Northeast Foods Automatic Rolls of NC

Pushing the Boundaries of Automation

A McDonald's supplier designs a high-volume bakery that boosts automation to new levels and recasts the role of production floor workers.

Kevin T. Higgins, *Senior Editor* | Plant photos by Sue Mitchiner

Operator Richard Obermeyer fills a quality control function while overseeing two makeup lines at Automatic Rolls of North Carolina. Photographer: Sue Mitchiner.

For years, the lights-out factory has been the holy grail of automation, the ultimate expression of production untouched by human hands. But as a practical matter, raw material variability and high-volume throughput make lights-out food production problematic.

A better goal might be grunt-free production, where machines do the heavy lifting and humans ensure product quality. In that case, Northeast Foods attained grunt-free baking with the opening of Automatic Rolls of North Carolina, *Food Engineering*'s 2012 Plant of the Year.

The Paterakis family owns Baltimore-based Northeast Foods, a commercial baking powerhouse with 13 production facilities either owned outright or in partnership. Five are part of the Northeast Foods group that stretches from Connecticut to Clayton, NC, where the newest plant began production in May 2011. Most of Northeast's production is buns—rolls in East Coast parlance—bound for McDonald's outlets. Meeting McDonald's needs requires high throughput and few changeovers, an ideal scenario for lights-out manufacturing. But rather than turning out the lights, management hopes automation will better illuminate processes and their outcomes.

Shawn Williams performs the final quality inspection as baked buns enter the bakery's packaging line. Quality inspectors are the only personnel in the packaging department. Photographer: Sue Mitchiner.

Two makeup lines push a continuous stream of oversized pans to a spiral proofer in Clayton, delivering 13,000 lbs. of raw dough an hour to an oven that bakes 1,400 hamburger buns a minute, or more than 2 million in an uninterrupted 24-hour period. Each shift has an operations team that borders on the skeletal. For any given shift, only a handful of workers are found on the 75,000-sq.-ft. production floor, and their responsibilities primarily are quality assurance, with a minimum of bending and lifting. Of the plant's 63 employees, most are maintenance or sanitation personnel.

Only four products are baked and bagged in Clayton: regular buns, quarter-pounder buns, Big Mac buns and bakery-style buns. But specifications are extremely tight, and deviations barely perceptible to the naked eye are unacceptable. Therefore, the people who ensure quality standards are met may be more important to the plant's ultimate success than the machinery. Engaging and involving them is critical, and the same has been true for others involved in the project, from the design stage through the plant's first year of operation.

Northeast's engineers believe they've achieved a new standard for rolls baking, though there are other distinctions in the Clayton facility as well. Two automatic storage and retrieval systems (AS/RS) were installed, including a lights-out freezer operation that was driven by supply chain considerations. The plant is Northeast's first with ammonia refrigeration. The fatal Imperial Sugar explosion was fresh in engineers' minds when design work began, and special care was taken to mitigate the possibility of such an event in Clayton. Sustainability considerations go beyond energy efficiency to include good neighbor

The gang's all here

The community of food professionals is finite, and though people change jobs, they tend to make a career in the industry. The same is true of professionals on the supplier and services sides, as this year's Plant of the Year project illustrates.

One engineer at A/E firm A M King Construction, Stuart Jernigan, has been associated with five Plant of the Year projects, though the Northeast Foods project is the first for A M King. Likewise, several engineers at Workhorse Automation played key roles in the installation of an automatic storage and retrieval system for baking pans at Pepperidge Farm, 2004 Plant of the Year ("Built for Speed," *Food Engineering*, April 2004).

Pepperidge's pan-handling system almost became a bankruptcy court asset. Before the supplier's assets were frozen, Colin McShane relocated the AS/RS equipment to the Pepperidge Farm facility in Bloomfield, CT, and an ad hoc group of engineers completed the controls integration work. McShane now is the owner of Oxford, PA-based Workhorse.

Both Pepperidge's and Northeast's systems were designed by Ken Mentch, an electrical engineer at Workhorse. The newest project's production volume dictated "the fastest pan system in the US," with up to 40 pans a minute either rotating back into production or being routed to storage, says Mentch. The pans weigh up to 25 lbs. each, substantially more than at the Pepperidge plant, and the cantilevered, single-mast crane that shuttles pan stacks weighing up to 3,500 lbs. requires considerably more horsepower. The most significant difference, though, is the controls. Five articulated-arm robots stacked and unstacked pans at Pepperidge. The gantry robot at Northeast relies on Allen-Bradley ControlLogix and operates much faster. "There's no proprietary software or specialty controllers," says Mentch. Integration into the facility's controls architecture also was greatly simplified.

