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I-Connect007
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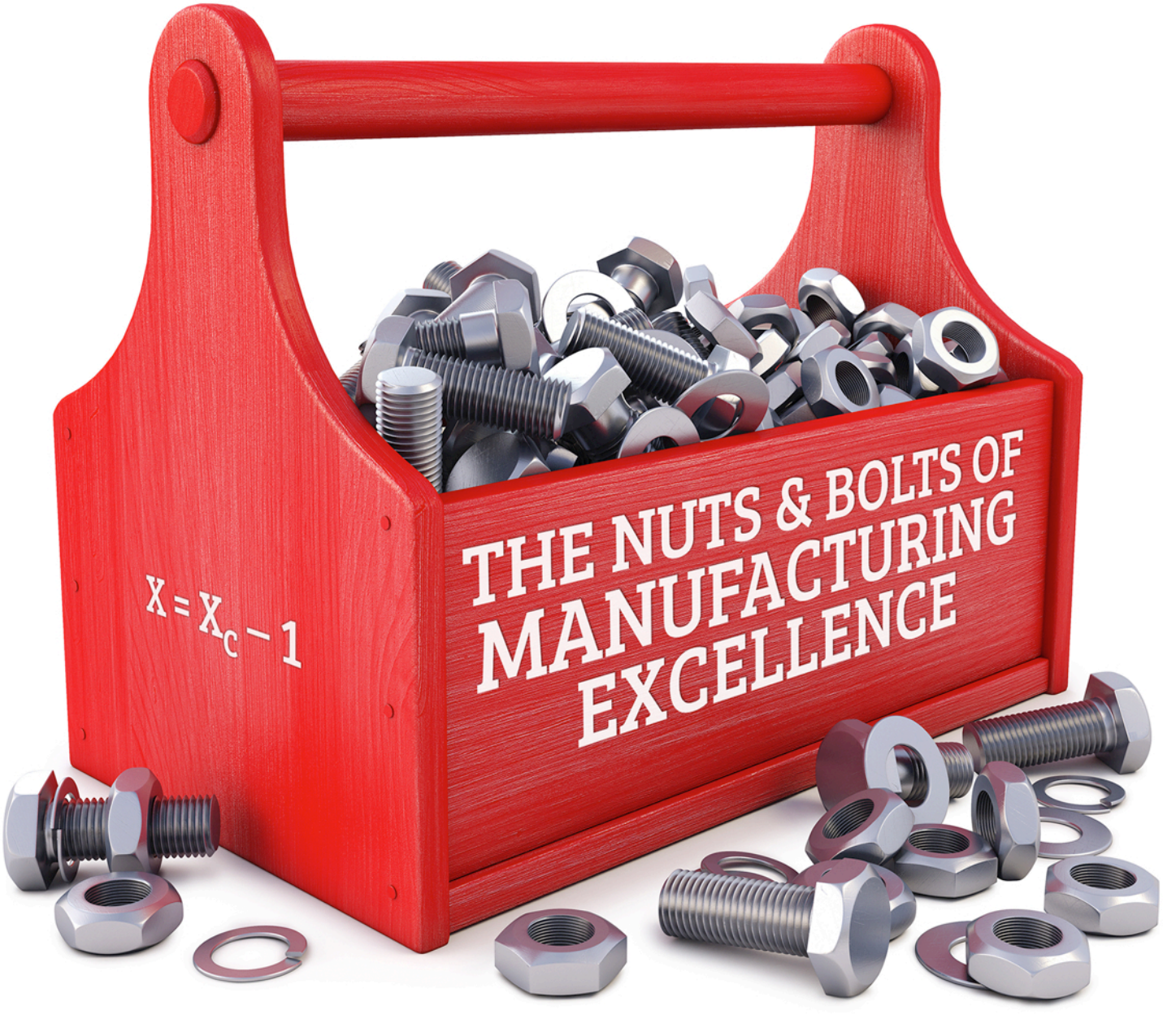
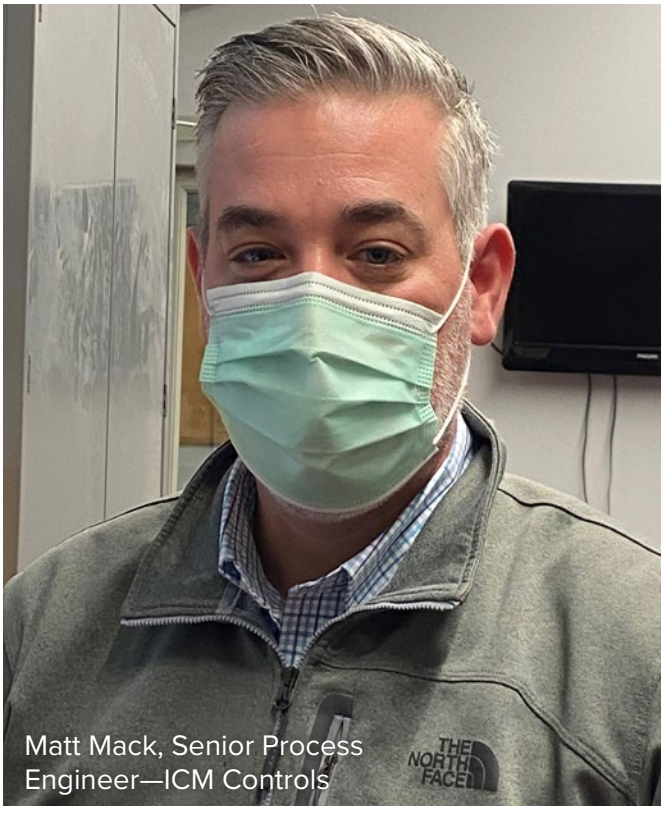


