Energy efficient humidity control

Meat and poultry production **White paper**

Introduction

One of the greatest challenges meat and poultry processors face is keeping food safe from airborne pathogens. Moisture and airflow within the plant plays an important role to maintain a hygienic process. Air from outside is introduced into the clean packaging areas and creates a positive pressure to the slaughter areas upstream.

The goal of this approach is to keep the slaughter areas neutral and prevent contaminated air from migrating into the coolers and packaging rooms. If the ventilation system is not designed correctly, then moisture will migrate from these areas into the processing rooms leading to condensation on the ceilings and walls that results in moisture dripping onto the food product (ASHRAE Refrigeration Handbook (2018)).

In addition to properly designed ventilation systems, maintaining clean meat and poultry plants requires daily cleaning and sanitation. Washdown cycles lead to high amounts of water introduced into the processing rooms. If not dried properly and efficiently, it can lead to further condensation issues when it is time to start production again. HVAC systems have been designed to properly control the right amount of ventilation for the plant and to dehumidify the air quickly and efficiently after washdown. Air handling units are designed with heating coils, cooling coils, high efficiency filters and occasionally desiccant dehumidification systems to condition the ventilation air and control the humidity of the process room before during and after the sanitation washdown cycles. Liquid desiccant systems are one option that can efficiently control the humidity and keep the air free of pathogens for the production areas of a meat and poultry plant.

Liquid desiccant dehumidification technology

Liquid desiccant systems are based on an absorption process in which a desiccant (in this case the brine solution) undergoes a chemical transformation.

When water vapor in the air comes in contact with the salt solution, its concentration and thus its chemical makeup changes. The temperature and concentration of the liquid desiccant determines the ability of the solution to remove or add moisture to an airstream. At a given concentration, the colder the solution becomes, the drier the air and vice versa.

When this concept is applied to a desiccant dehumidification system, two processes must take place for the desiccant system to work. Process air is cooled and dried with a conditioner and then the moisture collected by the desiccant solution must be transferred to a regenerator. Using heat, the regenerator reverses the process and drives the moisture out of the desiccant solution.

Figure 1 shows a cutaway of a typical liquid desiccant system showing the conditioner and regenerator. The conditioner pumps the solution through a plate and frame cooler where it cools the solution to a temperature set point dictated by the supply air resistance temperature detector (RTD). As process air flows through the conditioner, it comes in contact with the liquid desiccant solution and is simultaneously cooled and dried. As moisture is absorbed in the conditioner, the solution becomes dilute.

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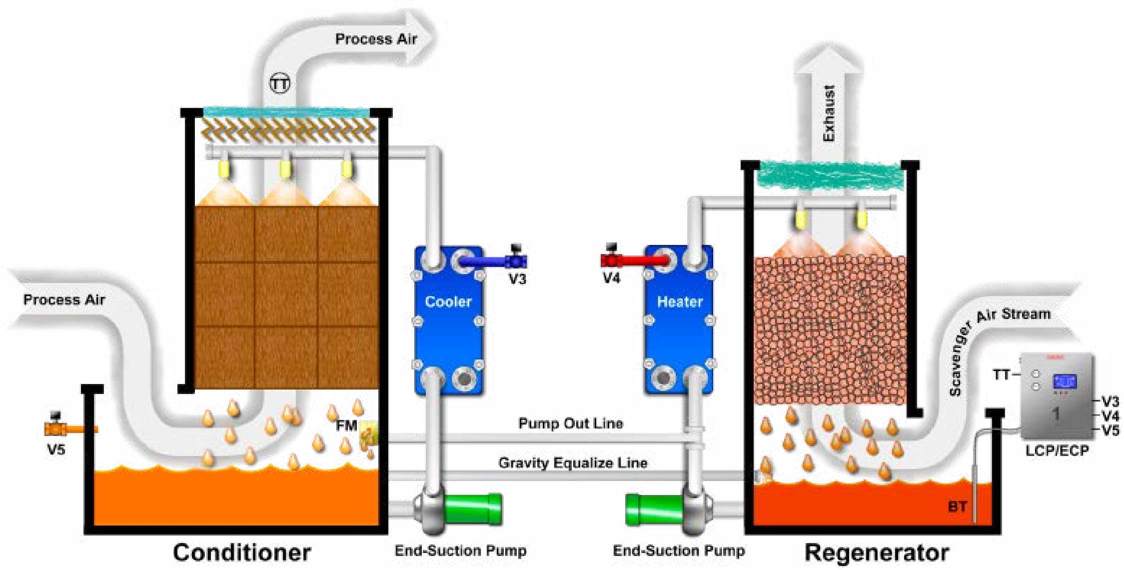