The two 8-pocket wide pan-o-mats only run at 88 cuts per minute. This relaxed rate allows accurate scaling and precise control of the dough pieces, which in turn enables very accurate placement of the dough pieces in the oversize baking pans. Photographer: Sue Mitchiner.

practices such as a containment system that ensures any material spills are isolated onsite.

Satisfy the supply chain

Direct store delivery (DSD) typifies distribution for fully baked breads and rolls, and it works well for both retail and foodservice distribution, particularly in urban areas. But McDonald's restaurants are found in rural hamlets as well, and the chain looks at suppliers to review DSD and deliver instead to distribution centers (DCs), where it makes logistical sense. Instead of a half-dozen suppliers' trucks driving through the countryside, all the patties, chicken nuggets and other menu items can share the ride in a single delivery. Frozen buns are the choice if fresh bun deliveries are too far away to meet spec requirements on usable remaining days of shelf life at delivery.

Two other Northeast Foods plants use chlorofluorocarbon refrigerants to accommodate DC distribution, but the production volume in Clayton put ammonia refrigeration into the realm of possibility. The addition of Eric Mohrmann to the corporate engineering staff a year before planning commenced also eased qualms, given his previous experience with ammonia systems. Mohrmann served as project engineer for the Clayton plant.

For a 13,000-sq.-ft. freezer like the one used in the Clayton facility, a chlorofluorocarbon such as Freon typically is used, says Brian King, president of Charlotte, NC-based A M King Construction. "They chose ammonia refrigeration for all the right [sustainability] reasons," King says. The decision did not go unnoticed by the plant's customer: McDonald's recognizes the Clayton facility in its *2012 Best of Sustainable Supply* report, highlighting the climate/energy considerations of the project under the heading, "Building the Sustainable Bakery." Despite the higher upfront cost, lower maintenance and operational costs make ammonia refrigeration more economical in the long run, and the existence of a municipal HAZMAT team addresses safety concerns. A key design consideration was to make sure peak load would be under 10,000 lbs., the threshold for process safety management requirements. A skilled technician and detailed documentation are ongoing requirements once that threshold is passed.

Despite its modest footprint, the high-velocity freezer boasts 702,000 cubic feet of storage. The installation of an AS/RS crane removed any height restrictions, and the freezer soars 54 ft. and accommodates 1,270 pallet positions.

Waste heat from the freezer's compressors warms glycol that is piped through the freezer's sub-floor, safeguarding against soil heaving and eliminating the need for electric heating. The ammonia system also chills glycol to 8°F and routes it to mixers and other process equipment.

Four ammonia compressors drive the system, though the fourth is redundant, reflecting a company philosophy of valuing uptime over lowest possible capital cost. Standby capacity also is engineered into boilers, air compressors and other infrastructure items. Two low-temperature compressors meet base demand, while a medium-temperature compressor outfitted with a variable frequency drive (VFD) ramps up and down, as needed.

VFDs are integrated into motor groups throughout the plant, including those powering freezer fans and condensers. The payback from those energy-efficiency investments was shortened thanks to King engineers' early outreach to local utility Progress Energy. The annual electric demand of a base design was compared to energy consumption of an upgraded system. As efficiency improved, so did the rebate Progress would provide. The tiered rebates

Raw dough is conveyed in the foreground, while baked buns exit the oven in the background. The plant is capable of producing more than 2 million buns in a day, with minimal human labor. Photographer: Sue Mitchiner.

helped rationalize multiple upgrades, such as R-49 insulation instead of R-41 in the freezer's metal panels. The cumulative affect is a freezer that draws 28 percent less electricity than a conventional design, or an annual reduction of about a 780,000 kWh.

"The incentives helped, but we're in this for the long term," says Dennis Colliton, Northeast's vice president of engineering. While most improvements will produce a return on investment within three years, management supported some that stretched ROI to seven years or more, provided there were benefits beyond energy efficiency alone. A prime example is the backup diesel generators, also an outgrowth of the early discussions with the utility.