Driving Down Cost with Process Engineering



Matt Mack, Senior Process Engineer—ICM Controls

Feature Interview by the I-Connect007 Editorial Staff

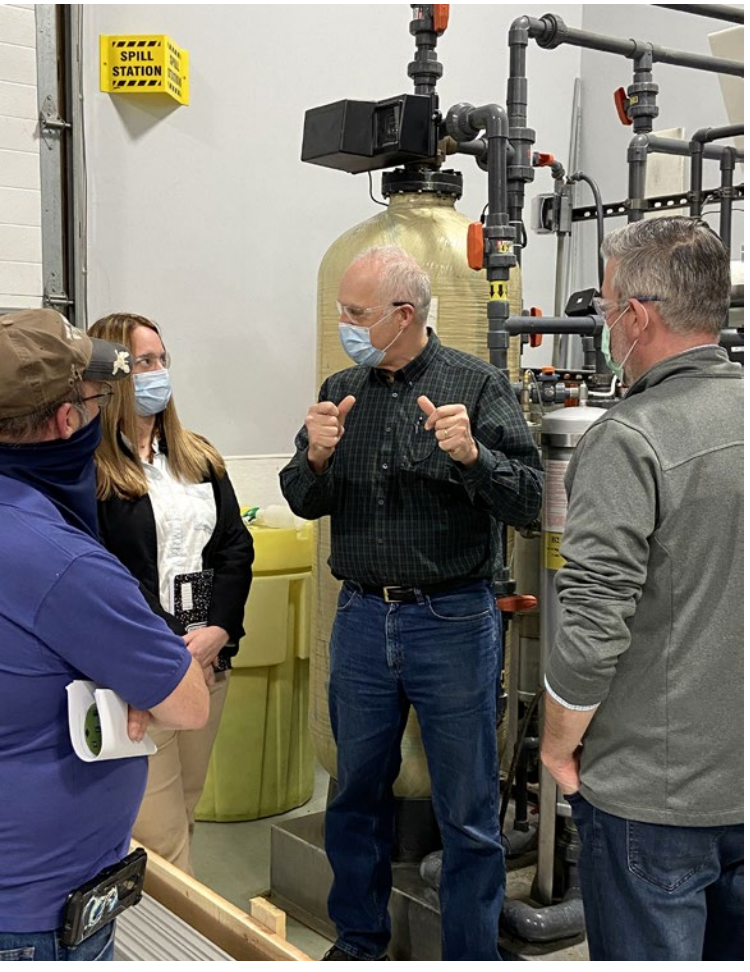
Nolan Johnson and Barry Matties talk with Matt Mack, a process engineer at ICM Controls. Matt shares how he's driving down cost through continuous improvement. He also discusses planning for the future with automation and AI. Matt started with ICM Controls in 2019. Prior, he worked at Whelen Engineering (now GreenSource Fabrication) for about five years. His career in the PCB industry began at Sanmina.

