Market Playbook: End of Arm Tools for Robots
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MARKET PLAYBOOK:
END OF ARM TOOLS FOR ROBOTS

Knowing about the right tools for the right application
will help your robots get a grip

By Andrew Williams

End of arm tools — also commonly called grippers, end effectors, robotic peripherals, robotic accessories, robot tools, or robotic tools — occupy a central position in many robotic systems. Their pivotal role as the interface between robots and the materials they handle means they are often viewed as extremely important components in workplace settings.

Such tools — which often take the form of fingers like those on a human hand, or vacuum-like suction tools — can carry out one or more tasks related to the manipulation or handling of objects in industrial or business systems. Tasks include, but are not limited to, pick-and-place operations, machine tending, packaging and palletizing, assembly, quality testing and inspection and surface finishing. In addition to these roles, end of arm tools are now increasingly commonly used with, or alongside, collaborative robot (or cobot) systems.

This report takes a closer look at the growing market for end of arm tools, and profiles some of the leading companies and products in the sector. It also considers some variables that businesses should consider when deciding to purchase and install grippers and similar tools. The report will also shine a light on some cutting-edge research in this space.

Market outlook

An October 2018 QYResearch report titled “Global Robotics End-of-arm Tooling Market Insights, Forecast to 2023” states the worldwide robotics end-of-arm tooling market has experienced a period of significant growth over the last couple of years — a trend expected to continue through 2023. The reports’ authors valued the market at $1.58 billion in 2017, with growth rising steadily to $2.42 billion by 2023, implying a fairly steady compound annual growth rate (CAGR) of about 8%.

A November 2018 report by market research firm Technavio, titled “Global Robotics End-Of-Arm Tooling Market 2019-2023”, concludes with a more optimistic assessment. This report predicts that by 2023, the robotics end-of-arm tooling market will achieve a more impressive 13% CAGR. The Technavio authors attribute the higher growth rate to an ongoing surge in the employment
of fused deposition modelling (FDM), and additive manufacturing in the creation of end-of-arm tools, which they claim is leading to more rapid customization, compared with conventional production methods. This also leads to higher cost-effectiveness and reduced delivery times, the report states.

However, the Technavio report also states the cost of installing robotic end-of-arm tools can sometimes be high, and says additional costs – including preventive maintenance, safety, operator training, and the deployment of complementary peripheral equipment – can hinder adoption of the technology.

Common Components
In general terms, the term robotic end-effector can be extended to almost any type of object attached to a robot’s flange — or ‘wrist’ — that carries out some form of function. In practice, such objects come in a weird and wonderful array of shapes and sizes — from robotic grippers, tool changers and rotating joints to collision sensors, press tooling devices and arc welding guns. The broad scope of functions and capabilities means that when it comes to choosing the devices best suited to an individual need, robot businesses and developers must be aware of a wide range of factors — or risk installing a system that is sub-optimal.

To help users navigate this potentially complicated scene, online engineering innovation hub ennomotive recently published a useful guide to some of the
most common types of robot grippers, as well as their industrial applications. These include basic two-fingered grippers like those produced by OnRobot and Robotiq, which are suitable for a wide range of industrial products and relatively simple to produce and program — as well as more complex, but less commonly used, three-fingered grippers from companies like KINOVA and IAI for the manipulation of more delicate objects and flexible-fingered units, such as the MultiChoiceGripper from Festo that can be useful for handling more irregularly-shaped objects like food products.

Other commonly used gripper types outlined in the guide include innovative grain-filled flexible balls — basically balloons containing some form of grain or rice that are laid onto the object to be picked then turned into a rigid shape by sucking in air — as well as larger robot grippers, like those manufactured by ABB, designed for operating heavy loads and palletized goods.

Creating customised robot grippers is typically an expensive undertaking — and users need to undertake additional resource-intensive tasks like application-related programming and workplace adaptation. Thankfully, ongoing advances in robotics technology are helping to make this process a lot easier — and some grippers are now even available in a kit form to enable easy assembly.

When choosing which gripping technology is the right one for you, it can also be helpful to establish a set of criteria against which you can evaluate a decision.

To assist companies in this process, RobotIQ recently published a useful eBook to ensure that the process of defining needs runs smoothly. Amongst other things, it highlights several technical specifications that businesses could usefully consider, including their overall gripping strategy, the tasks that will be performed, grip types, finger and fingertip varieties, required robot cell flexibility, the power supply that will be used (e.g. electrical, pneumatic or hydraulic), the ease of integration into existing processes, required payload and gripping force and gripper feedback and cost.
Leaders in the Space

Although ongoing advances in 3D printing and additive manufacturing are helping lower the barriers to entry for new businesses in the sector, several companies continue to enjoy a relatively large slice of the market. Here are some of the current leading players:

- Quebec, Canada-based collaborative robot application manufacturer Robotiq is one of the leading producers of end of arm tools and plug and play components for cobots. Amongst other things, the company manufactures the 2F-85 and 2F-140 Adaptive Grippers, which it describes as the world’s ‘best-selling grippers for collaborative robots.’ Key features of the units include a proprietary finger design that is capable of both internal and external parallel gripping, as well as a novel encompassing grip mode.

