The applications for robots in packaging operations has grown tremendously in the last 10 years. Robots first entered manufacturing plants because they are tireless works of art to the average human, handling 3-shifts a day. A robot’s ability to flawlessly repeat the same motion reduced human error and injury due to long term repetitive motion, eliminated issues of unstable labor force, and increased product output with consistent speed.

The use of robotics in your packaging line should be a strong part of your manufacturing strategy. The technological growth and reasonable ROI (return-on-investment) make robotic installation attractive to even small start-up operations. Usage and maintenance of the robots has become increasingly easy. If you do not utilize robotics in your current operation, read on to understand how robots can work for you.

The thought of start up costs for a small manufacturer can be daunting, but doing your homework can ease overwhelming feelings. Most manufacturers experience ROI in 12 to 18 months after adding robotic automation (Figure 1.) Considering the initial expenditure, this is a very short turn-around. A relatively straightforward calculation and discussion with an experienced robot supplier can determine if delta robots make sense for your operation.

### Figure 1. Example Payback Calculation

<table>
<thead>
<tr>
<th>Inputs:</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of staff:</td>
<td>2</td>
<td>Number of shifts:</td>
<td>2</td>
<td>Hours per shift:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assumptions:</th>
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</thead>
<tbody>
<tr>
<td>1. One robot replaces 2 people per shift</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Robot operating costs are approximately 50% of 1 person</td>
<td></td>
<td></td>
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<tr>
<td>3. Average cost of a robot system (1 arm) = $120K</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Results:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Payback:</td>
<td>14 months</td>
<td></td>
</tr>
<tr>
<td>5 yr. cumulative savings:</td>
<td>$426,000</td>
<td></td>
</tr>
</tbody>
</table>
Primary and Secondary Packaging Functions

Most manufacturing plants require what is known as primary and secondary packaging processes within their line. Primary packaging within a line usually takes place after a product is processed. For example, a protein bar is extruded and now needs to be wrapped. Another example would be to collate six small plastic bottles into a tray with a pamphlet, then wrap the entire tray and contents. Primary packaging needs to happen prior to the product leaving the plant for distribution and resale.

Secondary packaging is the next step within the packaging process. It’s taking the wrapped bar from example one and placing it in a carton. The same for example two, the wrapped tray of bottles is placed in a case. To determine if a product requires secondary packaging depends on the product’s need for more security (tamper-free or moisture resistance), less damage during distribution, or for marketing purposes. A small start up specialty bakery may only need primary packaging, for instance, in wrapping cupcakes. From that point, the baker hand packs the wrapped cupcakes in a tray for distribution. As future demand grows, the baker will no doubt outgrow his trays as a distribution method and require secondary packaging to protect his cupcake when using more efficient methods of distribution.

Robotic Feeding or Robotic Loading

Robotic automation has become easier to use from technological advancements over the years and much more cost effective for businesses. The technological advancements have also increased the flexibility in what robotic automation can offer. A manufacturer is not forced to build a packaging line around the robot, the robot is integrated into the packaging line, most often the manufacturer can utilize their existing equipment with small modifications. To take robotic flexibility one step further, let’s explore another function – feed placing or top loading of your product. Understanding the difference between primary and secondary packaging will help determine the need for these two functions.

Feed placing is most often a primary packaging function. The phrase “feed placing” refers to the process of placing or feeding a product directly into a horizontal flow wrapper, cartoner or thermoform infeed conveyor. When packaging food items, feed placing occurs on raw or unwrapped products, such as a chocolate bar, frozen or refrigerated foods, bakery items, or any product requiring primary packaging. Feed placing with vacuum allows for delicate handling of product preventing damage to the product. When vision is incorporated with feed placing, product can be presented in random orientation and still be picked and placed in the correct orientation into a wrapper infeed flight. The ability of the delta robot to track both the incoming product flow and target conveyor, allows the robot to seamlessly pick and place product without disrupting the flow of the packaging line.

