As the foundation of modern electronics, semiconductors evoke high-tech manufacturing and cutting-edge computation. It might be surprising to hear many key components of the equipment used to make semiconductors are aluminum sand castings. Palmer Foundry, a no bake and green sand casting facility in Palmer, Mass., has been supplying this high-tech industry—and others like it—for more than 25 years, and in the last two years, the metalcaster has committed to thinking and operating like its data-driven customers.

Since the beginning of 2012, Palmer Foundry has been implementing vast data collection throughout its two facilities and integrating the information from its processes, operations and products into an enterprise manufacturing intelligence system. The still-growing system has given the business a smarter way to operate and improved the way it maintains equipment, controls the working environment, adjusts raw material inputs, schedules pouring and identifies areas of potential capacity.

“You hear a lot about lean manufacturing, but this is much more powerful,” said Bob Logan, Palmer Foundry president. “Knowledge is power, and this is knowledge packaged in a form we can use.”

Palmer Foundry started its data management in 2012 with stand-alone pieces of equipment, such as the dehumidifier installed in the nobake facility in 2010. As an aluminum casting facility selling vacuum tight castings, the metalcaster is concerned about the amount of moisture in the air. Formerly, the best way to predict outside conditions was to visit a weather website and see the forecast. Director of Engineering Jim Lagrant installed temperature and relative humidity sensors on the plant floor and outside. Initially, the information was pulled into a spreadsheet, but trends could not be readily identified.

“It was a laboratory system and it wasn’t bulletproof, but the vice president, operations manager and president saw the value of this data,” Lagrant said.

By controlling the foundry ambient conditions on high humidity days, Palmer Foundry does not need to maneuver its pouring schedule to make castings impacted by the humidity, such as vacuum-tight castings.

“We want to control all the variables in the process to provide a consistent product, but we can’t control the weather,” Logan said. “I would tell customers to plan for about 17 days a year when we couldn’t pour their parts.”

The dehumidification system controls the moisture level in the air, and the first phase of data collection helped predict what days to run it at higher levels. With that success, more variables of the dehumidification system were collected as data points to help further improve its efficiency, such as when to turn on fans or whether it operates better with an overhead door open or closed.

After initial successes with data collection, Logan gave Lagrant the go-ahead to expand the data project. A survey of the shop floor revealed some equipment already installed with PLCs and others with no automation at all. Nothing was connected together.

“I identified which equipment just needed a communication
module to connect to our network,” Lagrant said. “For those that didn’t have a PLC, we figured out which data points to measure.”

For instance, in the melt department, Palmer Foundry wanted to keep track of bath temperature and the amount of current going into each of the three legs of its electric resistance heaters.

Next, Lagrant selected the hardware to wire into the equipment and commissioned the construction and installation of electric panels. Palmer Foundry also had to make some network upgrades and put network drops on the shop floor to accommodate the project.

“The timing for this is great right now because the industrial Ethernet networks are robust and the price has come way down on the hardware,” Lagrant said. “This would have been too cost prohibitive 10 years ago.”

In 2012, Palmer Foundry set up its system for the collection of 500 data points. In just a couple of months, the metalcaster had already used up all the data points on equipment from the melt department, shakeout department, sand transportation system, thermal reclaimer and dehumidifier in the nobake facility. In 2013, the company upped the ante with 10,000 data points to handle the rest of the needs of the nobake facility as well as Palmer

“Knowledge is power, and this is knowledge packaged in a form we can use.”

—Bob Logan, president, Palmer Foundry

With a background in mechanical engineering and product development, Bob Logan purchased Palmer Foundry with his business partner and brother Dave Logan in 2000.
would struggle and struggle because they would have to wait for the equipment to catch up with them,” Lagrunt said. “We are proactive now and looking at what the equipment is saying.”

In addition to connecting to the time-series data of the process equipment, Palmer also installed a statistical process control system. This commercial software package automatically connects to multiple databases containing transactional information about raw materials, in-process product process measurements, and laboratory data. The package scans the databases for new data points, automatically charts the points on control charts, and updates electronic overview dashboards. In addition to having a color-coded dashboard on their desktop, process owners will receive e-mail notifications if the parameter is trending out of control or jumps out of specification.

Instituting statistical process control has led to a few changes in operating protocols at Palmer Foundry, as well. At the casting facility, returns are degassed and stripped of magnesium, which must be added back in at the melt department to maintain the appropriate chemistry. When the company began collecting data on chemistry analysis of its metal, it wasn’t expecting to see its magnesium content drifting out of specification.

**Using the Data**

Logan admits Palmer Foundry is still unlocking everything all the data is telling them. But in just a year and a half, he already is seeing major benefits in environmental conditions and maintenance.

A PLC on the nobake shop floor performs supervisory control on intakes and exhaust fans tied into the environmental controls. When the furnace that breaks down aluminum returns exhausts onto the pouring floor, the enterprise manufacturing intelligence system sees the furnace is at high heat and turns on the fan by the furnace to put all the heat and moisture outside.

On the shakeout deck, Palmer Foundry would run its 30,000-cfm exhaust fan the entire shift. Now, using the automated PLC, the metalcaster can throttle the fan back when it is not actively shaking out.

