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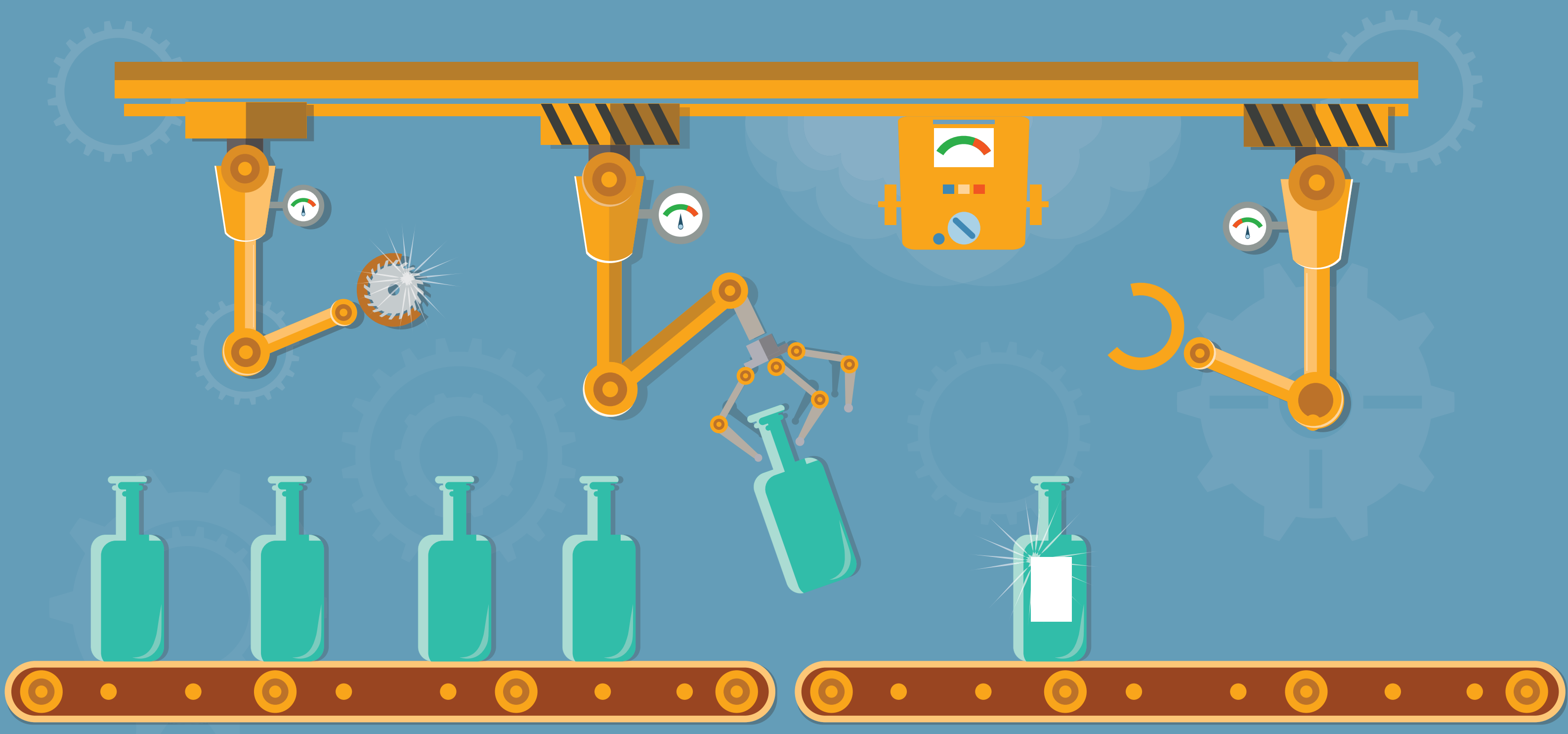
Industrial Robot Opportunities in Food and Beverage Processing

A review of industrial robot technology, developments, and applications in the food and beverage processing sector



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Synopsis: *While robot deployment in the food industry has been slower than in some other sectors on-going technology developments are leading to greater opportunities for manufacturers to benefit from increasing the levels of robot automation in their processes*

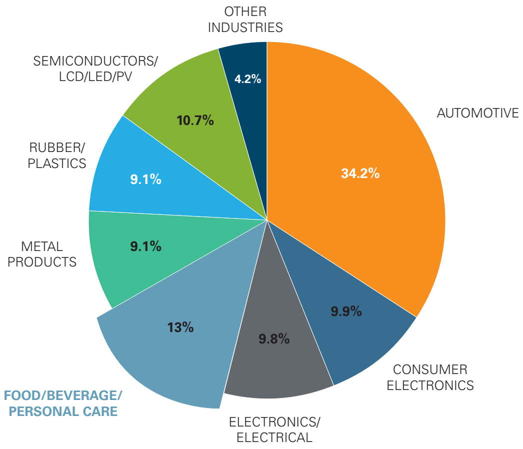
The market for industrial robots continues to grow rapidly, as new use cases and opportunities supplement existing applications. Historically, the majority of industrial robot deployments have been articulated robots primarily used in the automotive industry. In fact, according to IHS Markit as recently as 2012 almost half of all industrial robots sold globally went into the automotive sector.

