A brief primer on packaging robots

By John R Henry

Industrial robots have been around for a long time. They are ideal for many packaging operations and properly applied will give a boost to productivity and the bottom line. Improperly applied, they can be an expensive headache. Fortunately, life with robots has gotten a lot easier in recent years. A bit of attention to proper selection, installation and operation goes a long way towards a successful robotics installation.

Robots have many applications in packaging. Palletizing is one common use but hardly the only example. Robots are also commonly used for line loading such as depalletizing and decasing of containers, assembly and collation, carton loading and case erection, packing and closing. One Thai company builds continuous motion, inline fillers and cappers using robots to replace most of the container handling. Robots used to be limited by economics and capability. As prices plummet and capabilities skyrocket, they are increasingly limited only by imagination.

Some typical packaging applications include:

- Palletizing
- Case packing
- Carton loading
- Flow wrapper feeding

- Case opening and sealing
- Clean room operations
- Depallatizing
- Decasing
- Liquid filling
- Capping

Robots can often perform multiple tasks. In one application, a single robot loads the product cartons into a shipper case and pushes the case into the top sealer while kicking the trailing minor flap. As the case exits the sealer, the same robot picks it up and places it on the pallet.

In another example, the cases from 3 packaging lines converge at the end of the line. A single robot picks cases from each conveyor and places them on their appropriate pallets.

In another imaginative application in a fulfillment center, a robot picks the desired size case blank from multiple magazines, erects it, closes and seals the bottom and places in a packing station for loading. This makes for a truly random case erector bottom sealer.

Companies like Rethink Robotics and Universal Robots are redefining the whole concept of robots. Rethink's Baxter is a 2 armed, humanoid, robot that can be moved and trained in a few minutes to do pretty much whatever, wherever. Universal's robot is a single articulated arm that can be mounted anywhere. Advanced sensors and controls eliminate the need for safety guarding and both cost under $30,000 ready to work.

Definitions

Before discussing types of robot, it is necessary to define a few terms.

Robot

Robots can be hard to define. There are many mechanical devices used in packaging that perform functions similar to a robot but are not. Pick-And-Place devices have long been used for loading of cartons, for example. Advances in technology have brought some of these to the point of being robot-like but they are still not robots. Most pick and place systems are custom designed and built for a specific application. Most robots are standard designs that, primarily via software and end of arm tooling can perform multiple and varied tasks.

Axes

Axes or degrees of freedom describe the number of motions a robot can make. Two axes, X and Y (usually left to right and front to back) can address any point in a plane. The addition of a third, Z, axis allows it to reach any point in 3 dimensions. Additional axes such as yaw, roll and pitch allow the end of the robot arm to be positioned exactly as needed for more complex operations.

Envelope

Envelope, also called working envelope or reach, describes the space within which a robot can operate. A small robot may have an envelope of only a few inches while a large one might have an envelope of a dozen feet or more. As most robots move both horizontally and vertically, the envelope is usually 3 dimensional, rather than a flat plane.

End of arm tooling

End of Arm Tooling (EOAT) varies with application. In some cases it may be a mechanical gripper, in others, a suction cup, in still another a filling nozzle or a capping chuck. Some robot applications use multiple EOAT with one tool folding out of the way when not in use or using automated quick coupling systems to allow tooling modules to be interchanged.

Packaging robots

Robots come in a variety of types but most packaging applications use one of 4 types. . Within each of these types there are different styles. Factors such as load capacity, speed, reach, degrees of freedom and other requirements will determine the final selection. With the exception of the EOAT, and unlike many other packaging machines, robots are highly standardized. This makes them easier and less expensive to build, operate and maintain than many comparable purpose built machines.

Cartesian robots

Cartesian robots are sometimes called gantry or XY robots because of the way they move. They generally consist of a square or rectangular frame with a beam that can travel the length of the frame stopping precisely where needed. This provides the X motion. Mounted on this crossbeam is a second motorized car. This car can be controllably moved along the length of the crossbeam, providing motion in the Y axis. By controlling both the X and Y motion, the robot can be positioned over any part of its envelope. If vertical motion is required, an air or hydraulic cylinder or other lifting device can be added. A common use for cartesian robots is in palletizing. The gantry moves over a station where a product such as a box or bag is stopped in a known position. The product is gripped and raised as necessary. The gantry moves over the pallet, lowers the product into position and releases it. If necessary, a rotator can be added to the EOAT to rotate the product before placing.

Cartesian robots are very simple mechanically and can be expanded to virtually any size simply by lengthening or widening the frame.

Delta robots

Delta robots, which look something like spiders are sometimes called parallel link robots. They generally consist of 3 vertical arms, with each arm connected to a servo motor at the top. The spacing of the motors and the length of the arms determine the effective envelope. At their lower ends they are connected, flexibly, to the EOAT. The combined motion of the servos determine the position of the EOAT. The basic delta robot has 3 degrees of freedom (X, Y & Z). Additional manipulators can be added at the end of the arms to allow for rotation or other movement.