Nolan Johnson: We're interested in learning about your approach to process engineering. What's your thinking for identifying processes that are in need of improvement?

Matt Mack: I start with our price per panels and the costs that are associated with it. I start to think, how can we make the process smoother, more efficient, where I don't need to have as much human interaction with chemicals? That all starts with gathering data with chemical data. I'll do titrations, for example. I'll pick one line at a time that I will not have any dosing on, and I'll calculate the square footage of panels through X amount of time, how much it dropped in concentration, and I'll adjust dosing based on panel count. Then you have to optimize speed.

You can also do line speed, increasing or decreasing to optimize quality. I always strive for the 1.33 Cpk for the parts. It's not always possible, but we come pretty close. It took about six months to really get dosing right. Right now, we do chemical analysis about twice a week. That's much lower than recommended, but the data is not driving us to analyze it more. I asked our software guy to develop a chemical database that allows me to input the chemical data and track Cpk, track trends up and down, and in-spec/out-of-spec; if any of those rules are violated, it notifies me through an email.

Some of those are deemed critical, some are not. If any of it is deemed critical, we'll trigger the production's halt. If it's not critical, we might be able to do it on the fly. For instance, let's look at the copper concentration in a microetch. I might empty the line out before its formal dump, but it's not going to impact quality on the product. Those are some of the rules



Matt Mack (right) and Bill Phillips (left) discuss the company's R.O. (reverse osmosis) water treatment processes with Molly Reed and Bruce Graverly of Aries Chemical.

that I observe. Any time you see a trend of five points decreasing, it could be a dosing issue, so I would jump right on the dosing, and verify it's dosing what I've asked it to dose; second, maybe the chemical ran out and there's an airlock. I get a lot of those emails where it will show you process control.

Matties: When you stand back as a process engineer and take that 30,000-foot view of a process, what do you want to improve to optimize it? What's your process for doing that?

Mack: The first thing I monitor is speed. We track panels through and panels out. I would always start with asking: What are some of the slower ones, and how do I increase throughput on that piece of production? If you're going to have funnels where, let's say, the score machine is not putting out as many panels as the plating line, I might need to buy either a faster score machine or an additional score machine to maximize output. As we're ramping up here, there is some capex equipment that we're looking to quote in order to increase production on the floor. Generally, speed is what I look at.

The second thing would be chemical usage. If it costs us X to run one panel, what is the impact of that one piece of chemical on the panel? I look at price per panel by operation, as well. Can I get away with dosing less? For instance, for the pre-treat line, they recommended running something like 20 milliliters a panel. I actually optimized it to only run at about 8 milliliters. It saved us $18,000 over the course of a year. A lot of what drives me to look at process either optimizes panel production or price. Regarding price, for example, every six months I'll review price per panel to determine where we can improve and where we can't.

Matties: You're looking at bottlenecks in your process and the cost of materials. Where does cost of labor come in? Are you looking at automation to reduce labor cost in your process improvement as well?

Mack: Yes. There are some new things out that we've discussed, especially with capex. We are still doing screen solder masking. Scott, who brought me on board, has always looked into inkjet solder mask, which would decrease labor quite a bit. For set-up and tear-down times, it's taking us an hour to two hours a day just to set up and tear down. Inkjet would increase throughput through that process alone. You automate as much as you can, but you still need people.

We might be able to move someone to watch a couple different areas. Right now, we have loaders and unloaders, but even with that, you still need people. We've been doing a lot of cross-training as well, so when some of the

older folks retire, we might not need to replace them immediately. That's where we're at with labor. For now, we operate our shop with 13 people, and then two on second shift for secondary drilling.

Matties: Where does the smart factory come in to play for you? Where do you start bringing in AI? You mentioned you came from Whelen... do you continue their thinking with respect to bringing AI and smart factory into your facility?

Mack: In the future, yes. We haven't tapped into too much AI yet because we're still optimizing our panels. We're running about 2,000 a week on one shift, which is pretty good. We're getting about 400 panels a day. The goal, initially, is to ramp up panels per day, because that also decreases panel cost, and price per panel. The more panels I can put out with the people already here brings price per panel down. We're comfortable now where we're at. So, yes, AI will come in the future, but it hasn't started yet.

