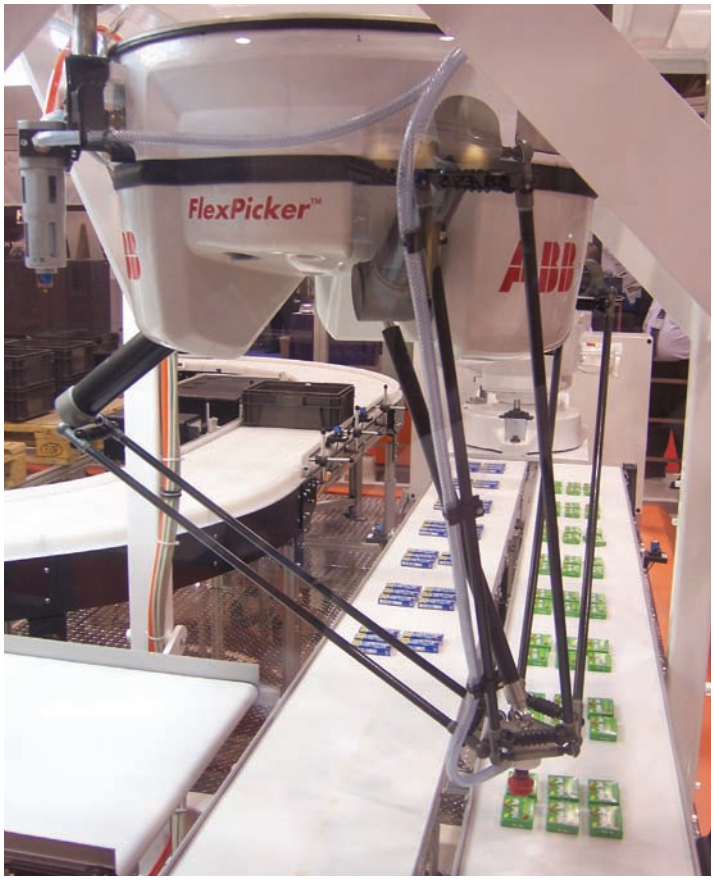
Robotics

White Paper
Ten Ways Robots Enhance Lean Manufacturing Environments

How large and small manufacturers are benefiting from Lean Manufacturing and Robotic Automation



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Ten Ways Robots Enhance Lean Manufacturing Environments – How large and small manufacturers are benefiting from Lean Manufacturing and Robotic Automation

Executive Summary

Traditionally, robots have not played a prominent role in the implementation of lean strategies. However, due to robots' repeatability, speed, accuracy and flexibility, the role of robots in lean implementations is constantly increasing. Automation equipment, which includes robots, is rapidly becoming a core component to lean manufacturing and the reduction of manufacturing costs.

Robotics have made it possible for manufacturers to vastly increase the scale of factory automation over the past three decades. With over 115,000 sold each year*, industrial robots have become a mainstay of all sizes and types of manufacturing facilities. This increase in robotic automation has resulted in higher production rates, improved quality with decreased requirements for human intervention, while elevating the nature of work by removing people from dull, dirty & dangerous tasks. Adding robotic automation however, does not automatically make a manufacturing environment lean.

Lean manufacturing is a management philosophy focusing on reduction of seven manufacturing related wastes as defined originally by Toyota. The wastes are:

1. Overproduction (production ahead of demand)
2. Transportation (movement throughout the process not required to build the item)
3. Waiting (Work-In-Process (WIP) sitting and waiting for the next production step)
4. Inventory (components, WIP and finished product)

