Maximizing work flow for an on-demand environment

Protolabs' Rapid Manufacturing in Nashua, N.H., stays in the fast lane on its way to earning The FABRICATOR's 2019 Industry Award

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(From left to right) Matt Garrett, David Puleo, Guy Pederzani, Jamie White, and Jim Worth are the leaders of Rapid Manufacturing's sheet metal team. In early 2018, after a kaizen event to re-examine material usage and storage, Rapid moved to using 40- by 48-in. blanks, that fit perfectly into the company's IPG LaserCube cutting machines. This move allowed Rapid to move away from pallet-based storage of raw material, and it simplified inventory control. Changes like this helped Rapid earn The FABRICATOR's 2019 Industry Award. Photos courtesy of Jim Vaiknoras, Wakefield, Mass.

They call it *continuous* improvement for a reason. There's always room for improvement—even when your name is Rapid Manufacturing.

Rapid is a $42 million custom sheet metal fabrication and CNC machining company in Nashua, N.H. The company, which is owned by Minnesota-based digital manufacturer Protolabs, was founded by Jay Jacobs in 2001 because he was underwhelmed with the service he got from metal fabricators in the area; he had come from the world of additive manufacturing, where quotes were returned quickly and prototypes could be delivered in days. But when he would try to reach out to sheet metal shops in his role as a manufacturer's representative, he was promised quotes in a couple of weeks and parts in a four- to six-week time frame.

Since those early days, the company has worked to live up to its name. In doing so, it has added machining capabilities and streamlined its operations, such as by developing eRapid, a free add-in for SolidWorks that allows users to get instant metal quotes within the design software. Turnaround time for sheet metal projects is typically about seven days, with exceptions made for those jobs that require them.

When you are good at your job, people notice. In this case, Protolabs, a global manufacturing company with multiple facilities that specialize in plastic injection molding, CNC machining, and 3D printing with a particular focus on

serving the prototype and low-volume production market, noticed what Rapid was up to. Company leadership for both Protolabs and Rapid had informally chatted at trade events over the years, and they became more formally intertwined as Protolabs began quoting sheet metal work and allowing Rapid to handle it. That successful working relationship paved the way for Protolabs to acquire Rapid in December 2017.

With both companies having similar cultures, focusing on automated processes and quick turnaround of projects, you might wonder just how much has changed for Rapid in one year under new ownership. Well, time moves fast. In a conversation in late December, a Rapid supervisor described a recent shop floor change with the phrase “back in the day”; he was sharing details about a *kaizen* event—to improve operational efficiencies—that had happened only six months previously.

The pace of production at Rapid has indeed picked up during 2018. Its rapid evolution is one of the main reasons it has earned *The FABRICATOR*’s 2019 Industry Award.

Speeding up One Event at a Time

“Over the years we have developed our core values based on speed,” said David Puleo, Rapid’s director of sheet metal. “Well, Protolabs’ mantra is accelerated manufacturing. So we don’t have any plans to slow down. Nobody wants anything slower these days.”

Protolabs delivered that message loud and clear to Rapid employees. Only days after the acquisition was finalized, Protolabs was in Nashua to hold the organization’s first formal *kaizen* event. (*Kaizen* comes from the Japanese words *kai*, meaning change, and *zen*, meaning good. This type of gathering comprises training, data collection, brainstorming, and implementation of ideas aimed at improving a certain process.)

During this first meeting Rapid employees were introduced to the Proto Excellence program, Protolabs’ formal continuous improvement effort, and plans for the next two years. The weeklong event set the road map as to how Rapid could find efficiencies that were not being recognized at the time.

“That first kaizen was a big thing for us because not only were we able to be a part of it, but also because it showed us how they wanted us to improve,” said Guy Pederzani, Rapid’s senior engineering supervisor.

After streamlining the shipping area, employees were able to create visible staging areas for items that were to be shipped via third parties or to be shipped to other Rapid facilities.

After that meeting, the first target for improvement was the inspection area, which was a bottleneck. In some instances, final inspection had to occur before anything was released to shipping. In other instances, in-process inspection needed to take place before a job could continue. In all instances, it was hard to tell what parts needed to be inspected for what reasons.

