

CASE STUDY: DMI COMPANIES

How to be an Innovative Manufacturer:

Lessons from the Field

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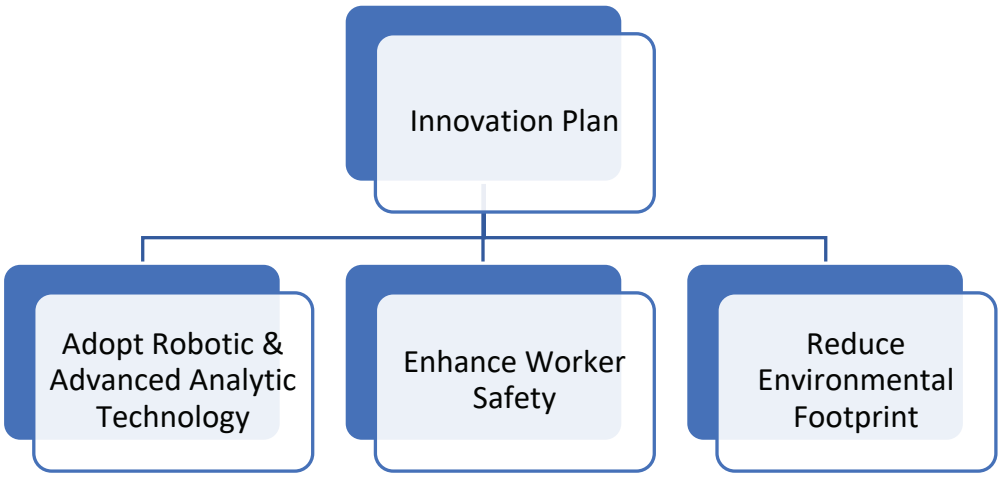
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A Leader in Innovation

DMI, a leader in innovation, operations, and sustainability in heating, ventilation, and air conditioning (HVAC), began its Industry 4.0 journey in 2015.

Involved in lean manufacturing and focused on continuous improvement for 15 years, DMI believed it had exploited as much of the low lying fruit in efficiency gains and gone as far as it could using this method. Continuing to manage the Lean program as a staple throughout its manufacturing cells and processes, DMI decided to take the next step to improve its operations, reduce the burden on its workers, and enhance the sustainability of its operations. Its new innovation plan focused on adopting robotic and advanced analytic technology, enhancing worker safety, and reducing its environmental footprint.

In moving to Industry 4.0 process improvement enhancements, DMI was interested in the use of automation – through use of "pick and place" robotic arms on two of its manufacturing lines – to further reduce costs, increase throughput to create more product production capacity, as well as solve human operator safety concerns.



DMI has 423 employees, some of whom are members of SMART (Sheet Metal, Air, Rail and Transportation Workers) Local Union 12 in Pittsburgh. Since the company was founded in 1978, DMI and Local 12 have developed a partnership, such that Local 12 understands and fully supports DMI's goals for automation and perfection in lean component manufacturing, product quality, timely delivery, workplace safety, and a well-trained workforce.

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Who are DMI Companies?

DMI Companies provides superior HVAC products to commercial, industrial, and residential contractors and builders worldwide through a vast network of domestic and international distributors.

- CEO: Ray Yeager
- COO: Doug Gudenburr
- CIO: John Bender
- IT/OT Manager: Natalie S. Chury
- Factory Superintendent – Monongahela: Doug Poundstone
- Tagline: One Source: Infinite Solutions
- Founded: 1978
- Locations: Washington County (HQ: Charleroi, Largest Manufacturing Facility: Monongahela), Southwest Pennsylvania
- Workers: 423 employees (nationwide); 250 employees (Southwest PA)
- Certification: TRUE Gold Zero Waste to Landfill (2018-2021)
- Awards: Manufacturer of the Year in Pittsburgh (2008 & 2009); Green Workplace Challenge (2014); Green Building Alliance (GBA) Enterprise Award (2019); KEEA Energy Efficiency Industry Champion Award (2021)
- Grants: Green Building Alliance Product Innovation Grant (2009), US Department of Energy Advanced Energy Project Awards (2010)
- Public Policy: US Manufacturing Council under the Department of Commerce (Member, 2015 – 2016); Pennsylvania Manufacturing Advisory Council (Member, 2021-present)



"It has been an impressive undertaking to see DMI Companies, Inc. make the investments in technology that improves production output and product quality. This technology has also been instrumental in creating a safer work environment by reducing the possibility of worker injuries from heavy lifting and worker fatigue. I especially like that DMI Companies, Inc. has instituted a maintenance technician training program which has created more opportunities for workers to get promoted and trained in emerging technology."