5. Motion (people or equipment moving more than required to perform the processing of the part)

6. Over Processing (due to poor tool or product design creating activity)

7. Defects (the effort involved in inspecting and fixing defects)

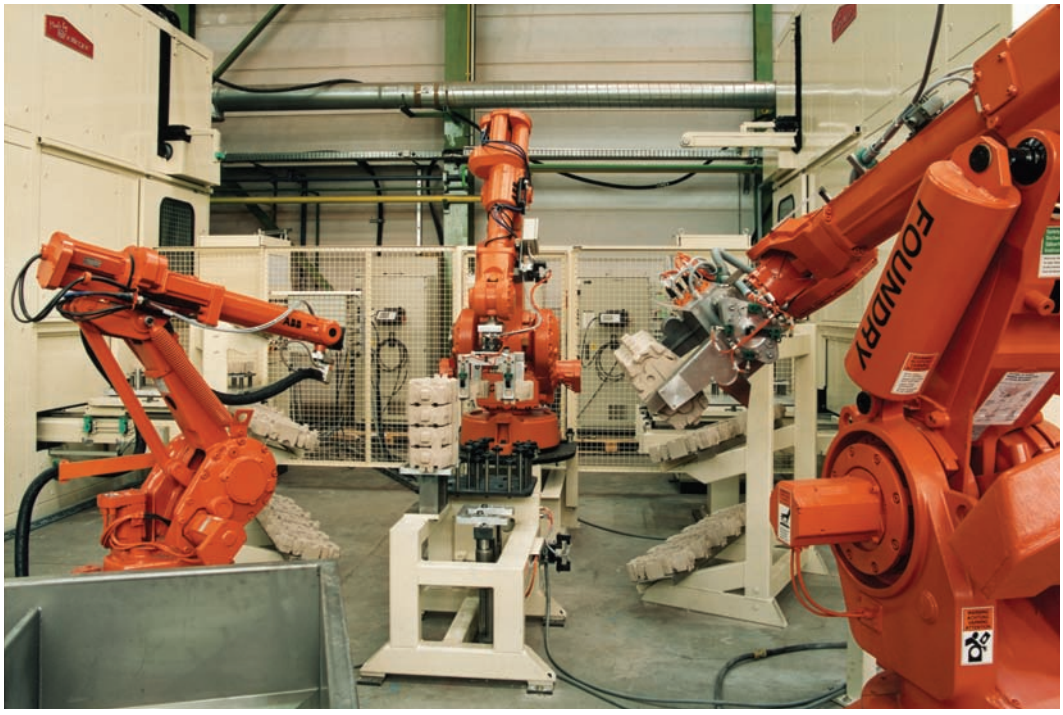
Robots are not innately lean since they could be used to automate a faster creation of waste, but they are often integrated within the manufacturing process to support and enhance a lean manufacturing system success criteria such as:

- Repeatability - Robots' drive product quality or consistency and reduces waste.

- Speed - Robots' can help increase production and reduce wait time.

- Accuracy - Robots' help to reduce scrap.

- Flexibility - Robots' reduce training and changeover time – with a target of Single-Minute Exchange of Die (SMED), and often achieving One-Touch Exchange of Die, (OTED) goals.