- Bedford, Mass.-based Soft Robotics manufactures several automation solutions and soft robotic gripping systems that leverage the company’s own material science and AI algorithms — and which are capable of grasping and manipulating items ‘with the same dexterity of the human hand.’ The company’s range is based on what it describes as a ‘fundamentally new class of robotic grippers’ that employ air actuated soft elastomeric end effector technology. Key units include the M4FC, M4FR and M5FC food and beverage grippers, as well as M2FR-n, M2FR-w and M6FR industrial automation grippers. Another key recent innovation is the SuperPick system — aimed squarely at the e-commerce, grocery, retail and logistics sectors — which combines the company’s existing technology with artificial intelligence to allow users to automate ‘highly unstructured tasks like bin picking, sorting and goods to robot fulfilment.’

- OnRobot is one of the early frontrunners in the manufacture of robot grippers for use with collaborative robots — also known as cobots. Formed in June 2018 following a merger between Danish outfit On Robot, U.S.-based Perception Robotics and Hungarian firm OptoForce. Provides customers with a ‘one-stop-shop’ for end-of-arm options, from the Universal Robotics certified RG2 and RG6 models to the Gecko Gripper and the VG10 Vacuum Gripper.

- Billed as a ‘leading global provider of specialized end-of-arm tooling and connectivity Tool Changer solutions,’ Glenville, N.Y.-based outfit Applied Robotics offers a number of standard and heavy duty grippers based on
either pneumatic or electric servo technology — ranging from vacuum, O-ring and needle varieties to ‘traditional angular and parallel configurations with long jaw travel and 180 degrees rotation.

- **Swedish firm** Robot System Products manufactures several tool changers and swivel tool changers based on its innovative TrueConnect system, a proprietary cutting-edge locking technology capable of automatically lining up vital electrical connector pins before contact is made — helping users to eliminate the range of problems associated with side-loading and in the process ‘drastically’ minimizing wear and maximising operational life. Popular lines include the TC range of tool changers and the STC range of swivel tool changers.

- **Swiss company** Stäubli describes itself as a ‘leading technological pioneer in the construction and development of robotic tool changing systems.’ The popular MPS product range is based on an innovative modular concept — and includes MPS COMPLETE a preconfigured robotic tool changers for ‘immediate use,’ MPS MODULAR, which users can apply to their own specific configuration and MPS CUSTOMIZED, equips users with the capacity to build complex application-specific systems.

- **Multinational manufacturing firm** SCHUNK — located chiefly in Germany, but with an extended presence in the U.S. — offers a comprehensive range of gripping systems, including devices adapted to carry out a bewildering variety of tasks, such as Parallel grippers, Co-Act grippers, Centric grippers, Angular grippers, Magnetic grippers and Rotary grippers.

- **North Carolina-based company** ATI Industrial Automation is one of the world’s leading robot arm tooling developers — and produces a number of sought after automatic and manual tool changers. Some highlights include their range of robotic tool changers and robot collision sensors.

- **Redwood City, Calif. outfit** SAKE Robotics manufactures a number of cutting-edge grippers, including the versatile EZGripper tool — designed for use by ‘next generation robots in unstructured environments’ — that can be used to carry out number of typically difficult to manage tasks.

### Recent Research

Recognizing the increasingly central role of end-of-arm tools in a wide range of sectors, a growing number of universities and research organizations around the world are researching and developing next-generation devices.

One interesting recent example is a Rochester Institute of Technology project
that aims to understand how elephants use their trunks to pick up small objects in an effort to help improve the design of flexible robot hands or grippers.

Another interesting recent initiative is the Dexterity Network (Dex-Net) project at the University of California, Berkeley (UC Berkeley). In order to support robots in the task of grasping almost any object without training, the project team has developed the patent-pending Dex-Net software, which builds on more than three decades of research combining a network of object models, analytical wrench mechanics and structured domain randomization — as well as deep learning and a range of additional proprietary innovations to rapidly compute pick points from depth images.

Ken Goldberg, Professor of Robotics and Automation at UC Berkeley, said the most recent innovation developed by he and his team is Dex-Net 4.0 (2018), which extends previous versions created for warehouse order fulfilment, adding “ambidexterity” — which he describes as “the ability to rapidly configure different gripper types, such as suction cups and parallel-jaw grippers.” A key feature of the new software is the inclusion of what Goldberg describes as “ambidextrous policies” for a dual-arm robot that “coordinates both suction grasp — or single point — policies with parallel-jaw grasp — or two points — policies.”