The main problem was a huge table that was supposed to be used as a staging area for parts to be inspected but instead became a collecting point for metal parts of all kinds. Even though a board clearly prioritized which parts needed to be inspected, quality technicians would need several minutes to look through the collection of parts to find the next one available. In some cases, the technicians just grabbed the nearest part and began the inspection process without heeding the job prioritization list.

Also, the technicians' computers were not close to the table. A lot of time was spent walking between the table and the computer in the back of the inspection area.

After the *kaizen* event, it was determined that the table had to go. A rack, with shelves for in-process, final inspection, staging, and first-article inspection, replaced the table. Quality technicians now had clear visual cues as to what type of inspections were waiting and how they should go about processing them.

As part of organizational improvements, shelves were installed under desks to remove clutter, and spaces were created for incoming carts that carried large parts. Computers also were brought closer to where the actual inspection work was taking place.

The reorganization reduced the number of steps required to conduct a part inspection, from 126 to 84, and the cycle time from 16 to 10 minutes. But that was not the only change to come.

Protolabs later added a Planar 2D inspection machine to Rapid's shop floor that could quickly verify product quality without the part having to be sent across the facility for inspection. Puleo said that the inspection device provides automatic feedback on part features and can alert a machine operator that something is wrong before he produces more parts. For instance, if a punched hole is not quite right, the tool may be in the wrong location, or it may be damaged.

"These *kaizen* events have emerged as a very systematic way of determining not only how we should have events, but also how we manage ourselves after an event. This helps to ensure that we don't slip back into the way we were doing things before," Puleo said.

The Changes Keep Coming

The next *kaizen* event proved to be Puleo's favorite. The target was the shipping department, and the first order of business was to move all the elements to the parking lot. This reorganizational effort was going to start with a clean slate. (Shipping for the day was handled at Rapid's other, nearby sheet metal processing facility.)

Again a table was the No. 1 item up for discussion. Was it really needed?

Clearly marked shelving was one improvement made to the Rapid inspection area after a kaizen event. Once all the changes were made to the area, inspection cycle times lowered from an average of 16 minutes to 10 minutes.

"They had a monstrous table that took up half of the area, and it wasn't really a necessity. They could get away with a smaller work area," Pederzani said. With Rapid's average part size fitting on a standard 8½- x 11-inch sheet of paper, that made sense.

With space freed up, the shipping department got creative with re-creating the area layout. Staging areas were opened up so that carts with parts to be shipped to customers or outside processors were clearly visible; they would no longer be lost on a cluttered table. Work areas were cleaned up so that shipping personnel could find tools and

materials quickly and easily. They also were standardized, allowing personnel to move from one station to another and not lose any efficiency.

When everything was moved back in from the parking lot, the shipping area did not look the same, Puleo said. Subsequent time studies revealed that shipping idle time, the amount of time from when the product is sent to shipping and it's been processed and prepared for pickup, has improved by 25 percent.

Not all of the *kaizen* events revolved around shop floor processes. One of the more impactful was a focus on going paperless.

"We had talked about the idea of a digital folder [to replace the paper packages that accompanied jobs] for about 10 years, and then we got acquired," said Matt Garrett, Rapid's programming manager, sheet metal. "Within three months, we just pulled off the Band-Aid."

As they made the transition to the paperless environment, Garrett said it really began to dawn on the programmers just how much time they were spending printing and preparing job routers. Inevitably shop floor personnel would lose a sheet or two from the packet and subsequently make a visit to the programming department to see if they could print out another copy. Also, if an engineering change occurred, a new job packet had to be created.

"Now we are basically giving them a digital version of that exact same thing," Garrett said. "We made it look exactly like the folders we were giving them, and now they have hotlinks they can just click on to get the information, whereas before they were digging through piles of paper."

Once the transition was made, programmers found that were spending almost 30 percent of their time printing documents and stapling them to create these paper packets. The newfound capacity helped to hasten the move to more offline programming through its CNC machine programming software. As a result of more programming responsibility being lifted from machine operators, Protolabs freed up more fabricating capacity on Rapid's shop floor.

Machine operators now have access to all the files that were once in the packet through the plethora of PCs spread across the shop floor. The documents are always there and always in the same place. If changes are made to the part design, the documents are updated automatically.

Management anticipates being able to move 37 percent more jobs through the shop because of the digital work flow.

All press brake operators have a clear understanding of what jobs need to be tackled because schedules clearly prioritize the forming work.