However, growth areas for robots has expanded to general industries such as the food and beverage and the consumer electronics industries. This has accelerated as costs have lowered, performance and dexterity have improved, manufacturing wage costs have continued to increase, as well as some re-shoring of manufacturing.

Within the food and beverage industry, one which is controlled by strict health & safety regulations, robots have previously been limited to tertiary and some secondary packaging tasks, such as palletizing, as they have not met necessary standards to be used in direct contact with food. However, manufacturers are increasingly developing robots with a high protection class suitable for handling unpacked goods and subsequent wash-down, creating new opportunities for the direct and indirect handling of foods.

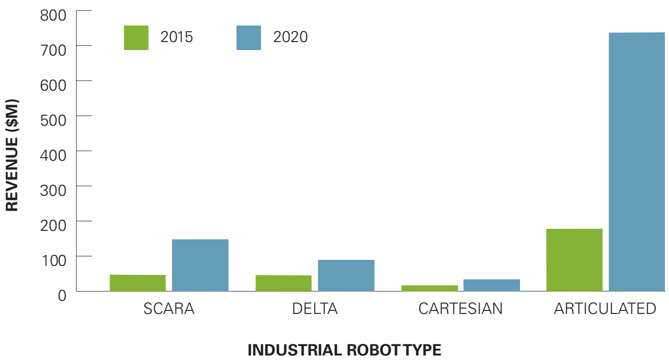
The food industry, with its greater immunity to economic uncertainty is also a target market for many robotics companies, as an area less influenced by cyclical swings in demand, therefore offering greater stability. As such companies have released new robots suitable for the sector.

Industrial Robot Sales by Industry - Americas (2017)



Source: IHS Markit

Industrial Robot Sales by Robot Type - Americas (2015, 2020)



Source: IHS Markit

The Industrial Robot Market

The industrial robot market in the Americas was estimated to be $3.5 billion in 2017, with the US accounting for over 70% of all sales in this region.

The market for industrial robots sold into the food, beverage and personal care industry in America is expected to reach $456.1 million in 2017, which accounts for 13% of all industrial robots sold in the Americas, with a cumulative average annual growth rate (2015 – 2020) of almost 30%.

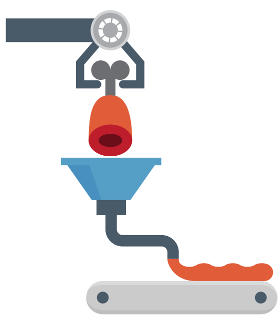
Articulated robots still account for the majority of industrial robots used in the food, beverage and personal care sector, with the primary use in secondary and tertiary packaging applications. However, the last ten years has seen an increased focus on the opportunities for using robots in primary packaging and food processing applications. This has seen growing demand for other robot types better placed for different applications, such as pick and place, such as Delta robots.

The labor-intensive nature of the food and beverage industry creates some ideal opportunities for industrial robot adoption, particularly as robots are increasingly designed to meet the stringent health and safety requirements previously mentioned.

This white paper looks at some of developments in robot technology, including collaborative robots, and artificial intelligence, as well as examples of how the technology has already started to be used in processing applications.

Robots and Their Use in Food Processing

The food manufacturing sector has been slow in incorporating industrial robotics, partially because of the large base of small to medium size enterprises (SMEs). The reluctance of SMEs to invest was influenced by a range of factors including, the low labor-cost, market demand variations and an understanding that robots are not suited for handling varying and delicate nature food products. However, the increase in market demand (and as such need for greater throughput), lack of low-cost labor, and advancements in robotic technology over the past decade, has led the food manufacturers to re-consider their orthodox labor-intensive manufacturing operations, and where robotics may play a part. Some applications already implementing industrial robots include:



Meat Processing: Meat processing (particularly beef butchering) is a complex task, due to the variability in shape and size of every animal carcass. A butcher must make adjustments in how to cut, according to the differences in position of bones in the carcass. The technological advancements have allowed the robots to adapt to the varying nature of the product with the aid of sensors. Sensors calculate the dimensions of each carcass before sending it through to the cutting process, which helps the robot to cut meat with precision even at high speed. Apart from being complex, meat processing is a dangerous job, with the high-speed cutters at different stages of the process for chopping meat into smaller pieces.