—Todd J Deitrick, Business Representative, Sheet Metal Workers Local 12

Another human resource focus for DMI is increasing the number of women in manufacturing. According to the US Department of Commerce, while women make up 47% of the workforce overall, only 30% work in the manufacturing industry and 25% of manufacturing company leadership. At DMI, 63 members of their workforce are women, and of those, 17 work on the manufacturing floor.

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Women in Manufacturing

I think most often when people hear that someone works in manufacturing they think "factory," "repetitive," "male-dominated," and "antiquated." I am here to tell you that what I think are things like, "efficiency," "data-driven decisions," "artificial intelligence," "predictive analysis," and "supportive management."

My focus is aiding in the transformational change of IT/OT by collaborating with various staff members throughout the organization to enhance the alignment between business process, Information Technology (IT), and Operational Technology (OT). This is a newly-formed cross-functional effort that was created when DMI began enhancing its operations with Industry 4.0 concepts.



In my current role, each day is an inspiring ride. I am challenged every day. I get to work with amazing people. I also get to witness the growing presence of women in multiple departments within DMI.

The concepts of Industry 4.0 and IT/OT are so exciting to me because it gives me a seat at the table to change the future, of not only DMI, but for the manufacturing community. It is such a rewarding feeling to know I can work with and positively impact every department at DMI by improving efficiency, gathering data to help make real-time decisions, all the while boosting profits.

My motto in life, whether it be when I am at work or at home being a wife and a mom, has always been "work smarter, not harder." That motto placed me where I am today, and I am so excited to be a part of this journey and to see what our futures hold!

—Natalie S. Chury,
DMI Companies IT/OT Programs Manager, a newly formed cross functional effort.

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DMI Manufacturing Line Automation

The DMI team took a holistic approach to two of its manufacturing lines: (1) Sealant and Adhesive Mix Room production("Sealant"); (2) Snap Pipe production ("Pipe").

Sealant & Adhesive Production Room

In the case of the "Sealant" production line (see picture on left), the challenge was the operator needed to continuously lift boxes that were 35-45 pounds – leading to operator fatigue as the day went on and a resulting decrease in throughput. Each robotic arm responded to this challenge, but there were still bottlenecks along the line that also needed resolution.

This included the human operator's ability to provide the raw material at the beginning of the line without impacting throughput. So, the team also developed an auto-dispense station in conjunction with adding the robotic arm. This limited the need for the human operator to participate in physical activities both at the beginning and end of the production line, reducing their fatigue, allowing them to focus on continued replenishment of packaging materials to the line thus increasing and solidifying throughput.



"Since the addition of the Robot (Betty) we have been able to increase daily through put by 66% with less strain and fatigue on the operator."

—Charlie Blaniar, 24-year Sealant & Adhesive Production Room Manager

"Before the addition of the robot to the mix room, I was lifting on average a total of 34,000 lbs per day. Since the installation of the robot, the total weight lifted has been cut in half. Ergonomically, this has become a better way to work. As a result, production has increased in numbers, as well as speed, while maintaining a steady level of energy throughout my shift. The robot has several safety features including two light curtains, a pressure mat, two e stops and a crush sensor."

—Chuck Sweeney, 2-year Mix-Room Dispense Production Worker

Snap Pipe Production Line

The "Pipe" production line (pictured below) has many moving parts resulting in the need for two human operators. One operator bundled and stacked the finished product, and the other had to monitor and adjust the various steps of the manufacturing process as the pipe was being made.

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This line faced two challenges:

1. Pipe bundles are very heavy – 2500 individual pipes (500 bundles) are manufactured each shift with each bundle weighing about 50 pounds;

2. Customers wanted the pipe bundles strapped (pictured left), which required another department and human-involved laborer step just prior to shipping.

