CONSUMPTIVE WATER USAGE OF EVAPORATIVE PADS

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Summary

Consumptive water usage by evaporative pads was measured during 7 days of a 3-week period at a Kansas (KS) dairy and a 2-day period at a North Dakota (ND) dairy. Water meters were installed between the water hydrants, and evaporative pads at each dairy, and were monitored. Data were recorded every 30 minutes during 5 hr at the KS site and every 15 minutes during 1 to 2.5 hr at the ND site. Ratio of pad area to cow equaled 4.8 and 4.5 ft^2 per cow at the KS and ND sites, respectively. Airflow rates through the pads were 1.2, 2.1, and 3.2 mph at the ND dairy and 3.3 mph at the KS dairy. During the study period in KS, the temperature humidity index ranged from 78 to 86 and water usage varied from 0.7 to 4.7 gallon per minute. Average pad efficiency equaled 62%. Water usage averaged 0.3 gallons per hr per ft^2 of pad when airflow rate was 3.3 to 3.6 mph. At the ND dairy, the water usage averaged 0.1, 0.3, and 0.38 gallon per hr per ft^2 of pad for the low, medium, and high airflow rates, respectively. The temperature humidity index equaled 65, 72.5, and 71 for the low, medium, and high airflow study periods. Pad efficiency averaged 93, 86, and 81% from the low to high airflow rates. Similar to pad efficiencies at the KS site, efficiency increased as the outdoor air temperature decreased.

(Key Words: Cooling Systems, Evaporative Cooling, Water Usage.)

Introduction

Consumptive water use for heat abatement increases the daily water requirements of a dairy during summer. Water usage depends on weather conditions, heat abatement system, and operational characteristics. Water demand for a low-pressure soaker system is based upon nozzle capacity and spacing, in addition to the number of nozzles simultaneously functioning. Water usage is determined by how frequently the nozzles spray water over the cow's back. In general, frequency is a function of outdoor air temperature. Low-pressure systems cool the cow by evaporating water from the body surface. Evaporative cooling systems cool the air around a cow's body to help minimize heat stress. There is little information on the water demand and water usage of evaporative pads. The objective of this study was to determine consumptive water usage of evaporative cooling systems.

Procedures

Water meters were installed on 2 dairies that use evaporative cooling. Dairy 1 was located in northeast KS, with a 110-cow facility. This dairy used two, 6-ft-wide pads. Pad 1 (south pad) was 20 ft long and Pad 2 (north pad) was 60 ft long. Water was supplied to each pad through a 1-inch water hydrant. Meters were installed between the hydrant and evaporative pad to measure water usage. Wa-

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ter usage was collected at 30-minute intervals between 1:00 and 6:00 p.m. on 7 days between July 18 and Aug 10, 2006. Ratio of pad area to cow was approximately 4.8 ft^2 per cow.

Dairy 2 was an 800-cow unit located in southeast ND. This dairy used 12 sections of pads, with a 1-inch water hydrant serving 4 sections of pads. Each pad section was 5 ft wide and ranged in length from 57 to 67 ft. There were 2 rows of pads stacked on top of each other to form a pad 10 ft wide by 365 ft long. Water meters were installed between the hydrant and pads, and data were collected every 15 minutes during 2 hr. Data were only collected during 3 periods because of a main water line malfunction. Airflow rate through the pad was adjusted during each period. The pad area to cow ratio was equal to 4.5 ft^2 per cow. The 3 airflow rates evaluated were 3.2, 2.1, and 1.2 mph per ft^2 of pad.

Results and Discussion

Figure 1 shows the water usage during the 30-minute intervals at Dairy 1. Average water used during a 30-minute interval was 75 gallons. Temperatures averaged 103°F on July 19 and the relative humidity was 30%, which is reflective of the highest water usage. The temperature humidity index on July 19 was 85.5. The lowest water usage was on Aug 10, when the average temperature and relative humidity were 83°F and 73%, respectively. The temperature humidity index on Aug 10 was 80. The increase in relative humidity resulted in the air being able to absorb less moisture. The greatest water demand for the dairy occurred between 3:30 and 5:00 p.m., when, in addition to the consumptive water used by the pads, milking equipment was also in operation. Water supply at the dairy was not able to meet the demands of the milking equipment and the pad, thus there was a decline in water usage during this period (Figure 1).

