Efficient water management

Sound strategy to address water-in, water-out is a necessity to avoid operational and permitting issues

by James McDonald and Jim Rieke

The dramatic increase in ethanol production has put a strain on water supplies and may be a limiting factor on future growth of the industry. Ethanol production consumes large amounts of water in relation to the amount of ethanol generated, using approximately 4 to 5 gallons (15 to 18 liters) of water for every gallon produced.

Modern ethanol plants should be aware of the importance of a sound water management plan and the associated treatment and equipment options available for building efficiency into critical facility functions.

When planning for a new production plant or expansion, a fully integrated water management plan is essential to:

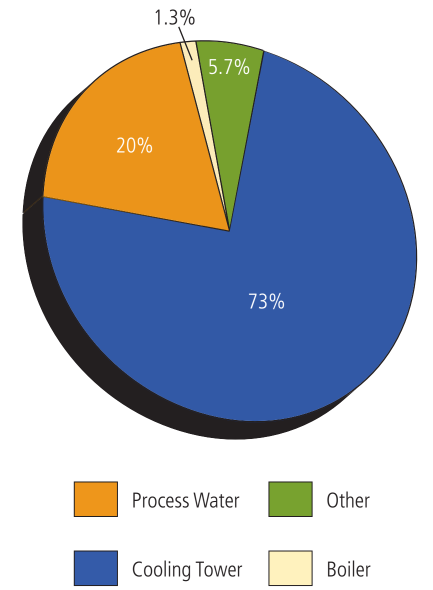
- minimize capital costs;
- achieve/maintain regulatory compliance;
- minimize operating and maintenance costs;
- and provide consistent, reliable, user-friendly production results.

WATER EVALUATION

Water source considerations play a large part in defining an efficient water management plan. City water, well water, sur-

(Above) Sound water management plan and associated treatment and equipment options are essential for building efficiency into critical facility functions.

Figure 1: Water Consumption



Source: Crown Solutions internal data.:

face water and other sources should be completely characterized through analysis along with potential impact on water chemistry, plant water equipment/users and the wastewater generated. The water source also needs to be examined for the ability to supply the volume necessary for potential expansions.

A block water flow diagram showing flows and flow rates is the next step before evaluating any specific water treatment equipment or chemical needs. This provides the basis for a plant-wide mass balance of water-in to water-out, with all the individual constituents identified.

The basis of this evaluation is identifying the main water users of the facility along with the associated quality of water needed and the subsequent wastewater generated throughout the plant.

Examples of key water users are ethanol process applications (distillation, fermentation, DDGS production) and CO_2 production, cooling tower makeup, boiler/steam production and water treatment systems.

The cooling tower is the biggest consumer of water in an ethanol plant, typically consuming 70% of all water (see Figure 1). Most of the water entering a cooling tower is lost via evaporation, but the blowdown is the largest contributor to wastewater generation. Maximizing the cycles of concentration of the cooling tower decreases the makeup demand and volume of wastewater. However, in the United States, the cycles can be limited by impurity solubilities and restrictions placed on wastewater quality by Publicly Owned Treatment Works (POTW) or National Pollutant Discharge Elimination System (NPDES) permits.

CHEMISTRY KEY TO EFFICIENCY

Water chemistry is a critical element in managing efficiency in an ethanol plant's water system. Efficiency in the cooling tower, due to its importance in the water balance of the facility, is dependent on the water chemistry. Properly applied chemistry will reduce scale, corrosion and microbiological activity in a cooling tower. Reducing scale and deposits provides optimal heat transfer surfaces in the heat exchangers, also contributing to energy efficiency. Minimizing the effects of corrosion will reduce maintenance costs, downtime, and extend the service life of major and ancillary equipment to reduce capital expenditures.

Typical chemistries applied include polymers (for scale and deposit control), phosphates and phosphonates (for scale and corrosion control), various other corrosion inhibitors (such as azoles, silicates and zinc), and biocides (including bleach, chlorine and bromine).

Though only consuming approximately 1.3% of overall plant water, boiler efficiency can benefit from the same methodology for scaling and corrosion control as the cooling tower.

Boiler chemistries may include oxygen scavengers (such as sulfites), polymers (for deposition control), phosphates/phosphonates (for deposition control), and neutralizing amines (for condensate line protection).

WATER TREATMENT EQUIPMENT

Proper application of chemistry is only a part of water management efficiency. Water treatment and process equipment works in tandem with chemistry to efficiently manage water and wastewater.

Equipment choice will largely depend on source water characteristics and management of various wastewater streams. Pre-treatment options, such as cold lime softening, clarification, ultra/nanofiltration, and reverse osmosis (RO), removes hardness that contributes to scaling and removes suspended/dissolved solids.

Treatment of these elements affect the cooling tower and boiler efficiency, but also serve as important components of the process water used in thin stillage evaporation following fermentation and distillation, as well as CO_2 production. This represents 20% of facility water consumption.