Nationally, electric utilities are pouring millions of dollars into efforts to shed demand during peak periods. A testament to those efforts are the three 1,000 KVA diesel generators positioned outside the Clayton plant's western wall. The generators can meet all of the facility's electric demand. In return for subsidizing their purchase, Progress Energy can request the plant to switch over to them when electric demand spikes. The power feed into the facility is synchronized with the grid, making the transfer seamless and imperceptible to equipment in the plant. Only a handful of requests were made in the plant's first summer of operation, and when that occurs, the utility pays Northeast double the industrial electric rate for the generators' output. Backup generators also allow Northeast to monitor severe weather conditions and effect a phase transfer when there is the possibility of a power interruption that could disrupt the facility's electronics.

Hard-way highway

High throughput characterizes all the Northeast Foods facilities, with a previous high-volume mark of 1,000 rolls a minute. To raise the bar even higher necessitated an unconventional approach to conveying and a re-engineered system.

Typically, pans with pockets four rows wide and eight rows deep are fed to the oven. Northeast engineers specified pans with an extra row, in a five-by-eight configuration. They maintain the wide side of the pan as the leading edge, a technique they call conveying "the hard way." Although line speed had to slow, the plant was able to set a volume standard 17 percent higher than the previous record rate.

The wide-side orientation means larger conveyor motors, wider turns and other modifications to the layout. The key change, however, was the introduction of an indexing conveyor where the two makeup lines are joined. In other plants, pans reached a T-shaped conveyor that altered direction 90° and lost the wide-side orientation. In Clayton, the lines come together at different elevations, with pans queuing on one level while an oscillating conveyor accepts pans on the other level. The oscillating conveyor alternates between the two levels and maintains the wide-side feed into the proof-box's spiral.

For the rest of the process, the only personnel involved are the quality inspectors who watch for defective buns as they are fed into flow wrappers. After buns are baked and before they enter cooling racks, a vision inspection system automatically

Two of the plant's four ammonia system compressors are equipped with variable frequency drives, optimizing load demand and lowering energy consumption by the 250hp units.

rejects product outside the parameters for color, shape, seed distribution and other specs. The high volume is a challenge for the machine, however, and the blotches and other flaws on some rejected buns are invisible to the naked eye. Slightly elevated waste levels are a price the manufacturer pays to assure customer satisfaction.

Carts usually ferry baking pans from the end of a production line to the start. That labor-intense and injury-prone activity was made obsolete in Clayton by a gantry robot and AS/RS. After baked buns are depanned, the pans enter either a recirculation loop or are detoured to the gantry system.

Liquid-sugar and vegetable-oil silos are below grade in a room that could contain 8,000 gal. of liquid in the event of a silo leak. Photographer: Sue Mitchiner.

Immediately before that juncture, the pans are rotated either 180° or 360° on an inline magnetic table while brushes and air knives remove any crumbs and other debris. The table's capacity is 40 pans per minute, and it handles weights up to 25 lb. per pan, according to Ken Mentch, an electrical engineer with Workhorse Automation Inc., Oxford, PA.

Mentch designed a handful of similar magnetic tables for other bakeries, but the table used in the Clayton facility is the first to combine cleaning, inverting and diverting in a single station. "That is the fastest pan system in the US," he says, with up to four pans being simultaneously handled.

Workhorse personnel fabricated both the freezer AS/RS and the pan system, including the AS/RS and gantry robot. When pans are fed to the gantry, they enter the robot cell upside down. The gantry maintains that orientation, and later the pans are stored on edge, a configuration that minimizes damages to the pockets that cradle the dough. Colliton anticipates damaged pans will become a thing of the past. The pan-handling system cuts changeover time in half and eliminates any worker involvement.

No workers interact with product after packaging until pallets are pulled from the freezer on a first in, first out basis. Filled trays are stacked 20 high automatically, then move on a 100-ft.-a-minute drag chain to a palletizer that combines four stacks and pushes the load into a stretch-wrapper. The completed pallet, with 25,200 buns, is then automatically delivered to the freezer AS/RS for inventorying.

The front of the production line is almost as hands off, though someone has to push a button to start the mixing process. After that, a recipe program takes over, metering in water, flour and other ingredients and delivering a sponge dough to a trough handling system that shuttles the dough into an adjacent fermentation room. The sponge room can accommodate 27 troughs; typical dwell time is about four hours. Based on data

A reciprocating conveyor alternately feeds dough to dividers on two makeup lines. The conveying system reduces stress on dough during the transport from the dough pump to the divider.

from the production management system, the dwell can be extended to seven hours, with the room's temperature and humidity adjusted automatically to match hold time with production demand.