Johnson: That sounds to me like you're still targeting simpler optimizations in your processes before you start pulling out the big guns of automation.

Mack: We want to do both at the same time. I grew up as a lab tech originally, so I really strive for Cpk and quality control. Right now, we AOI 100% of our panels. We might drive away from that because we're producing, at last count, 99.6% yield through the board shop. That number is really where I start.

Matties: There's a difference, too, between automation and AI. When I think of AI, I think of machines modifying the parameters based on the work the coming through, where you had a barcode, and the machine would adjust to parameters set on that board's barcode. Are you moving in that direction?

Mack: We've talked about laser markings on the panels in order to switch. Right now, our imaging process is still manual. We've talked about buying a flipper and being able to do that. If we do get a little more automation in our imaging department, we'll put down some laser markings beforehand, and then that'll be a whole automated staff and able to swap jobs. We just run double-sided boards right now, single-sided, double-sided. Our rounds are generally pretty big. We don't get a lot of small lots. As we search now, would we want it? Sure. Do we absolutely need it? Not yet.

Matties: When you're looking at the capex, are you looking at equipment that is capable? Is that a consideration for the purchases you're making now?

Mack: Yes. Obviously, I come from a place that was almost fully automated, so I get the idea about what we might use as far as equipment and automation.

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Matties: Whelen went for total factory automation, and what we're recognizing is, in the industry, it's going to be incremental steps. It's what we're calling a smart process strategy rather than a smart factory strategy. What process do you think you would want to prioritize to really make it the smart process?

Mack: We currently have two imagers, and we flip panels manually. I really want to start

there. We might not have to release as much product. That's another thing we've been also looking into. Our lot sizes are very, very big, and now that the board shop is probably the fastest in the plant, the rest of the plant runs three shifts, the board shop and safety stock can come down a little bit. If we can get automation where we can change part numbers on the fly, then that would ease that pain, too. That's where I'd start.

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In order to change part numbers on the fly, automation needs to be thought about. We panel plate right now, too. So as far as plating, it's one size fits all as we currently have it. I've also thought about different drill machines with a stack system where you can load up the machine and walk away. Right now, we drill about 24—six stacks of four up—in our two machines. Drill is a bottleneck, too, and usually is at most places. But after the DES, you could follow up with inkjet solder mask and then you've got half of your shop fully automated.

Johnson: It sounds to me like you've got an entire roadmap set up for what to work on, what's next and so forth.

Mack: Yes. I'm a data-driven guy, so data will drive those decisions.

Johnson: Given the upgrade plan that you've just laid out for us, how long do you think that will take?

Mack: If it was a full-time thing, if I put all my energy into it, it would probably take a year. Shutting down production is going to be rough. It's pushing me to start bringing in an inkjet solder mask, having to qualify thousands of part numbers. Some of our customers might say, "We trust you, go do it and qualify," while others might not. We could have the capex into the building within a few months, but it's the qualifying that would take probably the longest. If everybody was onboard, I could see it within a year.

Matties: You're going to run parallel processes, obviously, so you have to allow for that.

Mack: When Scott designed the [ICM] factory he had something in mind like inkjet solder mask for upgrading. I know we have some slots in our cleanroom that will allow for conveyorized systems. He had that in mind when we designed the factory.

Matties: You're a data guy, so when you look at the effect of the package of automation that you're talking about—imaging, DES, and solder mask inkjet—what's the impact of the savings that you're going to find in your production costs?

Mack: There's quite a bit, actually. I also am a waste treatment guy, so the impact downstream would be much less than what we're producing now. I also look at that. When we start producing more automated equipment, getting more panels out, what is the impact on the waste treatment system? With inkjet solder mask, for instance, we would reduce our waste in that process by 90%. The impact of not having to wash the screens, the debris on the screen, the chemical on the screen having to get waste treated, etc., then it would be just inkjet solder mask and there is no waste coming out of inkjet solder mask.

Matties: My thought is, if the savings are significant enough and the technology is available, why not make this a top priority action in your organization?

Mack: I was asked for a detailed list just last week of what impact inkjet solder mask would have, not even as far as ROI, but what would it do for us. I am working on that. The waste treatment thing was the first thing I thought of. I haven't put too much more energy in that yet, at least in the last week.

