UV — A Bright Idea for Food Safety

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In a market that is driven by cost and the need to produce product that is free from infection, whilst using fewer chemicals, ultraviolet (UV) disinfection is adopted increasingly by poultry and meat processors for a variety of applications. Infection from organisms such as Salmonella Typhimurium and Listeria will contaminate brine chillers, wash water, feed water, spray and drench water and will also infect poultry and meat marinades. The consequence of contamination is product recall, litigation, and long lasting damage to brand value and consumer perception.

UV light is a simple, non-intrusive method of disinfection. No organisms have developed tolerance to this technique, unlike chlorination, which is becoming less effective against numerous chlorine-tolerant species. UV light will render non-viable all of the known spoilage organisms, yeasts and molds, including those hardy species that can survive in low-oxygen marinades or sugar syrup solutions.

How Does UV Disinfection Work?

UV light is a physical, non-chemical process that has broad industrial and municipal uses. Systems comprise of 316L or Duplex steel chambers that contain high powered medium pressure UV lamps. Wiping systems keep the quartz sleeve free from fouling. A UV monitor camera is used to ensure proper disinfection, and systems can be supplied as duty/standby configuration. The medium pressure lamps that are usually utilized for these critical applications are compact and emit a broad spectral output, with a peak close to 265nm. This is the wavelength that is absorbed by the DNA, and causes most damage or “dimerization” to the DNA structure contained in the organisms nucleus.

UV light between 200nm and 300nm can pass through the water, and is absorbed by the DNA contained in the nucleus of all living organisms. When the UV light is absorbed, the DNA becomes so damaged that the organism is instantaneously rendered non viable. Normal cell function ceases; the organism cannot replicate respirate nor assimilate food. Once viability ceases, the colony quickly dies. Low pressure UV lamp based systems produce a single UV wavelength at 254nm. A number of independent research groups have raised questions about the ability of this single wavelength to permanently deactivate the organisms. Several species appear able to repair themselves after exposure to low pressure UV light. No repair following exposure to the more powerful medium pressure UV lamps has been reported.

No organism is capable of surviving UV light. Many species are now increasingly tolerant of chlorine, and emerging pathogens such as Cryptosporidium and Giardia demonstrate high chlorine tolerance.

UV light has been demonstrated to be very effective against Salmonella Typhimurium and Listeria Innocua. Up to 6 log removal of these species can be achieved with a correctly sized UV system. The UV light is non selective; any organism present in the water or marinade will be deactivated.

How Is a UV System Sized?

UV systems are sized based on three main factors: Flow rate, water or marinade quality and the challenge organism. Computational Fluid Dynamics (CFD) models are used extensively to design and right size UV systems.

The flow profile is produced from the chamber geometry, flow rate and the particular turbulence model selected.

The radiation profile is developed from inputs such as water quality, lamp type, and the transmittance and dimensions of the lamps and quartz sleeves.

Proprietary CFD software simulates both the flow and radiation profiles. Once the 3d model of the chamber is built, it is populated with a grid or mesh that comprises of thousands of small cubes. Points of interest, such as at a bend, near a sleeve surface, or close to the wiper mechanism use a higher resolution mesh, whilst other areas within the reactor use a coarse mesh. Once the mesh is produced, hundreds of thousands of virtual particles are fired thru the chamber. Each particle has variables of interest associated with it, and the particles are harvested after they exit the reactor. Discrete phase modeling produces delivered dose, headloss, and other chamber specific parameters.

When the modeling phase is complete, selected systems are validated using a third party to provide oversight that determines how close the model is able to predict system performance. Validation uses non pathogenic surrogates such as T1 phage or MS-2 to determine the Reduction Equivalent Dose (RED) ability of the reactors.

Most reactors are validated to deliver 0.5 log to 6 log reductions of typical infection organisms such as Listeria or Salmonella within an envelope of flow and transmittance.

The In line style of UV systems are both simpler to install and they achieve better performance than the larger low pressure types of systems.

Maintenance Requirements

UV systems are typically supplied with automated, on line wipers that keep the optical path free from fouling. UV lamps require replacement every year, and the quartz sleeve that houses the lamps every 2-3 years. Wiper seals typically require annual replacement. The routine downtime per system is typically 1-2 hours, and most manufacturers provide factory training for customers' technical staff if required.

UV Applications in the Meat-Processing Industry

Wash/rinse

UV is used to disinfect the water used to rinse whole WOGs (without giblets) and to spray, drench and tumble poultry parts before or after the chill process. All of the processing area wash down water, as well as the pipe CIP rinse water should be UV treated, as this is often a critical infection vector.

Feed water

UV light should be used to disinfect the feed water provided to stock. High stock density will cause elevation in stock stress, which can lead to increased mortality caused by reduced resistance to infection. UV light will deactivate all of the pathogens found in water.
As processors switch to providing re-used water (high quality recycled effluent) for stock so this application becomes more critical.

Injection brine and marinade disinfection

Brines are usually used on a recirculation basis, and offer an ideal growing media for a variety of spoilage organisms. Listeria Monocytogenes and Listeria Innocua can both be successfully removed from brine systems using UV light. High recirculation rates, and thin film reactor designs are critical for success in this application. The brine cycle can often be extended from hours to days when UV is adopted. The brine and marinade solutions can be used for injection or for cooling. Occasionally brine temperatures as low as 1 degree Fahrenheit are encountered.

De-ozonation and de-chlorination

UV light is effective at removing both chlorine, chloramines and ozone from water. System sizing is different to disinfection applications, as usually a higher dose is required. As water costs continue to rise, more poultry processors will examine alternative water sources. In many parts of the world, re-used effluent is replacing potable drinking water for rinse and wash applications. This usually requires dechlorination, and UV has proved to be a more cost effective method than GAC, or a chemical dechlorination process.

Waste water discharge or re-use

The effluent stream from a poultry processing facility typically contains a very high microbial load. Not unusually, the sewer district will levy a surcharge on the discharger to cope with the high load. UV light offers a method of reducing the load that is discharged, and with the addition of DAF / MBR and other wastewater processes can permit the re-use of the wastewater as outlined above. As water shortages become more the norm than an exception, poultry producers will be under even more pressure to minimize waste and to re-use whenever possible.

Jon McClean ispPresident of Engineered Treatment Systems LLC, and is a recognized expert in the industry. Based in Wisconsin, ETS manufactures UV systems in the USA for a broad variety of applications that range from ultra pure water for the leading semi-conductor manufacturers to disinfecting municipal effluent. For more information, please visit www.ets-uv.com *[1].*

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[1] http://www.ets-uv.com/