FINISHING TOUCHES

Force control: The key to successful robotic deburring

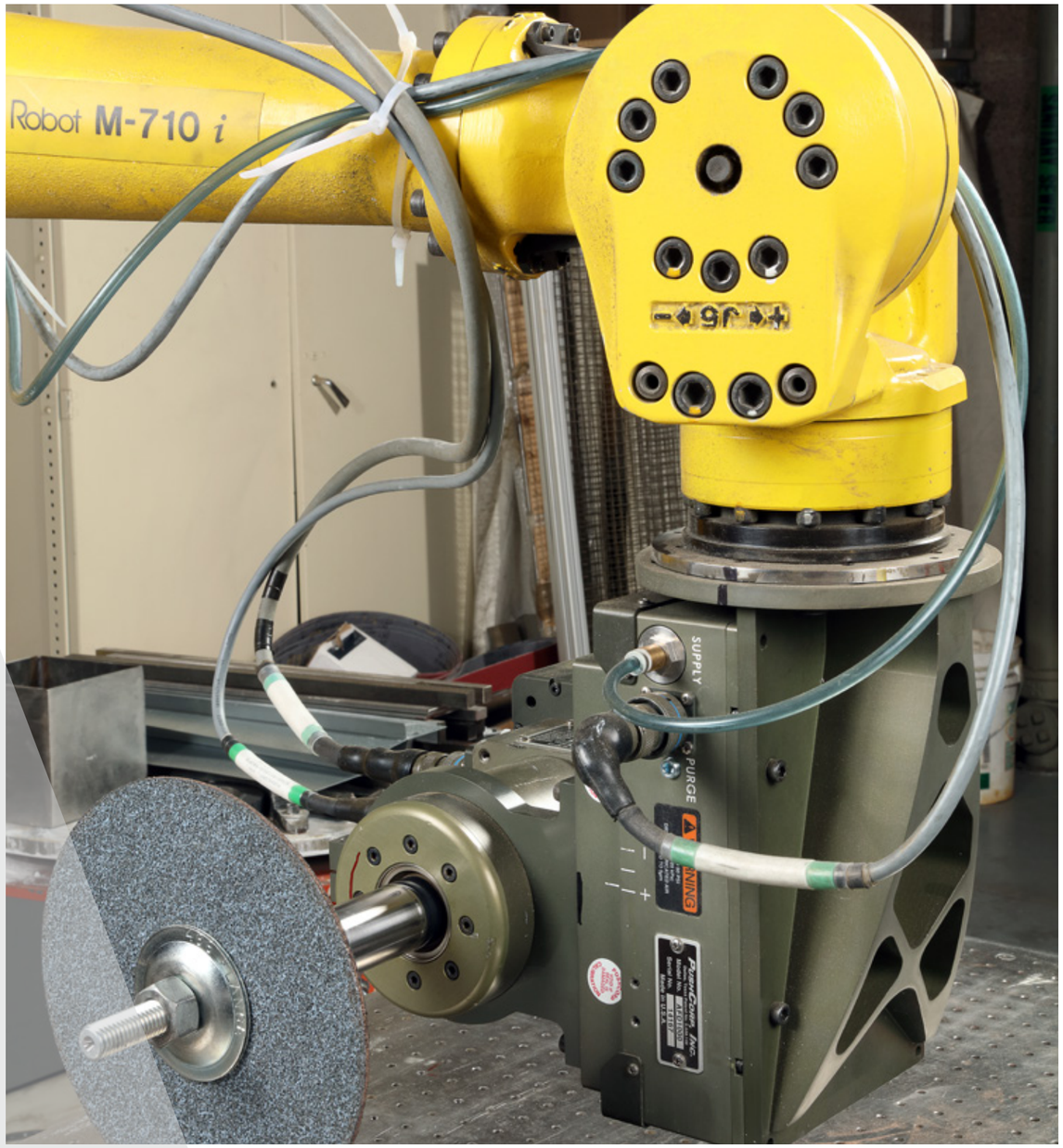
by Nathan Herbst, technical service engineer, 3M Abrasive Systems

Integrating automation into any industry brings challenges. For the metal fabrication and finishing fields, automating an application like deburring has its own unique set of considerations.

