Modifications to KSU Maternity Building

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Introduction

Dairy facilities at Kansas State University were constructed during the 1960's and 70's. Many of the buildings were constructed with low roof lines and minimal natural ventilation. Heat abatement procedures, including shade and sprinklers over the feed line along with increasing natural ventilation within the stall area, have been incorporated in the lactating cow pens. Additional shade and a fence line soaker were added within the last ten years to the maternity building, in an effort to reduce heat stress. During the hot summer months, close-up cows favored lying on the concrete, even in excess moisture from the feed line sprinkler system, rather than the bedded pack area. This caused an increase in mastitis after calving resulting in an increase in culling. Therefore, the K-State Dairy unit began to focus on further reducing heat stress in the close-up pen.

The dimensions of the maternity barn are 36 ft wide, 108 ft long and 9 to 10 ft high. The height of the bottom of the rafters hindered fan installation due to the type of equipment used to remove bedding. Another problem was the possibility of the cows reaching the fans. Natural ventilation was poor due to the sidewall height, solid sidewalls and lack of a ridge row opening. The building was enclosed on three sides and open to the south. The roof of the building is insulated. The north wall contained nine passage doors which remained open during warm weather. The Dutch doors allowed the top to be opened while the bottom remained closed in cooler weather. Originally, each door provided access to individual calving pens which had been removed.

The K-State Dairy team explored options to reduced heat stress in the maternity pen in addition to the feedline soakers. One goal was to create an environment which encouraged cows to lie in different parts of the pen. This was accomplished by distributing fans along the north wall. Also, an evaporative pad was installed to cool the air being blow into the bedded pack area of the maternity pen.

The evaporative pad, 4 ft by 80 ft, was installed north of the existing wall (Figure 1). The enclosed air chamber space between the pad and building was 6 ft. Eight 36 inch, ½ hp fans were installed in existing north wall. A fan was placed in the upper half of each door resulting in a fan spacing of 12 ft on center. Fans were mounted approximately 4 ft above the floor, to minimize blowing the bedding and potentially increasing respiratory problems due to suspended dust particles.

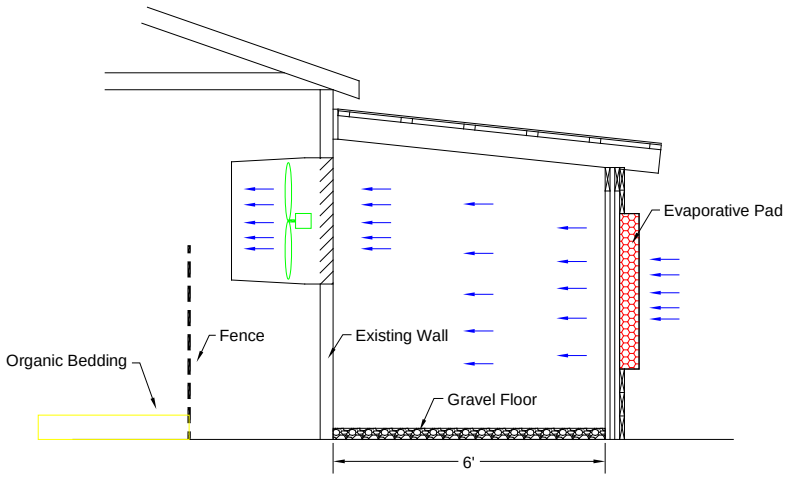


Figure 1 Cross section of air chamber and evaporative pad installed on north side of the KSU Maternity building.

Evaporative cooling is the result of warm air coming in contact with a stream of moisture or a wetted surface. The air temperature decreases and the humidity level increases as moisture is added to the air. Theoretically, the lowest air temperature obtainable occurs at 100 % humidity or saturation. Most designers assume the air temperature exiting an evaporative pad is reached when the air has absorbed 75 % of the moisture possible between inlet conditions and saturation. The temperature drop of the air across the evaporative pad is a function of the relative humidity. If two air streams are at the same temperature but have different relative humidity levels, the stream with the lower humidity will cool to a lower temperature than the air with higher humidity. The exhaust temperature from the pad also changes as the outdoor air temperature is changes.