Figure 1. Liquid desiccant system schemation

Maintaining the correct concentration is crucial to achieve the desired supply air humidity; desiccant solution is sent over to the regenerator. As the level in the conditioner goes up, heat is applied at the regenerator's plate and frame heater, and the moisture in the desiccant solution transfers to the scavenger airstream and is exhausted outside. Concentrated solution falls to the bottom of the regenerator and pumped over to the conditioner. The cycle continuously maintains proper concentration at the conditioner. **(Piegay (2017)**)

Application: Meat cooler and packaging
It is imperative that a production space is designed to dry the floors, walls, and equipment surfaces after washdown is complete to prevent the contamination of food products.

The FDA's 'Draft Hazard Analysis and Risk-Based Preventive Controls for Human Food' defines the risks associated with Wet Processing areas. It states that "wet floors facilitate the transfer of Listeria" and "condensation on overhead structures as a result of temperature and humidity control issues and from use of water in cooking and cooling operations creates a means of transfer of Listeria spp., including L. monocytogenes, from non-food-contact surfaces to exposed product and equipment food-contact surfaces." **(Draft FDA HACCP (2018))**.

Many hygienic HVAC systems are designed to quickly dry the room out after a daily sanitation, and Figure 2 below describes one way the system can be designed with a liquid desiccant system.

In Figure 2, a typical meat operation with half of the room for cooling and the other section for packaging is shown with a liquid desiccant system controlling the humidity. In this scenario, the design moisture load is 53 lb/hr to maintain 35°F, 60% RH in the space. Fan coil units in the space can handle the sensible load to maintain 35°F.

Because the liquid desiccant system manages all the moisture, defrost of the coils is no longer necessary and a primary refrigerant like ammonia can be centrally located in the mechanical room instead of out in the production area.

In addition to handling the internal latent load, the liquid desiccant system is also designed to make up air during clean-in-place operations. The system can be designed to switch from outside air depending on pressure of the production area to 100% makeup air with heat applied during the cleaning and washdown process.

Immediately after the washdown process is complete, the liquid desiccant system is designed to pull the room down to an acceptable humidity level prior to recommencing production. It is also important that the makeup air introduced to the space is handled by the desiccant dehumidification system.

In the scenario shown below, 1,700 CFM of outside air is introduced into the space to provide proper pressurization in relation to the slaughter areas upstream of the packaging and production areas. Without the liquid desiccant system, the space fan coil units would be exposed to 10 Tons of latent energy which is 114 lb/hr of moisture on a design summer day.