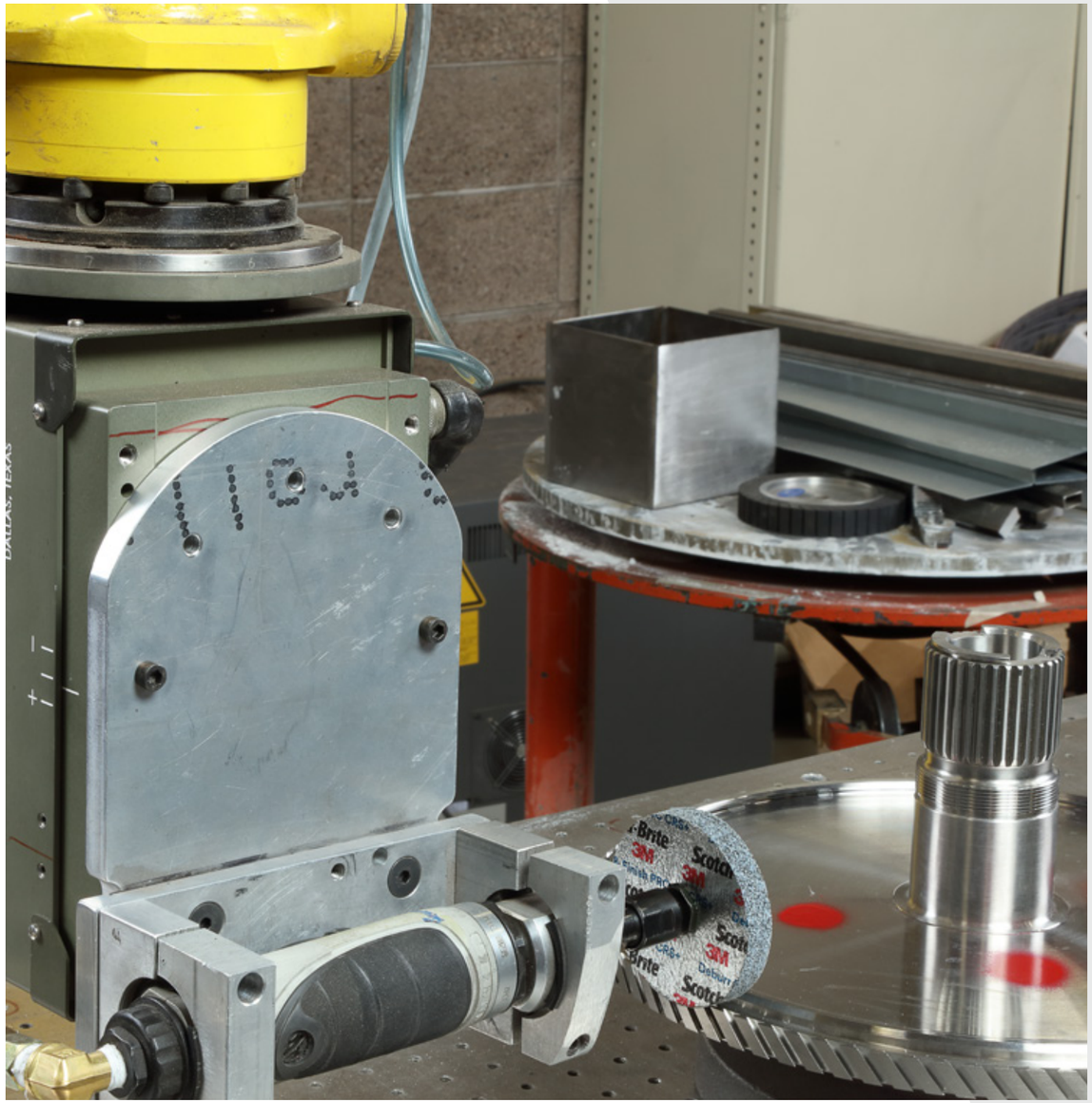
Deburring is not an application that always looks and functions the same. It's ambiguous, nuanced and often perceived as requiring the human touch of an operator. Sometimes, deburring is conducted on hulking objects like a ship hull while other situations call for the deburring of small parts such as orthopedic implants or turbine blades.

ADDRESSING CHALLENGES

At its most basic function, a robot is designed simply to reach a point in space. At 3M →



A force control device from PushCorp Inc. with a Scotch-Brite Unitized Wheel for deburring on a turbine blade.



Deburring with a PushCorp Inc. force control device and a Scotch-Brite deburr and finish Pro wheel.

Abrasive Systems, we see this in factory automation where repetitive motions, such as placing an object on a fixed-speed belt, are performed by a robot arm that pivots and repeatedly bends over. It moves objects based on predetermined coordinates, throughout a generally static process.

The challenges that come with integrating robots for applications like deburring include an abrasive's tendency to wear down and change in size and performance over time. Robots that have highly fixed, programmatic movements can't adjust to the wear of the abrasive – and, in most cases, robots cannot understand pressure or contact like operators who are trained to "feel" the job and adjust force as they go.

Robotic integrators, however, are able to add devices with force control and feedback to robotic cells that are designed to compensate for these sensory shortcomings. So, the challenges facing automated deburring are not unsolvable.

When setting up robotic controls for a material removal abrasive process, 3M examined several factors, including pressure. Ultimately, the findings showed that the key to successful robotic deburring is to design robots with the ability to change their pressure throughout – because controlled force yields consistent results.