The full assembly line (shown right) no longer has 2 human operators. By adding a robotic arm, an operator no longer must lift the bundles and another department does not have to facilitate the strapping of the bundles – so that only one operator is now required instead of two. As a result, DMI was able to reduce labor costs, improve productivity, and enhance worker safety. Prior to the pipe-line robot, DMI reports that four accidents had resulted in days away from work due to handling the pipe at the payoff table. Since the implementation of the robot, DMI has had no incidents that resulted in time away from work at the pipe-line payoff table.





Robotic Arm Utilization Focuses Workers on Problem-Solving, Enhances Worker Safety and Assembly Line Productivity, and Increases Profitability

One challenge DMI had in its operations is that each human operator is different in terms of how fast they work, how quickly they fatigue, and having a unique perspective on how they approach their tasks. This led to differences in throughput and quality depending on the operator. The use of robotic arms eliminates those differences, allows the operator to instead focus on critical tasks that are buffered from throughput dependency and line TACT time, which increases productivity and reduces costs.

Prioritizing Industry 4.0 activities

DMI used a number of methods to prioritize its Industry 4.0 investments. In 2016, DMI created an efficiency team that consists of a production manager, mechanical engineer, and industrial engineer. This team monitors the production lines and manufacturing processes, inventory, production costs, and other metrics. DMI charged them with identifying low-level

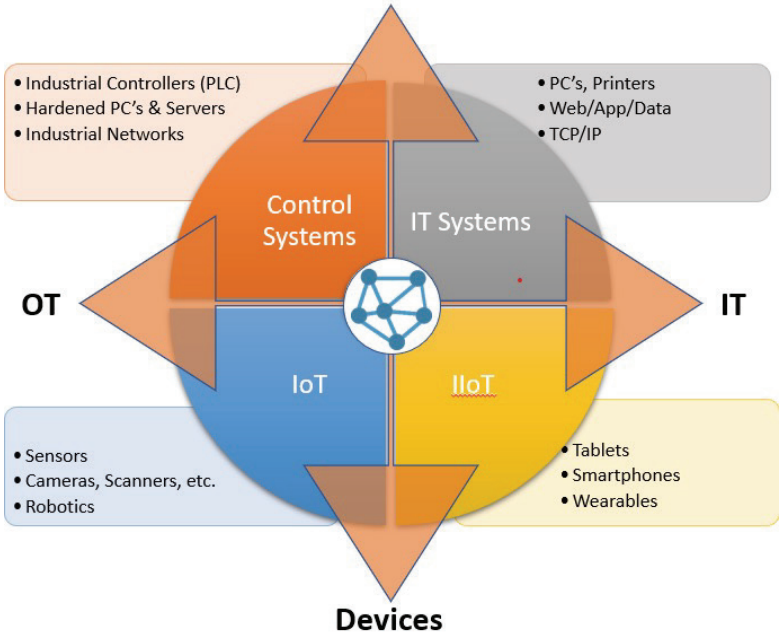
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opportunities for automation. When the ideas run out from a lean manufacturing perspective, the efficiency team makes a recommendation to leadership on ways to improve efficiency. The decision depends on cost, implementation ability, etc. In addition, the leadership team makes automation recommendations to the efficiency teams based on Industry 4.0 program goals, industry trends, or what they may have seen at other manufacturing operations.

The leadership team also goes on the factory floor to identify "pain points" – where staff has validated there is a problem and seek solutions for that problem. Finally, like most companies, DMI does strategic planning focusing on identified pain points as well as new ideas that the team identified to improve operations. The planning also includes continuous reviews of product cost, profit margins, etc. to identify production lines that may need improvement. The team then physically visits the line to identify options for improvement.



