In most foundries, the cleaning room is the most labor-intensive and least desirable departments in which to work, with a workflow process that is described as “chaotic” at best. With the wasted effort that accompanies moving and removing buckets of castings awaiting their next processing step, most foundries’ cleaning rooms are of the stuff that makes even the most patient bean counter shake his head. On the other hand, a capital cleaning room assignment can make an industrial engineer drool, knowing that the possibilities for improvement are enormous.

The cleaning room is most foundries’ main culprit of inefficiency—high work in process inventories, high material handling expense, excessive leadtimes (time sitting in queue) and high labor. To illustrate the degree of nonvalue-added effort, consider this: a presentation at the 1999 Steel Founders’ Society of America Technical & Operating Conference reported that more than 1500 miles of material handling per year was saved by a quick flow path analysis that helped a foundry rethink the placement of one piece of equipment alone.

Despite the fact that chaos is largely an “industry standard” for the cleaning room, it need not be an area in which people and forklift trucks are constantly sprinting at a frenetic pace. In an attempt to illustrate the creative possibilities currently employed, modern casting polled industry officials on some of the more progressive or “model” foundry cleaning rooms. What you have before you is the culmination of this project, which features three such models—in iron, aluminum and steel.

In the mid-1990s, long before a single Waupaca Foundry engineer sat down to draw up a facility concept for its new focused gray iron casting facility, a lengthy exercise was initiated to determine the optimal way to process rotors and drums. When producing quantities of up to 37,000 parts/day, Waupaca knew that continuing with the status quo would also bring along a significant opportunity cost.

So, a cross-functional team was formed to survey current industry benchmarks, future customer needs and how that would relate to what would be required of tomorrow’s foundry. Bill Powell, Waupaca Foundries’ manager of melt/metallurgy, recalled that the group was challenged to “think outside of the box, but keep one foot in it.” Incidentally, most of the concepts brainstormed by this group for the facility—which was intended from the “get-go” to set a new standard for labor-saving efficiency—focused largely on what happened to the parts after they were poured.

Among the key drivers were:
• automation to remove labor requirements, particularly in the unpleasant areas;
• efficient, inline flow;
• minimal non-value-added handling;
• elimination of in-process casting damage;
• uniform, consistent cleaning.

Through the engineering group’s “what-if” question-raising, a “wish-list” grew to a 5-page document that began to take on a life of its own. Ultimately, said Powell, this list was “just shy of marching orders” for the plant. In fact, the team had to justify any concepts it did not incorporate from that list.

One paradigm shift evident in the foundry was that the cleaning room, not molding or pouring, would dictate the plant’s production via a “pull system.” In other words, the cleaning room would set the pace for the plant’s production. For example, if a breakdown occurred in the cleaning room, mold production would cease. Said Powell: “The ‘pull system’ is a discipline many would like to avoid. In most foundries, potential breakdowns in the system are planned against by figuring out how to go around it.”

Illustrating the change in approach is the fact that customer-service and order-taking personnel work out of the plant’s shipping department, close to the action. Their decisions on the day’s shipping needs reflects scheduling up the line.

Waupaca’s costing system is advanced to the point that personnel recite the cost associated with each time a casting is touched, placed in a tub or relocated. They also know that there are everyday things that can be done upstream to gain efficiency later. Among them, said Mick Wennesberg, plant manager, are continually pushing the envelope on reducing the size of gates/risers so they are easily broken off at shakeout. While Waupaca’s cleaning requirements are simple—to clean off sand and grind the outside dimensions—their engineering work to eliminate
weak points and bottlenecks while maintaining low inventories was an exhausting endeavor.

Briefly, Wennesberg describes the flow in the plant (which began production quantities in 1997) as follows. Molds emerge from the 300-ft cooling lines onto a high-frequency shakeout conveyor. Upon being shaken out, the castings are picked and sorted via an automatic manipulator and then are placed onto special "trees" attached to a power-and-free conveyor. Once filled with castings, these trees are automatically released into a chamber that cools the castings to a uniform temperature before they enter a continuous blast-cleaning unit. Only following this step do human hands touch the casting for the first time—parts are manually unloaded and placed onto a conveyor which presents them to automatic stations where they are ground, inspected and packaged. Typically, parts are packaged and ready for shipment within 2 hr of exiting the mold cooling line.