Multiple robots coordinate to reduce cycle times and speed production

Lean Systems and Robots

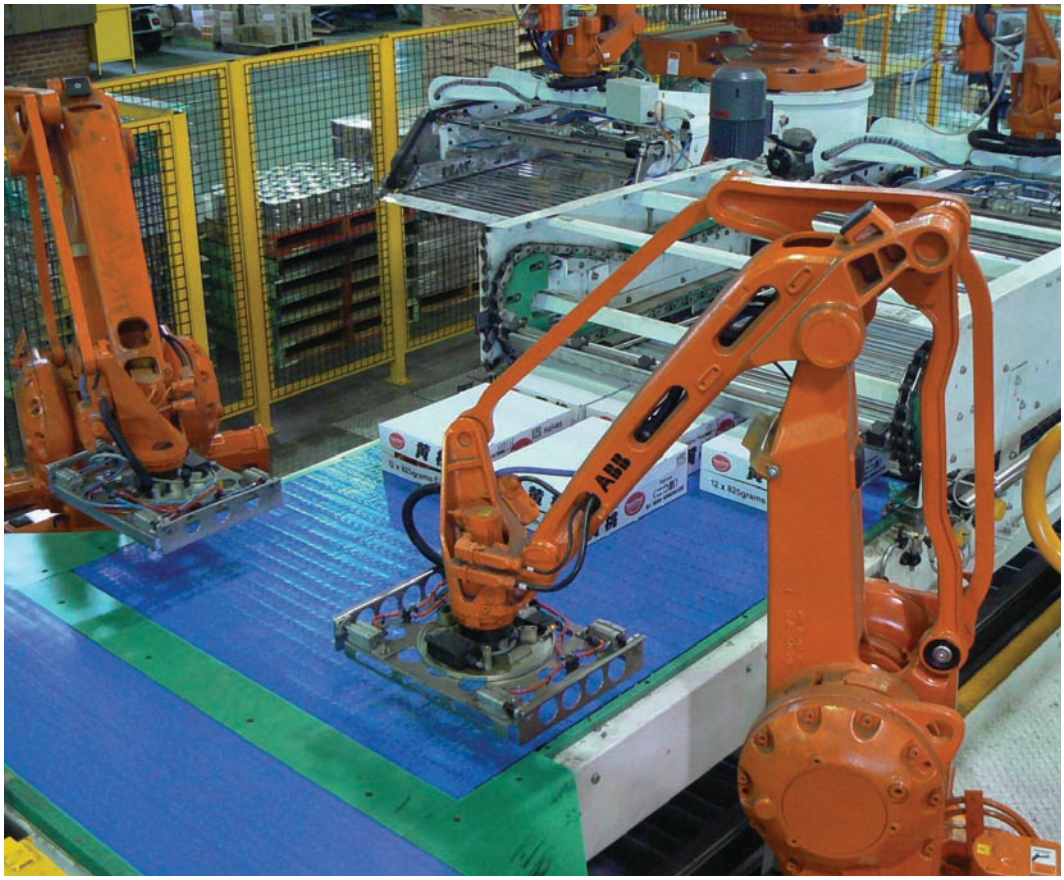
One thing that often gets overlooked is that automation systems (with or without robots) can actually speed up the creation of waste and reduce profitability if not designed into the system properly. No automation system or robotic solution is by nature lean by themselves.

Designing the manufacturing system to be lean is one of the largest challenges faced by engineers today. A few of the factors which must be taken into account while designing a lean manufacturing system with robots are:

- Allowable scrap rate
- Conveyor and other transportation requirements
- Cycle time requirements by station or operation
- Equipment reliability and downtime statistics
- Flexibility required in the process
- Human machine interface requirements
- Life cycle of manufactured product to ensure acceptable ROI
- Line automation requirements (% Automation Vs Manual)
- Line production rate requirement
- Product handling requirements
- Maintenance requirements
- Repair time of equipment
- Space availability for robotic operations
- Safety standards and ergonomics guidelines
- Number of product variants

Traditional production lines are designed to be an effective collaboration between man and machine. While the machines (including robots) can be programmed for optimal performance, people cannot. Effective "lean" robot cells must take this into account. An efficiently designed automated robotic station must take into account the "human variable" and not limit the stations ahead in the line by rigidly ensuring consistent system performance.

Most importantly, the decision to use robots must be justified by an ROI (return on investment) analysis. Small and large manufacturers have proven today's robots can significantly improve the ROI in a manufacturing environment, especially when implementing robots in support of a lean initiative – but again, planning is critical. The robots must be properly incorporated into the overall lean manufacturing environment to get the desired results.



Robots elevate the nature of work by reducing large lifting requirements in this facility

Case Studies – Robots in Lean Systems

Below are several common examples of robots strengthening a lean manufacturing environment to significantly help drive a positive ROI and support lean manufacturing goals.