"The Manufacturing Execution System (MES) was well implemented. The training I received was extremely easy to learn and then apply. Since the implementation of MES, I am always thinking of ways to make it even better. I'm very open to more changes that embrace technology!"
—Alcesta Bise, 10-year DMI production worker

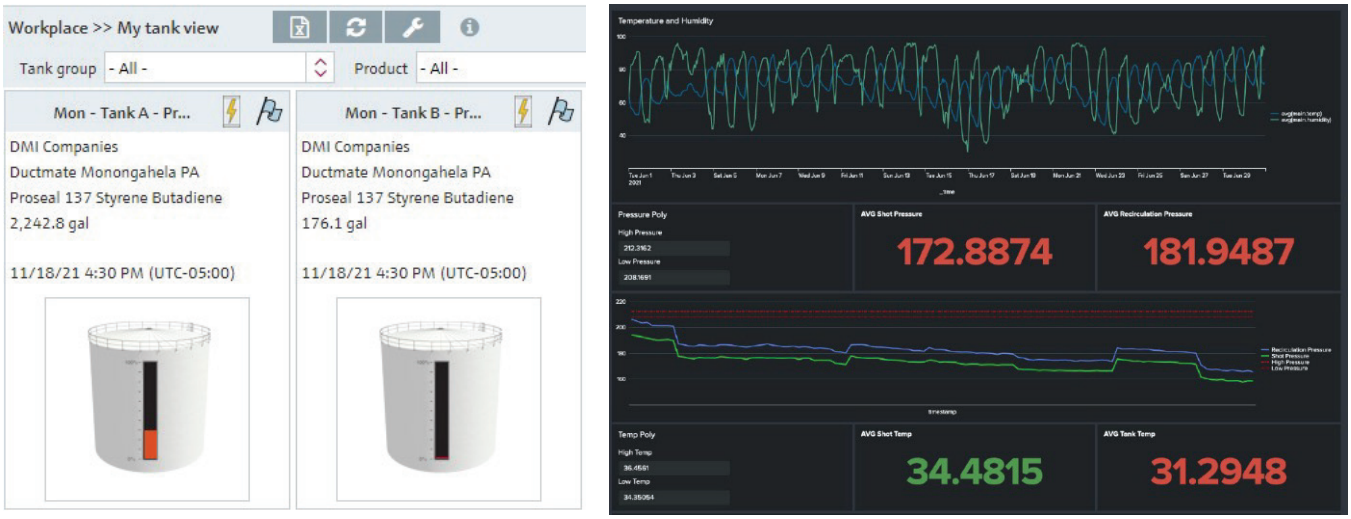


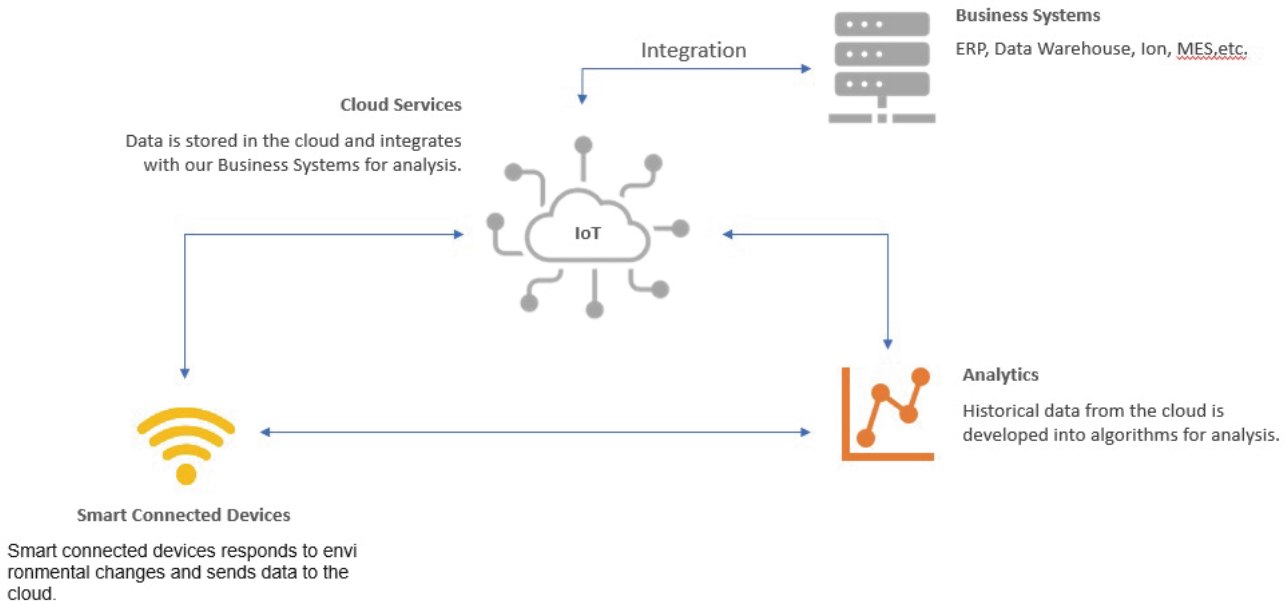
Smart Manufacturing

Another challenge DMI faced when it decided to embark on the Industry 4.0 journey was converging the information technology (IT) - computers and software that staff use at their desks and the enterprise - network infrastructure with the operational technology (OT) used on the production floor such as programmable logic controllers (PLC), industrial switching, industrial wireless, radio frequency identification (RFID) systems, etc. to support DMI's business strategy. DMI began to focus on the concept of "smart manufacturing" that leverages digital twinning, machine learning, the internet of things, and artificial intelligence.

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DMI's goal was to transform its business so that it could leverage digital technologies to make its operations more agile, flexible, and responsive while incorporating autonomous learning, yet it lacked in-house expertise. So, it brought in external teams who could help meet its goals (see figure below) through the use of "Internet of Things" (IOT) Being able to make smart decisions based on real-time activities throughout our business is key to our strategy. Combining internet-connected devices with cloud computing and machine learning enables DMI to make data-and evidence-driven decisions.



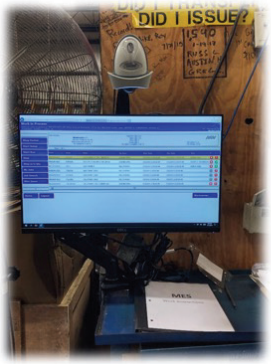


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DMI plans future investments in digital twinning – "a virtual representation of an object or system that spans its lifecycle, is updated from real-time data, and uses simulation, machine learning and reasoning to help decision-making." Specific examples include:

- Leveraging algorithms from three production lines as part of a pilot experiment;
- Reconstructing documents and control system logs from process monitoring videos;
- Measuring project success by monitoring energy/resource consumption, production line operating costs, and product line reconfiguration time.

This information will provide DMI's operations a self-configuring production control system that can learn from sensor and computer logs of manufacturing lines. Suggesting real-time monitoring and control strategies that can achieve safe and efficient operations and transitions between production modes. Machine learning can offer suggestions, and even make decisions on its own. This Artificial Intelligence (AI) decision-making is based on variables DMI identifies, to enhance efficiency of activities. Systems range from simple devices such as a PLC, to a complex system like Manufacturing Execution System (MES). MES (pictured below) focuses on activities such as lean execution, material tracking, machine level interface, workforce management, and Work in Process (WIP) quality.





Although initially the production staff's reaction was negative, thinking that the focus was to make them work harder, the reality was the opposite. Once the staff saw their production numbers, they became competitive with themselves and with other shifts, creating competition and fun for everyone on the floor to see what throughput numbers each could achieve. DMI invested in large screens (Vorne) so the production staff could see production goals and throughput for their shift with the goal to identify methods of improving operations. Overall, the implantation of the Vorne boards boosted morale among the production staff.



"As someone who can't even use the remote control for my TV at home, I was nervous about the new system at first, but it was very easy to learn. I'm looking forward to more technology changes that make my life easier."

