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PERFORMANCE OF AN EVAPORATIVE COOLING SYSTEM IN A GESTATION HOUSE

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INTRODUCTION:

This field study was conducted to determine the effectiveness of an evaporative pad cooler for modifying the environment in a gestation house in Kentucky and to compare the measured results with the calculated performance of evaporative cooling systems. The building used in the study was a 68-crate gestation house, as described in Figure 1. The building was oriented east-west and was well insulated. There were no windows in the facility. It was fully occupied, throughout the study, with sows with an average weight of 350 lbs. A negative pressure system was used to ventilate the building with a 36" single-speed exhaust fan located in the east end wall (Figure 1). A 4' x 12' evaporative pad was located in the west end wall adjacent to the air intake. Shutters were mounted on the outside of the building to provide shade for the pads and to protect them during inclement weather.

The fan created a negative pressure within the building during operation. The fan operated continuously throughout the test and provided an air flow of 135 cfm per sow or one air change every 1.57 minutes.

The manufacturers suggested water flow rate through the pad was 7.5 gpm. The actual flow rate was reduced by a valve used in the recirculating line but the pad remained wet throughout the study. A single-speed pump was used to recirculate water in the system. Water flow through the pad was controlled by an on-off thermostat which was set at 70°.

All the ventilation air was brought into the building through the pads.

FIELD TRIAL METHOD:

Dry bulb temperature and relative humidity levels were continuously recorded at three locations in the gestation facility during July and August, 1980. Hygrothermographs were used to record modifications in the ventilation air as it passed through the building and were placed in the following locations: outside the building at the west end wall, inside the building at the west end wall adjacent to the evaporative pads, and inside the building at the east end wall adjacent to the fan (Figure 1).

CALCULATION METHOD:

As air passes through an evaporative pad which is wetted with recirculated water, the air will be cooled. Pad cooling efficiency will depend upon the face velocity, the uniformity of wetting, and the percentage of air which passes through the wetted areas versus that which passes through cracks or other openings. Estimating the pad cooling efficiency and knowing the outside air temperatures, the temperature of the air leaving the pad can be calculated.

As air moves through the house, it will pick up heat conducted through the walls and ceiling and heat released by animals and equipment. For finishing or gestation operations where heat is not added, the equipment input would be small; however, for poultry laying houses where lights are necessary for protoperiod control, it could be significant. The heat produced by the animals, in contrast, would be quite large in fully occupied houses. Though heat is given off by the animals in both latent and sensible forms, only the sensible heat needs to be considered for summer cooling analyses since no condensation would take place within the building. Increase in the heat content of the air as it moves through the house can be calculated. If the sensible heat produced by the pigs is obtained and if the heat input from equipment is estimated, the exit air temperature can be calculated.

RESULTS:

A record of the observations made during a 4-day period of hot weather, beginning July 14, 1980, is shown in Figure 3. Outside temperatures reached maximums between 97° and 103°F in the mid-afternoon. During that portion of the day the outside relative humidity reached minimums which ranged from 26 to 36%. On these days, an 85% efficient evaporative cooler would have the potential to cool the air 20 to 24°F. Although Kentucky is regarded as being in the humid southern region, these humidity readings indicate that even in the mid-South the potential for evaporative cooling can be excellent during the hottest part of the day, when it is needed most.

While maximum and minimum temperatures outside the facility ranged from 102 to 70°F, temperatures inside the house near the pads ranged from 81 to 65°F (Figures 3 and 4). Exit air temperature during the same period ranged from 82 to 72°F Figure 4). Relative humidity levels were at or near saturation (86-100%) as air entered the building and ranged between 63 and 78% at the exit.

At night, when outside temperatures were lower and relative humidities were higher, the temperature and humidity levels in the house remained near the outside conditions.

To further determine the performance of the cooling system, temperature and relative humidity recordings at 2:00 p.m. were evaluated for 3 weeks between July 12 and August 9, 1980. These are shown in Table 1. Observations from July 19 to July 26 were unavailable because of inking problems with one of the hygrothermographs.

Outside temperature and relative humidity for each observation are shown for comparison with the measured air temperature leaving the pad. Pad performance was determined by evaluating the difference between these temperatures. Differences ranged between 9 and 25°F, with an average difference of 17°F. The evaporative pad system clearly proved capable of reducing the ventilation air temperature.

Calculated values of the air temperature leaving the pad were determined and are shown in Table 1.

An operation efficiency of 83% was assumed as specified by the pad manufacturer at the observed face velocity of 0.65 m/s. Comparison of the observed and calculated temperatures indicate that the measured values are slightly lower than predicted. This is illustrated in Figure 5. The average difference between the two values was 1°F which is within the accuracy of the instrumentation used in this study. Measured values would, in fact, be lower if the pad system had a higher operating efficiency than assumed.

Building performance was also evaluated for the 2:00 p.m. observations, by computing the temperature of the air at the exit. Heat production as a result of equipment was neglected.

Since the evaporative cooling of the inlet air reduced the interior temperature below that of the ambient conditions outside the building, the conduction heat transfer resulted in a heat gain. For the building and conditions in this study the conduction heat gain was about 15% of the heat produced by the pigs.

Measured and calcualted air temperatures leaving the building, are shown in Table 1. A comparison of the two values indicate that the calculated values tend to be higher than the observed values. This is illustrated in Figure 6. Such a result would occur if the sensible heat production is over-estimated.

CONCLUSIONS:

The following conclusions are based on the results of this study:

1. Evaporative pad cooling systems can reduce the temperature of swine gestation houses and consequently reduce the heat stress for gestation sows in confinement in Kentucky.

2. Evaporative pad cooling systems can be effective towards reducing excessive temperature levels in areas with high average humidities because humidity levels tend to be low during the warmest portion of the day.

3. Equations can be used for predicting pad and building performance provide results which can be used for design purposes.

4. Humidity levels within the evaporative pad cooled facility tended to decrease from near saturation at the pad to more moderate levels near the fan as sensible heat is added by the animals.