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Original Paper

Assessment of temperature parameters in the heated and unheated part of the hall object

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ABSTRACT

The article is aimed at the assessment of the temperature of the indoor environment in the heated and unheated part of the mechanic-repair hall object. Examined hall was provisionally separating by PVC hinge in the middle (dividing the hall into a heated and unheated part), with a view to reducing the cost of heating it, which was provided by two hot air heaters. In the paper, we assessed the effect of the PVC hinge to the temperature of the indoor environment. The measurements were carried out during winter temperature extremes. In the monitored hall, the surface temperatures of the floor construction were permanently recorded in 5 minute intervals during 24 hours with the surface temperature detector DT 10 and the air temperatures by the Dataloggers Comet and then there were statistically evaluated their interdependencies. By regression analysis it was detected a significant dependence between air temperature and floor temperature at all three measuring points F1 - F3 ($P < 0.05$), in the heated part of the hall. The degree of dependence R was between 0.68 and 0.87. Similarly, it was also assessed an unheated part of the hall, where regression analysis of the results showed that there is very high dependence ($P < 0.05$) between the air temperature and the floor temperature at the measuring points F4 and F5 what is also evident from the time course of the recorded temperatures. The degree of dependence R was between 0.86 and 0.92. There were statistically compared the temperatures of the air in the heated and unheated part using the Tukey HSD test, where statistically significant differences were found, which was also confirmed by statistical analysis of F-test ($P < 0.05$). By measuring the internal air temperature, it was found that the critical point of heat leakage was the uninsulated sheet metal gate, where the lowest temperatures from -2.5 to 5 °C were measured. Due to large heat losses, the entrance gates were also separated from the heated part of the hall with PVC tarpaulin. For this reason, we focused on this part of the hall in which we statistically assessed the internal air temperature in the heated and unheated part of the hall at the entrance gates, where there were found significant differences from the statistical analysis of F-test and also by the Tukey HSD test ($P < 0.05$). In the part at the entrance gates the PVC curtain prevented a large leakage of heat. In the heated part of the hall, where was reached more stable temperature, were not recorded extreme values, as opposed to the unheated part of the hall, where occurred relatively high temperature fluctuations. Based on the results it was detected significant effect of PVC curtain on the temperature course in the hall.

KEYWORDS: heating, air temperature, surface floor temperature, hall object, PVC hinge

JEL CLASSIFICATION: Q49

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INTRODUCTION

In the past, emphasis wasn´t placed to energy performance of buildings, which we feel currently mainly in old large area buildings with high energy costs [1]. Many adverse economic aspects, in particular the significant increase in energy prices, encourage efforts to search for new alternatives in all areas of environmental engineering. Otherwise it isn't even in heating [7]. At the time of use of production facilities, floor structures are in most cases the most stressed part of the building [5]. Most industrial hall type buildings are large and the accurate design of the substructure construction is influenced by many entry parameters from the standpoint of structural analysis, building thermal technology, building hydro-insulation technology and anti-radon measures [10]. The most important internal influences can be included the indoor air temperature, the warming of the surrounding surfaces, the relative humidity of the indoor air and the movement of the indoor air [5]. Internal air temperature is influenced by variations in outdoor conditions such as temperature, solar radiation or meteorological situation [8]. The thermal and humidity conditions of the working environment are determined by temperature, relative humidity and air flow rate [11]. The objective of the hall objects modernization should be the energy consumption reduction [2], [3], interior climate improvement [6] and improvement the way of heating. Manufacturing buildings will have to very quickly adapt to the ever-changing market demands [4].