– Helen Necciai, 34-year production worker

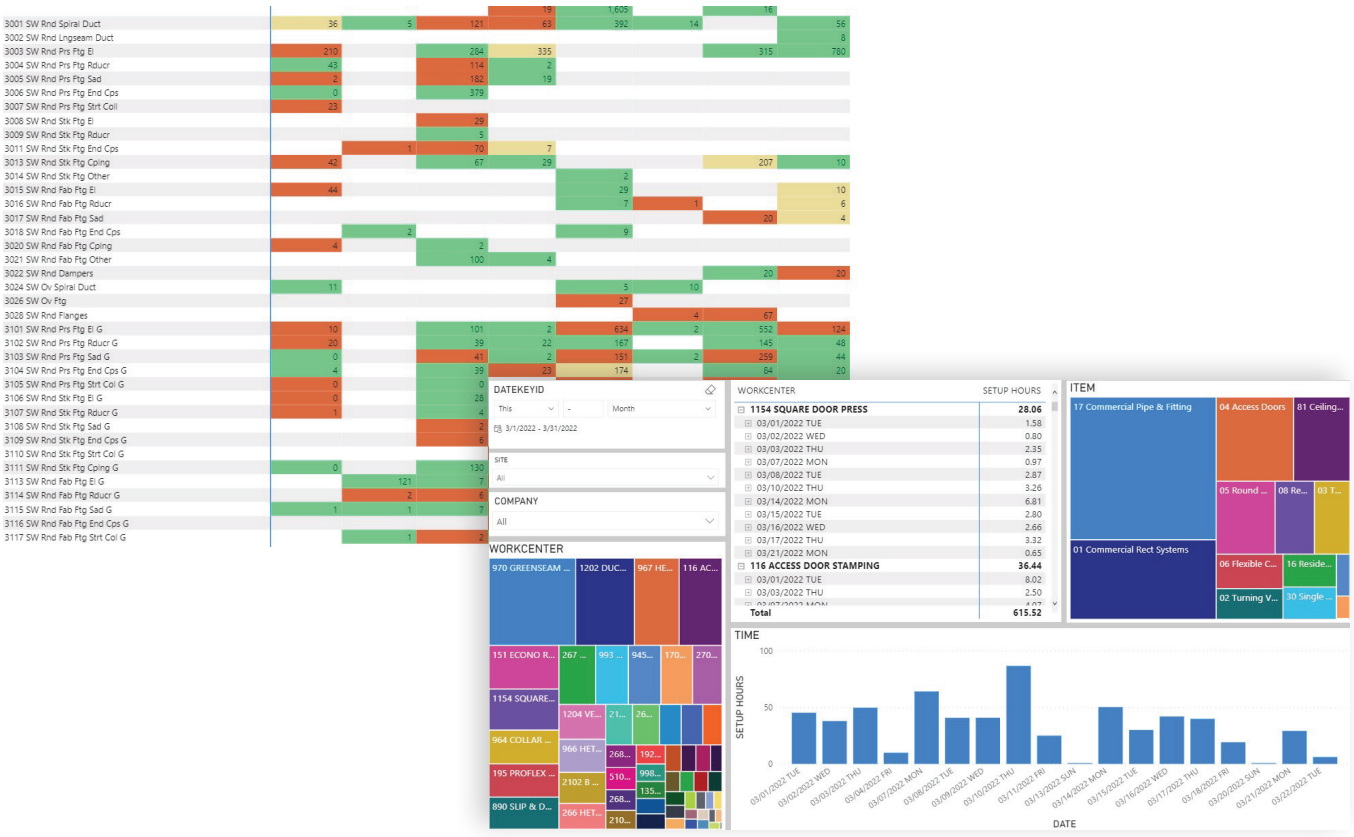
The Smart Manufacturing system also provides data necessary to dynamically build product from a rules-based configurator (CPQ), instead of using offline tools and manual data entry. The system also creates bill of

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materials (BOM), routing, cost, and pricing. Without human intervention, internal business rules are automatically applied during part configuration – as developed by the customer placing the order. The implementation of CPQ provides several billions of permutations of product that are now available to be ordered and manufactured.

DMI also implemented visual planner (VPi) software that identifies the requirements for product production, performs shop-scheduling routines, matches supply against demand to identify needed materials and production resources as well as materials requirements planning (MRP) for schedules. This not only ensures material is on hand but also determines if production staff is appropriately distributed to meet demand.

DMI's most significant challenge in the digital space was its data warehouse that aggregates structured data from across multiple systems, and then selects and organizes the data for comparison and analysis through dashboards and visualizations. This helps management better understand if sales, manufacturing, and shipping are reaching DMI's goals. This information is updated every 15 minutes and is available to all as visualization models within Microsoft Teams (see below). DMI decided to use simple colors such as green ("On Target") or red ("Needs Attention") to bring awareness with simple but effective visualizations management.