Johnson: To think about inkjet solder mask having a positive impact on factory effluent is not necessarily the first thing that people think about, at least not with the conversations that I have. That makes for an interesting insight, not just for direct influences from changing out equipment, but also in the rest of your process; it buys you an advantage.

Mack: We talk about, when we increase production and add another shift, how waste treatment has to be one of the biggest priorities because we need to manage the flow, because we have an RO membrane system where we regenerate our wastewater. What is the impact of running 16 hours instead of eight? We also have an evaporator. The environmental impact is a big thing when you start talking about increasing production or perhaps increasing automation.

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Matties: When you look at a process, what's your methodology for benchmarking? Do you compare it to other industry standards, or are you just looking at what your needs are?

Mack: We do cross-training. We train people to run to targets. We need to hit this number for production standard. I also think of ideas, such as how I could speed up the line. How do I get more product out of this line? Sometimes you hit a dead end and you can't, such as with copper plate. We want our plating efficiency to be at or over 100%. The plating recipe we currently have is producing a panel every 54 seconds, and until that becomes a bottleneck, that's pretty good. Again, it always goes back to throughput. How do I increase speed? Can I increase temperature, for instance? Can I increase temperature to increase speed, or concentration? It's ideas of that nature.

Matties: I'm thinking also about upper and lower control limits. How do you tighten that parameter so you can get finer lines (or whatever the requirement may be), or by other opportunities when you tighten your parameters you can then create new market opportunities for your organization?

Mack: Initially, we would increase chemical analysis. I might be calibrating dosing pumps, or at least verifying calibration of dosing pumps a little more often, so that when I do get that data set, I can trust those numbers. That's what will tighten up your process control window. It goes back to being data driven. Part of this system hasn't gotten there yet; I still want to generate Cpk on the fly. It gives me the Cpk, I can drive rules based on the Cpk for process control and know whether I need to tighten up my control or I if can get a little looser on the control.

Matties: What's the most important process inspection tool a process engineer has?

Mack: An eye loupe (laughs). It really is the best tool that I have. I walk the lines multiple times a day with an eye loupe in hand. I do a cross-section once a week. I was doing them every day, but I saw no change in process control, so we're down to validating once a week. We also do a CMI. We'll do a plating thickness on first

panel out, for first article inspection, and then we do random sampling for CMI data for panel thickness, at least with surface thickness.

Happy Holden: What kind of experience from Whelen do you think you can bring forward to ICM?

Mack: I can bring double-sided work, bare board work, and speed wins. For double-sided and bare board, we need to optimize speed and panels out. I know we want to ramp up production; instead of adding another shift, how do we get more throughput with what we have? Throughput comes with automation, process control, speed, and driving those numbers up as high as humanly possible with the current technology.

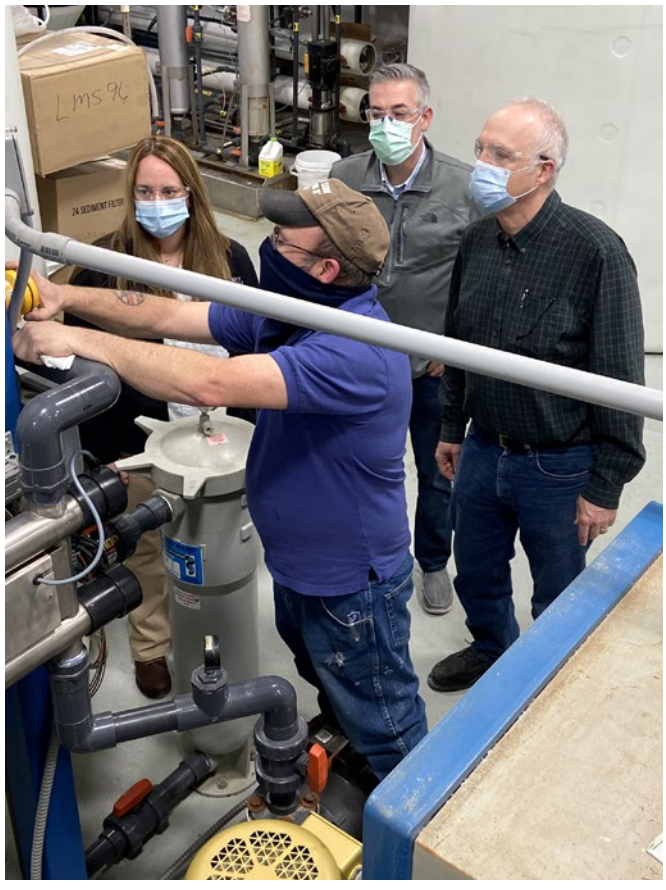
Matties: What is your thought on continuous flow manufacturing? Are you moving in that direction?