The simple mechanical design of the delta robot allows them to move rapidly, cycling at speeds up to 200 moves per minute and faster. This makes them excellent for high speed loading applications such as picking cookies off a conveyor and stacking them in a flow wrapper infeed.

SCARA robots

SCARA (Selective Compliance Assembly Robot Arm) robots generally operate in the X and Y axes. SCARA robots consist of a vertical column with a horizontal arm at the end. A servo motor controls movement of this arm allowing it to swing in a full circle or arc. A second horizontal arm, mounted to the end of the first and also servo controlled, can also move in an arc or circle. The combination of the two arms allows the end of the second arm to be positioned precisely anywhere in the robot's envelope of motion. A plunger or other mechanism can be added to the end of the second arm to provide additional axes of motion.

SCARA robots have the advantage of being cheap (some are under $10,000) and fast. This makes them ideal for simple pick and place operations such as inserting components into cartons.

Articulated robots

Articulated robots are what most people think of when they think of industrial robots. Articulated robots come in a variety of sizes and styles capable of handling ounces to hundreds of pounds, reaches from inches to 10 feet of more and 3 to 7 axes of motion. Common packaging applications include palletizing, case packing, depalletizing and decasing but they find many other uses as well.

An articulated robot is comparable to a human arm. Shoulder, elbow, and wrist joints allow positioning of the hand in virtually any orientation and position. The articulated robot consists of several arm segments, each with a servo motor giving it a single degree of movement. The combination of segments allows the EOAT to be positioned anywhere in any orientation. The segmented flexibility of the arm also allows it to reach into odd locations. For example, if part needed to be inserted from below, the articulated robot can be configured to reach under and insert upward.

The mass or weight of the arms prevents most articulated robots prevents them from achieving the higher speeds of a delta or SCARA robot. Their complexity also tends to raise their cost which may make them overkill for simpler operations.

Vision

Robots have traditionally relied on parts being placed in a known position and orientation for pickup and then placement in a known position and orientation. This did not necessarily need to always be the same, robots could be programmed to pick from a series of locations such as pockets on a tray. They could also be programmed to place in individual pockets or stack in a pattern on increasing levels as on a palletizer. The drawback is that it depends on the program knowing precisely where each position is. This is fine for many applications but limits flexibility.

Machine vision (or simply "vision") systems have been around for a long time but used to be expensive. In a YouTube video roboticist Rodney Brooks of Rethink Robotics tells of buying a camera for machine vision in the 1990s for $50,000. He tells us that he recently bought a webcam for under $5 that has more capability than the $50,000 camera. Cognex now has a camera that they claim is price competitive with photoeyes for higher end sensing applications. One company has combined a robotic palletized with a Kinect X-Box system from Microsoft to allow sensing and positioning of cases in random positions and orientations.

This dramatic improvement in price/capability has allowed robots and cameras to be integrated in ways that were never cost effective before. Absent vision, a delta robot could pick cookies off a conveyor only if each cookie was precisely positioned and oriented. Add a camera to the end of the robot and now it can "see" the cookie wherever it may be, pick it up, turn it to the proper orientation, locate the appropriate moving pocket on a flowwrapper infeed and place the cooking into it.

This ability to see and work with randomly positioned components greatly simplifies the design of many packaging machines. Instead of needing to build precise positioning into the machine, the builder now only need to position the part of product approximately. The vision system adjusts as needed to the actual position.

Programming vs teaching

Older robots needed to be programmed to perform each task. This required a skilled technician at a keyboard and could be time consuming. Many robots still require some programming but advances in control and computing power allow many robot operations to be taught rather than programmed. Teaching a robot involves an operator placing the robot in teach mode and moving the end of the arm in the required operation. This may be done by moving the arm manually on smaller robots or from the control panel on larger sizes. As the arm is moved, a learn button is pressed at each intermediate point to lock that step in memory. Once completed, and tested, the learned motion is added to a menu for future use.

Safety

Robots, like any other machine, are inherently unsafe. They require attention to detail in selection, installation and operation to make them safe and to prevent personnel injury. Traditionally this has meant safety interlocked cages that prevent people from getting within the robots range of motion. A robot with a 5 foot reach might normally only move within a very confined space, such as conveyor to case and back. Because it has a 5 foot reach, it could conceivably malfunction and reach any point in that envelope. Unless the robot can be physically confined to a smaller area, even in the event of malfunction, the cage needs to cover 5 feet in all directions which can use a lot of floor space.

Some newer robots are designed to be inherently safe. Sensors in the robot, combined with series elastic actuators allow humans to work alongside the robot without danger. If the robot does make contact with the person, it is no more than a gentle nudge. These robots are the exception, though they may become more common in the future. Always follow all safety recommendations of the robot manufacturer, local safety laws and the judgment of inplant safety engineers.

Robots will continue to become less expensive, more capable and easier to use in the future. This will open up new applications that may not even be imaginable today as well as many other existing applications that are not currently economically feasible. We hope that this primer will serve to get the reader thinking about how to appropriately apply robots in their plants.