Department of Animal Science

HOW AND WHY EVAPORATIVE COOLING SYSTEMS WORK

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Modern poultry houses are equipped with summertime cooling systems that include an arrangement of large exhaust fans at one end (Figure 1) and evaporative cool cell pads (Figure 2) at the other end of the house. To master operation of their tunnel and evaporative cooling systems, poultry growers should understand the relationship between temperature and humidity and how this relationship impacts chickens. On the part of the grower, it requires both common sense and an understanding of the First Law of Thermodynamics because the relationship is simple and complex at the same time.

Figure 1

Figure 2

Relationship between temperature and humidity

As temperature goes up, humidity goes down, and vice versa. That's the simple part of how nature works and explains the use of the phrase "it's a dry heat" when it may be 120 degrees F. There is almost no humidity in the air at that temperature. As a result, evaporative cooling works great in the Southwest. Consider the weather of the average Tennessee poultry farm on a summer morning at sunrise. It's around 70 degrees F with humidity at or near 100 percent. The temperature dropped overnight, the air became saturated, and condensation formed on surfaces.

Evaporative cooling is practically useless under these conditions because the outside humidity is too high. However, it's a different story when cool cells run on a hot summer afternoon.

Evaporation alters temperature and humidity

Evaporation of water from cool cell pads has a cooling effect on hot air passing through the wet pad material. This is the complex part that includes the First Law of Thermodynamics. To evaporate water, heat (energy) is required. The heat comes from whatever object the water is in contact with; in this case, that object is the hot air as it passes through the wet pads. The First Law of Thermodynamics states that energy can be changed from one form to another, but it can't be created or destroyed. We do not destroy the heat in the air as it passes through the wet cool cell pads, instead the heat is used to change water from liquid to vapor. In return, temperature is lowered but humidity is raised (from high temperature to high humidity).

We convert sensible heat to latent heat. For every gallon of water evaporated, 8,700 Btu of sensible heat is taken out of the air to decrease temperature (Donald, 2000) and converted to latent heat which increases humidity. Again, energy can't be destroyed, but its form can be changed. Growers may wonder if cooler water trickling through the pads would make a difference in the cooling potential, but it does not matter. Most of the energy comes from the phase change of liquid to vapor. A gallon of water at 50 degrees F has a cooling potential of 8,900 Btu, while a gallon of water at 90 degrees F has a cooling potential of 8,700 Btu. The cooling potential is essentially the same (Simmons and Lott, 1996), so the water temperature doesn't matter.

The 80-80 rule

Something that does matter is the condition of the outside air. The higher the temperature, the drier the air. And the drier the air, the higher potential/force that water can be vaporized, hence the more efficient the pads. The way nature works is that, in most cases during the summer, if the air temperature is 80 degrees F, the relative humidity is roughly 80 percent, hence, the 80-80 rule. If the air temperature is above 80 degrees F, in most cases, running cool cell pads will likely be beneficial. If air temperature is below 80 degrees F, the cooling effect of running the pads is minimal at best. If the relative humidity is above 80 percent with air temperature below 80 degrees F, let's say from 9 p.m. to 9 a.m., running cool cell pads offers little or no benefit. Why? Because it is difficult to evaporate water into air that is already 80 percent saturated with moisture and get much cooling benefit (Czarick and Lacy, 2000). Although, there are those few exceptions each summer when nighttime temperatures stay above 80 degrees F until after midnight when it may be beneficial to run pads longer.

However, pads should not stay wet 24 hours a day. They are called evaporative cool cell pads for a reason. Pads must be allowed to dry out at least once per day (Campbell et al., 2006). Failure to do so can increase the risk of algae growth and reduce life expectancy of the pads by keeping them wet for extended periods of time. Pump life will also be shortened by using it during periods when little cooling benefit is possible such as overnight or during periods of high outside humidity. In addition, high in-house humidity created by running the pads overnight increases wet litter potential which is detrimental to paw quality and affects flock performance.

Growers often ask, "When should water start to run over the pads?" Many growers tend to run water over the pads too soon (at too low a house temperature) to stay ahead of heat stress. Little if any benefit can be gained by running water over the pads before temperatures reach 82-85 degrees F with larger birds. This assumes the house has adequate air speed, such as 500 feet per minute in a 500-foot house (600-700 feet per minute is preferred for this size though). Running pads at 80 degrees F or less is counterproductive and may do more harm than good in terms of humidity and litter condition.

