A ROADMAP FOR IMPLEMENTING ROBOTIC OR AUTOMATED MATERIAL REMOVAL IN METALWORKING OPERATIONS

Abstract

This white paper provides a comprehensive roadmap for implementing robotic or automated material removal solutions in metalworking operations. The process involves understanding the benefits, assessing readiness, evaluating requirements, and setting objectives, as well as selecting the right technology, designing the system, testing and integration, training, and ongoing maintenance. Successful implementation can significantly improve efficiency, accuracy, and safety in the metalworking process.

Introduction

The integration of robotics and automation in metalworking operations is becoming increasingly prevalent, driven by a need for enhanced productivity, improved precision, and a safer working environment. For years now, automation in metalworking has been visible in CNC laser or plasma cutting, automatic band saws, mills, lathes, etc. In addition, over the last decade, there has been a significant increase in the presence of robotic welding systems, and now collaborative robotic COBOT welders, to help address the increasing challenges of finding skilled welders across a variety of industries.

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Material removal is a fundamental aspect of metalworking, encompassing processes such as grinding, sanding, finishing, polishing, deburring, and cutting. Most material removal applications (in metal) are made after welding, but some can take place before, or even during, the welding process, like: surface prep, cutting, or weld cleaning between passes. And it is not always glamorous work – polishing stainless steel to a mirror finish is just as essential as grinding down heavy flashing on a cast metal part – but both processes are time consuming, physically demanding, and require experience that is challenging for many companies to find, hire, and retain.

The American Welding Society projects a shortage of 375,000 welders by 2026 in the US alone, and while robotic welding systems can help shoulder some of that burden, the welders themselves are often responsible for several downstream process as well – like weld grinding, deburring, etc. – and if the welder is nowhere to be found, what does that mean for the pre-, mid-, or post-weld material removal work? These are some of the reasons that a company would consider automating some, or all, of their material removal processes.

This paper outlines a structured roadmap for effectively planning and executing the integration of robotic or automated material removal in metalworking operations.

UNDERSTANDING THE BENEFITS

Before initiating any implementation, it's essential to understand the potential benefits of incorporating robotic or automated material removal in metalworking operations. These benefits include:

1) Enhanced Efficiency

Automated material removal systems can operate continuously, providing a consistent, high-speed performance, which significantly increases overall efficiency and throughput compared to manual processes. Often, cycle times of any given process will be significantly reduced; alternatively, even if cycle times are not the main concern, the throughput of a robot that doesn't need to stop working means productivity gains are almost always assured.

2) Improved Precision

Robotic systems can be programmed to execute precise movements and to control parameters like force and speed, resulting in highly accurate material removal processes, ultimately improving the quality and consistency of finished products due to minimized risk of error and re-work. Consequently, automated, or robotic processes are either always good, or always bad which illustrates that once the automation process is fine-tuned, the precision and repeatability is second to none.

3) Increased Safety

According to the US Bureau of Labor Statistics, in 2020, there were 373,300 non-fatal occupational injuries and illnesses and 341 fatal ones in the manufacturing industry alone. By automating hazardous or repetitive tasks, the risk of injuries to human workers is reduced, creating a safer work environment, increasing employee satisfaction, and minimizing workers' compensation claims. In the industry, these types of tasks or jobs are often considered "3D" or "4D", which stand for "Dirty, Dangerous, Demeaning, and Dull". While an automated or robotic process may not eliminate those roles completely, they can often take over 70%+ of those 4D jobs, allowing the workforce to contribute to the business in other valuable areas that don't involve such physically taxing duties, letting robots take on that load.

4) Cost Savings

Although the initial investment can be substantial, automated systems can lead to long-term cost savings due to reduced labor costs, increased productivity, and less waste. Often, the greatest benefit is being able to retain your current workforce and channel their talent towards tasks or jobs that are of greater interest to them, and of greater value to the company. A great way to quantify the impact of automation is by evaluating the output-per-dollar-spent since productivity and throughput gains will allow for increased production, greater stock availability, and, therefore, enhanced customer satisfaction, all without requiring any changes to the size of your workforce, cost of materials, or any other variable.