This cleaning room design, said Wennesberg, improved upon Waupaca's previous company standard (considered an industry benchmark by its own accord) by removing 2-3 jobs from the traditional cleaning process. These bodies were needed for tasks such as picking off castings, as well as more traditional grinding, stacking and shipping tasks.

Impressively, the only work-in-progress in the department at any time is whatever is on the line, and most shipments are driven onto the truck within 4-6 hr. Besides the financial gains associated with low work-in-progress, Powell said it also plays a big role in quality assurance. "There's no room anymore for work-in-progress, we need to know about a quality problem as it occurs." Another departure from traditional practice is that scrapped casting boxes hold no more than 3 castings at a time, highlighting immediately that attention is needed.

Here's a closer look at some of the critical points in the system:

**Shakeout Manipulators**—Knowing that its customers' machine tools react violently to nicks and dings in castings, Waupaca wanted to minimize drops and other opportunities for castings to strike against each other during shakeout and in part handling. In addition, this type of equipment removes the most unpleasant and ergonomically problematic job into arguably one of the "nicest," as operators reside in an air-conditioned cab.

**Cooling Chamber & Continuous Spin Blast**—Considered an industry-first, Tell City's design involves a chamber to bring 1000-1200°F (537-648°C) castings down to a uniform 300°F (148°C) temperature for fast, efficient processing. According to Powell, castings of varying temperatures would be less efficient to process and would present varying surface finishes. Waupaca also needed each part to receive precisely the same amount of shot, in the same location. As such, it was determined that a tree holding multiple castings could be suspended in a cabinet and programmed to spin in the same way to ensure that each component receives the same processing as its neighbor, or a casting on any other tree.

**Automatic Grinding**—Like its molding lines, Waupaca designed and built automatic grinding machines to meet its own unique needs. As each casting is conveyed into the machine, two dies fixture the part and rotate it before a grinding wheel automatically moves to the casting surface. Upon completion, the die and wheel return to their original position and the finished casting is conveyed to the end of the line for inspection. The foundry measures its grinding wheel costs in cents per ton, and its costs at Plant 5 are significantly below the average of the rest of the facilities in the Waupaca family.

**Inspection & Packaging**—These functions have been directly integrated into the process to gain even greater efficiencies. Following the specified in-process inspection, castings are placed directly into the packaging the customer's assembly line wants. Said Powell, "We want to be an easy foundry to do business with, whatever and however the customer wants it packaged—skids, baskets, boxes, racks, cardboard, etc." Besides the random dock audit, each container undergoes a post-inspection where the packaging, piece counts and labeling are verified before a barcode is issued to the shipment, which also prompts the invoice to be cut. If at any time a need exists to hold parts that are in question, the system would not allow unapproved pallets to be loaded. The part quarantine process is made possible from a desk.

The results are visible in the plant, and its forward-thinking engineering and use of automation was a key reason that the facility received the '99 AFS Plant Engineering Award (see "Waupaca Tell City: A Model for the 21st Century," June 1999 *modern casting*). Like many foundries, Tell City's largest labor requirement remains in the cleaning room. But very much unlike other foundries, the required number of cleaning room employees is just 3 per line (each entire production line can be operated by 5 workers). Again, only on two occasions is there a manual intervention to the process—to unload castings from the tree after blasting and at inspection/packaging.

The most telling metric is the fact that each ton of castings sees only 30 minutes of time in the cleaning and finishing area, and it is evident through a walk-through of the plant. "Visitors are amazed by the lack of people that it takes to ship the tonnage that we do," said Wennesberg. "Over the last 3 years, efficiencies have improved to where the cleaning room can take pretty much whatever we throw at it. Phase 1 has become the cleaning/finishing benchmark for all Waupaca plants."
In the late '90s, Hayes Lemmerz International, Inc.'s Wabash Operation (formerly operated by CMI International), Wabash, Indiana, underwent a shift in production. Its niche as a high production operation for aluminum intake manifolds was being diversified. The plant was slowly shifting from 4 jobs and 30,000 castings/week to 11 jobs at the same level of production. Beyond manifolds, the foundry was to produce components such as cylinder heads, intake ducts, and wheel hubs. For a foundry with only one molding line, the major affects of this diversification of jobs was going to be felt most in the cleaning/finishing department.

