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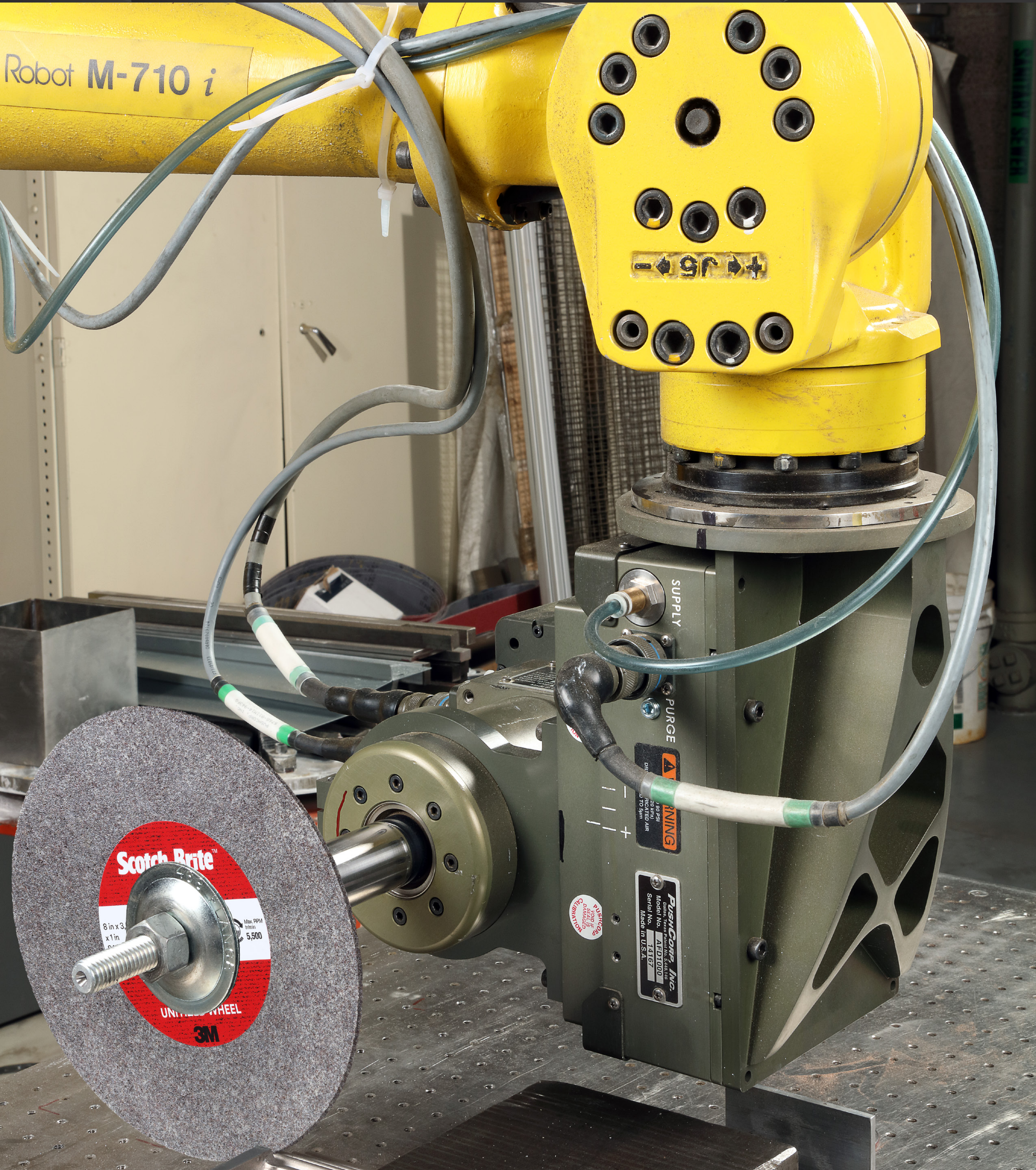
Force Control: The Key to Successful Robotic Deburring



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Force Control: The Key to Successful Robotic Deburring

Integrating automation into any industry brings challenges. For the metal fabrication and finishing field, 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 like orthopedic implants or turbine blades.