5) Resistance to Workforce Fluctuations

Having a robotic system in your manufacturing facility could help mitigate the impact of changes in workforce availability. Automated or robotic processes typically have higher output and throughput than manual labor and are capable of working multiple shifts daily. This means that the risk of stock shortages and underproduction due to workforce fluctuations could potentially be reduced. With the ability to redeploy some of your workforce to higher impact and less physically taxing jobs, production levels could remain less affected by workforce shortages in the future.

ASSESSING READINESS

Assessing organizational readiness is a crucial step in planning the implementation of robotic or automated material removal solutions as well as when designing the improvement or expansion of pre-existing robotic systems. Below are a few key considerations when assessing readiness to automate:

1) Technical Infrastructure

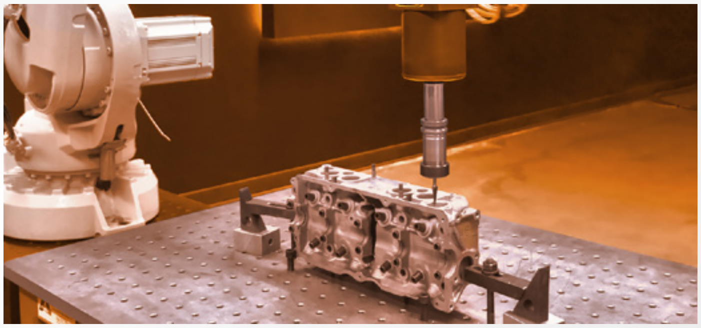
Evaluate the existing infrastructure to ensure compatibility with automated systems. This includes available power supply, networking capabilities, and space for installation. Most metalworking machinery (CNC milling machines, press brakes, shears, bending systems, rollers, plasma cutting tables, etc.) require the same power sources as robotic material removal cells. If you already have any of those in your facility, you are likely well-equipped already.

2) Workforce Skills and Training

Assess the skills of the existing workforce and identify training needs to ensure a smooth transition to automated processes. Training programs may be necessary to operate and maintain the new system efficiently and successfully. Some questions to ask are: Could your current employees/operators easily move from doing the work, to managing a machine that is doing the work? Do they have prior experience with similar automated systems? If yes, the training needs are minimal. If no, training is required. Fortunately, today's systems are more and more intuitive and easy to learn, similar to learning how to use a touch-screen tablet or smartphone.

3) Regulatory Compliance

Understand and comply with relevant industry regulations and standards concerning the integration of robotic or automated systems into the workplace. "COBOTs" or collaborative robots, which are becoming more and more popular due to them being user-friendly and requiring limited programming, are great in certain applications, but may not deliver the productivity of industrial robots when it comes to your operations. There are different safety regulations and space requirements to consider as well when deciding between different types of robots.



DEFINING REQUIREMENTS

What is "success"? What does "good" look like?

Clearly defining the specific requirements for the automated material removal system is crucial for a successful implementation. Does 100% of the process need to be automated? What about only 80% of that process, since those are the least pleasant tasks for your workforce to perform? These requirements encompass:

1) Material Types and Sizes

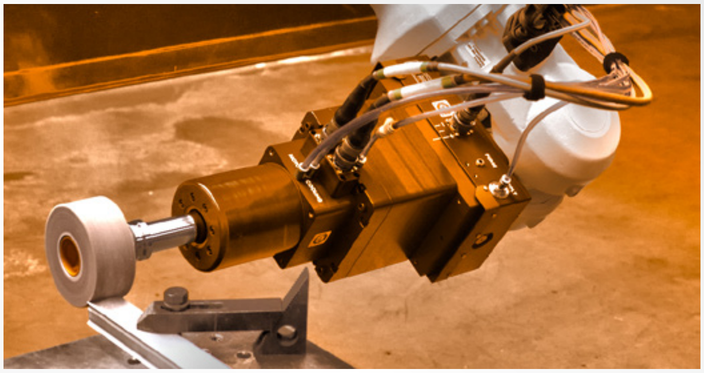
Identify the types and sizes of materials that will be processed by the automated system to determine the necessary capabilities and specifications. Robot payload is an important factor to consider based on the size of tooling used at end-of-arm when it's a tool-in-hand process but also when it's part-in-hand. Tool-in-hand refers to the robot arm being directly equipped with a tool. Part-in-hand means that the robot picks up the pieces, bringing them to a stationary working tool.

