

Reducing Energy and Water Usage During Food Processing

Implementing energy- and water-efficient practices and technologies is a priority in food manufacturing plants. Developments with heat and water recovery in continuous-process cooking provide critical reductions in energy usage.

By Jim McMahon

Many processes in food manufacturing can be modified to reduce operating costs while at the same time improving sustainability. One of the most important objectives to achieving this is reducing process energy and water consumption.

Reducing energy and water usage in industrial manufacturing, including food processing, is a key focus of the U.S. Department of Energy's sustainability initiatives. The department's Energy Star and Industrial Technologies programs address process functions in manufacturing plants that utilize process heat, steam, compressed air, electric and other systems that could potentially be a source of wasted energy and natural resources. These programs put particular emphasis on new technologies to achieve energy sustainability.

One technology that helps satisfy these sustainability initiatives is a continuous-



Pasta run with a multi-stage quench system is quickly cooled to take the heat out of the product and bring its temperature down to a safe 40°F range quickly to reduce the potential of bacterial growth.

process cooking and cooling process for pasta, rice and vegetables.

Continuous-Process Cooking and Cooling

Continuous-process cooking and cooling evolved from the batch method, which has been a standard in industrial and commercial cooking and cooling systems. Among its drawbacks, the batch method is somewhat limited in maintaining precise temperature and time parameters of pasta, rice or vegetable food products in the cooking and cooling process. The batch process also is limited in its agitation capability to keep the products separated during the cook and chill processes. Agitation facilitates product consistent temperatures.

Early continuous-process cooking/cooling systems used conveyors to move food products through the processes in series. Any cooker-cooler is only as good as its ability to precisely control the product's exposure to time and temperature parameters throughout the process. Conveyor-based systems may be prone to variable production rates, which introduces variations in product temperature and can result in inconsistent product quality.

Conveyor-based systems were superseded by rotary drum continuous-process cooker-coolers that utilize an auger method to move food products through an enclosed, water-filled drum. Considered the industry standard for continuous-process cook and chill methods, rotary drum cooker-coolers have improved the processing of pasta, rice and vegetables.

These improvements have ensured more uniform processes and allowed cookers and coolers to handle even higher throughputs. Step-blanching, for example, enables incremental temperature increases to be made throughout the process. Gentle mechanical agitation can be imparted to the food products as they progress through the cook and chill processes. One system applies a combination of air and water injection that physically and buoyantly supports heavier loads, more evenly distributing food products in cookers and coolers.

Controls automation integrated into rotary drum continuous-process cooker and cooler systems has largely made these



A mid-process quench cycle with unheated ambient-temperature tap water (65° F) captures much of the product's heat before it enters the primary chill cycle.

improvements possible. Programmable logic controllers (PLCs) provide precise automated control of process functions, including recipe management, and enable uniform cooking temperatures and control of water flow, achieving a consistent end process. The control systems minimize the time required to perform complex tasks and increase efficiency in cooking and cooling process operations. They reduce operator error and process cycle times, enable improvement in product quality and consistency, and increase production throughput and equipment return on investment.

The benefits from these automated process technologies also have minimized energy and water consumption. Compared to batch systems and conveyor-based cooker/cooler, the developments in rotary drum continuous-process cooker-coolers enable them to process the same volume of pasta, rice or vegetables in less time, using less energy to heat the water required for the processes. Monitoring energy and water usage as well as managing process systems in these rotary drum cooker-coolers have played important roles in supporting sustainability efforts in food processing plants.

Recapturing Heat and Water from Cooker Overflow

With conventional rotary drum continuous-process cooking, the cooker is filled

with ambient-temperature (approximately 65°F [18°C]) water and heated to 200 to 205°F (93 to 96°C). In the processing of pasta, rice or vegetables, the water needs to be continually heated to compensate for the constant addition of ambient-temperature product. This requires energy.

Additionally, in the processing of pasta and rice, because water is absorbed into the products during cooking, ambient-temperature makeup water must be continually added into the rotary drum. This increases the heat load requirements of the cooker and also requires energy.

During a process run of pasta, rice or starchy vegetables, which may continue for 20 consecutive hours, as much as 10 gal of water can be overflowed per minute to reduce starch buildup in the water. This means an equal amount of makeup water must be added. The volume of overflow and makeup water varies depending on the size of the cooker as well as the type and volume of pasta, rice or vegetables being run.