Addressing the Challenges of Robotic Deburring

At its most basic function, a robot is designed simply to reach a point in space. We see this in factory automation where repetitive motions like placing an object on a fixed-speed belt is performed by a robot arm that pivots and repeatedly bends over. It moves objects based on pre-determined 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 cannot 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, we look at several factors, including pressure. Ultimately, we've found the key to successful robotic deburring is to design robots with the ability to change their pressure throughout—because, controlled force yields consistent results.

How to Implement Force Control

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

1. 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 item 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.

2. 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.

Product Tips

Use coated abrasives when particularly heavy material is being removed. **3M™ Cubitron™ II 969F** (shown below, left) for example, is a flap disc specifically engineered with a tough polyester backing to hold up under more demanding applications, such as deburring. Similarly, **3M™ Cubitron™ II 984F Abrasive Belt** (below) 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.

Convolute deburring wheels feature a 3-dimensional non-woven web and abrasive mineral convolutely wrapped around a core. These are typically used in applications when the part is being presented to the abrasive. Unitized wheels feature the same 3-D non-woven web and abrasive material, but in a layered construction. These are most commonly used when the abrasive is mounted to a tool that is being brought to the part.

Importance of Abrasive Speed and Quality

Whether you've migrated to, or are 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 you to alter speed as you move through 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 (Surface Feet Per Minute or Meters per Second) and cut rate also decrease. Variable speed allows you to increase the RPM of a wheel, to maintain performance even as the wheel diameter changes.

To optimize wheel efficiency and performance, it's therefore important to measure the abrasive diameter and deliver 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, you will also boost productivity and minimize downtime.

When designing a robotic cell, it is also critical to consider an abrasive's overall properties, and to 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 require change-outs, waste time and result in low payback.

When using abrasive belts, consider mineral grade, abrasive type, 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 the cut performance and life of the product. 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 will generally provide the best speed and life.

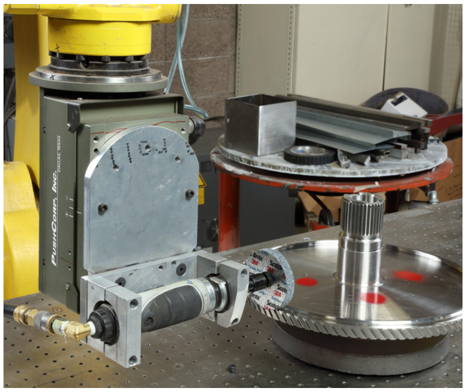
3M offers an advanced line of belts engineered with long-lasting abrasives to help ensure predictable, quality results with less reliance on operator skill.

Part Consistency Affects Process Consistency

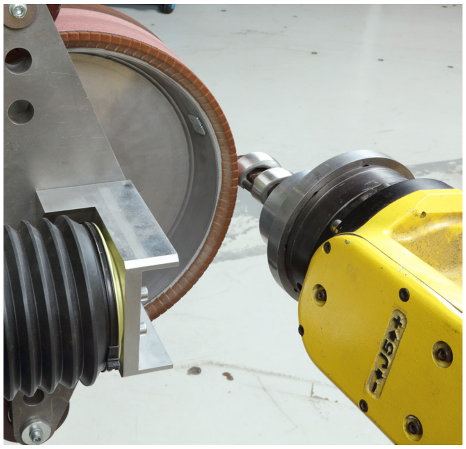
Another source of variability is the part itself. A good candidate for robotic finishing will be a very consistent part in terms of burr size and shape. If a part has variability, it can be difficult for a robot to determine when the part has been successfully completed. A vision system can be installed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

Commitment to Deburring Automation Success

Despite the variations robotic deburring presents, the results must remain consistent. At the 3M Customer Abrasive Methods (CAM) Center, we have done extensive experimentation with various cells to determine the challenges, and solutions, for advancing robotic deburring. We help integrators by working alongside them to ensure the automation set-up process goes seamlessly. We help shop owners test for ways to achieve optimal cycle times and productivity. Comprehensively, 3M is committed to ensuring consistent automation results with quality customer service and high-performing abrasives.



Force control device from PushCorp, Inc., shown with a Scotch-Brite™ Unitized Wheel for deburring on a turbine blade.



FerRobotics Active Belt Grinder deburrs an orthopedic implant with a 3M™ Cubitron™ II belt.

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