If centralized machine programming made sense, such an approach might make sense for other areas of the fabricating facility too. That became obvious when a *kaizen* event tackled the hardware insertion process.

Every job shop does some form of hardware insertion. It's hard to be a full-service sheet metal fabricating provider and not offer it. Rapid has done it for years, but instead of having a centralized hardware kitting operation like

production houses do, it relied on its hardware machine operators to collect their own hardware. They would look at the bill of materials and go shopping.

That led to a whole host of problems. It was difficult to track inventory with so many operators having to manage it. Time was wasted searching, counting, and ordering, and sometimes jobs wouldn't get done because the right hardware couldn't be found.

The solution to alleviate the game of hardware hide-and-seek was a centralized hardware preparation area. Now one person is responsible for staying on top of the hardware inventory. The hardware room has been organized with color-coded bins (for example, imperial units are kept in yellow bins). Now the organizer can tell quickly if hardware needs to be reordered based solely on a visual check of the bin.

The hardware organizer also picks the items for each insertion job for the day. The kits are then placed outside on a rack, ready for the hardware installer to pick them up. Each bag inside the bin is marked clearly with the job number and the quantity of hardware parts in the kit. A red bin indicates it's for the Rapid sheet metal facility where the hardware department is located, and a yellow bin indicates that it's destined for the nearby sister shop.

Puleo said that Rapid feels much more confident that it has gotten control of its hardware inventory as a result of the centralized organizational approach. Gina Kennison, the hardware organizer, has proven so adept at the task that she also has undertaken inventory control for masking tapes used in powder coating, he added.

Fueling the Rapid Pace of Change

Protolabs has almost 140 employees that work in 60,000 square feet of Rapid's manufacturing space in two sheet metal facilities; including the Rapid team, Protolabs now sits at nearly 2,500 employees in the U.S., Europe, and Japan. Given the pace of production flow and commitment to continuous improvement, the company has tried to find the right balance of capital equipment investments and personnel training to create a flexible environment that is also incredibly responsive. This past year has proven to be a year of experimentation.

One of the first focuses was on eliminating single points of failure. This lined up with Proto-labs' infinite capacity model. In other words, if Rapid had a machine down, it wanted to have additional capacity elsewhere to take up the slack.

To make this vision a reality, Protolabs invested in an additional six IPG LaserCube cutting machines and four Murata M2044 TS servo-electric punching machines. The machines have smaller footprints than traditional laser cutting and punching machines, respectively, which helped Rapid to maximize its placement in its sheet metal operations. In fact, the new equipment organization allowed for the incorporation of a Nordson Plug and Spray quick-color-change powder coating operation literally steps away from the blanking area in one of the facilities. Theoretically, a part could go from laser cutting/deburring to powder coating in just a few seconds.

"We have to make sure that we have the right capacity in the right places. That means people capacity as well," Puleo said. "To be able to be extremely flexible, our employees need to know multiple roles. Whether it is upstream or downstream, they need to be able to transition back and forth from one role to the other."

Gina Kennison stands in front of Rapid's centralized hardware room, where she prepares kits for the hardware insertion jobs scheduled for the day. Rapid used to rely on machine operators to gather the appropriate hardware for jobs, but time studies revealed that wasted a lot of time. The centralized storage area has resulted in more efficient processing of hardware insertion jobs and better inventory control, which helps to prevent redundant purchases.

One of the more noteworthy changes Rapid made when they started rearranging the shop floor was asking the laser cutting machine operators to take on deburring as well.

“We had these laser cutting operators that were fixated on making sure the laser cutting machine light was green. It would create a bottleneck at deburring. Ultimately, we were still sitting and waiting in bending,” Pederzani said.

Now automated deburring machines or manual stations (in both instances, steel and aluminum deburring is done separately) are located close to laser cutting. The blanking machines are used more as a “valve,” according to Pederzani, releasing parts only when they are needed for a new job. Queues of parts that sat around for days have been eliminated.

Protolabs applied the same thinking about standardization and cross-training to Rapid’s welding department as well. Each welding booth was different, which made finding certain tools difficult if a new welder was working in the area for the first time. Management also noticed that some welders were skilled in or liked to do only certain processes, and that led them to choose only certain jobs, causing some work to be done in an untimely fashion.

Protolabs invested in Strong Hand Tools modular worktables for quick fixturing and standardized on Miller Electric welding power sources. Layouts for eight welding areas in the two sheet metal facilities also were made the same. Clamps were color-coded to ensure they would stay in the work area they belonged.