Material Handling and Machine Tending Applications (Repeatability and Speed)

Prior to robots, material handling and machine tending were purely manual tasks. Operators would transport material from one fixture or machine to the next, wait on the equipment to finish its task, and then relocate the processed part(s) to another tool or process fixture. Several operators were usually required. Today, these labor-intensive tasks are often accomplished using robots, especially in operations requiring high speed and accuracy.

Many applications, such as baked goods coming out of an oven on a conveyor, are picked and set into their packaging. Then, the individually packaged products are automatically placed into cases, ready to be palletized. The palletizing robot can then place cases accurately on the pallet. Each of these robotic applications may be configured specifically for the customer the product is being shipped to. For example, Walmart may have a different packaging and palletizing requirement than Costco or Kroger. Each order can be picked, packaged and palletized automatically to meet the customer's unique requirements.

How do robots make the system lean?

- There is no wait time for operators. A material handling robot can be set up to multi-task, performing additional processing operations between operations.
- Robots have negligible downtime. Robots deliver a limited production loss compared to manual operations which tend to be error prone and inconsistent in terms of production rate, shifts, work breaks, etc.
- Robots are less expensive to operate, compared to human labor – especially when overtime is required. Robots' return on investment can be quickly realized when there is high demand for the manufactured product.

Two robots work in coordination to remove and deburr the part, then spray the die to prepare for the next drop. This application of robots also removes humans from this high temperature environment

- Robots are capable of highly accurate, highly repeatable tasks, which results in lowered scrap parts once the robot tasks are optimized.
- Robots do not get fatigued and are not subject to heat, dust, humidity and other challenging work environments

Multiple Applications - One Robot (Flexibility and Speed)

To incorporate robots into a lean manufacturing environment, engineers should look to process as many operations as possible within the given floor space.

Standard industrial robots have a single tool mounted to a single arm, which is more efficient than human labor, but limiting due to the lack of flexibility. Today's robots can incorporate tool changers to allow the robot to handle more than one task. With one robot now able to perform multiple functions, the manufacturer will see improved utilization, and has the ability to create a leaner manufacturing environment overall.

In the die cast industry, robots are commonly used for material handling parts as well as de-gating and finishing operations like deburring and grinding.

Robots in an automotive body shop are often used for material handling of parts as well as welding or sealant application. Robots that need to perform more than one function are built with tool changing equipment that can be used for robots to disengage/engage new end-effector tooling. Servo motor driven external axes allow robots to be more flexible by acting as auxiliary axes of motion to ensure maximum robot utilization.

Advances in robotics have given engineers the flexibility they need to incorporate robotics into a lean manufacturing initiative. Robotics have furthered engineering's ability to optimize operations based on floor space, cycle time and feasibility constraints. Over time, multi-arm robots will become the norm, continuing the progression of manufacturing operations that are faster and leaner.

Robots and Vision Applications (Flexibility and Accuracy)

Vision technology and robots are a natural pairing and the combination has resulted in making robotic operations leaner than ever before. Vision systems are commonly used to allow robots to vary their motion targets based on vision generated guidance information.

Operations that required making visual distinctions and decisions (such as racking/ un-racking of parts, part picking from bins, and part inspections) were once exclusively handled by human operators. By combining robotics with vision guided systems, these same tasks can be performed by robots with higher consistency, accuracy, repeatability and speed. Vision-equipped robots can also reduce imperfections and scrap material in finishing operations such as routering, grinding, and sealing — contributing solidly to lean manufacturing.

In the inspection arena, robots are utilized heavily in flexible measurement systems (FMS). Robots mounted with vision cameras can collect information from multiple locations, dramatically reducing the number of vision cameras and fixtures required to inspect parts.

Using vision-equipped robotics, lean manufacturing environments can be significantly improved, especially in areas where the movement, flexibility and simple decision-making of the human operator was once required.

