for cooling	q_{rac}	kWh/m^2per year	32,07	42,95	128,80
Energy use	q_T	kWh/m^2 per year	303,07	277,48	241,07
Total energy consumption	Q_T	MWh/year	513,61	470,25	403,85
CO_2 emissions	i_{CO2}	kg/m^2 per year	54,56	48,19	30,86

The principal results are shown in a grahical representation in figure 1:

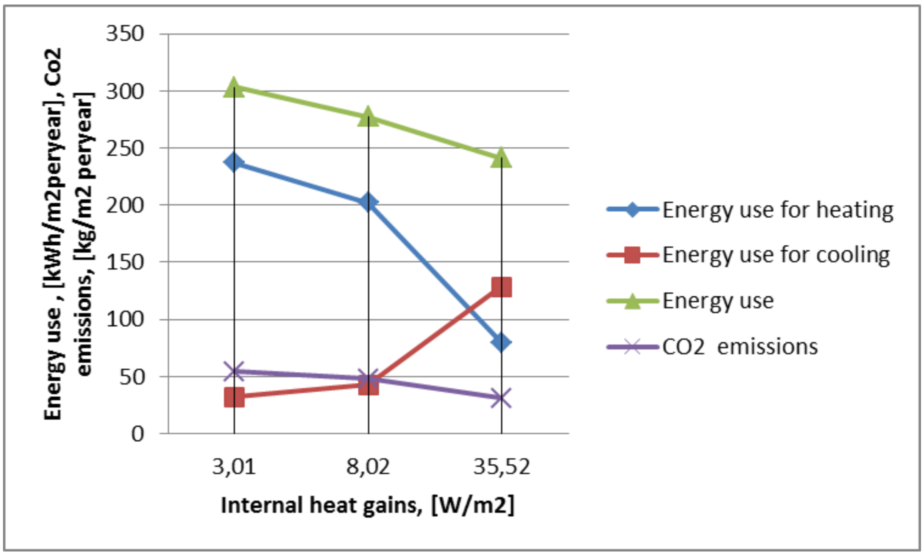

Figure 1. The variations of the energy used for heating, for cooling and total energy depending on the internal heat gains

4. CONCLUSIONS

Energy consumption and CO_2 emissions for an industrial hall depend on the internal heat gains. As shown in figure 1, big internal heat gains involve an increase in the energy used for cooling, a decrease in the energy used for heating and finally a decrease in the energy consumption of the whole building.

To realize the most efficient energy configurations for the industrial hall, is necessary to know precisely the destination of the hall, its type of production process and the number of occupants.

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