Top loading is usually a secondary packaging function. The phrase “top loading” refers to the process which involves picking incoming product, loading it from the top into a carton, tray or case. Applications for top loading include: placing a single or multiple products into a carton or collating and placing small items such as boxes, pouches, or containers into cartons, trays or cases. Feeding placing and top loading can be handled in one of three pick & place patterns:

- **Collation**

- **Cross Belt**

- **Inline or Parallel**
**Collation** is probably the most common of the three types. This means incoming product is presented in a single stream to the collator chain where it is collated in groups, picked with a defined product count and placed in a lug chain of a horizontal wrapper or in a carton or tray. Often multiple products are picked together using “squeeze and spread” end-effector technology. This dramatically increases the throughput of the robot by picking multiple products with each pick. A key benefit to using collation is that vision is not required because product is already oriented in the collator chain.

The second type, **Cross Belt**, indicates incoming product flow is perpendicular to the out-going flow. Cross Belt is ideal for products coming in at a random placement and orientation. This is typically used in feed placing for the primary packaging of raw product. For instance, picking product from a belt directly after an oven or bar extruder and placing it into the lug chain of a wrapper, is a common cross belt application. Vision is often required in these applications since the products are usually not oriented prior to entering the robotic cell.

The third type, **Inline or Parallel**, allows incoming product to flow parallel to the out-going flow. Inline is commonly used when the product is arriving in single or multiple streams, or on a narrow belt. Counterflow is often the most efficient means of product and carton presentation to the robot cell, meaning the two flows oppose each other as they enter the robot cell. This ensures that the robot arm responsible for making sure a carton is full before leaving the robot cell has a full stream of product to quickly pick from.
Combining Robot Mechanics and Intelligence With Feed Placing and Top Loading for More Flexibility

To further increase flexibility, a robot cell can be configured with multiple arms for both feed placing and top loading functions, utilizing a single controller. In addition, both functions can be programmed with vision systems and advance tracking, capable of picking and loading moving targets.

The product application, desired speed, and equipment located upstream and downstream of the robot are all factors when determining to use feed placing or top loading. The function of feeding or loading is not affected by the number of robot arms in motion or by the type of end-effector used. For example, a soft snack cake will require a more delicate picking and placing process at a slower speed than, say a more durable item, such as wrapped deck of cards, which can be run at a much higher speed. The picking device at the end of the robot arm, known as the end-effector, is available in numerous configurations to pick-and-place nearly any item. Most common are the vacuum suction cup style and mechanical grippers. End-effectors are available as a single pick or multiple pick option. The multi-pick option can pick from two to twelve items at once. Also available is reflex pick technology, which allows you to pick an individual product, retract, and then pick another product with the same end effector using a different vacuum system. Each product picked can then be individually oriented to the other products, using a 4th axis of motion to rotate the product, to create the ideal pack pattern.

Most robot manufacturers incorporate flexibility into their machines, such as the ability to use different types of end-effectors. This is critical when packaging requires going from a single pick to a multi-pick or packaging another product type.

Another type of flexibility is the option to add or change recipes within the software programs, which control the arm of the robot, whether there is one or multiple arms in the robot cell. The ease in which the software allows a user to create recipes for new products, or optimize/troubleshoot existing processes, is an important criteria in selecting a robot that provides flexibility over the length of your investment. State-of-the-art software now enables users to visualize the picking process in 3 dimensions on the HMI (human machine interface) to provide a precise view of robot movements in real time. This makes diagnosing errors of missed products or sensor malfunctions straight forward, and optimizing pick-and-place patterns intuitive. Similarly, software that allows new recipes to be simulated in 3D in a virtual production environment without running product, ensures new recipes achieve the required performance prior to test runs.

Examples of End Effectors

Mono Pick  Multi-Suction Cup  Squeeze Spread Rotate  Reflex Pick  Gripper
Another type of flexibility is the option to add a vision system. Vision systems utilize various algorithms to identify product position and orientation. This enables products to enter at random and the delta robot to track, pick and properly orient the product prior to placement. This is an amazing capability considering a robot with three arms can place up to 400 ppm, depending on the product. Vision can also be used for product inspection. For example, product dimensions can be inspected and if the product is out of specification, the robot allows it to pass without picking it.