MATERIAL AND METHODS

The object of research was hall of the agricultural purpose built-construction. The height of the heated part of repair object was 8.8 m in internal dimensions of hall 36.4 x 18 m, which is 655.2 m^2 of the total heated area. Almost the entire longitudinal wall of the hall consisted of window openings of a total width of 33 m and height of 1.8 m. The heating of the repair workshop in the winter season was due to its large dimensions and associated high heating costs provisionally solved by separating of hall with PVC hinge to two parts. One part of hall was heated and the other part was unheated. In the hall there was also a large heat loss through the uninsulated entrance doors of 5.1 m wide and 5.4 m high. For this reason, the doors were also separated from the heated part of the hall in winter season by the PVC hinge. Heating of the repair workshop was ensured by two hot air heaters with maximal power 49 kW. The heating medium of the heaters was natural gas. For reasons of economies on heating costs was examined object in winter season utilized by workers only partially. The hall was heated during working hours on a thermostat set to 11 °C and out of working hours and during the weekend it was heated to 6 °C. The measurement was carried out during the winter temperature extremes at the weekend operation. By experimental examination, the internal surface temperatures of the floor structure and the internal air temperatures were considered in the examined parts of the hall. The surface temperatures of floor construction were recorded by temperature detector DT 10 in 5 minute intervals during 24 hours. In the heated part, the surface temperatures of the floor structure were monitored at 3 locations F1 - F3 and in the unheated part of the hall at the 2 points F4 and F5 (Figure 1). The internal air temperatures were measured at the same intervals using the Datalogger Comet.