“Coming out of stealth mode in 2019, Ambidextrous Robotics will offer advanced robot grasping software for logistics and warehouse order fulfilment, allowing robots to grasp almost any object without training,” Goldberg said.

“Ambidextrous software can be applied to almost any combination of bins, 3D sensors, robots, grippers, and suction tools without expertise in the physics of robot grasping,” he added.

Looking at the next few years, Goldberg said one of the key research and development challenges facing the industry will center around the creation of software designed to “rapidly compute robust pick points for previously unseen objects.”
Elsewhere, many businesses are proving that cutting-edge research in this space is not the sole preserve of university-based academic teams. One interesting example is NVIDIA, where in-house researchers have created an innovative system that employs deep learning techniques to equip a robot with the capacity to perceive everyday objects around it for the purpose of “grasping the objects and interacting with them.” By using this approach, the robot can carry out basic pick-and-place tasks on several known household objects, including “handing an object to a person or grasping an object out of a person’s hand.” The device achieves this using an off-the-shelf RGB camera, which imbues it with the ability to accurately ascertain the position of objects around it. According to NVIDIA, the capacity to know the 3D position and orientation of objects in a scene — commonly known as a 6-DoF (degrees of freedom) pose — is a critical ability that enables robots to “manipulate objects even when those objects are not in the same place every time.”

“We want robots to be able to interact with their environment in a safe and skilful manner,” said Stan Birchfield, a principal research scientist at NVIDIA. “With our algorithm, and a single image, a robot can infer the 3D pose of an object for the purpose of grasping and manipulating it.”

**Applications and vertical markets**

Grippers and other end-of-arm tools are increasingly viewed as vital technologies across multiple industries, from the automotive, food and beverage and pharmaceuticals sectors, to semiconductor and electronics production and industrial machinery manufacturing. End effectors are also often crucial component parts of cutting-edge warehousing and logistics systems.

The list of tasks that end-of-arm tools can perform is already extensive, with new applications introduced at a steady rate. Broadly speaking though, grippers and other tools tend to be used for activities that can be grouped under broad headings — these include pick-and-place operations, machine tending, packaging and palletizing, assembly, quality testing and inspection and surface finishing.

Another recent development in this area is the increasing use of grippers designed for use with collaborative robots — or cobots. One prominent recent example is at the Swedish metal parts supplier, FT-Produktion, which has employed a combination of a UR5 robot arm — or cobot — from Universal Robots, a dual gripper solution with two RG2 grippers from OnRobot and a turnkey docking station from EasyRobotics to enable cobots to pick up a
new item while simultaneously setting down another, helping to ‘significantly’ improve production times and automate its processes.

The Åseda-based metal parts company, which counts global behemoths such as Volvo, Renault, and Scania among its customers, initially discovered the benefits that cobot solutions could offer for small and mid-sized firms from local machinery dealer Edströms, which offers comprehensive training courses for staff engaged in the operation and reconfiguration of cobot arms, grippers and filling modules. Since completing the installation, the company said its new cobot cell can produce a batch of 150,000 parts in under two months — a feat made possible in large part by an integrated gripper that removes a raw part from a ProFeeder device and inserts it into a CNC machine every 25 seconds. As part of this same robot arm movement, the other gripper removes a finished part from the CNC machine and places it in a container — a feat made possible by the RG2’s double gripper function — a process that reduces the cycle time by an impressive 12 seconds per task.

In a recent press release, Joakim Karlberg, who owns and operates FT-Produktion alongside his sister, revealed that the necessary manpower needed to cope with ongoing demands for productivity increases is “hard to come by these days.”

“Thanks to automation, an operator can keep three or four machines running at once without stress. We can already see many more opportunities for improved optimization and automation. If things keep going as planned, we imagine we’ll have two additional cobots in our facility within the next two
At FT-Produktion in Sweden, adding a cobot arm from Universal Robots and a two-finger gripper from OnRobot has helped the metal parts producer improve efficiency in its operations.

years," he said.

“Robotizing the high-volume production run has enabled us to eliminate monotonous manual tasks, giving employees more time to work on smaller runs with greater variation in their tasks,” he added.

**Conclusion**

With the varieties and capabilities of end-of-arm tools at an all-time high, a growing number of businesses around the world consider the technology to be necessary and an affordable addition to existing processes. Several analysts are predicting that the robot gripper market will enjoy a period of continued buoyancy into the next decade and beyond. The continued success of incumbents and new entrants in the sector suggest that these predictions will be proven accurate.

Even so, it remains the case that many companies — particularly small and mid-sized enterprises — would benefit from a clearer understanding of the range of capabilities offered by modern tools and end effectors, as well as improved guidance relating to the process of selecting the device or devices most suited to their own workplace setup.

In the short term, it is difficult to deny that end-of-arm tools will become a more important part of the manufacturing and logistics processes — particularly with the continued growth of collaborative robots. Industry trends such as rising device autonomy and increased system complexity will likely amplify this growth in coming years.