Average daily water used by the pads was 1.65 gallons per hr per cow during a period from July 18 to August 10. Pad water usage equaled 0.30 gallons/hr per ft^2 of pad. Pad 2 equaled 75% of the total pad length, but only 68.5% of the water used was metered through this pad. The remaining 31.5% was used by Pad 1. This slight difference may have occurred because of some water leaks in Pad 1 or exposure of Pad 2 to the prevailing weather, which caused some drying of the pad.

Figure 2 shows the relationship between outdoor air temperature and relative humidity and temperature humidity index. Average temperature humidity index was 82.7 ± 1.6 during the 7 monitoring periods. Cooling efficiency of the pad was calculated by using psychometric properties of the air. Efficiency was based on the ratio of actual water metered to water required to raise the relative humidity of the incoming air to 100% or the saturation point. Figure 3 shows the relationship between outdoor air temperature and pad efficiency. The average pad efficiency was 61.8 ± 19.2%. Actual pad efficiency was probably greater because metered water included water leakage. As the outdoor air temperature increased, the pad efficiency decreased (Figure 3). In other words, as the temperature increased and humidity decreased, more moisture probably was absorbed by the air, but the volume and velocity of the air through the pad may have limited the amount of moisture absorbed. Efficiency might increase if pad thickness or area were increased, assuming no increases in air movement or volume, or a decrease in air movement and volume for given pad properties.

Consumptive water usage at the ND dairy equaled 30.1, 91.5, and 115.7 gallons per 15 minutes for the low, medium, and high airflow rate studies, respectively. Measured airflow rates through the pad averaged 1.2, 2.1, and 3.2 mph for the low, medium, and high airflows, respectively. On a per-cow basis, water usage was 0.45, 1.37, and 1.75 gallons/hr per cow while the evaporative pad was operating. Figure 4 shows a comparison of the water used per ft^2 of pad for the KS and ND sites. Similar water usage was observed between the KS dairy and the medium airflow rate at the ND dairy. Measured airflow rates were 3.3 mph through the pads at the KS site and 3.6 mph during the medium airflow rate study at the ND dairy. Water usage by the pad did not increase in proportion to the airflow rate. When the high and medium airflow rates were compared, the difference in air velocity was 47%, but the increase in pad water usage was only 27% greater. Pad efficiency averaged 93, 86, and 81% for the low, medium, and high airflow rates, respectively.

Similar to the pad efficiencies at the KS site, efficiency increased as the outdoor air temperature decreased at the ND dairy. Pad efficiency during the period with medium airflow rate may have been influenced by a 20-mph wind from the southeast blowing into the pads. Water leakage at the KS dairy seemed, by visual observation, to be greater than that at the ND dairy. Some of the difference in evaporative pad efficiencies between the 2 sites may be explained by water leakage. Pad efficiencies decreased as water leakage increased; therefore, maintenance is critical to prevent excess water usage.

Water usage by evaporative pads was measured at 2 dairies during summer 2006. Water usage was approximately 1.75 gallons/hr per cow when 100% of the fans were operating during hot weather. Results of this study, in which there was between 4 and 5 ft^2 of pad per cow, suggest that water demand and supply should be designed based on an average consumptive usage of 0.33 gallons/hr per ft^2 of pad area.