"This diversification was going to tax our existing cleaning/finishing department," said Mark King, cleaning/finishing production supervisor. "We had to reduce the baskets sitting around, the labor being used, and the efficiency of the department in terms of the amount of time it takes for a casting to be processed."

The old cleaning/finishing operation consisted of three separate lines for processing castings, at the end of which were baskets for cleaned castings. These baskets were transported by forklift between processing lines or back and forth to shotblast, which was located in another part of the plant. "The extra shuttling of castings didn't seem as inefficient with only a few components, but we knew the confusion was going to escalate with the increased jobs," said King.

Wabash's reinvention of its cleaning/finishing department began with the creation of a continuous improvement team (CIT) to analyze the current situation and establish the best methods for improvement. The CIT was made up of hourly and salary employees Mark King, Tim Green, Gary Buzbee, Marty Schaal, and Bruce Ashbaj.

"Our primary goal was to reduce labor on the line and the number of touches on each casting," said King.

The CIT team's initial determination was that the department could be optimized without any extensive capital outlays. Although new trim presses and saws were going to be required to accommodate new part numbers, the most part, the foundry could reorganize the 8000 sq ft of space to produce continuous flow, eliminate basket storage and forklifts, and improve efficiency.

"All it took was to extend our monorail and reengineer the belt conveyors," said King. In addition, the foundation for Wabash's new cleaning/finishing department was the idea that it was nothing more than an extension of the foundry's molding line, and that the casting production process was to be one continuous flow from mold production through final inspection.

The work flow of the new cleaning/finishing operation begins as the castings ride the shakeout conveyor (where vibration removes the runner systems) from the foundry's single flaskless horizontally parted green sand line (270 molds/hr.). The castings are manually loaded onto a power-and-free overhead conveyor system and transported to a rattle machine to facilitate coldbox core removal. The castings then are continuously indexed on the overhead conveyor system to the cleaning/finishing area.

The first operation in cleaning/finishing is saw-off of the riser and/or gating system that is still attached after shakeout. Depending on the component, a worker will load a casting into a maximum of two different dies on the saw machines (13 total saws in department). The casting then is placed back on the overhead conveyor and fed to one of seven trim press operations (including a rotary fourstation trim machine) for the removal of flash, fins, etc. After being manually loaded back onto the overhead conveyor, the castings are indexed to one of four manual grinding stations.

Once the castings are ground, they are placed onto a continuous belt conveyor system, which passes the castings through a dedicated visual inspection station and then into one of two cabinet shotblast systems. At shotblast, the castings are manually placed on hangers (up to six castings per hanger), shotblasted, and then placed back on the belt conveyor and sent through final inspection.

The first key for Wabash's cleaning/finishing is that no single operation (rattling, cutoff, trim, grinding or shotblast) takes more than 30 sec/casting. As a result, castings are not removed from the overhead or belt conveyor systems for more than 30 sec and the foundry is able to continue the in-process cleaning/finishing in a once-through assembly line fashion throughout the department. This is achieved in part by the positioning of the equipment and the conveyor systems. The layout of cleaning/finishing ensures that even though castings are touched at each of the five stations (cutoff, trim, grinding, shotblast and final inspection), the workers are just shuttling the components a foot or two between the conveyors and the cleaning/finishing equipment.

Another important measure Wabash takes is that each step in its cleaning/finishing serves as a casting inspection point as well, ensuring that components do not undergo needless procedures if defective. This approach is efficient because each cleaning/finishing worker (from cutoff to inspection) is cross-trained on all 16 positions. As a result, the workers rotate through different jobs every 30 min. King states that the foundry has improved efficiency and casting throughput by 20% from the old department setup to the new.