The human touch

Receiving is probably the most labor-intensive area of the facility, though the work is not too physically demanding. Once a day, a lift truck hoists a pallet loaded with minor ingredients, and someone must transfer those supplies to a pneumatic conveying system. The receiving staff also serves a QA function, locking in delivery trucks' transfer hoses to the plant's screens for flour, vegetable oil and liquid sugar and yeast. Receiving personnel compare delivery samples with the supplier's certificate of analysis, then visually inspect the screens before unlocking the hoses and accepting delivery.

"We hired the best receiving crew I've ever seen," says Corporate Engineer Andy Black. The silos and tanks that hold raw materials are positioned in below-grade depressions deep enough to hold the tanks' contents. If an 8,000-gal. liquid sugar tank were to rupture or a 150,000-lb. flour silo were to fail, the crew would immediately close any storm water drains and call in a septic service company to vacuum out the spill.

Black is the architect of the production management program that integrates the multiple automation systems and ensures quality data are captured and analyzed. "After going through several canned software programs, we decided to build our own system that can grow with us," he explains. "We're on the cusp of all-digital data collection." That, in turn, opens the door for more sampling and root-cause analysis of drift in product specifications.

Scattered throughout the production floor are flat screen monitors that provide real-time reporting on manufacturing performance and shift-by-shift comparisons of run and reject rates. Some shifts occasionally beat the target of 96 percent throughput and a 1 percent reject rate. The monitors were put in place a few months ago, and Plant Manager Richard Tommy says they already have provoked friendly competition between the shifts.

As many as 30 programmers were onsite during the equipment installation phase, though Black and one other electrical engineer integrated the multiple automation systems themselves. Almost 600 IP addresses are on the network, including 60 Allen-Bradley PLCs. NEMA 4 enclosures protect both the electronics and the workers. If any flour dust were to get into the enclosures, the potential for explosion would exist, so keeping the dust out is just as important from a safety standpoint as it is from an electronics standpoint. Discreet air conditioning units serve the panels.

For security purposes, no VPN keys are provided to non-Northeast personnel; isolation of the plant network from the corporate information system provides a physical firewall. A separate network ties together the plant's 50 cameras. Hacking into the Ethernet network would not provide access to the video network.

Activities on the floor trigger recording by a DVR, allowing managers to review what transpired prior to an event. The system is a valuable tool for correcting improper procedures, notes Tommy. By reviewing the tape, "I learn, I teach, I move on," he says.

A library of almost 100 verbal alarms was built to direct mechanics and other personnel to areas requiring attention. "You can get too granular with voice alarms," allows Black, and the objective is to get the right personnel to an area requiring attention, then "let them figure out the problem and the solution." The system also helps identify problems that are chronic or repetitive, triggering corrective action.

Flour dust is an unavoidable byproduct of volume baking, and multiple strategies are used to control it. One of the most striking is the extensive use of suspension rods to lift conveyors and other equipment off the floor. A collateral dead load capacity of 15 lbs. per square foot (psf) is typical for warehouse buildings. Clayton's roof trusses

Uniform color, shape and size are evident as hamburger buns head to a depanner. While only four types of buns are produced, the plant must meet stringent quality standards. Photographer: Sue Mitchiner.

were designed to support a 25 psf load, with additional capacity in some areas to support hanging conveyors.

At A M King's recommendation, high-density cement was poured in all dry areas of the production floor. The composite added about $1 per square foot but eliminated the need for a urethane or epoxy topcoat. Colliton wanted to avoid the delamination and spider-webbing problems that plague resin flooring over time. The high-density cement is backed by a five-year warranty that guarantees it will accomplish that. The floor also has a polished veneer that makes it difficult for flour dust to cling to the surface. The cement mix only requires one expansion joint per 15,000 sq. ft. of poured surface, compared to one joint per 1,000 sq. ft. in a typical installation.

The cement would not be appropriate in a washdown environment, but management's aversion to wet cleaning ensures floors will be kept dry. "If Dennis had his way, there wouldn't be any drains," one engineer laughs, but limiting floor drains to the proofer and the mixing area isn't just about protecting the concrete. Managers also want to protect the machinery and

Brian King (left) of A M King Construction and Northeast Foods' Dennis Colliton confer in a room overlooking the production floor at Automatic Rolls of North Carolina.

electronics, and a drain is an open invitation to water use. Once a drain is installed, the thinking goes, a hose caddie soon will follow. Mixing water and flour in sanitary lines results in high BOD loads, another incentive to minimize water consumption.