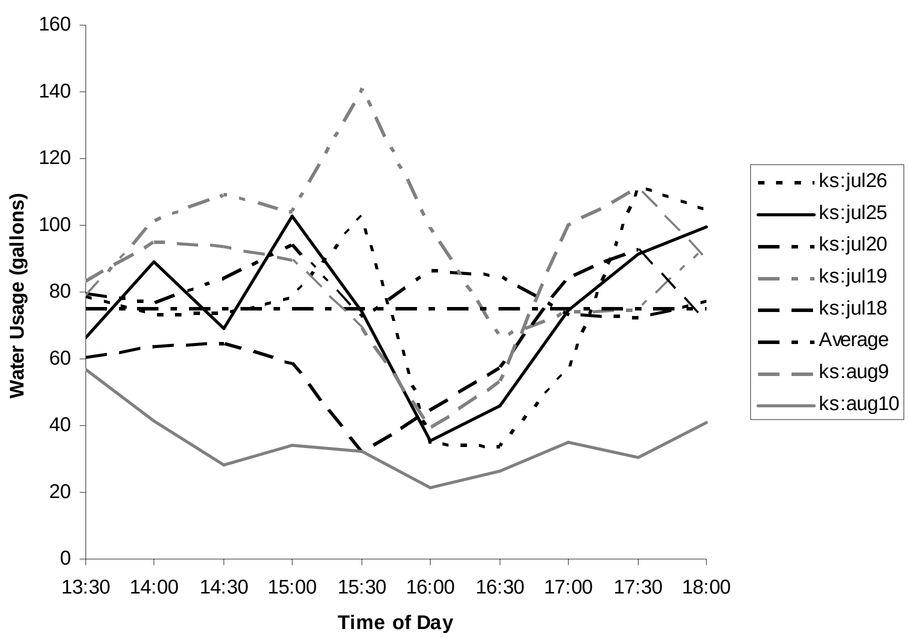

Figure 1. Water Usage by the Evaporative Pads during 30-minute Intervals at the KS Dairy.

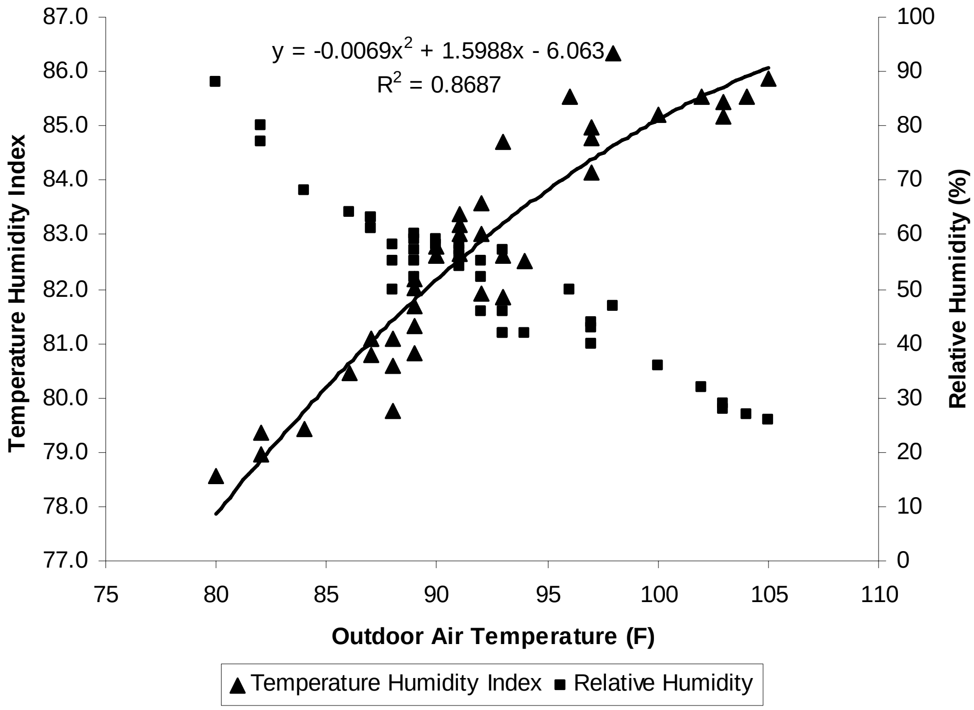

Figure 2. Relationship Between Temperature and Temperature Humidity Index during the Study Period at the KS Dairy.