Results

The temperature drop across the pad is shown in Figure 2 from August 1 to 15, 2007. During the first week in August the pads were off and there was no temperature difference between the ambient air and air inside in the air chamber (pad temperature in Figure 1).

Figures 3, 4 and 5 compare the temperature, relative humidity and temperature humidity index during a 24 hour period when the pad was either on or off. The pad was allowed to dry between 12:30 and 6:15 a.m. thus there were no temperature differences during this period. The evaporative pad cooled the air temperature between 10 and 15 ^{o}F in the afternoon. Since the air passing through the evaporative pad absorbed moisture, the relative humidity was increased in the afternoon when the pad was on (Figure 4). The increase in relative humidity was a function of ambient relative humidity. Figure 5 shows the temperature humidity index was reduced by 3 to 5 units when the pad was operating.

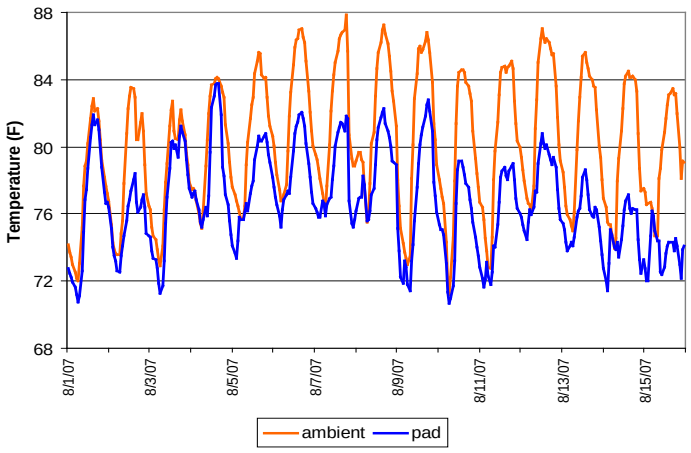


Figure 2 Ambient temperatures entering the evaporative pad and the exhaust temperatures of air entering the maternity bedded pack area.

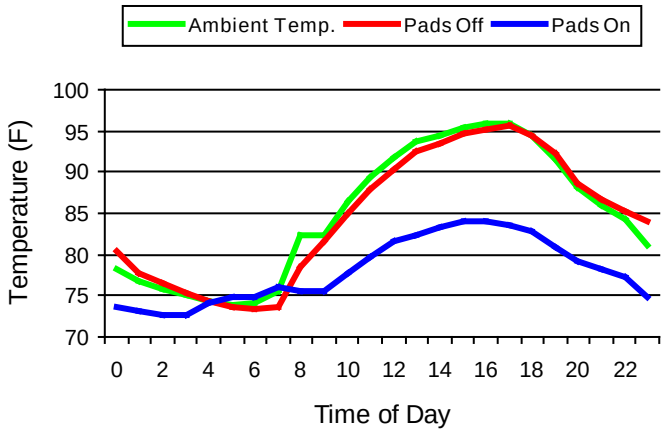


Figure 3 Impact of evaporative pad on air temperature during a 24 hour period

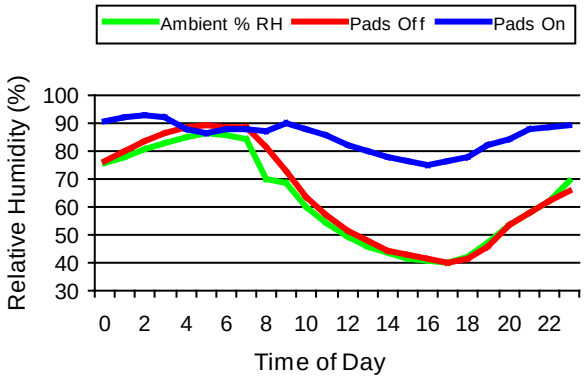
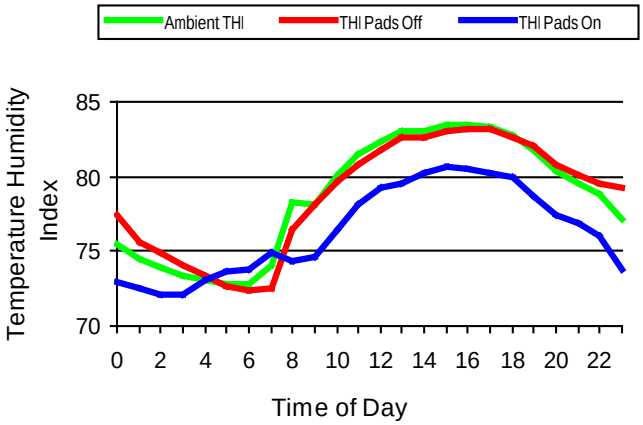