2) Throughput and Capacity

Estimate the required throughput and capacity of the system to ensure it can handle the expected production demands efficiently. Also ensure that your upstream processes can provide the expected workload to the robot or automated system. Oftentimes focusing on current bottlenecks is a great place to start in order to ensure there will be sufficient satisfactory gains in terms of productivity.

3) Process Variability – Ensuring Machine Compliance

Consider the variability in the material removal process, such as different shapes or surface finishes, and ensure the system can adapt and adjust accordingly. When looking at material removal, traditional accessories like abrasives naturally wear down as they work. In order to ensure your automated system is getting the highest output out of the abrasives tools used, force compliance devices are often used to allow for automatic compensation for (a) part-shape variability, and (b) orientation of working angle. In consequence, "active" or "passive" types of force compliance devices are essential to ensuring the most efficient and capable robotic material removal systems. Active compliance devices apply consistent force in any orientation automatically. This makes it a great candidate for parts with curved surfaces. Passive compliance devices, however, rely on external, customer-supplied air pressure regulators to set the applied force. They work extremely well for less demanding flat or prismatic parts or more specialized processes like weld shaving, where high-accuracy force control is unnecessary.



SELECTING THE RIGHT TECHNOLOGY

Choosing the appropriate technology is a critical step in the implementation process. Factors to consider include:

1) Robotic Platforms

Evaluate different robotic platforms (e.g., articulated, COBOTs, SCARA) and select one that aligns with your specific requirements and budget. If there are other pre-existing robots in your facility (like, for example, in robotic welding) and you have a preferred brand based on reliability, service, etc., then you can often find a capable robot for material removal applications from that trusted partner already, to ensure maximum compatibility and minimize the need for additional training.

2) End-Effector Tools

Select suitable end-effector tools based on material and process. Also, it is important to consider if the robotic process will be part-in-hand, or tool-in-hand, or both. Compliance tools are often required when working with a consumable product – like abrasive wheels – which change size and shape as they are used. An end-effector tool that can compensate for that wear or change in force based on directional usage is crucial to ensure process reliability and conformity across the life of the consumable, as well as to eliminate the need to re-program machine paths for every piece.

3) Control Systems

Choose a robust and user-friendly control system that allows for easy programming, monitoring, and integration with other components of the manufacturing process. Choosing a good integration partner, who has some experience in the operations you're trying to automate, is also important as they can handle a lot of the programming uncertainties you may have, especially if you do not have anyone with experience already on staff. Choosing a product provider with an established relationship with integration partners can further help streamline processes and reduce project timeframes without sacrificing quality.

DESIGNING THE SYSTEM

Designing the automated material removal system involves creating a detailed layout and architecture that ensures optimal performance and safety. It

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is also important to note that when one looks at an automated or robotic material removal system, even though the goal is to replace previously manual tasks, the process itself could sometimes be modified significantly when adopting a robotic cell. Areas of access, piece fixturing, size of tool, and consumable used are all variables that are usually constrained when it comes to human work and the tools that can be used by them. When it comes to robotic systems, the end result can often be attained faster and more efficiently thanks to the wider breath of accessories that can be used. Considerations include:

1) Integration with Existing Processes

Ensure seamless integration with other manufacturing processes and systems, creating a cohesive and efficient production line. As mentioned above, ensuring that the automated system will have no adverse effects on any other upstream or downstream processes is important. Understanding the "starting point" of the work piece, and the desired "end result," as well as what happens in between, is all part of the robotic system design process.