Mack: I don't know if our shop with its current setup would benefit. It's a thought, though.

Matties: You lose a lot of speed in work that sits idle, don't you?

Mack: It might be idle, but with our scheduler, we're about three to four months out of current demand. It's not the greatest to have queues, but with automation will come fewer queues. When we start thinking about automation, starting with the imaging process, there won't be a queue there anymore. We have a pre-clean line. I've thought about putting a U conveyor there: it comes out of the laminator, goes around, then imaging automation takes over, flips it, and it goes down the DES line. That's a thought. We typically have two queue areas, but we'll have zero.

Matties: When work queues up, my understanding is that you have to add additional cleaning processes, which means more bath maintenance, storage, and purchasing. If you can get rid of those additional steps, you're presumably lowering cost and increasing quality. I think that continuous flow manufacturing makes a lot of sense, but, of course, your shop has to be tuned to that.



Matt Mack (back center) looks on with Molly Reed and Bruce Graverly of Aries Chemical as ICM's Bill Phillips draws a wastewater sample for testing.

Mack: Yes. We can make it that way. It takes some radical thinking and time. Unfortunately, we don't have the luxury of a ton of time, but I know it's thought processes as we continue to grow.

Matties: One of the things that was critical in the continuous flow and smart factory is the front end. You have to have all that data right from your CAD or CAM department as it's coming in.

Mack: Correct.

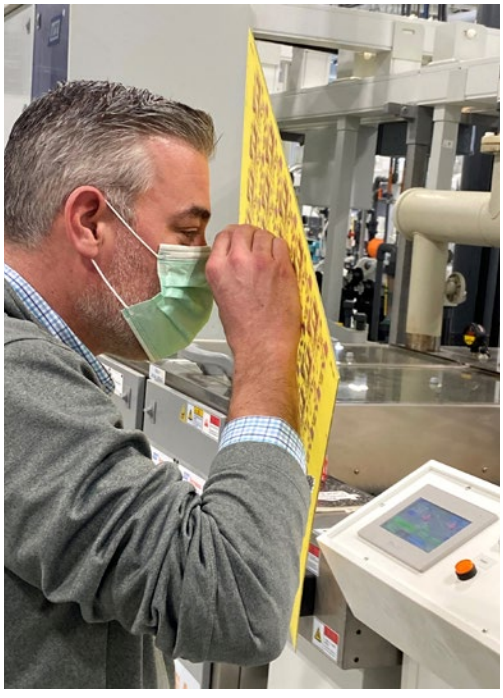
Matties: How are you connecting the data flow from your front end throughout your factory? What tools are you using there?

Mack: We have a CAM350 system. I don't get involved too much there. There are a lot of hard workers up there. They'll put it into a folder, and I'll upload it onto our CAM350 software and shoot it over to either the Camtek machine or the Miva imaging machine.

Matties: That'll give you the parameters you need for the processes throughout the factory?

Mack: Correct.

Matties: It's those process that, ultimately, you want to be able to feed directly to the equipment, and then have the laser tag adjust the parameters. That's the ultimate goal, right?



Matt Mack inspects a circuit board with an eye loupe in the PCB fabrication shop.

Mack: Correct. If you build up more part numbers in a database system like that, especially with Camtek, they've got their new AOI machine, and so every time we start loading a new job onto that machine, it now has it in its directory. Any time an obsolete part number comes out, front end does pull it out, so we're not bogged down with obsolete part numbers. Both of those systems have pretty big databases that work together, but we don't have any barcoding thing yet. We'll get there.

Johnson: Matt, it sounds to me like a key to being a good process engineer is being a good communicator with people, which is not always an obvious skill when we think about process engineers. Will you talk about that?

Mack: I have daily stand-up meetings, and then we have weekly staff meetings. I've always been a person who asks questions. When I do the engineering on the floor, I ask operators specifically, "What do you see? What do you think?" etc. That drives some of my thinking. I might have an idea, but they'll tell me whether it's feasible because they run the machines.