Fresh air intakes now are controlled based on how much air is being sucked out of the plant—helpful on those cold winter days when employees found it tough to open doors because of internal pressures.

Maintenance personnel can avoid equipment downtimes with predictive indicators and more quickly troubleshoot breakdowns when they do occur.

When the dehumidification system is plugged up with dust, sand and pollen to a certain level, an email is sent automatically to maintenance to change the filters. Similar emails are sent when the current draws on one of the electric resistance heaters drops, indicating a problem with a heating element. Maintenance personnel are alerted of the issue before it is too late and the metal in the furnace goes cold.

In sand handling, a vent valve in the pneumatic transportation system vents out air when sand goes into the chamber, affecting the sand flow rate. The valve fails over time, so Palmer Foundry tracks how long it takes for the vessel to be filled. As that time creeps up, maintenance can predict when the valve will start to fail.

“Previously, the knockout operators

_While some pieces of equipment were collecting data, the manufacturing intelligence system integrates the information to summarize it into actionable information._

Palmer Foundry has nearly tripled its business since 2001.
“Prior to graphing out our analysis, we probably overcorrected,” Lagrant said. “Now, when we make a change to the recipe, it is automatically and visibly evident we made the right amount of addition.”

Further, the melt additions such as magnesium and grain refiners are no longer calculated manually. Instead, a touchscreen runs the calculations, so if the crucible is half full, the system provides automatically how much to add.

Playing Detective
The manufacturing intelligence system helps Palmer Foundry arrive at the “why” of something faster than ever. When the company first installed its dehumidification system, maintenance personnel were unfamiliar with the equipment and troubleshooting took a long time. By establishing and then measuring and tracking various data points related to the equipment, such as water temperature and pressure, Palmer Foundry can identify areas where the equipment is not working properly.

“It saves us hours and days of sleuthing,” Logan said. “We can go back and do forensic analysis of all our processes and our equipment.”

This ability particularly comes in handy in customer relations. Palmer Foundry can show customers how processes were running at the time a specific part was cast. For instance, if a customer calls about a casting received with a rougher surface finish than expected, Palmer Foundry can identify the day it was poured and all the key process parameters in the facility for that day.

“Maybe we had a sand rate issue, which likely caused the surface roughness,” Lagrant said. “And we can show the process owner was notified of the problem, he acknowledged it and corrected it, along with the data supporting it.”

The data knowledge goes the other way too. One of Palmer Foundry’s semiconductor equipment customers was in a scramble to fix a problem with chromium appearing on the wafer. When Palmer was approached about possibly being the culprit, it had the data to show its processes were in control and operating within specification. The customer saw it needed to look at other sources of contamination.

“They have to figure things out in a hurry, so it helps to point them in the right area to resolve a problem,” Lagrant said.

Logan sees Palmer Foundry’s manufacturing intelligence system as a necessary tool to show its high-tech customers they speak the same language.

“Some of our semiconductor customers have two hours to fix a problem or they are fined by their customer,” he said. “They told us we can’t be magicians anymore. We have to provide straight answers, and we can give them that.”

Customer Support
While Palmer Foundry ramped up its manufacturing intelligence, it was working toward ISO-9000 certification to become an approved vendor for its semiconductor customers, which it achieved in 2013. The metalcaster supplies vacuum-tight aluminum castings to the companies that supply the Intels of the world, as Logan put it. Its castings are used in all processes tied to producing semiconductor technology, including stripping to clean the wafer, etching, planarization and lithography, as well as in the robotic components used in the systems. The metal chemistries of the castings must be tightly controlled so the parts can withstand the vacuum environment.

Palmer Foundry ships its large castings (up to 1,300 lbs. shipped weight) to the Midwest, West Coast, China and
Singapore weekly. And while the semiconductor industry is its biggest market, the metalcasting facility also produces performance aluminum components for mass spectrometers, slaughterhouse equipment, blood analysis equipment, and MRI equipment as well as industrial products. The company still produces castings for one of its first customers from when the company was founded in 1951. The industrial hoists and lifts for that customer must bend instead of fracturing; part failure could be fatal.

One of Palmer Foundry’s newest markets is cast aluminum vacuum chambers used in LED manufacturing equipment. Everything else in the manufacturing system is connected to the chamber, so when the customer ramps up, Palmer Foundry must be able to respond quickly in kind.

“They don’t want to hear they can’t sell their $6 million piece of equipment because they can’t get a casting,” Logan said. Palmer Foundry uses readily available ingot and relies on its manufacturing intelligence system to help with scheduling and efficiency so it won’t affect its customers’ deadlines.

Data-driven process control also helps the metalcaster make a convincing argument to convert to a metal casting.

“To convince an engineer to take a leap is not easy,” Logan said. “But when engineers come and look at our process, they see it’s not black art.”

Palmer Foundry is continuing to find data points to mine and conclusions to make from its manufacturing intelligence system, and now it is rolling out metrics analysis for the business side of operations, such as scrap rates, job bookings and shipping rates. The company also is in the planning stages of a potential 10,000-sq.-ft. expansion to accommodate the increasing size of semiconductor manufacturing equipment.

“We’re just going to keep getting better and better now that we have the infrastructure in place,” Logan said. “It’s a foundation for us going forward.”