The overflow water is discarded as wastewater, but it takes 200 to 205°F heat energy out along with it. For every gallon that leaves the cooker at 200 to 205°F as overflow, a gallon of makeup tap water at approximately 65°F must be added. The cooker then must heat that water to 200 to 205°F to continue the cook process. This too requires energy. In essence, not only is the overflow heat energy from the cooker being wasted, but new energy must be added to heat the water in the cooker.

To address these concerns, a continuous-process rotary drum cooking system has been designed by Lyco Manufacturing, Columbus, Wis., to capture and reuse the heat from the 200 to 205°F overflow water. Leaving the cooker, the overflow water, instead of being put down the drain, is moved to an adjacent storage tank, where it is pumped through a heat exchanger. The heat is transferred from the hot overflow water to a reservoir of ambient-temperature makeup water before it is put into the cooker.

With this process, the makeup water can reach 125°F (52°C) — considerably higher than the approximately 65°F tap-originated makeup water used in previous continuous-



Multi-stage quench systems can reduce product temperature from 200 to 60°F (93 to 15°C) in 21 sec.

process cooker systems. This reduces the cooker's heating load requirements.

Additionally, the starch-laden overflow water, which previously had been discarded, is screened to remove particulates and reused as makeup water to compensate for product absorption, providing water savings.

The new technology can be integrated into existing rotary drum continuous-process cooking lines. The upgrade can pay for itself, in energy savings alone, in as little as six months.

Energy Recuperation from the Quench System

In rotary drum cooking and cooling, the pasta, rice or vegetables come out of the cooker at 200 to 205°F (93 to 96°C). The product then immediately goes into a chiller, where it is cooled in 35 to 40°F (1.6 to 4.4°C) water.

Initially, the water put into the chiller is tap water with a temperature of about 65°F (18°C). To bring the chiller's water temperature down to the 35 to 40°F range needed for cooling product, energy must be expended.

In addition, as hot food products are released into the chiller, the water must be continually cooled to take the heat out of the product and bring its temperature down to a safe 40°F range quickly to reduce the potential of bacterial growth. This too requires energy.

Bacteria predominantly grow in an environment that is between 40 and 140°F (4.4 to 60°C). During the cooking process, raw ingredients are heated past 140°F as quickly as possible to the final cooking temperature to minimize the time that food products can be influenced by bacterial growth. The same is true on the other end of the process line with the cooling of the product: Reducing its temperature as quickly as possible to below 40°F is essential.

In the cooker-cooler system, the addition of a mid-process quench step via a small reservoir between the cooker and cooler has improved the energy usage in this cook and cool process. Instead of moving the product directly from the 200 to 205°F water temperature of the cooker and into the 35 to 40°F chiller water, a

mid-process quench cycle with unheated ambient-temperature tap water (65°F) can capture much of the product's heat before it enters the primary chill cycle. Because the quench tap water is not preheated, it does not require energy input.

Quenching reduces the temperature of the pasta, rice or vegetables down to the range of 110 to 120°F (43 to 49°C), capturing 45 to 50 percent of the cooked product's heat energy in the quench water. The 110 to 120°F water in the quench then can be used in the cooker for makeup water to rehydrate the product rather than bringing in the 65°F tap water to reach the 200 to 205°F temperature cooking range. This reduces the energy draw normally needed to heat the cooker water.

The quench then releases the product into the chiller, which now only has to bring the product temperature down 70 to 80°F (38 to 44°C) to reach the targeted 40°F (4.4°C), instead of needing to bring the temperature down 160 to 165°F (89 to 91°C) if the quench cycle was not in place. The energy savings in the chiller from the reduced refrigeration load is significant.

The quench system maintains 100 percent uniform product cooling with less than 1 percent product damage according to the manufacturer. Rice, most varieties of pasta, and select vegetables can be cooled in the quench to 110 to 120°F before entering the chilled water cooler. The quench system from Lyco Manufacturing uses patented plenum technology to achieve its high-speed cooling without damaging the product. The pasta, rice or vegetables are pulled through the cooling plenum at the bottom of the tank by venturi effect, which increases the velocity of the fluid without pump impeller contact. The venturi effect creates a pressure differential that pulls the water and product through at a high speed with the capability of moving 300 gal of water and product through the plenum per minute. **PH**

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