Wabash's total maximum time for a component once it is first loaded on the monorail modern casting / January 2001
after shakeout through inspection is 20 min. As a result, castings are ready to be delivered to the in-house (70% of the time) or out-of-house machining plant the same day. However, 10% of its castings must undergo an out-of-house heat treatment (shipped and returned to the foundry within 24 hr) before in-house shotblasting. As a result, this segment of castings requires 2 days processing time (still only 20 min. in-house).

One critical factor, according to King, that often is overlooked by foundries when designing a cleaning/finishing department is the relationship this operation has with the molding line. Wabash controls the production of its 11 different components to ensure that no more than 2 different parts are sent through to the cleaning/finishing department at one time. As a result, the cleaning/finishing department can set up its tooling and process flow specifically for those components, eliminating changeovers. This ensures the continuous flow of the castings from the beginning of production to the end without a backlog.

This relationship is taken a step further in regard to the number of castings made per mold. If a component is produced three-on as opposed to two-on, then it will require extra steps (multiple grinds or saw cuts) to be processed in cleaning/finishing. Wabash processes three-on components at an average of 700/hr and two-on at 520/hr. It is critical that there is communication upfront between molding and cleaning/finishing to ensure that the two casting combinations being sent through to cleaning/finishing doesn't involve too many process steps.

The final measurement of Wabash's efficiency is its 12.5 labor man-hour per ton of finished good figure. With an industry average of 44.9 (based on 1997 figures), Wabash's reinvention of its cleaning/finishing department can be labeled as "Best in Class."

| 6000 tons. | Molding Process: Investment, nobake. | Foundry Size: 175,000 sq ft (28,000 sq ft cleaning/finishing area). |

Cleaning and finishing operations were an important consideration as Conbraco Industries, Inc., Conway, South Carolina, began planning its new $25-million steel foundry in 1994. From the start, the firm wanted a state-of-the-art finishing operation that would minimize human variability and maintenance costs.

Conbraco, which primarily casts copper-base alloys (see “From Conception to Casting: Conbraco’s Greenfield Expansion,” modern casting, July 1999, p. 38-41), was building its steel valve business by adding steel casting capabilities to its Conway facility. Because space was limited, flow and material handling always seemed to be afterthoughts, according to Conbraco Foundry Manager Fred Schlick. “We spent a lot of effort getting things cast, but when it came to cleaning, we threw people at our production problems,” he said. “Rather than continuing to add to our old facility, we decided to build a new foundry where things were laid out right and where we had added space for our growth potential.”

In the new steel facility, castings take 3 days from order to shipment, and the finishing room is critical to maintaining this schedule. Conbraco’s cleaning and finishing operation is modeled on a lean manufacturing flow-through system, and the first components in are the first out, Schlick said. Ceilings are 28-ft-tall, and conveyors and material handling is above the shop floor to maximize space.

The foundry casts valves in investment and nobake molds, and “workcenters” cater to each of these lines. Investment castings go to five workcenters (a conveyed blast system, runner cutoff, salt and pickling tank, grinder gate removal, and heat treatment), while larger nobake castings see four stations (blast cleaner, runner cutoff, robotic grind, and heat treatment).

Castings are transported on a pallet by forklift from the casting area to be blast-cleaned, after which they are transported by crane to the cutoff station. A basket system on roller conveyors is used to shuttle castings to the salt bath, grinding and heat treatment, respectively. Nobake castings move from pallet to the basket system at the cutoff station.

The foundry’s cleaning and finishing operations use robots to provide consistent flow and take cost out of the system. Robots have taken the guesswork out of scheduling as flow-through time is readily predictable for any job, Schlick said. Computer screens show exactly where parts are in the process.

An order can make it through the entire cleaning and finishing operation in 6 hr, but they typically spend 24 hr in the department. The operation processes 1 million lb of metal each month, with 400,000 of that being finished castings and the rest gating and riser systems. Components are touched by human hands only minimally, to load and unload equipment at each workcenter.

Robots also have minimized setup time before a shift, Schlick said. “Programs run as consistently in the morning as the afternoon,” he said. “With a person, we never got that—employees would always group castings together by job number before moving them to the next workcenter. That’s why we’re able to deal with castings on a first-in/first-out basis with robots—because robots look at each individual casting, we don’t have
to group jobs by order number."