Figure 4 Impact of evaporative pad on air relative humidity during a 24 hour period

Figure 5 Impact of evaporative pad on air temperature humidity index during a 24 hour period



Differences in core body temperatures when the pad was on or off, are shown in Figure 6. Evaporative cooling lowered core body temperatures a 0.5 ^{o}F. During a 24 hour period, the duration of core body temperatures above 102 ^{o}F was 16 hours when the pad was off as compared to 6 hours when the pad was on.

Table 1 gives the water used from August 14-17, 2007. The air absorbed 101 to 112 gallons per hour on August 14, 15 and 17 when the relative humidity averaged less than 50 %. The temperature drop across the pad was approximately 14 ^{o}F. On August 16, the humidity averaged 65 % and water usage reduced to 65 gph and the average temperature drop was 9 ^{o}F. This illustrates the impact of the relative humidity on the cooling potential of the air. Approximately 0.33 gph per square foot of pad was utilized which is similar in other studies.

Figure 6 Impact of evaporative pad on core body temperature of close-up cows.

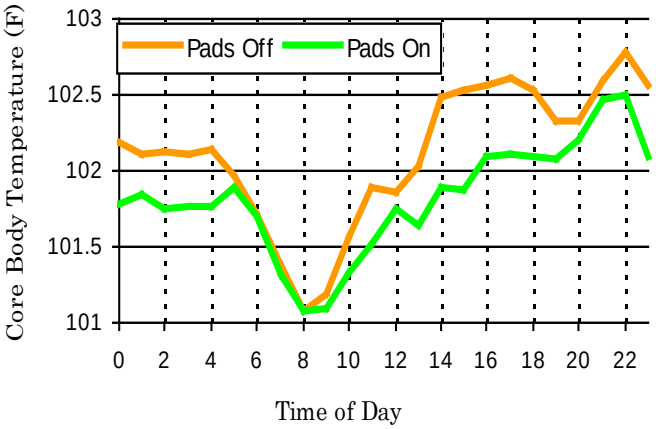


Table 1 Water performance of evaporative pad and water usage from August 14 to 17, 2007.

Date	Ambient		Evaporative Pad		Water Usage	
	Temp (^{o}F)	RH (%)	Temp (^{o}F)	RH (%)	gal/hr	gph/sq.ft.
Aug 14	91	43	77	82	101	0.32
Aug 15	91	41	76	83	110	0.34
Aug 16	86	65	77	92	65	0.20
Aug 17	94	43	78	90	112	0.35

Summary

An evaporative cooling system was installed in the KSU Dairy Maternity building. The cooling system reduced the air temperature in bedded pack area 10 to 15 ^{o}F during the afternoon hours. Relative humidity was increased to 70 to 80 %. However, the temperature humidity index was reduced 3 to 5 units. Cows were not observed lying on wet concrete as previously had been seen during summer heat. However, cows did appear to stand during the afternoon hours in front of the fans to take advantage of the cool air being blown into the bedded pack area.

Evaporative cooling may provide an alternative to dairies with facilities where side wall heights limit installation of fans. An advantage of the evaporative cooling system is that no additional water is added to the lagoon. A fence line soaker system may still be necessary to encourage cows to eat and provide additional cooling.

Acknowledgements

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