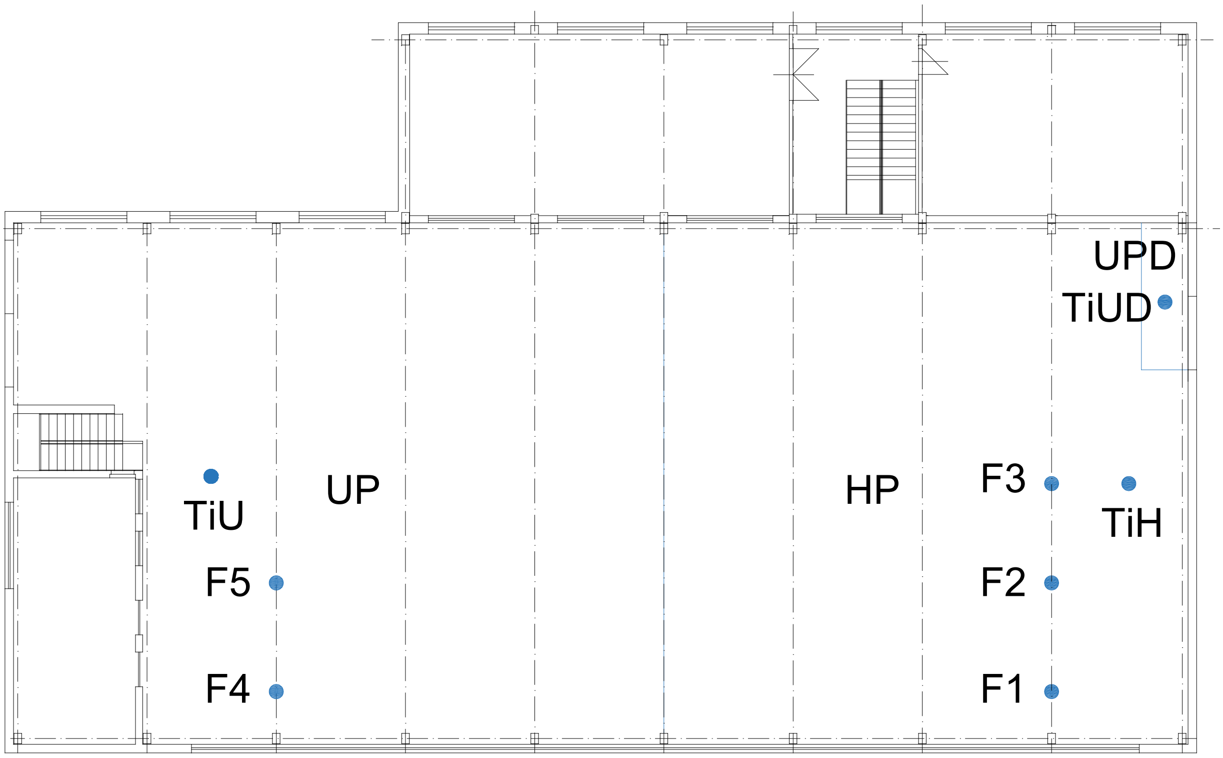

Figure 1 Scheme of measuring places in the mechanization and repair hall

F1 – F3 surface floor temperatures in heated part of hall,
F4 – F5 surface floor temperatures in unheated part of hall
TiH – internal air temperature in the heated part of hall
TiU – internal air temperature in the unheated part of hall
TiUD – internal air temperature in the unheated door
HP – heated part of hall
UP – unheated part of hall
UPD – unheated part – door

RESULTS AND DISCUSSION

The regression analysis of the results showed (Table 1) the significant dependence ($P < 0.05$) between the air temperature in the heated part of the hall and the floor temperature at all three measuring points F1 - F3. The degree of dependence R was between 0.68 and 0.87. From the measured temperature course in the heated part of the repair hall we can conclude that the internal air temperature has a significant influence on the floor temperature at the measuring points F1 - F3, as can be seen from Figure 2.

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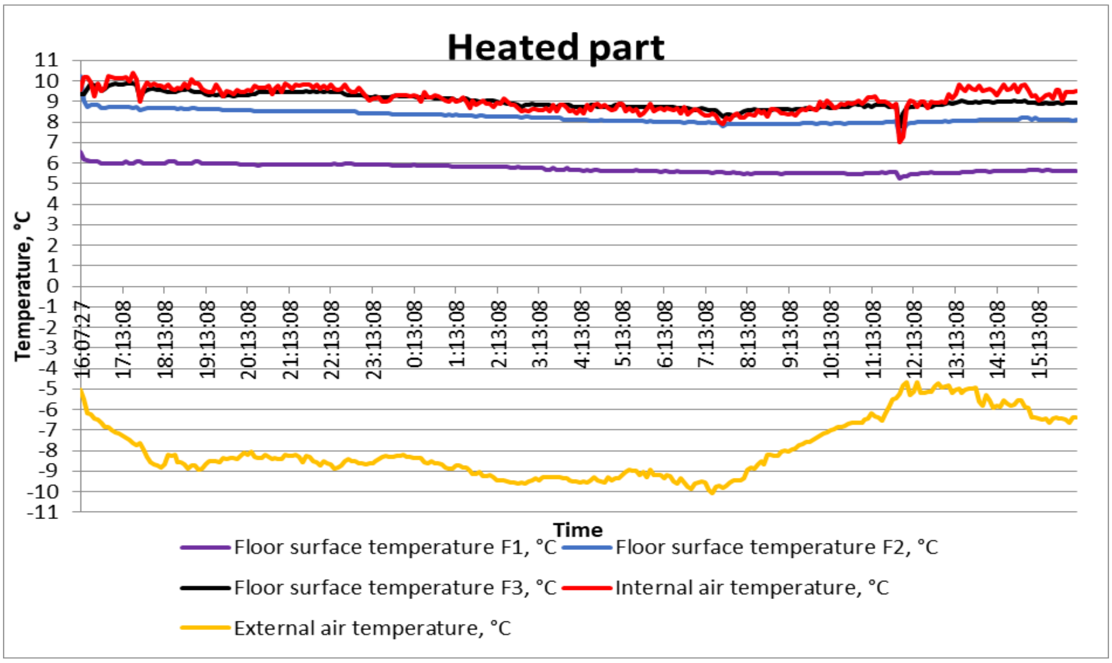

Figure 2 The time course of measured floor surface temperatures in heated part of the repair indoor object and internal and external environment temperatures

Table 1 Results of regression analysis with dependent variable Floor surface temperature, $P < 0.05$

Dependent variable	Air temperature HP
Floor surface temperature F1	R = 0.680080
Floor surface temperature F2	R = 0.741369
Floor surface temperature F3	R = 0.879005