In fact, according to the U.S. Bureau of Labor Statistics, meat packing is one of the most dangerous job in the US, and the use of robots to reduce worker risk here are clear.

Fruit and vegetable handling: With the variation in size, shape, color and fragility, handling and processing of fruits and vegetables can be challenging, and the use of robots has been limited due to concerns of potential deformation or damage of the product. As discussed later in this whitepaper, improvements in gripper technology have helped overcome some of these concerns, with robots with increased sensing and sensitivity to pressure being utilized in handling of delicate produce. As well as gripper technology improvements, the increased use of machine vision solutions is enabling robots to handle and sort different fruits and vegetables, by differentiating them according to their size, color, shape and type. For example, robots are being used in quality control by picking out rotten or sub-optimal products before packaging.

Pick and place for processed food: One of the biggest opportunities for industrial robots has been for simple pick and place applications, for food products with limited variation, which results in less complexity. Here the most challenging task is to pick and place randomly oriented finished products from the assembly lines and correctly place them to be packed and palletized.

Benefits and Consideration of Robotics

The introduction of industrial robots comes with significant potential benefits, but there are also challenges that must be considered. Some of the key elements that should be considered are provided below:

BENEFITS

Throughput: Industrial robots offer an advantage over humans in that they don't get distracted, lose attention, get tired, go on holidays or get sick. Along with other technologies, such as vision systems, they can process information at a greater rate and can be set-up to operate at far higher throughput levels than that of a human worker. As well as offering improved speed, robots offer a greater level of accuracy and repeatability, especially at high speeds. This not only improves the rate of production, but also reduces downtime and wastage through human errors, such as incorrect positioning of a product.

Quality control and damage: With developments in complimentary technologies, such as gripper technologies, the ability of robots to operate with more fragile produce and reduce damage has improved significantly. As this technology continues to improve this will broaden the potential applications where a robot may be used. Where robots were only used for more robust tasks, increasingly they will be a preferred option to human handling of fragile produce as they can be both gentler and more consistent, reducing potential wastage through damage of products.

In addition, the integration of vision systems, along with rapid developments in artificial intelligence and deep learning is creating opportunities to better automate quality control of products. Cameras can be used to monitor attributes, such as size, shape, color, etc. and use this information to identify deviation from acceptable parameters. For example, a cake that has been burnt can be identified and removed from the production line.

As well as working in dirty environments, robots are another technology that can protect workers from more dangerous conditions. While automation and safety equipment has already helped significantly in reducing workplace injuries, robot use to work with potentially dangerous cutting and pressing type machines, as well as in environments where harsh chemicals are present, can also be used to further reduce risks to workers.

Working environment: A common argument in support of the use of industrial robots is that it can relieve human workers from jobs that are dull, dangerous or dirty. There are many jobs that are tedious and repetitive, tasks that robots are well suited to. Especially, with current low levels of unemployment, this frees up workers to work on more creative and higher value tasks, as well as protecting from repetitive tasks causing injury (i.e. repetitive strain injuries).

Within the processing industry there are benefits to workers being protected from jobs that must be conducted in unpleasant conditions whether its working in more extreme temperatures, being exposed to high levels of noise, or just having to interact with foul odors or unpleasant substances.

CONSIDERATIONS

Capital Investment: Although industrial robots can improve the efficiency of production lines, they require significant upfront investment. The high capital cost is not only from the upfront payment for hardware and software but also includes installation, integration, training and education costs, as well as the cost of necessary safety equipment (i.e. light curtains). Running costs such as maintenance, repair and programming, should also be considered, which may include the need for additional in-house or third-party expertise. Therefore, when considering an industrial robot, it is important to calculate the total cost of ownership (TCO)