Final Thoughts



Secure (Plant-wide) 802.1AC Wi-Fi



Manufacturing Execution System



Virtual Desktop Infrastructure



Mobile Solutions



Transportation Management System



Business Intelligence



Integrating data points



IoT Sensors / Smart Solutions

When undertaking a new way of producing products, DMI suggests the following guidelines:

- Educate and bring along your senior leaders and board of directors so they can see the excitement and benefits of Industry 4.0 in improving operations, reducing costs, and enhancing worker safety.
- Having real-time data instead of end of the month or part way through the following month data dramatically improves decision - making efficiency and quality.
- Networking with other organizations and industry experts can serve as a key to success as well as a way to identify opportunities to obtain government grants to help in this transition process.

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"This subject matter – IT/OT, IoT and AI - is very difficult to understand for many senior leaders within an organization. It is critical they comprehend these concepts to allow your organization to get where you want it to go. At DMI you can readily see there is excitement with our senior team. There is also tremendous amount of excitement with our Board of Directors.

DMI senior management has been able to explain these tools to assist us in the business transformation we require for success. Corporations need senior people who are able to justify to Owners, Presidents, CEOs, and the Board of Directors how important their business transformation is to the long-term success of the firm. But remember, you must crawl before you walk and walk before you run."

—Raymond Yeager, CEO, DMI Companies

Frequently Asked Questions

1. How did the robotic arm improve worker safety?

When the operators began on the snap pipe production line, for example, they were big, burly guys in their 20's. Ten years later, they are now in their 30's and have the aches and pains that come with age. Although workers were rotated in and out to reduce this impact, this led to differences in throughput and productivity. The robotic arms provided needed consistency and improved planning and management of production. The human operators were then also able to better manage the quality of production and focus on problem-solving.



"The pipe machine at one time was one of the most labor-intensive machines in the entire company and is now one of the least labor-intensive machines since the robot was installed. On average (per 10-hour shift) I would pick up 16,000 pounds of metal and place them into the rack daily which was very hard on my body.

Now with the robot in place it has also improved my life outside of work. I'm no longer fatigued to the point I just want to go home and get on the recliner. Instead, I actually have enough energy to do things with my family when I get home from work."

—Joe Tessi, 27-Year GSI Pipe Machine Production Worker

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2. How did the robotic arm improve productivity?

The manufacturing operation was already operating full-time 5 days a week and some overtime on Saturdays to meet demand. More throughput per assembly was necessary for customer satisfaction. The robotic arm was the start of a process to identify how to respond to this need and then determine what additional steps were necessary.



"Because the robot runs so consistently [as opposed to humans whose production varies from one person to another], producing a production schedule for the pipe machine has become a lot easier. It has shaved a ton of time off of my day which allows me to spend more time on the company's strategic objectives. The robot has also increased the daily throughput which in turn lowers labor costs and increases our capacity per shift. Currently costs are down about 10% in the pipe area."

—*Shawn Kiester,* 20-Year Snap Pipe Production Line Manager

3. How do you monitor the robotics operation?

Human operators currently monitor the robotic arm's activities. The DMI team, however, plans to add in digital monitoring as its next project. Monitoring is a key attribute to the long-term success of the operation.



"The new system allows me to monitor all operations from my office at the touch of a button instead of walking the production floor. Often, our customers want their order faster than is normal. With the robotic arm, I can more confidently estimate the delivery time for our customers for our sales staff because the robot's output is consistent.

Another benefit of the robotic arm that I did not know before its arrival is that it could do two tasks. The arm not only picks up the pipe, but it also places a set of pipes in a banding machine and then places it in a rack. This was previously done by the shipping staff who are in a separate area.

Since the robotic arm does both activities, we were able to have one less staff member in that area and were able to move him into a new production position where we needed additional help. In the end, rather than decreasing staff due to the robot, we started an apprenticeship program, in partnership with our local union, and hired three individuals to train to become maintenance technicians."

—Doug Poundstone, Factory Superintendent – Monongahela

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4. Did you hire an outside expert or implement your Industry 4.0 strategy with existing staff?