2) Safety Measures

Incorporate safety features such as sensors, emergency stops, and protective enclosure, to mitigate risks associated with automated systems. Often, collaborative robots ("COBOTs") are marketed as not needing an enclosure due to slower moving speeds, nor built-in safety measures that stop the robot when unexpected contact occurs. For material removal with high-speed or hazardous accessories on the end-of-arm tool that could potentially cause physical harm if not properly considered, COBOTs are not necessarily the safest choice.

3) Ergonomics and Accessibility

Design the system to be easily accessible for maintenance and equipped with user-friendly interfaces to streamline operations. An important thing to evaluate is where, when, and how operators will need to access the workpieces that have been worked on by the robot. Should the robot have two separate working bays, so while one is being loaded/unloaded, the robot remains in action? If maintenance needs to be performed on the robot, will it require dismantling the entire cell to access certain parts? Thinking ahead can help reduce these potential issues and delays.

TESTING AND INTEGRATION

Thorough testing of the automated material removal system is essential to identify any existing or potential issues and ensure a smooth integration into the production environment. Before embarking on an entire automation project, consider consulting a robotic laboratory that could replicate or program a version of the manufacturing tasks you are trying to achieve, on an actual part you plan to produce. For an easier, smoother process, if you already know what consumable you want to use, contact your provider to see if it offers a clear pathway towards automation and works with partners offering complementary services, therefore being able to assist you from beginning to end. Investing a relatively small sum early on in the project (usually a few thousand dollars) to validate the process you are hoping to build pays off, since the development phase usually entails a project cost of $500K or more, depending on the provider. Therefore, thorough planning and validation before embarking on the project will reduce the risk of unexpected issues or delays, as well as of additional costs that may be incurred along the way. These steps include:

1) Functional Testing

Verify that the system operates according to specifications and meets predefined requirements for accuracy, speed, and safety. Ensure that the metalworking or material removal process you want to achieve is feasible. Find a "de-risking" lab or a robotic lab with similar types of equipment that could run a simulation of what you are trying to achieve, since investing a small sum up front will validate the subsequent hundreds of thousands that are likely to be part of any automation project.

2) Integration Testing

Integrate the automated system with existing processes, machinery, and software to validate seamless communication and data exchange. If the robotic system is to be integrated with other robotic systems (i.e., loading/unloading systems, machine tending, conveyor systems, etc.) ensure that your integration partner accurately assesses all of these relevant systems and how they interact. This will prevent you from building a new working system at the expense of another upstream/downstream system because how they might "communicate" was not considered. It will also reduce the risk of injuries, delays, machine idleness, or damage to equipment.

3) User Training

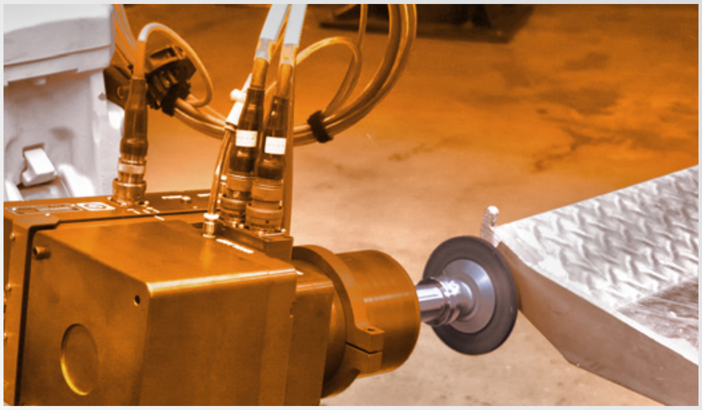
Provide comprehensive training to operators and maintenance personnel to familiarize them with the system, its operation, and troubleshooting procedures. Ensure that either the robot manufacturer, integration partner, and/or end-of-arm tool manufacturer is available and willing to provide training or support beforehand. If this is not something these providers are willing to do, then you may be better served looking for a more engaged partner, even if the cost up front is a bit higher. Downtime in the future will always cost more than capital spent on planning and prevention.

4) Implementation and Training

Deploy the automated material removal system into the production environment and closely monitor its performance during the initial stages. Offer on-the-job training and support to operators to ensure a smooth transition. Make sure that over the first few days and weeks, the new system is being closely monitored, and that you have designated go-to workers who can ensure the system's success and who are able to stop the equipment quickly if something appears to be wrong.