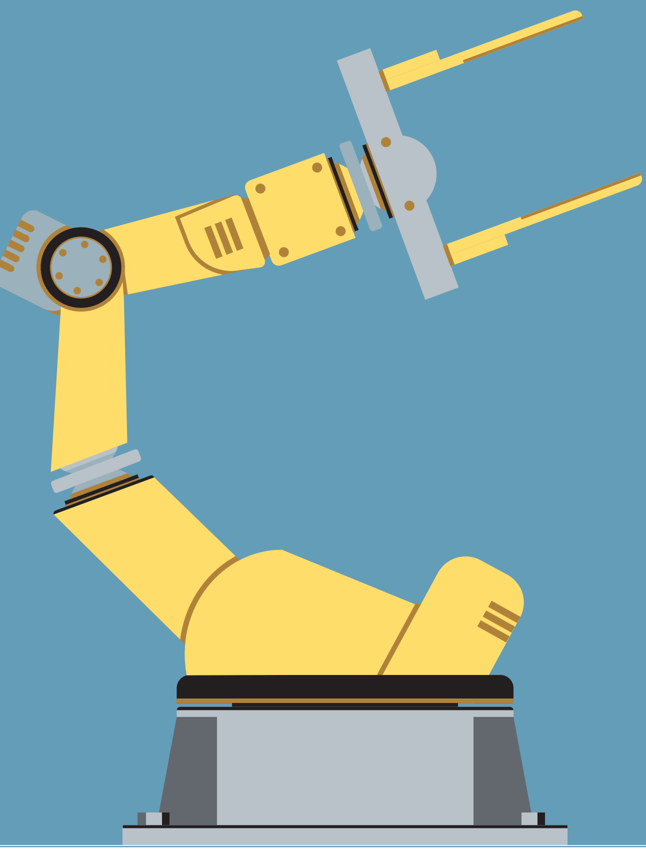
Expertise: Training is required to support the programming and operation of robot equipment. Significant advancements have been made by robot vendors in improving the user interface and the ease of programming robots, but in many cases a different set of programming skills are necessary. This necessitates acquiring new expertise. Integrating robots into a production line can also be a challenge, especially on high speed lines.

Application assessment: The range of applications that can be addressed by industrial robots is expanding beyond more common secondary and tertiary packaging applications, to uses within the processing and direct handling of food. However, there are still limitations to the tasks that can be addressed including when fine and dexterous movements are required, or where access to tight spaces is needed. In addition, robots also (currently) lack the creativity and decision-making ability that human workers can provide.

Systems integration availability: A less common challenge that may impact the timing of a project is the availability of systems integrators. Although not typically a challenge, should for example, several large automotive plants (with large volume orders) make significant robot investments this can account for much of the available systems integrator resources, meaning scarcity of integrators to support the typically lower volume projects in the food processing sector.

Robots Selection Criteria

Robot selection varies depending on application. For example, a SCARA robot may be used for compact pick and place movements, while Delta robots may be selected in applications requiring maneuverability of lightweight objects at high speeds. The parameters that should be consider prior to selecting an industrial robot type include:



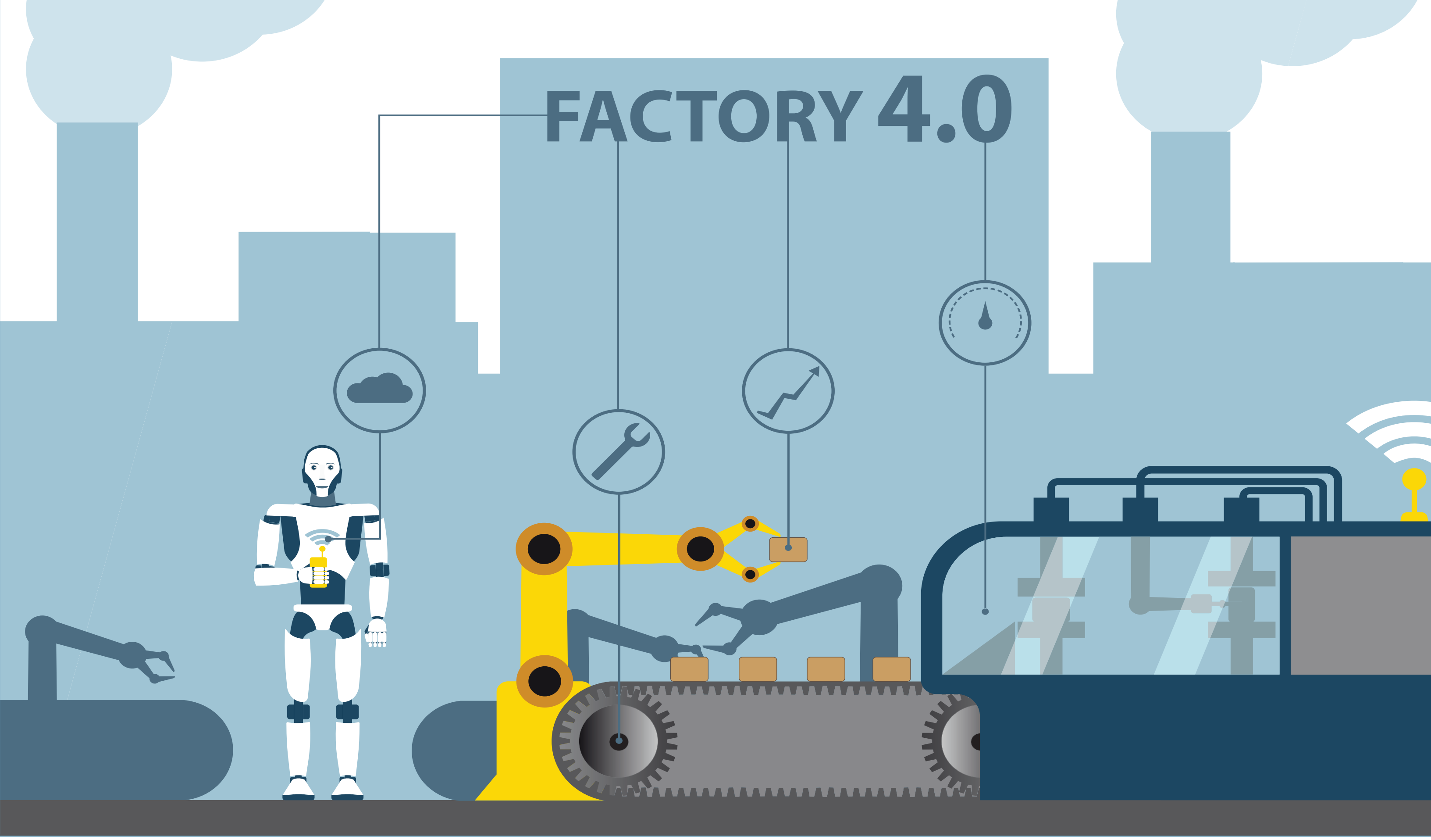
Payload: The total capacity of the Industrial robot should be greater than the combined weight of payload and end-effector at the end of the robotic arm. Although the payload capacity is provided by the manufacturer, the additional weight of extra parts that might be attached to the robot arm should also be considered.