From a training perspective, Protolabs cross-trained all Rapid welders to be able to perform all welding processes, creating much more welding capacity. They also became responsible for their own grinding, which welders did not really appreciate at first. But Pederzani said time studies were conducted with the new arrangement whereby the welders would grind after each welding job was completed, and everyone discovered that product flow was much more consistent. Large queues of work-in-process were eliminated.

“We also found that the welders were now taking a little more time to make sure their welds were perfect because it made grinding that much easier,” Pederzani said.

The successes connected to this type of equipment layout and cross-training of employees have led Protolabs to establish cellular manufacturing concepts at Rapid that through specialized configuration of equipment can speed the process that’s already rapid.

Puleo said he believes that this type of setup is perfect for a majority of Rapid’s parts, but more importantly, it eliminates waste just by its design. Everything is nearby. The tools and machines are consistent with what the operators have learned to use elsewhere in the company. Programming is done offline, so fabricating activity is maximized.

“This type of speed and flexibility requires cross-training on steroids,” Puleo added.

Welders are now required to grind their work after welding. As a result, they are being more careful with their welds, and Rapid has eliminated large amounts of work-in-process that used to stack up in front of what used to be the grinding department.

To help get employees and new hires ready to take on new duties, Protolabs has invested in some cutting-edge training tools. “It’s really about ‘gamifying’ skill development,” Puleo said.

Miller Electric's AugmentedArc™ welding simulator is a tool that is used to get people up to speed on gas metal arc, gas tungsten arc, and shielded metal arc welding using augmented reality technology. When trainees look at the "coupon" in front of them they see a plastic form with markings on it; when the hood comes down, the helmet's external optical sensor captures and sends images of the coded coupon to the device's computer, which generates 3D images of metal workpieces, augmenting them into a real-world welding environment. In the case of a GMAW gun, when the trigger is pulled and the arc is sparked, the trainee can start laying down a bead without fear of messing up and wasting material.

By providing immediate feedback on users' techniques, such as tip-to-material distance and welding speed, the welding simulator quickly helps correct errors. The trainees can make adjustments during the actual augmented reality welding exercise. Also, the trainees' performance can be scored, graphed, and recorded for later playback to share with them.

Pederzani added that the unit also is good for experienced welders looking to brush up on a certain process. For instance, if a welder hasn't done a pipe weld in a long time, he can take some time on the augmented reality welder to recall proper techniques and take some practice runs.
The company also has invested in a powder coating simulator. The unit, however, is a virtual reality device. When trainees put on the goggles, they are looking at an entirely virtual spray booth environment without any elements of the actual world that is around them.

SimSpray Powder is designed to teach people how to use a manual powder coating gun and hone specific techniques on complex geometries. Tutorials and lessons cover the basic coating intricacies, common pitfalls, and defects found in the powder coating process. In-process tracing gives trainees an idea of what the proper gun angle should be, how to adjust to be at the correct distance, and how transfer efficiency and mill buildup are going. Pederzani said the virtual reality device also addresses the correct technique for Faraday effects (an electrical phenomenon that can make it difficult for a powder coating to adhere to internal corners and recesses).

"Again, this gives you the ability to get the immediate feedback in a realistic environment," Pederzani said. "This is really great because the individual can get around the entire part during the exercise."

People Changing With the Environment

A lot occurred in 2018, and a lot more change is coming in 2019. That's the pace that Rapid can expect now.

A person has been hired to help facilitate these *kaizen* events. Also, space has been dedicated to host these regularly occurring group meetings. The introductory flurry of waste-elimination exercises is now a part of the company culture in only a few months.

"I've had people actually stop and say to me that things must be slow because there is not a lot of work in front of their work area," Puleo said. "What they don't realize is that we are getting out more throughput because it's all about flow. It's not about creating these big piles of WIP."

Guy Pederzani demonstrates the company's Nordson Plug and Spray quick-color-change system. A powder coater can change colors by unplugging the spray hose from one outlet to another and engaging the purge cycle. In less than a minute, a new color is ready to be applied.

"It's like slowing down the process to speed up the process," said Jamie White, Rapid's associate product manager, sheet metal. His co-workers, who had gathered around a table for the interview, nodded in agreement. They knew exactly what he was talking about.