Half the municipal water coming into the plant ends up in the product, and the rooftop cooling towers consume a big chunk of the balance. Northeast invested in meters that quantify the gallons of water that actually go down the drain. After validating metering accuracy, municipal authorities agreed to base sewer surcharges on the actual amount of water sent to the treatment plant, not the amount of incoming water.

"We wanted to go farther in water management," adds Colliton, and two water systems were installed, one for process water, the other for housekeeping purposes. Both systems rely on rooftop solar panels to preheat hot water to 120°F. Process water is heated another 20° by an on-demand water heater, while a 115-gal. conventional tank stores and distributes housekeeping's hot water. "It's a pure solar preheat system," says Colliton. "There's no auxiliary heating until needed." Compared to other Northeast Foods facilities, the solar system is expected to save more than 53 million Btus a year, or the equivalent of about 15,500 kWh.

Fifteen rooftop air handling units deliver 400,000 cubic feet a minute of filtered air to the production area, enough to provide

eight air exchanges every hour. A beefy HVAC system was essential to removing heat from cooling buns and airborne flour dust.

Good housekeeping is essential for dust mitigation. Sanitation crews wage a continuous mitigation effort. "You're fighting a dusty environment, and that can be difficult," says Tommy. When production is down, the 10-person sanitation crew wipes down every horizontal surface on the floor, he adds. Portable vacuums are replacing other methods of dust removal, and managers are working with vendors to develop equipment refinements to reduce flour dust.

In addition, extensive use is made of natural lighting, with skylights outfitted with refraction lenses bathing the production area with sunlight. Light harvesting, coupled with induction lighting that consumes half as much energy as metal halide, helped lower electrical consumption to about a third of what would be needed for a comparably sized facility. Induction lamps also use a high-frequency generator to excite the bulb's gas, doing away with fluorescent lamps' electrodes, which are wear parts. Consequently, the fixtures deliver up to 100,000 hours of service life.

Total team approach

At a time when almost every greenfield project is labeled "fast track," the Clayton facility distinguished itself by wedging design, permitting and construction into an exceptionally tight framework. Some of the credit goes to local authorities, who committed staff to the interim permitting process to keep construction on track.

A bigger factor was the collaborative approach between engineers at Northeast and A M King. Colliton took a small leap of faith by scrapping the company's usual construction methodology. Instead of retaining an architect and then bidding the job to a general contractor, he opted for a design-build approach after meeting with professionals from A M King, which had not previously worked with Northeast. The A/E firm's fee was established upfront, resulting in greater flexibility to specify upgrades and improvements as the project progressed.

"There were no egos in the room, no preconceptions about how the project should proceed," says King. "Northeast's engineers made us feel we were a valued part of the team."

Specifications are often omitted when a manufacturer works with an architect, resulting in change orders and project costs that spiral "out of control," adds Colliton. "This was a complete collaboration with both King and the equipment vendors. Now I'm convinced design-build is the way to go." From groundbreaking to production startup, less than 10 months elapsed.

Explosion panels are engineered into the walls and ceiling of the flour-sifting room, which is isolated from the facility's production area and runs without operator involvement. Photographer: Sue Mitchiner.

Despite the plant's high level of automation, the team was careful to build in flexibility to accommodate the art as well as the science of baking. "I'm a big fan of letting the baker make fractional adjustments," says Black. Some elements of production simply are not conducive to a lights-out approach. "There are still things where you must have people involved, and that's coming from an automation guy," he says.

A side benefit of automation is relieving plant personnel from mundane tasks, allowing them to add more value in terms of product quality and production flexibility. All operators are cross-trained in four different positions, and they have an enhanced understanding of the plant's objectives and improved-performance efforts. Tommy instituted a well-received open-door policy for all manufacturing meetings. "There are no secrets," he emphasizes. "We're all working on one team."

"Skilled operators become a valuable asset to the organization and are part of the success of the company," adds Colliton. Reduced labor is always the cost justification for automation investments, but the soft return of increased staff member effectiveness is expected to pay big dividends in the years to come.

The lights may remain on in this plant, but automation is shining a brighter light on the science of baking. ❖

For more information:

Brian King, *A M King Construction Co., 704-365-3160, bking@amkingconstruction.com*

Ken Mentch, *Workhorse Automation Inc., 717-581-6636, kmentch@workhorseautomation.com*