Working Envelope: The distance and working space the robot is required to operate within is not only dependent upon distance between the robot and the products being affected, but also the number of axis and degrees of freedom the robot must operate in.

Footprint: The space available on the production line for the integration of a robot. This is particularly important when introducing robots on large existing lines.

Speed: Speed and acceleration rate of industrial robots are critical when considering the desired throughput. Over specification can result in increased costs, however, customers should also consider future-proofing performance in the case that demands on throughput of the line increase.

Accuracy and repeatability: This is the ability to move to an exact point (sometimes on a micron level) and then the ability to repeatedly actuate to a programmed point in a work area with accuracy. Based on the requirements of an application, different robot types may be more suitable. The following table highlights some of the benefits and limitations when selecting different types of industrial robots.



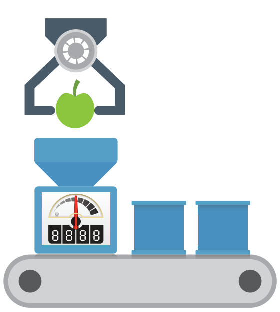
Benefits and Limitations by Industrial Robot Type

	BENEFITS	LIMITATIONS
ARTICULATED ROBOTS	High loads/very flexible	Large footprint/ lower speed / high cost
CARTESIAN ROBOTS	Large work envelope / simple programming / maneuverability of heavy loads	Large footprint / lower speed
DELTA ROBOTS	Very high speed / light weight / good repeatability	Cannot operate flexibly in 3D / low loads / small working envelope
SCARA ROBOTS	High speed / high repeatability / flexibility in 2D plane / small footprint / can be used in dirty environments	Limited payloads / limited dexterity (normally up to 4 axes) in 3D

Technology Trends in Robotics

Robot technologies continue to improve, getting safer, faster, more reliable and able to handle a greater variety and load of products. These developments relate not just to the robot itself but also ancillary technologies such as the end of arm tool, vision systems, artificial intelligence etc. As these continue to develop, the range of addressable applications is also expected to grow. The following discusses some of the key technologies supporting wider robot deployment.

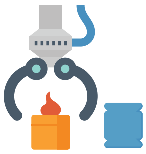
End of Arm Tooling (EOAT) or Gripping Technology



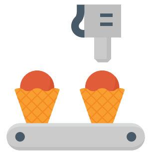
As well as the robot itself, developments with gripper technologies, have expanded the breadth of applications that industrial robots can be suitably used in.

Within the food processing sector, grippers are in direct contact with the handled products, as such they must meet necessary hygiene standards. Grippers are also required to perform handling and grasping operations at high speed whileat the same time being delicate so as not to damage the product being moved. High speed operation can be challenging when it comes to the food and beverage industry, because of the inconsistent properties of the product (such as size, shape and texture). Modern grippers have evolved to support the actuation of a wide range of products, from miniature to enormous and robust to delicate.