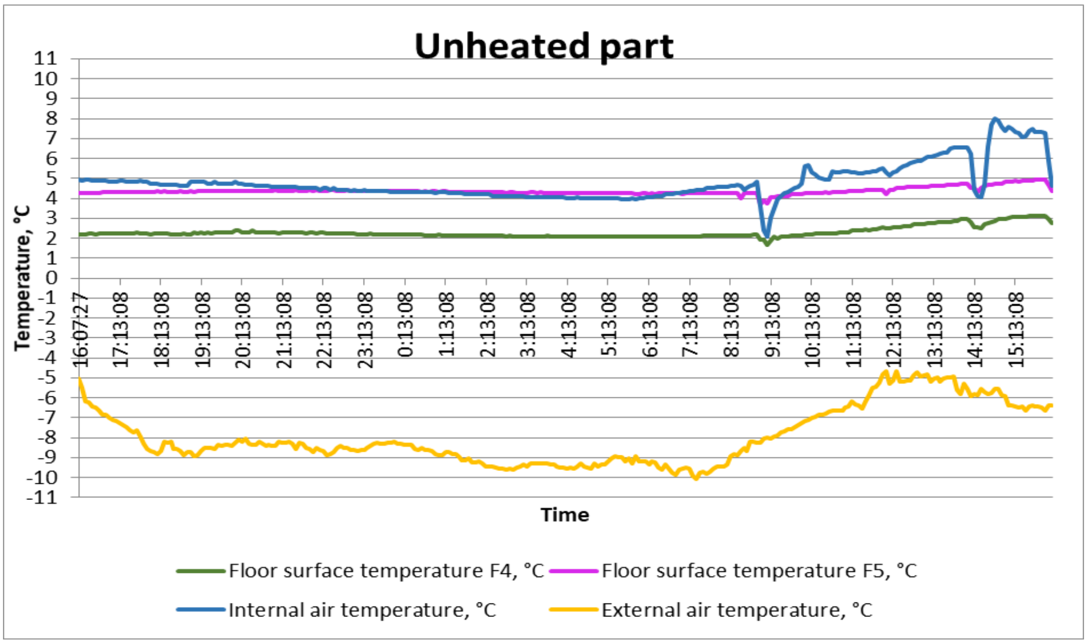

Figure 3 The time course of measured floor surface temperatures in unheated part of the repair indoor object and internal and external environment temperatures

By assessing the influence of indoor temperature in the unheated part of the hall on the floor temperature at the measuring points F4 and F5, we determined a very high dependence (P < 0.05) by regression analysis (Table 2). It is evident also from the time course of recorded temperatures in 24 hours (Figure 3). The degree of dependence R was between 0.86 and 0.92.

Table 2 Results of regression analysis with dependent variable Floor temperature, P < 0.05

Dependent variable	Air temperature UP
Floor surface temperature F4	R = 0.924374
Floor surface temperature F5	R = 0.866105