Cooperative Applications and Coordinated Motion (Flexibility, Speed and Accuracy)

The latest robotics trend gaining acceptance as a lean process is coordinated motion. In this system, two or more robots are controlled by a single controller. The controller allows for easy communication between robots to simultaneously perform coordinated operations on a single large part. Coordinating robot movements can significantly reduce the time wasted in the manufacturing process.

Roof assembly in the automotive industry is now commonly performed with one robot firmly gripping the automobile roof, while other robots weld and assemble the roof to the main auto body. Robots are also used for part transfer between assembly stations instead of transfer equipment like lift and carry systems or shuttles. The automotive industry is just one example of how coordinated robotics can aid in lean manufacturing, improving cycle times and reducing scrap waste.

A single robot is used to organize small quantities of inventory to efficiently stage individual orders to be shipped

Custom-designed fixture tooling is required at almost all product manufacturing plants. If the assembly process allows for a slightly lower level of structural accuracy, robots can be used in place of hard tooling fixtures. Robots with docking end-effectors or “geo end-effectors” allow for reduced tooling content and greater flexibility while maintaining a significantly high degree of accuracy and strength.

Two robots are used to load, unload and weld parts with little human intervention and with a high degree of accuracy

Robots and Cycle Time (Speed and Accuracy)

Many food packaging applications are solved by an operator (or team of operators) manually picking and packaging the products. This adds costs, can be physically demanding, and may create the potential for product contamination. Often fixed automation is used, but this can severely reduce the flexibility of the application. When product marketing develops a new product or a customer demands a new package size or type, the fixed automation is often too inflexible to cost effectively deal with the change. Robots have become a powerful tool in the automation of pick and place applications such as pancakes, sausages, muffins and many other packaged or pre-packaged foods.

Robots speed the palletizing of motors while reducing waste, and the concern of a worker being hurt

In major manufacturing assembly plants, there are often hundreds of robots performing material handling, machine tending, welding, finishing, painting and other assembly operations. Wasted robot motion can cause cycle time issues, creating bottlenecks and loss of production. Poor path planning can cause product quality issues that can lead to scrap parts. The cost of lost production is a major drain on overall corporate profitability. Ensuring that the cycle time for robotic workcells is optimized is very important to the lean manufacturing plan.

Some of the common cycle time issues impacting lean manufacturing are:

- Lack of part inventory for robots causing delays in production
- Unsafe work conditions causing slow human operation in situations where robots and humans work in a cooperative environment
- Poor equipment design resulting in wasted repair efforts
- Bottlenecked stations causing part blocking or starvation at other stations

- Individual robots over cycle causing entire station to be over-cycle
- Wait times on other equipment causing robots to go over-cycle
- Poor processing resulting in work overload on robots, operators or machines
- Poor human machine interface causing delays in manufacturing
- Poor software and controls engineering resulting in inefficient I/O and communication between equipment

Detailed planning of robotic operations prior to system integration can go a long way towards controlling equipment and labor costs.

Workplace Safety and Robots

Most manufacturing operations have a degree of human injury risk. One of the primary reasons to automate a process using robots is to improve workplace safety. High-risk tasks like unloading parts from a fast-moving press or working with molten metal are definitely not tasks suited for human operators. In these cases, robots are invaluable in lowering the risk of injury or death.

An unsafe workplace leads to fear-driven human inefficiency, lowered production rates, higher insurance and workmen's compensation costs, and high employee turnover. Conversely, a safe workplace boosts morale, increases employee retention and lowers costs, which ultimately improves the bottom line. And again, robots can significantly elevate the nature of work by removing people from dull, dirty & dangerous tasks.

Robots can make the work environment safer by performing functions that are unsafe for humans, but robots themselves can be unsafe. For example, if a robot cell is not guarded properly, operators may take longer to service the station because of fear of injury. Whenever robotics are used, the environment must be carefully analyzed and proper protocols instituted to keep the workcell safe. If the employees don't feel safe, the robotics implementation will not be as lean as designed.