ONGOING MAINTENANCE AND OPTIMIZATION

Continuous maintenance and optimization are critical to maximizing the benefits of the automated system. As an operator or business owner, it is key to know what the objectives are and to be aware that you might need or wish to further improve on the original system design as you see it in action or learn more about the subject, or as new technologies come out or new needs arise. Key actions include:



1) Routine Maintenance

Establish a maintenance schedule to inspect and maintain the system, replacing worn-out parts and optimizing performance. Generally, all components of the robotic or automated system should have a manufacturer-recommended maintenance schedule. It's important to follow the latter to maximize the life of your investment.

2) Performance Monitoring and Continuous Improvement

Regularly monitor system performance, collecting data to identify areas for improvement and optimization. Implement feedback mechanisms to gather insights from operators and other stakeholders, driving continuous improvement in the system's efficiency and effectiveness. When evaluating this data, always consider the programmed working parameters of the consumable (diameter, grit, RPM, etc.), or machine speed (mm/sec or in/min). After running the system through enough cycles to ensure the robot/automated system can deliver what is intended, you can test accelerated parameters to see if cycle time can be further reduced with the same end results. Perhaps different abrasives accessories can be used to further reduce the steps required in the process. All of these different variables and their impact can be tested once the system is functional to ensure constant enhancement of the process.

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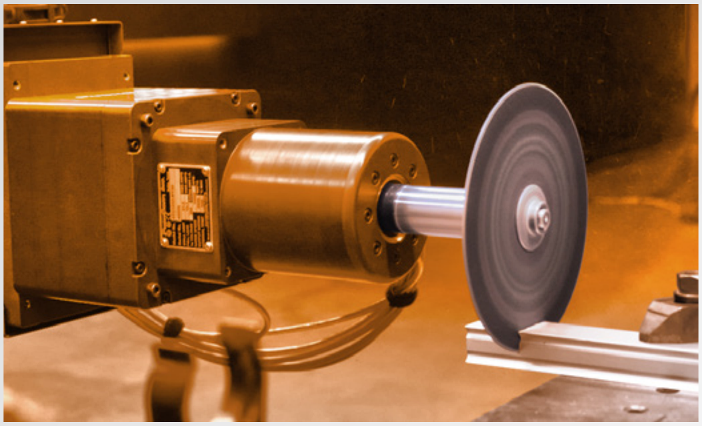

To learn more about the advantages automation and robotics can offer your company, reach out to our team of experts by clicking here, calling 1-877-626-8492, or emailing automation@walter.com.

Conclusion

Implementing robotic or automated material removal in metalworking operations can revolutionize efficiency, precision, and safety. By following a structured roadmap that includes understanding the benefits, assessing readiness, evaluating requirements, and setting objectives, as well as selecting the right technology, designing the system, testing and integration, training, and ongoing maintenance, organizations can achieve successful and sustainable implementation.

By choosing an experienced team to work alongside you throughout this process, the planning and implementation can take place within weeks instead of months. With proper planning and execution as well as with the proper guidance and recommendations from trusted experts, the integration of automation into material removal processes can give you to a competitive advantage in the metalworking industry and ensure a sustainable combination of human and robotic resources that can help you grow and scale your business in the years to come.

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Through his nine years working at WALTER in various product and commercialization roles, Ryan has developed a thorough knowledge of the objectives and realities of industrial end users. His strong relationships with customers and his awareness of new industry trends and standards enable him to successfully spearhead the development of new solutions and comprehensive support strategies. Ryan holds a Bachelor of Commerce degree from McGill University.

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Cédrik is well-versed in the technical challenges end users face across numerous industries as well as in industry needs and requirements for abrasives and other tools. With a Bachelor of Engineering from Polytechnique Montreal, combined with six years as a product manager for WALTER, Cédrik continuously works on the creation, design, and improvement of WALTER products and solutions to answer the needs of today's metalworking professionals.

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