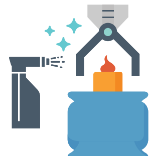
The type of gripper selected should be considered based on the line and the product being handled, considerations in selection include:



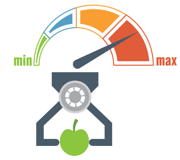
Flexibility
robot working with a variety of products of different sizes and/or shapes



Cycle Times
speed of line needed



Hygiene
grippers must be easy to clean

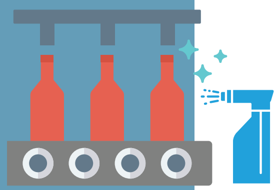


Controlled Pressure
feedback needed to eliminate damage to fragile produce.

Different types of actuation technologies are suitable for different applications. These include vacuum, pneumatic and electromechanical grippers. Some of the differences between these technologies follow:

Advantages and Disadvantages of Different End of Arm Tools

	ADVANTAGE	DISADVANTAGE
VACUUM (ASTRICTIVE)	Can handle fragile products / good for high speed loading & unloading applications / can adapt to handling of non-uniform shapes	Lower accuracy / cannot handle products with loose particles on top (i.e. cakes) / limitations on use on some surfaces i.e. porous materials, objects with limited flat surface (i.e. angled or curved), or dirty / less energy efficient
ELECTROMECHANICAL	Good sensitivity for handling fragile products / high accuracy / flexibility of position gripper i.e. for partial opening and closing	High cost especially when actuated by a servo / greater control complexity / higher weight of gripper
PNEUMATIC	Compact and lightweight / high speed / low cost	Lower accuracy and sensitivity / no range of positions only open or closed / challenging to adjust pressure of gripper
HYDRAULIC	Capable of actuating on very high loads, however, not used in food and beverage applications due to the risk of fluid leakage and possible contamination of product	



Hygiene and Harsh Conditions

One issue that has dampened the use of robots in the food and beverage sector is the challenge in meeting regulations around food hygiene and easy cleaning of robots. The ability to effectively clean equipment is a prerequisite for food handling technology. Protocols set by the US Food and Drug Administration (FDA) require complete sanitization of any surface that comes in direct contact with the food. To meet these criteria, robots used in processing applications are typically being designed with; epoxy paints (which are more abrasion and chemical resistant); food-grade grease for lubricating mechanical components; greater use of plastic rather than steel components, for example with covers and enclosures; as well as improved sealing to support an IP67 (Ingress Protection) rating allowing for wash-down of the robot.

Collaborative Robots (Cobots)

A significant new addition to the industrial robot portfolio in the last 5+ years is the collaborative robot, also known as Cobot. This has been introduced both by existing suppliers as well as many new vendors, such as Universal Robot and ReThink Robotics.

A cobot is one that can work safely alongside humans without a working cell or industrial fencing. It is equipped with additional sensing, which allows it to quickly identify contact with foreign objects within its working envelope and stop movement immediately. This allows it to operate directly with humans without fear of causing injury. In contrast to traditional industrial robots, cobots can operate without additional equipment such as caging, light curtains etc. minimizing the footprint of the robot, as well as reducing the cost of ancillary equipment.

There are many key benefits that make cobots particularly suitable in helping the food and beverage industry increase the levels of automation utilized, and whilethe majority of cobots support payloads below 10kg, this is still suitable for a wide range of applications, such as pick and place.

Easy programing: While traditional robots require someone with programming expertise to help set-up the robot, Cobots can be simply programmed by having an operator move the robot to desired fixed points, which are memorized by the robot and then can be automatically repeated.

Easy set-up: Many cobots are almost set-up out-of-the-box. In addition, as they do not need additional safety equipment or fencing, they can be quickly introduced to the manufacturing line.

Flexibility: They can be easily repositioned to other parts of the production line, without disassembly. This enables the robot to support multiple different tasks, and it can also be quickly adjusted to support the production of various SKU's.

Artificial intelligence: Developments and use of robotics and artificial intelligence are becoming more intertwined, as robot vendors look to supply solutions that can not only replace some repetitive human tasks, but also support and enhance decision making processes. Artificial intelligence (AI) / deep machine learning* capabilities are set to provide an advanced level of analytics to the manufacturing sector. As seen in other industries, the power of big data analytics can be disruptive to traditional vendors and end-users that are slow to adopt. The consensus in industry points to a similar level of disruption in manufacturing.