Windchill is more important than cool cells

Remember the cool cells are only one part of the overall cooling system in a poultry house. Tunnel fans are the most important part, with cool cells working to enhance the tunnel fans, not the other way around. The first requirement for successful chicken cooling is airflow. Sufficient air velocity to provide a good windchill effect is more important than any other item in a hot weather broiler house (Donald, 2000). Pad cooling is complimentary to tunnel ventilation and relies on the large volume of airflow created by the tunnel fans to improve sensible heat loss from the birds (Donald et al., 2000; Donald, 2000). It is windchill created by the fans that serves as the primary cooling mechanism.

Evaporative cooling increases the cooling effect produced through air movement, but the increased humidity reduces the bird's ability to cool itself through respiratory evaporation. Evaporative cooling is successful only when the ventilation system is adequate (Donald, 2000). Why can high air speed offset a high humidity issue? Air speed increases the amount of heat loss to the air surrounding a bird, reducing its need to depend on respiratory evaporation for cooling (Czarick and Fairchild, 2009). High in-house humidity is less of a problem for the bird if it does not depend as much on respiratory evaporation (panting) as a cooling mechanism. However, air speed down the house should exchange the air at least once per minute, even with cool cells, to prevent a temperature rise from one end of the house to the other. A faster air speed is better – 600-700 feet per minute in a 500-foot house is better than 500 feet per minute (Dozier et al., 2005).

On extremely hot days, the fans and cool cells work together to keep the birds alive. Depending on how the house controller is programmed, there are multiple combinations between the fans and cool cell pads. However, for maximum cooling on older birds, all tunnel fans should be on before water is allowed to the cool cell pads. This provides maximum airflow down the house and produces the greatest windchill effect. It is vital that none of the fans shut off when water is allowed to the cool cell pads and house temperature starts to drop. If fans shut off, air speed down the house decreases at the same time house humidity is increasing, which increases heat stress on the birds. If fans shut off when cool cells come on, set points on those fans that shut off and the cool cell set point are too close together. Increase the range between the set points on the fans that shut off and the cool cells to prevent fans from shutting off when the cool cells run.

Use sensors correctly

Do not use the temperature sensors near the pads to base temperature settings for the pads. Exclude the first couple of sensors nearest the pads when programming the cool cells. Litter in front of the pads tends to be wetter because of the slow air speed and very high humidity in front of the pads. The higher the cool cell temperature settings are, the drier the litter will stay.

The coolest and most humid air in the house is directly in front of the pads. As the air moves down the house, its temperature increases as it picks up bird heat along the way (often 3-5 degrees F) and humidity decreases. The lower humidity allows it to pick up more moisture from the litter than was possible in front of the pads. Therefore, litter down the house may be drier than litter near the pads.

Foggers: Use or don't use?

In summers past, many growers have indicated that they did not lose birds on hot afternoons until after they turned on the foggers. This is because foggers increase the humidity further in air that is already highly saturated. Once the air becomes too humid, birds can no longer cool themselves through respiratory evaporation and will succumb to heat prostration, even with air movement from the fans around them. Operating foggers in a cool cell house may increase the heat stress load on the birds if the humidity level is already high from the cool cells. Often, growers that turn foggers on at 3 or 4 p.m. are picking up dead chickens by 6 or 7 p.m. This is because the in-house humidity became too high, preventing the birds from using respiratory evaporation as a heat dissipation method. In addition, operating foggers may decrease air movement over the birds. When foggers are running, tunnel fans often pull some of the fog outside. This fog wets the shutters, pulleys, motors, fan belts and blades. Wet shutters also collect dust which turns to mud and weighs down the shutter, forcing the fan to work harder. Wet blades collect mud and wet fan belts slip on the pulleys reducing the fan's air moving capacity.

With reduced air movement, birds become heat stressed at lower temperatures. If wind speed goes from 500 feet per minute to 300 feet per minute due to poor fan maintenance, wet equipment, etc., a significant amount of windchill is lost (Czarick and Fairchild, 2003), resulting in heat stress at temperatures as low as 78 degrees F. In such a situation, birds dealing with severe heat stress will likely not survive the loss of a significant amount of windchill. If we lose wind speed, we lose chickens. Moisture from foggers may also wet feed line motors and electrical connections, causing circuit breakers to trip, melting connections, or starting electrical fires. Foggers may also rapidly deteriorate litter conditions leading to increased paw quality problems and a decrease in animal welfare conditions. As a result, if you have a well-functioning cool cell system, you may not need foggers. Use migration fences throughout the house to prevent too many birds migrating to the cool cell area.

Evaporative cooling can be beneficial for keeping broilers alive during hot weather. However, it requires an understanding of the relationship between temperature and humidity. It's vital to understand that the job of a cool cell system is to assist the tunnel fans and manage the house accordingly.

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