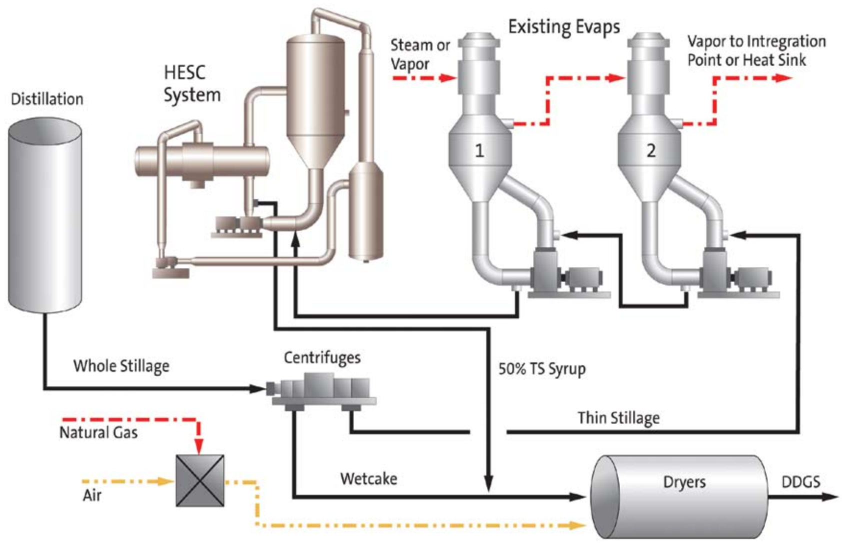
Process water makeup has rather high quality requirements. These are typically met with RO, but the use of nanofiltration and ultrafiltration should also be considered. The same RO unit used for process water can also be upsized to produce boiler makeup water. Providing high-purity water from RO units to a boiler, for example, enables higher cycles of concentration, which results in lower fuel usage, water consumption, wastewater generation, chemical usage, and a cleaner, more efficient boiler.

Water recycled internally is generally the largest source of process water volume in a typical ethanol facility. After fermentation, distillation and suspended solids separation, the remaining thin stillage stream represents a very large water flow - nearly 1,324 liters per minute (350 gallons per minutes) in a typically-sized plant.

Evaporation of water from thin stillage allows for recovery of this process water for recycle and produces a more concentrated syrup co-product. The syrup can be shipped "wet" or further dried with the previously removed wetcake to increase shelf life.

Conventional ethanol plant designs generally utilize multiple-effect falling film evaporation equipment to concentrate stillage from 8%TS to a range of 30% to 35%TS. The evaporator con-

Figure 2: High Efficiency Stillage Concentration System integration



densate that is produced is recycled back into the process. Due to the high viscosity of stillage above 30%TS, it is often difficult to concentrate syrup any further using conventional falling film technology.

If a dry product, distillers dried grain with solubles (DDGS), is to be produced, the remaining water in the syrup and wetcake is removed utilizing gas-fired direct contact drying systems. Nearly all of the process water going into the dryer is evaporated into the atmosphere with little condensate recovery. Further, direct contact dryers are relatively inefficient, requiring nearly 3500 kJ/kg (1,500 Btu/lb) of water evaporated and represent the highest operating and capital expenditures in the facility. A proprietary technology, introduced by HPD, utilizes an intermediary step of electrically-driven mechanical vapor recompression (MVR) evaporation to more efficiently concentrate syrup and remove water prior to the dryer.

Providing this supplemental evaporation of 11.3 t/h (25,000 lb/h), the High Efficiency Stillage Concentration (HESC) system concentrates syrup from 30% to 50% without the difficulties of fouling caused by the viscosity of the process stream. Heat transfer efficiency is gained in the absence of fouling, while recovering nearly 20% of quality condensate back into the process. (See Figure 2 for HESC system integration)

This represents energy savings of approximately $2 million per year based on natural gas costs of $7.60/GJ ($8MM Btu), while an additional 50 gpm of quality condensate is recovered for recyle into the facility and serves as makeup process water offset.

WASTEWATER MANAGEMENT AND REDUCTION

Wastewater is typically made up of cooling tower blowdown, boiler blowdown, RO reject, and pre-treatment equipment, backwash, and regeneration waters (filters, softeners).

In the U.S., ethanol facilities are often located in more remote areas, so the capacity of the local POTW should be considered. An ethanol plant can produce 2,081 liters per minute (550 gallons per minute) of wastewater, which can be a daunting number for a small POTW. An ethanol plant may find that customized wastewater treatment equipment and methods may have to be applied on-site prior to a discharge.

The balancing of water treatment equipment and applied chemistry greatly affect the way in which wastewater is managed. The reduction of effluent volume and the management of the constituents in the wastewater dictate how the ethanol plant disposes its wastewater.

If the characteristics of the waste stream are not clearly understood, discharge to nearby waterways may be prohibited by the U.S. Environmental Protection Agency limits for specific components. The same can also be said for sending wastewater to a POTW. Even if the POTW can receive the volume and quality of the wastewater, the rates for handling high levels of certain components may add to the cost of disposal.

CONCLUSION

Water management is a complex, specialized field that must balance economics, efficiencies and facility needs. Companies, such as Crown Solutions, recommend an integrated water management approach where a balance of chemical, equipment and operational solutions are all considered.

As water supplies become strained due to the rapid expansion of the ethanol market, the management and associated efficiencies required become more critical. A sound strategy to address water-in to water-out is a necessity to avoid operational and permitting issues. Maintaining an understanding of the balance between water chemistry and water treatment equipment ensures that these efficiencies can be realized in production, water consumption, energy management and compliance with regulation of wastewater. BB

James McDonald, PE, CWT, is the technical resource engineer at Crown Solutions, Vandalia, Ohio, U.S. He can be reached at 1.937.890.4075, x212 or by e-mail jmcdonald@crownsolutionsmail.com.

Jim Rieke is the senior sales manager for the renewable fuels industry at HPD, Plainfield, Illinois, U.S. He can be reached at 1.815.609.2047 or by e-mail jim.rieke@veoliawater.com.

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