Robot vendors have been active in ensuring they have the capabilities to support this trend. In December 2015, Fanuc began to showcase the results of its partnership with artificial intelligence startup Preferred Networks Inc. at the Tokyo International Robot Exhibition. Here deep-learning algorithms use trial and error to learn how to pick up randomly positioned objections with 90% accuracy. The algorithms, already used to minimize human involvement when Facebook users tag photos, are inspired by the way living things process information. The short period from Fanuc's initial investment in Preferred Networks to showcasing the results of the collaboration (less than six months) highlights the pace of artificial intelligence development. In January 2018 Preferred Networks Inc announced a joint venture in collaboration with HITACHI and FANUC, for improving an Intelligent Edge System, for maximum utilization of AI in industrial edge devices.

Many other robot companies are making investments in artificial intelligence, whether through small acquisitions, joint ventures or partnerships. ABB, for example, has been active in acquisitions having purchased artificial intelligence start-ups Vicarious, as well as PointGrab and Bonsai.

Potential applications for artificial intelligence are extensive; for example, recognizing robots with a high risk of breakdown and minimizing downtime by pre-scheduling maintenance and ordering spare parts; optimizing robot movements by analyzing vision system and sensor data to reduce the time taken to complete a task; and network-connected robots learning together, to reduce the time taken to learn new tasks. In addition, combining artificial intelligence with machine vision systems is supporting significant developments in quality control, providing the eyes and brain behind the robot to enable it to identify faulty products and remove them from the production process.

As artificial intelligence moves out of the research phase, new and previously unthought-of applications will also be discovered.

*IHS defines machine learning as 'a science involving the development of self-learning algorithms' and defines artificial intelligence as 'a science involving the development of a system or software to mimic human response and behavior in certain circumstances'.

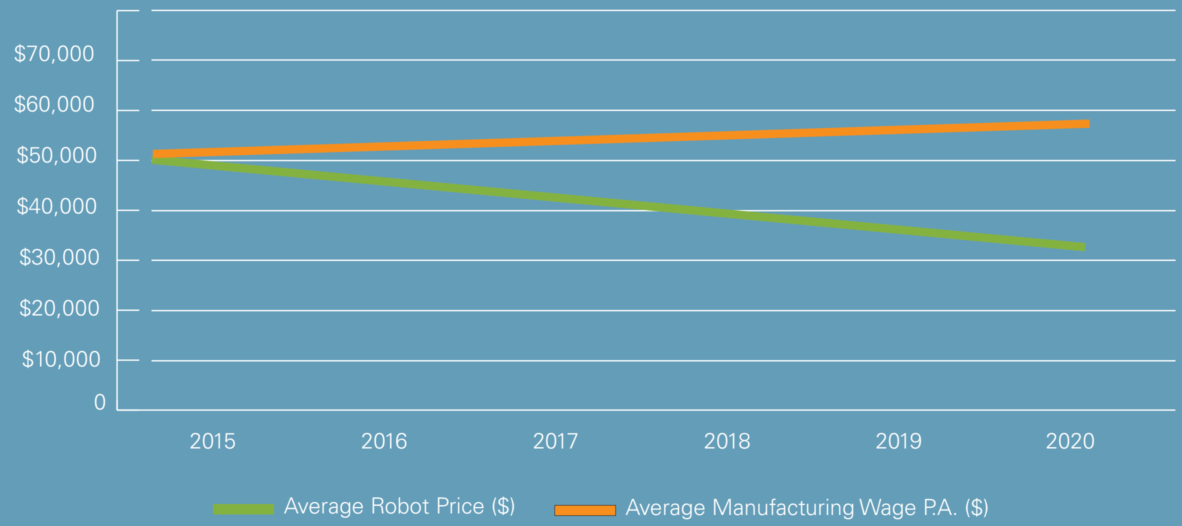
Other Considerations Influencing Robot Adoption

Cost of labour vs. robots

The cost of purchasing an industrial robot vs. the average annual manufacturing wage* is diverging, with manufacturing wages in the US increasing while the average cost of industrial robots continues to drop. It should be noted that the cost of the robot refers to only the upfront cost of the robot itself and doesn't take into consideration other costs that would impact total cost of ownership (TCO) including, integration, software, programming, repairs, electricity consumption etc. Nonetheless the TCO benefit of introducing robots to replace some human jobs is becoming more advantageous. As the price difference increases the number of companies that will need to consider robot investment to remain competitive will also grow.