**Calculate Robotic Automation In To Your Operation**

The flexibility and speed of delta robotics make it the ideal solution for many feed placing and top loading applications. Today, many customers are starting to understand that adding robotics to their production line is more financially reasonable than expected. As previously stated in the article, most manufacturers experience ROI in 12 to 18 months after adding robotic automation. This is a very short turn-around when considering the long-term benefits of delta robotic automation:

1. Lower labor costs
2. Increase capacity
3. Reduce employee injury
4. Increase sanitation levels due to reduced human contact
5. Reduce product damage due to gentler product handling

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Example of 2-Arm Delta Robot Cell

The Paloma-D2 pick-and-place Delta Robot aligns and places products into cartons, cases or trays. Its stainless steel construction meets hygiene standards and regulations for food handling. Fast production changeovers of less than 5 minutes are made possible with its Gemini 3 software and tool-free changeable form sets.
Appendix A: History of the Delta Robot:

An Unrecognized Issue Spurs Challenging Technology Innovation

The challenge many manufacturers face, especially start-ups, is a lack of understanding long-term costs when problems are not resolved and the root of problem areas not identified. At the start of any type of business, most companies have limited funds, and therefore they invest the bare minimum in capital equipment until they experience continual growth. Many manufacturers tend to function for years with the original equipment and manufacturing process, even though they see their profit margin shrinking from a host of areas – anywhere from rising production costs, inconsistent output, healthcare costs, employee turnover, and increased overtime hours. They are at a loss as how to get their arms around all the issues. Most managers are very hands-on in their operation and usually are so busy with day-to-day tasks that they don’t see the real problem until it is presented to them.

This was the scenario that led to the development of the Delta Robot technology featuring parallel axis functionality. Reymond Clavel, a professor at the Institute for Robotic Systems (IRS) in Lausanne, Switzerland was a visitor at a newly opened chocolate factory in 1984. Professor Clavel was stuck by the many employees who all day long methodically boxed small chocolates that rolled off the assembly line. He reported back to his colleagues and they agreed there must be a way to make a robot take over this monotonous, repetitive, exhausting work. A robot could potentially fill a box with chocolates in a matter of seconds. An exciting challenge for a robotic expert! In less than a year, Professor Clavel and his colleagues produced a prototype and applied for a patent. The original form had merit, but there were still weaknesses and Professor Clavel felt the way it worked was too complicated. After a week of analysis and simplifying the design, Reymond Clavel produced a model with nearly optimal specifications, as we know today, the Delta robot.

Understanding The Difference Between Conventional And Parallel Robots Along With Function And Movement

To fully understand the unique advantages of the Delta Robot technology, it is necessary to understand the workings of a conventional robot too. A conventional robot resembles and functions much like a human – pivoting at each joint to pick-and-place items. Although the concept works well for some industries, it has limitations in others. Conventional robots are well suited where it is necessary to handle items weighing over 5 lbs. each or those that do not require precision placement.

The Delta Robot technology was designed to handle light weight items with a high degree of accuracy. At the time of development, almost all robots were conventional in design and based on the principle of serial geometry where a single chain or arm, formed by sections and joints, were to work as a human arm. The name “Delta” is derived from the concept basis of the human deltoid muscle. Using this concept, each robot arm mimics the function of this shoulder muscle, providing a greater range of movement than conventional robot joints.

Prior to the Delta Robot technology, conventional robots were equipped with operating arms, some exceeding 40 pounds and required the motor for movement to be mounted to the arm itself, usually at each arm joint. Conventional robots usually have four to eight axes to achieve the desired movement. The ability to carry this massive amount of weight greatly reduces production speed. Plus conventional robots were limited to one degree of motion – a single pivot back-and-forth.

When you consider the European chocolate industry, a typical chocolate candy weighs one-third of an ounce. Highly inspired to relieve the laborious process of humans filling hundreds of boxes with small chocolates, Reymond Clavel used this knowledge and changed the motor location to be mounted on a stationary base, therefore allowing the structure of the arm to be much finer in design and very light in weight to pick up delicate chocolates.

The new configuration developed by Professor Clavel created what is known as a parallel robot. This is when several chains or arms are linked in parallel to the stationary base to perform more mobile movement – more than a simple pivot back-and-forth as with conventional robots. The joints of each arm are dependent on one another, which allow each joint to change the position of the entire arm by utilizing the Delta technology of three degrees of freedom or motion, as controlled by the software. An optional fourth degree of freedom is used to rotate or squeeze items closer together in the pick-and-place process. This unique finding revolutionized the way robots were used.