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Heating-up of livestock buildings by sunshine

Summer heat penetration through outer walls and roof areas of livestock housing has substantial influence on interior temperatures. The surface temperature of the outer wall is critical for the transmission of heat through the wall. This heat, depending on material and choice of colour, is often substantially higher than the air temperature.

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Keywords

Stable climate, summer heat protection, heat transfer, stable

Literature

[1] Landwirtschaftskammer Hannover

[2] Arbeitsgemeinschaft für Elektrizitätsanwendung in der Landwirtschaft

Insulation warranties and energy requirement information for conventionally constructed livestock buildings are unfortunately still the exception and in practice even less attention is paid to summer heat insulation. As with every other building, a livestock house consists principally of six shell areas, i.e. ground plate, roof and four sidewalls facing the main points of the compass. All these shell planes exert a certain climatic influence on the interior temperature, affected by selection of material and time of year. Heat collects or is lost, whereby heat transfer through the floor plate has naturally the least variation and influence with winter and summer temperature differences here within a range well below those that can occur with the other shell surfaces.

The main reasons for planning an investigation into this aspect were:

- to determine the temperature differences between outer air and outer wall surfaces
- to establish the time taken for heat transmission (amplitude difference) within the wall construction.

Investigation methods and results

Conducted over several months during summer 2001 at the FAL, were investigations into heat transfer, i.e. the effect of solar radiation (surface temperature of the outer wall) on the building interior temperature. On the south façade of a conventionally constructed feeding pig building the „real temperature progression“ was measured with NiCr-Ni Thermodraht sensors on the surfaces and within the wall construction in 5-minute rhythm and using DIN 4108 calculations and this was compared with the temperatures within the building.

Because of the better access offered to installed measurement instrumentation the data was measured on the outer wall of an area not filled with pigs, thus no factors were recorded that would have certainly influenced the measurement data such as those caused by heat production by livestock (heat production/heat emission) 1800 W/large animal unit [1], according to DIN 18910 and [2] around 900 W/large animal unit).

The comparison data from the „room temperature of the feeding pig building“ were recorded at four-hour intervals in a neighbouring, climate controlled compartment filled with pigs. In this case climate controlled meant air conditioning for cooling as well as for heating the interior.

For demonstrating the facts and measurement results here, two warm days in August 2001 were selected, ones which certainly represent no exceptional situation during the year as a whole.

The temperature progression on the surface area of the outer wall, the separation surface of facing /air space, the separation area insulation/inner wall construction and the inner wall surface is demonstrated by a line diagram The curves show clearly the (expected) time delay in temperature progression in the case of heat transmission in the investigated outer wall. As comparison parameters air temperatures measured in the shadow taken by the German Meteorological Service (DWD) for the area Brunswick are used as well as the temperatures from the building interior. As mentioned above, the interior air is additionally influenced by the air conditioning equipment so that the recorded building interior temperature cannot be seen as the result of exterior air, heat emission by pigs and the under-pressure ventilation, although this has no influence on the principle findings.

The highest air temperatures recorded by the DWD for August 25, 2002 at 31.1 °C were between 17.00 and 17.15, lowest at 06.00 being 16.5 °C. The heat transmission-critical outer surface temperatures, i.e. the development of the building interior temperature – in this case on the south side of the building – were at the documented times 48 °C and 22.3 °C respectively. The highest surface temperature was recorded on the south wall at 14.35 and was 55.3 °C. With this, the difference between the theoretically calculated value and the recorded temperature was still 24.2 K.

The sensors mounted during the construction of the wall could determine the heat transmission and therefore the amplitude delay. The highest surface temperature was