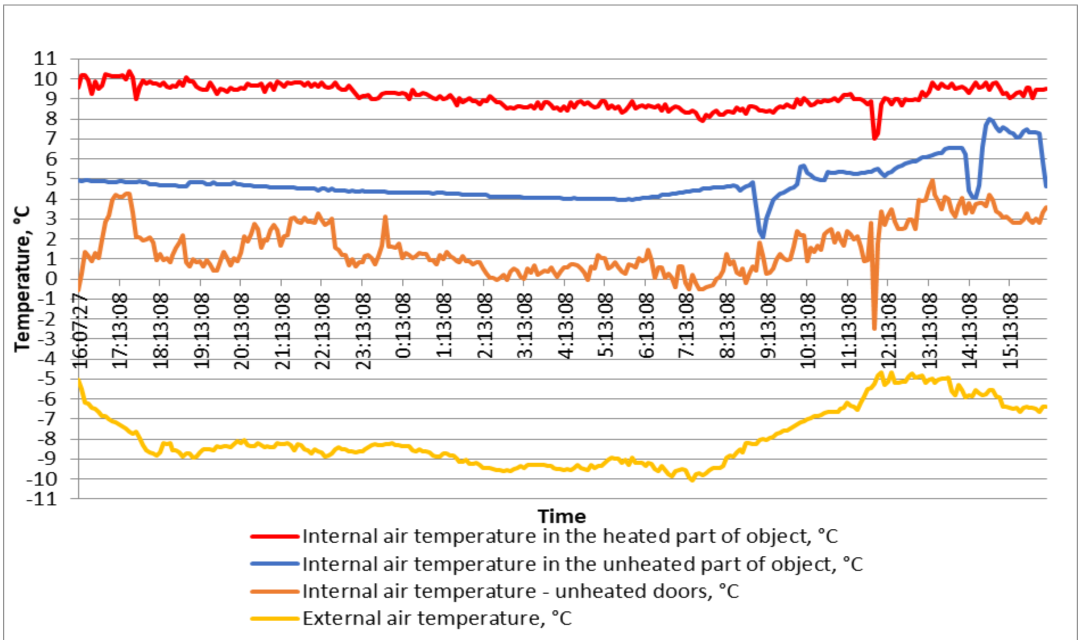

Figure 4 Comparison of air temperatures in individual parts of the hall during 24 hours in the winter season

There were compared the temperatures of the air in the heated and unheated part of the repair hall using the Tukey HSD test (ANOVA, Statistica 10). Based on this, we found statistically significant differences (Table 3, 4) between the air temperatures in the examined parts of the hall. By the F- test there were detected a statistically significant differences among indoor temperature in the heated and unheated part of the hall, shown in Figure 5 (P < 0.05). The air temperature in the heated part ranged from 7 to 10 °C while in the unheated part from 2 up to 8 °C during the 24-hour measurement. The lowest temperatures occurred in the unheated part at the entrance doors where the internal air temperature ranged from -2.5 to 5 °C, as can be seen in Figure 4. For this reason, we assessed the internal air temperature in the heated and unheated part of the hall at the entrance doors. By the statistical analysis of F-test we found the significant differences (P < 0.05) (Figure 6).

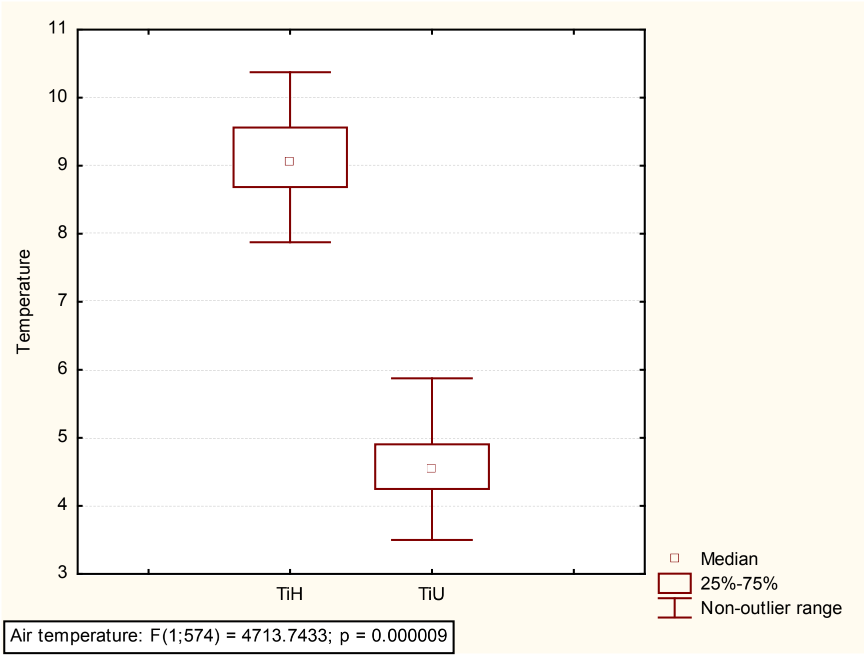

Figure 5 Comparison of internal air temperature in the heated and unheated part of hall (Statistica 10, F test, Anova, P < 0.05)