Many applications require the strengths of both people and robots, but until recently, this could be very dangerous. Now specialized software can allow robots and operators to collaborate much more closely without compromising on safety. This combines the flexibility of human interaction with the precision and handling capacity of robots to make applications lean, accurate and very safe to operators.

Conclusion

Robots, if used correctly, can enhance a lean manufacturing environment. Robots offer speed and accuracy that can't be achieved with human labor. Robots can also reduce operating costs, reduce scrap – and are flexible for future changes. Few other manufacturing solutions can reduce waste as well as robots when designed into the system properly.

Robotics' capabilities have only increased with time, while costs have continued to fall. Major robot manufacturers are constantly upgrading their robots with increased payload capacity, greater accuracy, increased reach and range of motion, improved speed and acceleration, faster communication with external equipment, better safety features, and lower operational costs.

If you have not explored incorporating robotics into your manufacturing environment lately, it is probably time to take another look. With a lower cost, more capabilities and a large number of successful manufacturing implementations, robots can increase your return, improve quality, reduce costs and help you eliminate waste.

If you would like to see a few of the applications where robots can excel and improve your manufacturing operations, please visit http://www.youtube.com/user/ABBRobotics.

Ten Good Reasons Robots can Enhance Lean Environments

The following list is based on research conducted by the International Federation of Robotics (IFR).

1. Reduce operating costs - Robots are cheaper to operate compared to humans. Energy savings can be significant due to lowered heating requirements in automated operations. Current estimates point to a potential 8% savings for every 1°C decrease in temperature. Savings of 20% can be achieved by turning off unnecessary lighting in automated areas.

2. Improve product quality and consistency - Robots are inherently accurate and have a high degree of repeatability. The risks of errors caused by human factors such as tiredness, distraction, or the effects of repetitive and tedious tasks do not affect robots. This results in improved end product quality.

3. Improve quality of work environment for employees - Robots can take over tasks that are hazardous for humans thereby improving working conditions. Staff motivation can also be improved by training them to take on more technically challenging applications involving robots.

4. Increase production output rates - Robots can be left running for long shifts, overnight, and during weekends with little supervision. This enables true 24 hour production runs to increase output levels. New products can be introduced faster into the production process. Programming of new products can be done offline with no disruption to existing process.

5. Increase product manufacturing flexibility - Switching from one process to another is very simple with robots. Consequently, systems with robotic automation can accommodate variations in product and process resulting in maximum ROI on capital investment. The development in vision systems for robots has resulted in a huge increase in the flexibility of robot usage.

6. Reduce material waste and increase yield - Robots perform routine functions to fine tolerances reducing rejects and scrap waste. Improved accuracy from using robots means you can have more products finished first time to the quality standard

demanded by your customers.

7. Comply with safety rules and improve workplace health and safety – Robots can take over tasks in conditions that are hazardous to human workers. Robots can also handle tasks that if done manually, could lead to ailments such as repetitive strain injuries (RSI) or vibration white finger. Welding environments are inherently hazardous for human eyes; this safety issue can be avoided by using robots. Tasks that are ergonomically challenging could potentially be handled by a robot thereby improving the plant safety record.

8. Reduce employee turnover and improve recruitment – Running a manufacturing plant with automation requires a technically skilled workforce. The work is challenging and the associated problem-solving requirements make the tasks intellectually stimulating. Consequently, employee turnover is reduced and the facility attracts high quality employee candidates.

9. Reduce capital costs (inventory and work in process) - Robots are a cost effective option to manual manufacturing. The ROI from using robots is quicker than manufacturing with operators. Robots can be programmed to produce products on a just-in-time basis thereby reducing the amount of inventory or work in process product.

10. Save space in high value manufacturing areas - Robots can be mounted on walls, ceilings, rail tracks and shelves as well as firmly mounted to the floor. They can also be programmed to perform their tasks in confined places thereby saving valuable floor space.

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