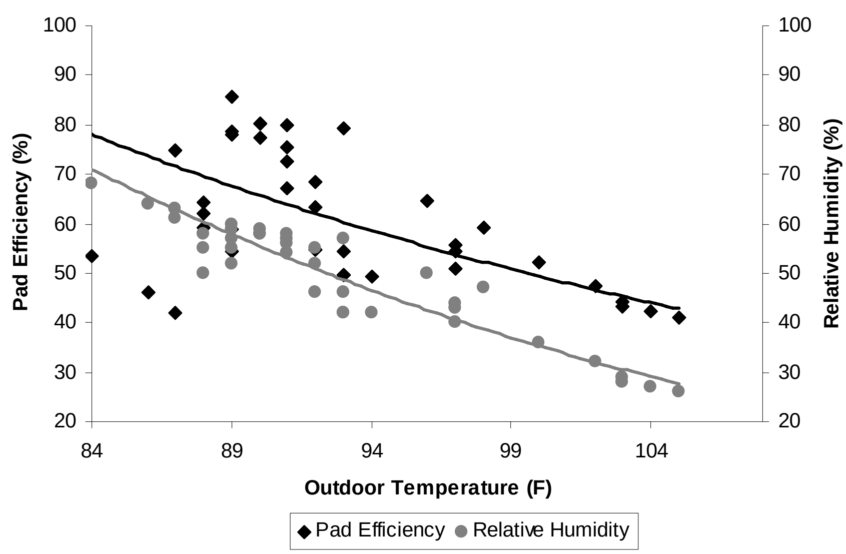

Figure 3. Influence of Outdoor Air Temperature on Evaporative Pad Efficiency.

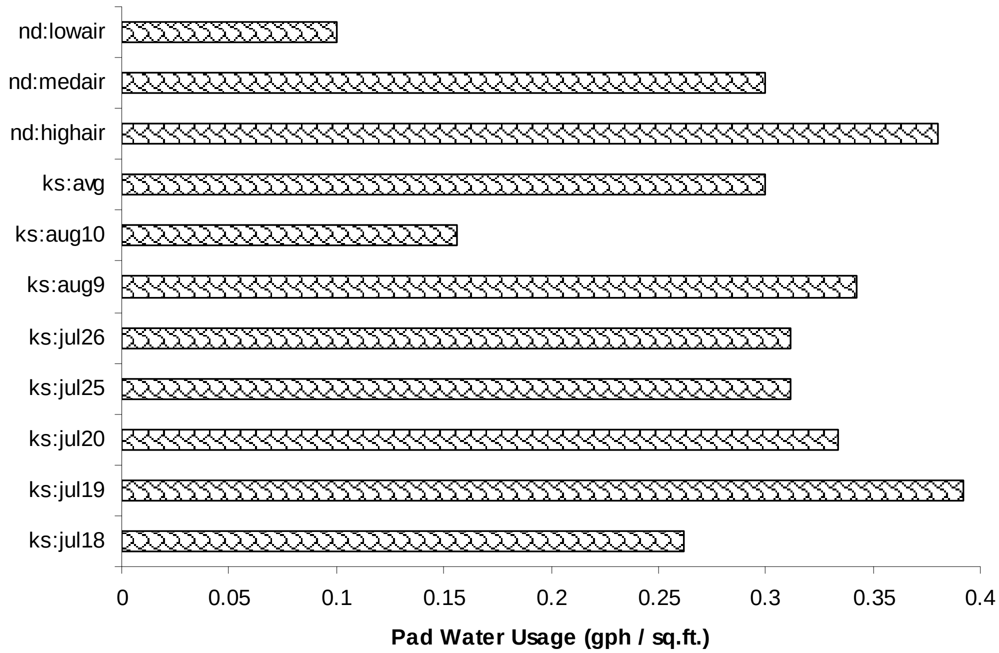

Figure 4. Comparison of Evaporative Pad Water Usage during All of the Monitoring Periods at the KS and ND Dairies.