IMPLEMENTING FORCE CONTROL

The term "deburring" refers to a wide variety of applications: removing flash from castings, eliminating heavy slag following flame cutting, refining very fine edges of turbine blades, radiusing soft substrates like aluminum and plastics, among others. As such, it's necessary to use different force control devices for different applications. Here are two common ways that 3M integrates force control on robotic systems:

- *Mount the force control device between the robot wrist and tool:* This method is ideal for situations where →

- the robot is taking a tool with an abrasive to a fixed part. It allows the robot to apply a consistent force as it articulates around the part being deburred. This is used in cases when a part is too large or awkward to bring to an abrasive on a fixed piece of equipment.

- *Build the force control device into the supporting equipment of the robotic cell:* This implementation is used when the robot presents the part to the abrasive that is run on a separate piece of equipment such as a floating head back stand or pedestal grinder. The force control device is used with parts that are small enough to be picked up by the robot, such as small turbine blades, orthopedic implants, automotive suspension parts, firearm components and more. For this kind of system, presenting consistent parts is the key to achieving consistent results. While some types of equipment have compliance built into them, others (like a basic bench grinder) can be mounted to a force control table or to a pivoting/sliding assembly with a force control device behind it.

ABRASIVE SPEED, QUALITY

Whether a fabricator or manufacturer has made the automation migration or is still just considering robotics, there are other variables that should be considered in addition to force control devices. These include equipment speed, product characteristics and part consistency.

3M recommends investing in equipment that allows users to alter speed throughout the life of an abrasive. This is particularly important when using abrasive wheels, which change diameter with use. As a convolute deburring wheel decreases in size, for example, its surface speed (feet per minute or meters per second) and cut rate also decrease. Variable speed allows users to increase the RPM of a wheel and maintain performance even as the wheel diameter changes.

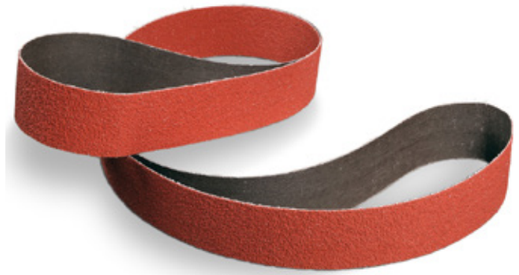
To optimize wheel efficiency and performance, it's important to measure the abrasive wheel diameter and deliver →

RIGHT FOR THE JOB

Use coated abrasives for particularly heavy-duty applications. 3M Cubitron II 969F, for example, is a flap disc specifically engineered with a tough polyester backing to hold up under more demanding applications, such as deburring.

Similarly, the 3M Cubitron II 984F abrasive belt is a versatile belt well-suited for high-pressure applications with minimal belt changes due to its durability. A force control device is necessary in these situations, increasing pressure as the abrasive dulls and accounting for wear.

Use convolute deburring wheels for most applications when the part is being presented to the abrasive. Unitized wheels are most commonly used when the abrasive is mounted to a tool that is being brought to the part.



The 3M Cubitron II 984F cloth belt is well-suited for medium- to high-pressure applications, such as those involving stainless steel, exotic alloys, carbon steel, cobalt chrome and nickel alloys.

Designed for high-performance and durability in deburring and finishing applications, 3M Unitized Wheels feature 3-D nonwoven web and abrasive mineral in a layered construction.

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feedback to the speed controller. This can be done by measuring the wheel with a sensor or by observing the robot's position to calculate wheel size and adjust the RPM accordingly. By improving speed and consistency, users also boost productivity and minimize downtime.

When designing a robotic cell, it's also critical to consider an abrasive's overall properties and take advantage of larger abrasives with premium characteristics. The careful selection of wheel size, density, grade and type – and using higher density convolute and unitized deburring wheels – can maximize abrasive life. On the other hand, low-quality abrasives or small-diameter wheels warrant changeouts, waste time and result in low payback.

When using abrasive belts, it's important to consider mineral type, abrasive grade and belt length to determine the best product performance and life. Simply, a longer belt means more material and longer life. The mineral type of the abrasive, such as ceramic versus aluminum oxide or silicon carbide, can also affect cut performance and abrasive life. Finally, the abrasive grade (mineral size) can play into how quickly the work is done. Completing the job with the most aggressive mineral that meets the finish requirements generally provides the best speed and life.

PART CONSISTENCY

In addition to the abrasive, another source of variability is the part itself. A good candidate for robotic finishing is a very consistent part in terms of burr size and shape. If a part has variability, it can be difficult for a robot to determine when the part has been successfully completed.

A vision system can be installed on the cell and used to measure, inspect and customize the robotic program, but this adds complexity, increases cycle time and raises cost. Ideally, the parts coming in will be the same every time, so the process can be characterized and cycle times remain constant and consistent.

Despite the variations robotic deburring presents, the results must remain consistent. At the 3M Customer Abrasive Methods Center, extensive experimentation with various cells has been conducted to determine the challenges and solutions for advancing robotic deburring. The company also helps integrators by working alongside them to ensure the automation setup process goes seamlessly.

Furthermore, 3M helps shop owners test for ways to achieve optimal cycle times and productivity. Comprehensively, the company is committed to ensuring consistent automation results with quality customer service and high-performing abrasives. ●

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