The foundry avoids cleaning and finishing castings that have internal defects. A real-time X-ray will take a cast part, rotate it to view it at different angles and helps operators detect problems and identify the cause before problem castings are ever sent to the cleaning room. The foundry uses this system for all new jobs, as well as any current jobs that undergo a process change.

Following is a description of unique portions of Conbraco's system.

**Blasting**—While Conbraco's nobake line is blasted in conventional equipment, investment castings are processed by a conveyored blast line that removes ceramic shell from parts with shot. The castings are fed into the equipment automatically by conveyor.

Previously, the foundry used a caustic soda salt to remove ceramic from corners, but this left the foundry with an unnecessary waste stream. In addition, an acid and pickling process used on stainless steel castings compounded the problem. The solution was to incorporate the two in one common rinse tank, which essentially neutralizes the waste rinse water from the processes, eliminating the waste stream.

**Cutoff**—With its previous system, Conbraco noticed inconsistency in the length of gates after cutoff from one job to next. The solution was to add an infrared target light that shows the operator where to cut using a robotic handler. Coupled with the ability to manipulate castings along three axes, this system provides Conbraco with the most consistent abrasive cutoff.

In addition, electronic servo actuators have greatly reduced downtime because motions are timed from point-to-point, and if this deviates from standard, they are changed before the equipment goes down.

**Robotic Grinding**—The grinding area of the new foundry was especially important because operating costs were skyrocketing, and the foundry could not afford to continue using grinding belts at its usual pace. While in the planning stages for the cleaning department, Conbraco began working with a supplier to extend belt life and determine optimal grinding pressure.

“We knew we needed controlled, steady pressure in grinding,” Schlick said, stressing that due to inconsistency of pressure used by different operators, grit was being stripped from the grinding belts prematurely. The foundry supplied test castings in different alloys, and the supplier suggested best grinding pressures and speeds for each. “We realized that the only way we could actually achieve this consistently was to install a robot with a controlled force head,” Schlick said.

Conbraco's system features a robot that “communicates” with the grinder so that when the belt comes to a heavy section requiring extra processing time, the robot slows down, allowing the belt to “catch up.” In addition, the grinding equipment has an inspection area in which a small probe measures tolerances and the amount of gate remaining on each part. If there is excess stock, the grinder continues the removal process. The equipment also features a belt wear sensor that aids in predictive maintenance. If the pressure to remove a gate is too high, it indicates that it is time to replace the belt.

Conbraco was one of first foundries in the country to use this type of robotic grinding system, and it was quick to realize the benefits, installing a second cell in 1999. The work previously accomplished by 12 grinders is now done by one cell, and while each cell cost $300,000 to install, the foundry saw a 6-month return on investment. Conbraco was spending $200,000/year on grinding belts while now, the foundry spends just $30,000/year.

The robotic grinder is ideal for large jobs (castings up to 600 lb), but small parts, which had been processed with a small hand grinder, presented another challenge. Conbraco worked with its belt supplier to develop a rotary table that keeps constant speed and feeds castings through a merry-go-round-style system that can handle 8000 parts in the same time a worker could handle 800. Instead of plunging into each casting with a mechanical feeding device, the new equipment uses a pressurized control carousel. Conbraco's next refinement to this system will be the installation of a pick-and-place robot to feed the machine, Schlick said.

**Vacuum Heat Treatment**—While the foundry has a standard heat-treatment line, the majority of castings go through a second vacuum heat treatment process. Nitrogen is used to quench stainless steel to avoid corrosion and scaling (which can be problematic with oil and water quenching) while controlling the quench rate.

Conbraco's finishing room is air-conditioned, with the thought that if people are comfortable, they'll be more productive. In addition, the foundry's injury rate is EMOD 0.83, and Schlick attributes this to the lack of manual lifting and grinding. "You really can justify the cost of automation just by the reduction in injuries."

With its new cleaning and finishing operation, Conbraco has noticed an overall 28.6% per lb of finished castings cost reduction.