In the beginning when the robotic arm arrived, programming it was not part of the DMI team's core competency, so an outside expert was hired and brought in to help with setting up and programming the robot. The DMI team still did much of the work themselves to learn how it was done, but the outside experts provided guidance along the way. This aspect also enhanced the team's understanding of what additional professional development and training were needed on a long-term basis. When the project began, the team identified the broad goal of Industry 4.0 and then began to apply its principles further and further into its production management and operations. Through this effort the team learned organically how to implement the strategy.

5. Have you found that optimizing your production line provided resources you could use for other projects?

Absolutely. When you start talking about robots and robotics, automatically people were concerned about losing their jobs to that automation and that has been nothing but further from the truth. DMI has initiated an apprentice program to upskill employees. In addition, like many manufacturing companies are suffering currently, DMI is experiencing a labor shortage. So DMI has been able to add employees and move existing employees into new positions instead. In addition, we have been able to consider new ways of doing business and improving production. DMI agrees with Amazon when it states:

"To address the issue of people losing their jobs, technology increasing productivity doesn't mean people will need to do less work. Because for each task robots take on, humans expand their responsibilities elsewhere. It's the nature of the workplace efficiency and the free market system that productivity generates more activity, not less. As Amazon acknowledges, the fulfillment centers that have robots often have higher employment numbers because inventory moves at a faster pace, which requires extra associates."

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6. Is DMI done with Industry 4.0 or is there more to do?



DMI believes it is not even close to taking advantage of all Industry 4.0 has to offer. This is a "game changer" in how they think about their company's production and operations. The future possibilities are exciting and are a foundation for continuous improvement across all four of its manufacturing facilities. The next step for DMI is a "Connected Plant Floor" that will empower DMI's operations teams with live machine data, real-time status of manufacturing orders, shipments, and inventory, as well as documents, forms, schematics, and videos all viewable remotely on any mobile device.



"When developing an ROI keep in mind many variables require judgement and can be somewhat subjective. For initial projects have an open mind and apply proper managerial judgement in developing the technology savings. Future projects will begin to fall into place."

—Raymond Yeager, CEO,DMI Companies



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How has DMI reduced their environmental footprint?

- DMI's Monongahela facility became Gold recertified through the TRUE program!
  - Its landfill diversion rate is now over 96%.
- Adopted 'Environmentally Preferred Purchasing' strategies.
  - The goal of this is to encourage source reductions through procurement.
  - The purchasing department was trained on how to find the most eco-friendly, responsibly-sourced products and services for all our company needs.
- Monongahela's "Rag Roll-out":
  - Originally, DMI's production staff utilized old pieces of clothing as rags. These rags were minimally absorbent and needed to be thrown into our dumpster once soiled.
  - Now, DMI works with a local vendor to purchase efficient cotton rags which are collected and resold back to the vendor.
  - With this seemingly small change, we've been able to reduce our rag waste by 100%.
- Sustainable practices have started spreading to DMI's Wagoner, Oklahoma plant.
  - All cardboard and shrink wrap waste will now be diverted from landfill, baled and sold to local commodity buyers. DMI's goal is that the Wagoner plant be certified zero-waste site by 2023.
- Put Green Engineering strategies in motion.
  - In October, DMI's engineering team designed and created a new semi-automated punch press for our Fire & Smoke department.
  - DMI sourced the needed components from scrapped, discontinued, or on-hand items which allowed us to cut costs and reduce waste during the construction process.
- Made DMI's headquarters in Charleroi, Pennsylvania as energy efficient as possible.
  - Built in 1889, our current headquarter building was once a bank, hotel, and housed numerous other operations. With retrofits and redesigns, the building is now Energy Star certified. We first achieved this feat in 2012 when the building was 123 years old. Now, it is considered one of the most energy efficient buildings of its time in the world!
- DMI's Manufacturing Execution System (MES) implemented in 2020 with the roll-out of Industry 4.0 has allowed several of our production floors to go completely paperless.

For More Information:
DMI's 2020 Sustainability Report

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Catalyst Connection is a southwestern Pennsylvania economic development organization dedicated to serving manufacturers. For more than 30 years, Catalyst has operated with a focus on powering potential through delivering technical assistance and management consulting services and developing long-standing partnerships across the region. Catalyst maintains a deeply held commitment to modernizing manufacturing and enabling opportunity across business enterprises, individuals, and throughout communities.

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