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Surface temperature of slatted floors out of different materials

A thermal imaging camera was used to show the development of the floor temperatures of different slatted floor elements in a pig fattening pen. For the determination of precise values, the body and the slits must be measured separately, which leads to methodological problems not only with regard to the chosen measuring technique. As compared with summer conditions, the floor temperature only shows a very slow development in relation to the indoor temperature in the winter. The temperature differences found between the individual slatted floor elements depend on the material and not so much on the percentage of slits (0 to 50%). The resulting floor properties must be seen in connection with the seasons. The temperature differences are not sufficient for the reliable control of animal behaviour with regard to adequate lying surface acceptance.

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Literature

References can be called up via internet (www.landtechnik-net.de/literatur.htm) under LT 08306

Structure and surface temperature are significant characteristics of the surface properties of floors in animal houses. Depending on the area of application in animal housing, the properties of the material used can be of considerable importance for the functional reliability of housing systems with solid floors or for animal health in farrowing pens. In choice tests, the pigs select their lying area not primarily based on floor properties, but rather based on temperature [1]. In principle, solid floors are preferred for resting. Under practical conditions, surface temperature data for different floors vary not only as a function of the housing system. At temperatures common in practice, slatted concrete floors should be 3 to 5 °C colder than solid concrete floors and 7 to 8 °C colder than a manure mattress [2]. It is questionable how large this difference is in other temperature ranges because it is becoming more and more difficult to compensate for outdoor temperature fluctuations in conventionally equipped warm stalls at a reasonable expense. Under the conditions of temperature stress, which occurs sooner today than in the past depending on performance (> 18.5 to 23.0 °C) [2; 3; 4], observations show that the animals leave their resting areas for cooler pen sections.

Studies which lasted several years [5] showed that temperature comfort and pen structure are the two main factors which support animal behaviour in the desired manner depending on the structure of the animal house. The study presented below was intended to show which contribution the design and the material of the slatted floor can make towards the development of floor temperatures at increasing room temperatures.

Material and methods

A compartment with a volume of 177 m^3 (~ 2 • 35 places, 35 m^2 per pen), which is relatively small for pig fattening, was built into an existing animal house shell with a slurry channel system (channel depth: 70 cm) underneath. On the stall floor, several variants of commercially available slatted floors from different manufacturers were installed (concrete floors with a slit percentage of 0%, 10%, and 13%, plastic floors with a slit percentage of 10%, and triangular section steel elements with a slit percentage of 50%). During the studies, no animals were in the stall, and the slurry channel was entirely empty and clean. With the aid of a gas heater (4 to 15 kW), the animal house was heated up to three room temperatures (20 °C, 25 °C, 30 °C) controlled by the climate computer (manufacturer: Skov) once during the warm season (July 2007) and once during the cold season (November 2007). Except for the 20 °C measurement in the summer (without heating), a pre-heating time of at least 48 hours was kept. In the trial compartment, 15 different measuring points were determined on the floor (*Fig. 1*). In temporally defined intervals, these points were measured with a thermal imaging camera and an infrared thermometer. In the evaluation, only the results of the thermal images with a higher informational value are shown.

For the radiation emission factor of the floors used, a standard value of 0.95 was determined. In order to show a continuous temporal course, exactly the same image parts were evaluated. This requires that the photos are taken at the same height and the best possible frontal angle between the camera and the floor element. As a distance from the slatted floor surface, a height of 1.2 m was kept. Using a total of 90 photos, which showed a section of approximately 12,000 points, separate measurements of the slatted floor bodies and the slits were carried out and evaluated. This approach is problematic under methodological aspects because air temperatures in the slits cannot be measured without aids. For this purpose, the slits were sealed with different materials (parchment, adhesive plastic tape). The temperatures averaged over the image points were considered in the calculation based on the percentage of the surface (slatted floor body 0.5 to 0.9, slits 0 to 0.5). In the evaluation, the positioning of the slatted floor element in space was taken into consideration, and distance from the gas heater was corrected accordingly.

Results and discussion

Largely independent of the stall floor used, the slatted floor temperature of 20°C required for stalling-up is reached in the winter only after the relatively small compartment (room height: 2.37 m) has been heated for 48 hours. In the summer, however, the floor temperature is supported by the outdoor climate and follows the outdoor temperatures relatively far. Unfortunately, the different stall floors can compensate for this development, which is a heavy burden on pigs, only to a small extent. The differences caused by the material used have an effect in particular when temperatures in the animal house are low. This leads to different surface temperatures. As expected, the lowest temperatures are measured on triangular section steel, whereas temperatures on plastic are the highest. In the unheated animal house, the surface temperatures of the metal floor grids determined in the summer are even higher than those of all other materials. This shows that the material properties only have an effect if a certain necessary temperature gradient exists between the floor and a medium (the building shell), which allows the heat to be dissipated. In the winter, the foundation removes the heat in a particularly efficient manner because it is cool, which results in heat dissipation from the interior of the building. This can be advantageous for the design of the standing areas of fixed sows in farrowing stalls if space and floor temperature range above an optimum. Without animal occupation and at an average annual compartment temperature of 25 °C, which is often reached, the metal floor is approximately 1.5 °C cooler than the alternative plastic floor. In the winter, the differences caused by the material grow with indoor temperature. In the summer, they become smaller and can even be inverted.