Table 3 Tukey HSD test; internal air temperature is variable in heating part of object and unheated part of object, homogeneous group, alpha =, 05000

Number	Position	Average value	Homogeneous groups	
			1	2
1	TiU	4.796007	****	
2	TiH	9.118707		****

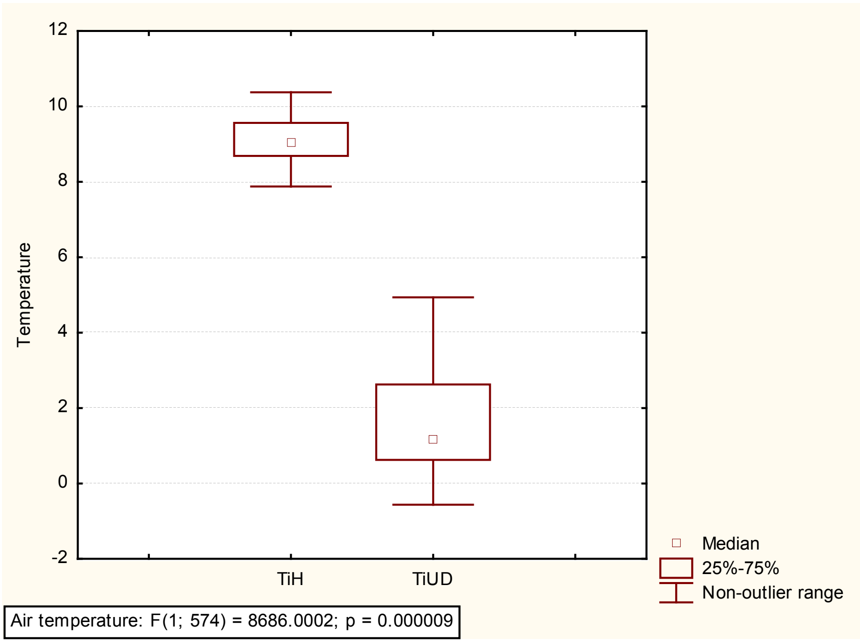

Figure 6 Comparison of internal air temperature in the heated part and unheated part at the entrance doors (Statistica 10, F test, Anova, P < 0.05)

Table 4 Tukey HSD test; internal air temperature is variable in heating part of object and unheated doors, homogeneous group, alpha =, 05000

Number	Position	Average value	Homogeneous groups	
			1	2
1	TiUD	1.572483	****	
2	TiH	9.118707		****

Based on the measured data it can be concluded, that more stable temperature was reached in the heated part of the hall, where the extreme values were not recorded [9]. In the unheated part of the hall there were relatively high temperature variations, where they significantly changed the internal air temperature. The heat from the heated part of the hall partially flowed into the unheated part, while heating the air, but the heating effect did not show up at the floor temperature in the unheated part of the hall. This may be due to the fact that a certain amount of heat primarily destined for the creation of thermal comfort in the interior escapes from the baseplate to the cooler subgrade. As indicated [10], outgoing heat represents heat losses which unfavorably affect the overall energy efficiency of the building. These heat losses represent approximately 15 to 20 % of the overall heat losses of the building [10]. The biggest heat loss occurred in the unheated part of the hall at the entrance door, where the using of PVC hinge to separate the door from the heated part of the hall was the most significant effect.

CONCLUSIONS

The heated part of hall meets only the minimum requirements for the indoor environment, when considering the minimum permissible operating temperature for a given class of work. An additional heat source should be considered at the workplace in the case of a "light work" requirement. Based on the results obtained and at the given outdoor air temperatures, which ranged from –10 to –4 °C at the time of measurement, it is possible to note the considerable influence of PVC hinge on the temperature course in the hall. The use of PVC hinges as a room divider in order to save energy for heating is a possible alternative solution especially for old large-scale hall buildings, where the possibility of thermal insulation of building structures and the exchange of transparent elements would be too expensive.

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