* assumes a constant average 1783 hours worked per year (OECD)

Comparison of Robot Price and Average Manufacturing Wage



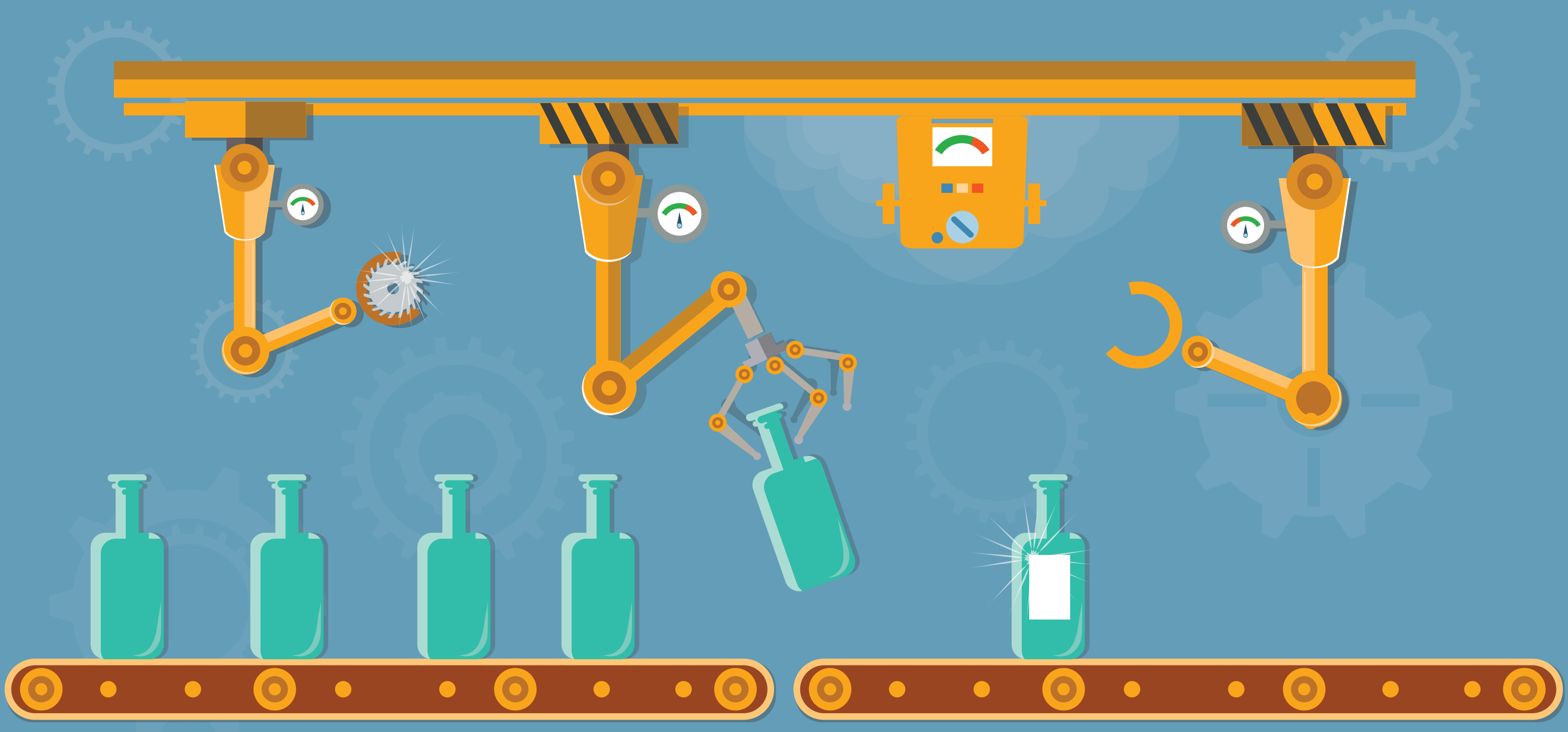
Source: IHS Markit, OECD

Much has been made about the potential threat of robots (as well as other technologies such as artificial intelligence) eliminating jobs from the current workforce. While in isolation this is a very real issue, other factors must be considered.

Firstly, not adopting new technologies can have a negative impact on a company's ability to compete in relation to levels of profitability against local and international competitors. Losing market share will also quickly impact a company's employment levels.

In addition, many manufacturers are facing on-going challenges with filling available manufacturing positions. According to the Bureau of Labor Statistics the unemployment rate in manufacturing for February 2018 fell to 3.6%. The introduction of robotics can contribute to covering this shortfall, while also creating opportunities for employees to focus on higher level tasks.

While there is the challenge that some manual jobs will be replaced by robots, companies can address this by supporting employees through retraining programs to enable workers to "upskill". One leading robot manufacturer recently explained how, in their own workforce, they had replaced workers with robots for metal casting, which was a dangerous job. The company worked on retraining employees for new roles that are being created such as application engineers and designers, roles that didn't exist within the organization 8 years ago. This model of retraining the workforce can also be a cost-effective method of acquiring new skillsets within the organization, with retraining often a lower cost option than recruiting new employees.



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