Theoretically, the physical properties (thermal conductivity, mass) of different floor materials can make a positive contribution towards the functionality of the entire system. In particular in pig fattening, however, where relatively few materials (concrete, cast iron) are available, it has been proven that they do not guarantee sufficient functional reliability of the stall system [5]. One possible explanation could be that under practical conditions and in particular at high stall temperatures the available materials can absorb and, if necessary, dissipate heat only to a limited extent This also applies to floors out of different materials even though the material characteristics differ significantly. The indicated thermal conductivity values of cast iron, concrete, and plastic amount to 45 W/mK, 2 W/mK, and 0.2 to 0.3 W/mK, respectively [7].

Due to their cost efficiency, slatted floors out of concrete, whose thermal conductivity is considerably lower than the thermal conductivity of steel, are preferred in the fattening area. On these floors, the temperature differences found range below 1°C. Thus, they are significantly lower than the values stated in the literature [2]. One possible reason for an imprecise determination of the floor temperature can be a methodological problem because infrared thermometers also measure not just one point, but an entire section. The average slit temperatures determined in the present study are 2 °C lower than the temperatures of the slatted floor bodies. Depending on the material, this difference grows with indoor temperature.

Due to the same design and the small differences in the percentage of slits between fully (13.1 %) and slightly (9.6 %) perforated slatted concrete floors, their surface temperature differs by only 0.5 °C. This explains why in many practical observations and under the conditions of an unstructured pen design [6], no clear preference for slit-reduced slatted floors is determined beyond the first fattening period. Given standardized and constant room temperatures, the acceptance of the floors as a lying area grows with the reduction of the slit percentage [5]. Thus, this can presumably only be a question of lying comfort. In order to guarantee the functional reliability of housing systems with static functional areas, room and floor temperature, pen structure and perhaps also adequate lying comfort are the factors which must be optimized with decreasing importance. As can be proved, the potential effects of the design of the slatted floors are small and not sufficient to control animal behaviour. Non-functional housing systems with solid floors must be considered to have a rather adverse effect on animal protection.

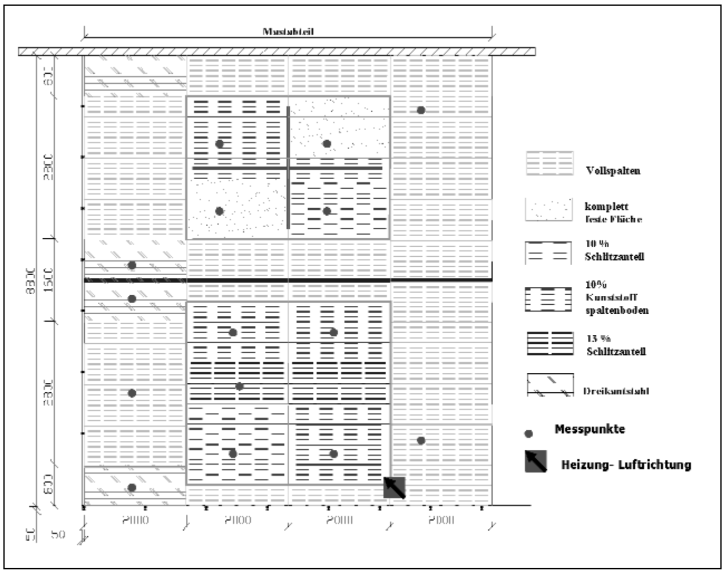

Fig. 1: Distribution of the measuring points within the pig-fattening pens

Table 1: Surface temperatures of various floor elements

	Indoor temperature °C		
	20°C	**25°C**	**30°C**
	Winter	*Outdoor temperature °C = - 0,3°C*	
		Thermal image	
Triangular section steel	14,0	16,9	20,2
Concrete (0 %)	14,5	18,7	21,6
Concrete (13 %)	15,1	18,2	21,4
Concrete (10 %)	15,4	18,9	21,8
Plastic (10 %)	16,0	19,1	22,3
	Summer	*Outdoor temperatur °C = 17,3°C*	
Concrete (0 %)	17,4	22,1	26,3
Concrete (10 %)	17,5	21,4	27,2
Beton (13 %)	17,8	20,7	27,2
Plastic (10 %)	17,9	21,9	28,2
Triangular section steel	18,7	20,3	26,5

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