When I start to bring those ideas up, let's say at a quality meeting, we might say, "I have this idea." We have project lists, and usually will follow up on them weekly, if not daily. ICM is really good at having us communicate with each other. In staff meetings, quite a few people attend. All our senior managers are there listening and asking questions. Most of those meetings include questions from senior management: "How are we doing this? How can we make you better? How can we do this? How can we do it faster?" The communication at ICM is amazing.

Matties: In your function, where do the suppliers fit in? How involved are your suppliers in what you do?

Mack: They're involved as often as I need them to be. With process control, now that we're in a pretty steady state, they call. I contact my chemical rep once a week. We usually have a 10-minute phone call about any issues or concerns. He'll come in if I need help with an issue; that's been few and far between since we've optimized, at least on the chemical end. The only supplier I deal with is the chemical supplier.

Matties: What advice would you give a young process engineer?

Mack: Talk to the operators. The biggest thing is communication, especially with suppliers and operators. Once you start validating your decisions with data, and then you start communicating with your team, most of the times operators are more than happy to help me with my vision because they feel like they're being part of the task. That's what I would advise young process engineers.

Matties: You've mentioned data repeatedly. It's obviously very important. What training for analytics or statistics do you look for in a process engineer?

Mack: I'll always go back to Cpk. Process engineers need to understand that the 1.33 industry standard can be achieved. That data really needs to drive some of the decisions that you make as a young process engineer.

Matties: They just need to understand what data to collect, how to collect it, how to manage it, how to interpret it, and then how to disseminate it?

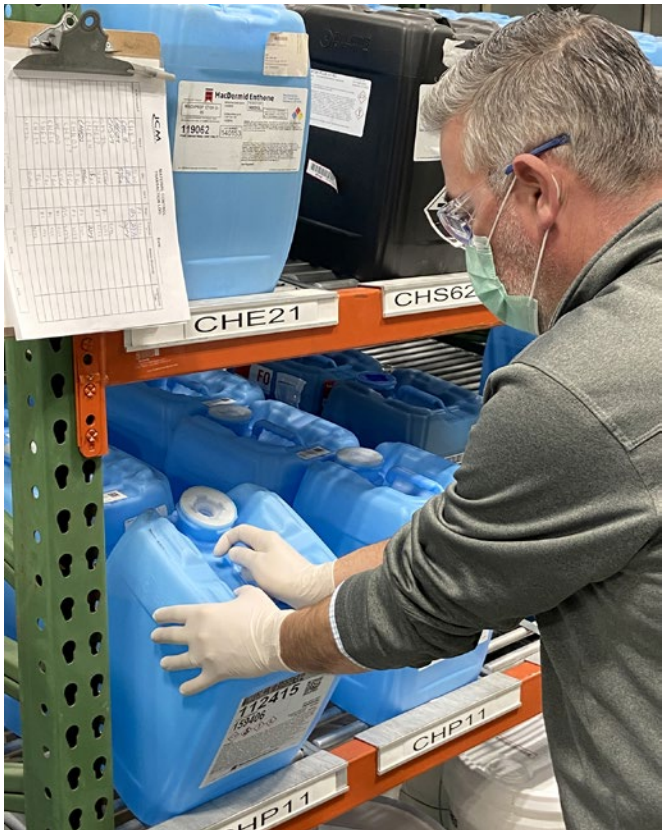
Mack: Correct. I've taken Minitab courses a couple of times, and they offer a really good system to start using those tools for analytical and process control.

Matties: Right, because with what you're talking about, there's obviously a math skillset that's required.

Mack: I started as a lab tech. My job was gathering data, and I would report to the process engineers on some of the data that I collected. Once you gain some experience with that data, it will drive you to what comes next.

Matties: What's a typical day look like for you? Give us a rundown, a day in the life of..., if you will.

Mack: After I check my emails, I'll go for a walk through the shop. Then I'll start validating some of the processes that we've set up. I'll go and verify line speed to make sure they're correct. As parts start to come out, so does the eye loupe. I'll usually look at a panel on each process once an hour. I'm walking the floor quite a bit. When I get a few free minutes, I'll start looking at the data. I also do the chemical analytics here, too. I'll pick a project for the day—let's tinker with this and see what happens.