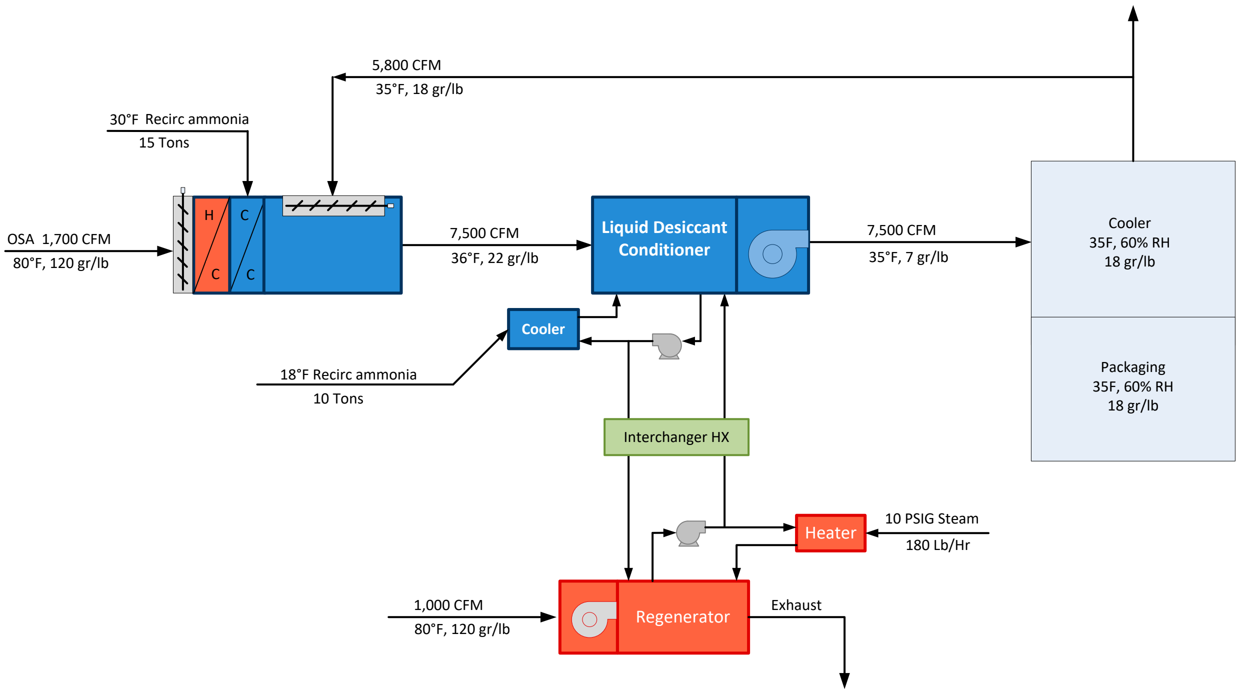

Figure 2 Airflow diagram

To maintain 35°F, the coils are utilizing a subfreezing refrigerant which means frost will form and sequential defrosting of coils is necessary. This leads to exposing heat to the coils and the surrounding production space. In addition to the inefficient energy usage associated with defrosting coils, this scenario also poses a risk of Listeria exposure.

The FDA's HACCP states that "Frost formation due to condensation at freezer entry and exit points provides an opportunity for moisture accumulation and a constant source of water for Listeria spp. to multiply" (**Draft FDA HACCP (2018)**). Along with controlling humidity, which creates an environment less than ideal for contaminants, and eliminating condensation where bacteria and mold can grow, the liquid desiccant system will also capture and eliminate bacteria and viruses from the airstream. The biocidal properties of the liquid desiccant system promote a hygienic design for this food application. **(Griffiths (1996))**

To summarize, the sequence of operation would be as follows:

Production mode

The liquid desiccant system is designed to maintain the production area at 35°F, 60% RH +/- 2% RH when operating in conjunction with the room fan coil evaporators. The fan coils should operate dry, that is, without moisture condensing, and perform sensible cooling only during production, eliminating condensation blow-off of moisture and possible contamination.

Wash/sanitation mode

The liquid desiccant system's air handling fan only runs in the bypass setting, and 100% outside air OSA is heated and the production area is purged with warm air to dissipate the wash water vapor. The liquid desiccant system and the preconditioning unit are off. The warm wet air is exhausted from the building using exhaust fans. **(Piegay (2017))**

Conclusion

Various HVAC designs are available to the food manufacturing industry to control the humidity in production spaces. The goal of each of these designs is to create an environment that prevents the spread of pathogens such as Listeria. With a liquid desiccant system, the room can be quickly dried, provide energy savings over a conventional refrigeration system and the liquid desiccant's biocidal properties eliminate bacteria and viruses from the air.

For more information please click here.

References

ASHRAE (2018). “Refrigeration Handbook.”

Piegay, Mark (2017). “Refrigeration Applications Utilizing Liquid Desiccant Dehumidification Systems.” 2017 IIAR Annual Meeting, San Antonio, TX.

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