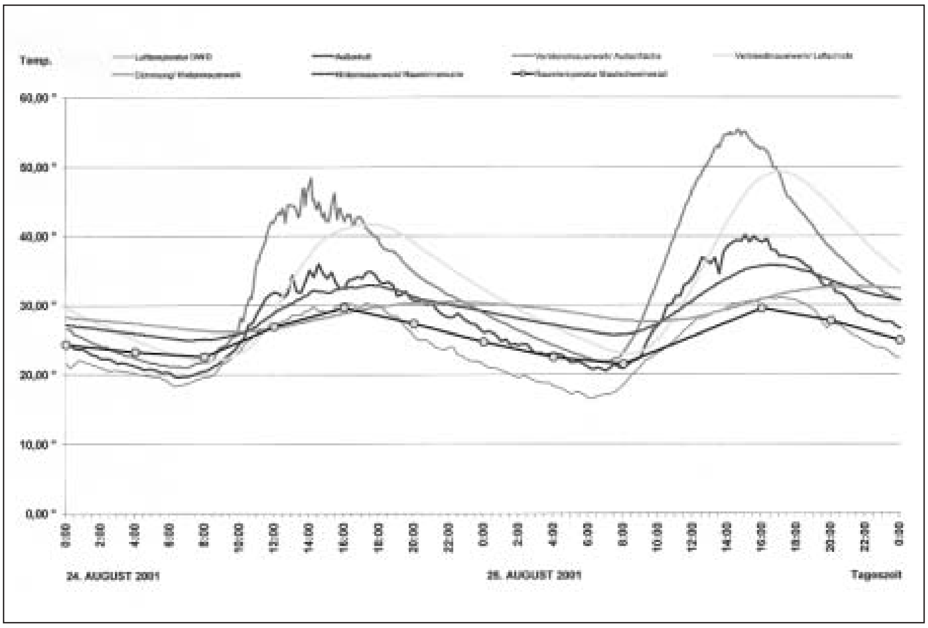

Fig. 1: Line diagram of surface and wall dividing area temperatures over a period of 48 hours featuring the outer wall of a conventionally built feeding pig house.

55.3 °C at 14.35. The interior of the wall facing (facing brickwork 1.8) indicated at this time a temperature in the area separation layer facing/air gap a temperature of still 44.6 °C and only reached the maximum value of 49.3 °C 2 1/4 hours later. A further time and temperature delay occurred at the separation layer insulation/inner layer (glass wool WLG 040, d = 80 mm; lime sand fullstone 2.0). Here on this particular day at 20.35 the highest temperature was measured and at 9.50, the lowest, being 32.7 °C and 27.6 °C respectively. This was also the measurement point where the least variation between day and night temperatures was recorded.

Equally significant and interesting is the time of lowest temperature in this curve, in the late morning, i.e. at a time when the east façade was once again recording highest temperatures and even the south façade was showing clearly rising ones. Peak temperature was in the evening , i.e. when outer temperatures were already falling rapidly. The cross point was reached shortly after 20.00.

The inner surface temperature of the wall was characterised by a slightly wider temperature range. Observing the temperature line in *figure 1* shows that here the lowest as well as the peak point was earlier than those in the separation surface insulation/wall interior construction. The reason for this contra-running tendency comes from the influences of the other shell surfaces enclosing the interior space: enabling an additional heat discharge in the case of sinking outer temperatures , i.e. an additional cooling effect, but on the other hand bringing an earlier and longer-lasting heat introduction.

Conclusions

What conclusions and deductions can now be arrived at with these results for the planning and the running of an insulated, conventionally constructed and mechanically ventilated livestock building?

- As much attention should be paid to summer heat protection as to other temperature influences in the planning of livestock buildings.
- All building shell surfaces influence the heat situation in a building.
- Through skilful and considered selection of material and appropriate wall construction the warming up of the interior air space can be substantially delayed; in given cases by six to eight hours.
- Even the colours used for outer walls and roof areas play an important role in interior temperature – and as is known not least for the avoidance of building damage (cracks from temperature-caused tensions).
- It should be considered whether, possibly through a suitably controlled ventilation programme, the building interior temperature and the heat radiating wall interior surface can be positively influenced so that the highest interior temperature could be achieved at a time when the exterior temperature has already again dropped. Increased airflow rates in the cooler night hours – depending on appropriate interior volume and wall interior material – could certainly improve the situation.
- In every case the ventilation equipment should have sufficient capacity to cope with critical situations such as fully stocked compartments, fully-grown animals and extreme temperatures.
- A welcome effect for pollution protection could be that the highest airflow rates are reached at a time when the affected population take less notice and when odours are less intensive because of the relatively cooler temperatures.

Fig. 2: Measured and computed temperature development (according to DIN 4108 at predetermined area temperature) in the outer wall of a conventional feeding pig house.