In addition to process controls, Matt Mack also checks inventory on the chemicals used in ICM's board fabrication facility.

I'm a problem solver, so when we do have an issue, I'm the point of contact to make production downtime minimal. Usually, you get one or two hiccups a week, but they're usually manageable. Typically, I'm just walking the floor looking at panels.

Johnson: Matt, this has been really informative. I think there's a lot of insight here. Thank you.

Mack: You're welcome. PCB007

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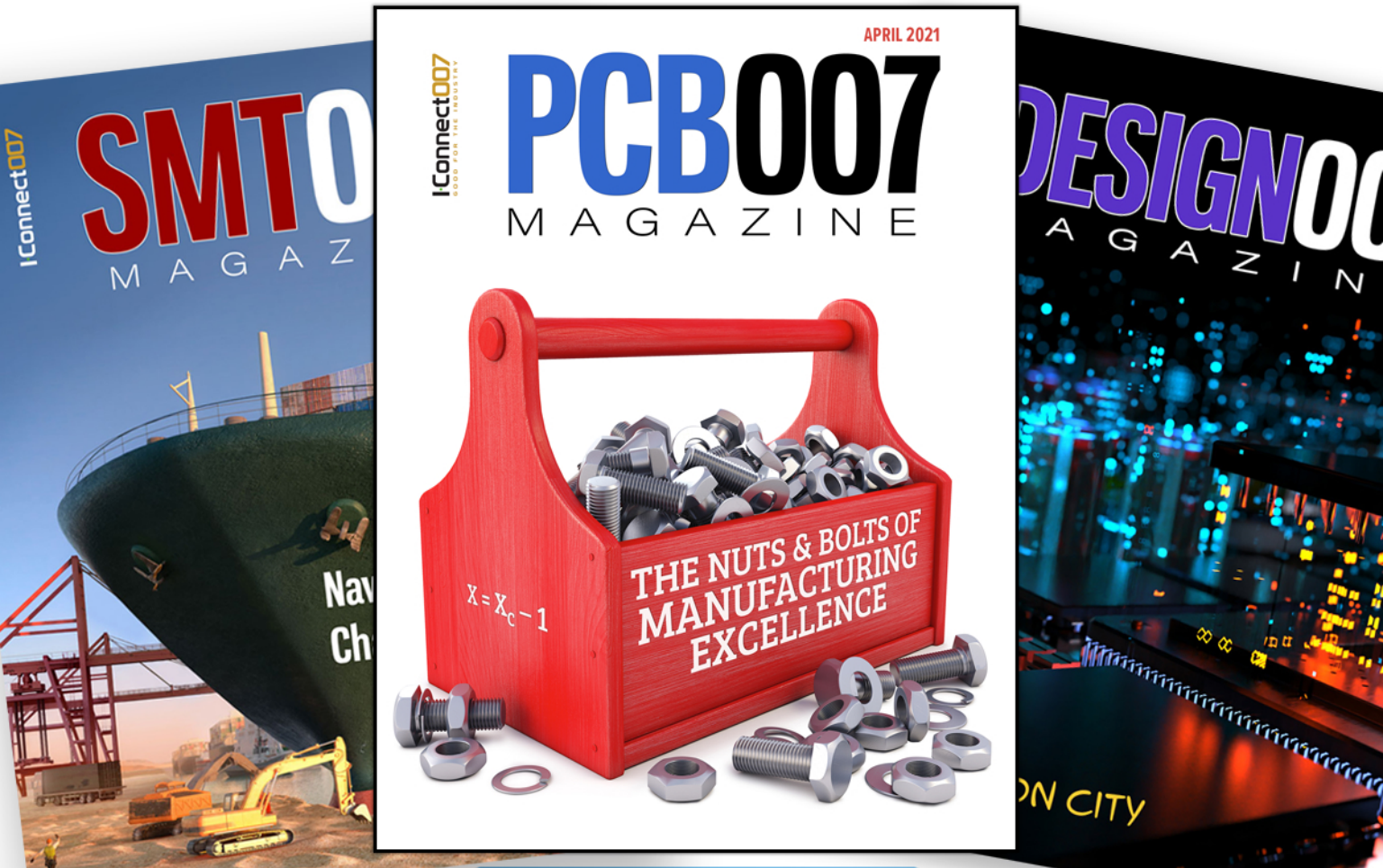

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