As originally published in the IPC proceedings.

A Robot's Place in SMT

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Issues in the SMT process

The SMT industry's one constant is change. Standards are continually updated and components are miniaturized for space savings. In addition to the changes that come, the industry is also faced with continuing to deal with areas that fail to change and update. A typical PCB manufacturer lays out a line based on the need to put solder paste on a PCB, place parts in the paste, and then reflow the product (Figure 1). The board size, typical components placed, and the required speed for the line are then considered. Eventually a SMT manufacturing line is purchased that can handle a large majority of the process needs. In almost all cases, there will be a component that cannot be handled by the automated process currently in use on the factory floor. This is not a problem that is caused by the engineer who specified the line, nor is it the chosen vendor's false advertising. This problem plagues virtually all PCB manufacturers because it is not cost effective to purchase a specialty machine to handle a component that is expected to go away and not be used any more, or the component that is thru-hole and was expected to be replaced by a SMT component soon.

Manufacturers are expected to build as demanded and very often that demand is outside of the specifications which they thought were adequate, but the quantity does not justify new special equipment. PCB manufacturers, for example, face the challenge of placing very large connectors, whose size is outside the specifications of SMT machines (Figure 2). Some manufacturers use thru-hole components in products (Figure 3), yet not enough need for this exists to justify a thru-hole machine.

Infrequently used components may fail to justify standard packaging for use, and oddly shaped parts may simply be beyond the scope of what a standard SMT machine can handle. In addition to the difficulty in managing the changes in size and type of component for placement, manufacturers must also consider the cost effectiveness of any solution they devise for managing these "out of spec." placement issues. Rarely do these issues justify the expense of purchasing a specialty machine. Rather, the manufacturer finds it more cost effective and more realistic to manage these processes with human resources. These manufacturing difficulties are not caused by poor engineering design, or by the chosen vendor's inattentiveness to customer needs. At the end of the day, manufacturers have come to accept that they will purchase a SMT line for the manufacturing floor that is capable of handling a large percentage of their process needs, but those out of specification parts will always exist.

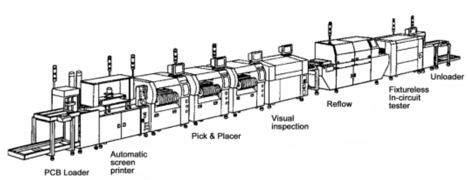

Figure 1 - Typical SMT Manufacturing Line

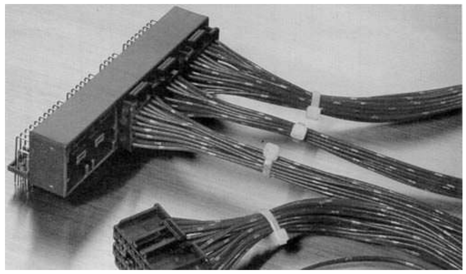

Figure 2 - Large connector

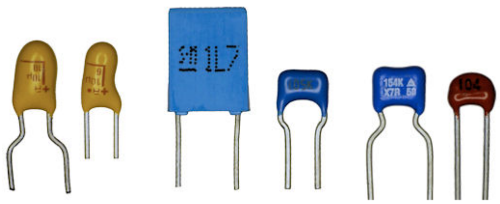

Figure 3 - Plated through-hole components

Current solutions to the issues

Today's most common solution is the implementation of a manual operator station (Figure 4). At this station, a human places that large connector, odd shaped part, or thru-hole component in the line. The expectation is that the human be as accurate, efficient and productive with this manual process as the rest of the automated line. However, we all know this is not possible. Human production is not as predictable as automated production, and humans get sick, take vacations and need rest breaks. Employee overheads are also ongoing and ever increasing costs. Though a robot would normally be a capital investment, the cost is over a 3 to 5 year range and becomes maintenance only. The cost of hiring is an ongoing expense that only increases year after year.

A second common option for managing manufacturing "out of spec." items is through outsourcing, though this comes with its own unique challenges. Specialty companies charge a premium for their services, yet the manufacturing company must give up control of the production quality when they make the decision to outsource a process they are accustomed to owning. In some cases, sending a unit to a specialty shop for partial assembly may be the only option, but the cost and knowing that the quality are not within your control make this a difficult decision. If the customer of the final project has tight deadlines and outsourcing causes a delay, the company who outsourced is then in jeopardy of losing business. Much time and effort must be spent when looking for an outsourcing partner who can complete the "out of spec." work. The quality standards must be checked along with how timely they complete the work. When looking at the cost of outsourcing the price of paying for the work completed is only part of the total.

Figure 4 - Manual operator station

How robots can solve these issues

Today's robots can solve these manufacturing issues, allowing for more productive and efficient lines. In addition, the robots themselves are more cost effective than the ongoing costs of human labor. The cost of a robot is normally a capital investment that is analyzed by management for Return on Investment (ROI). To do this, you must look at the overall cost of the operator, their production speed, and any quality deficiencies. The purchase of a robot is normally a 3 to 5 year payoff, after which the expense is reduced to maintenance and utilities. A robot that matches the cycle time of the manual operation will most certainly surpass a human in efficiency over time. Robots are mechanical machines that are computer or PLC (Programmable Logic Controller) controlled.

Calibration routines allow them to be tuned for accuracy and they are sold based on the repeatability. Properly maintained robots will run processes they are designed to perform for thousands of hours without any change in accuracy or cycle time changes. When a process requires vision, robots use camera systems that are far beyond the capabilities of the human eye and can ensure better accuracy and quality. The majority of SMT machines in the market today are designed to pick and place from tape, tray, and sticks. There are also parts without packaging that must be part of the line's process. Robots can handle these unique placements far more efficiently than an operator working on his own.

These components without packaging can be placed on a pallet. The robot then brings in the pallet and finds the parts that can be placed, using a camera system. The robot then picks and places all possible parts. Afterward, the operator can shuffle or rearrange any parts left and retry. This eliminates the costly attempts to design packaging and feeding mechanisms for these parts. Some parts are presented for placement with leads parallel to the PCB surface rather than perpendicular. This poses a problem for the standard SMT machine's capability. This problem is easily overcome using a robot with a swing nozzle. The swing nozzle can pick a component and then swing the leads up to ninety degrees to make them perpendicular with the PCB for placement. This eliminates the need for an operator at a hand placing station or expensive repackaging of the part. Stick feeding is common for SMT but large or unique components in stick have often required expensive and one off designs.

Since robots have started to be used in the SMT process stick feeders that allow for the stick handling portion to be adjustable and only the actual component track to be customized have been developed. These stick feeders are less expensive and make it more possible for PCB manufactures to handle a larger range of stick components. SMT machines are built for speed and accuracy. With that in mind, the SMT machines typically have height restrictions as well as only moving in X, Y, R, and Z.

A robot on the other hand, can have less height restrictions and more moving axis. With the added height those tall or overly large parts can now be placed. Additional axes allow robots to do more than pick and place. Robots can pick up screws from a feeder and torque the screw into position; they can assemble cases in final assembly areas. Another solution robots in SMT have brought about is finding lead tips of Plated Through-Hole (PTH) parts, which typically give SMT machines difficulty with vision. New camera technology now can find the lead tips of PTH parts significant distances from the component body, allowing insertion without damage to the leads.

Case Study 1

A customer had plated through-hole capacitors that required two persons at manual stations to trim, form, insert and clinch the leads. This process cost the company not only time on the line, but the expense of two operators who can not do any other jobs. The equipment vendor was asked if they could provide a machine that was capable of completing the process. After an investigation period the vendor responded with a quotation for a machine and feeder that could perform the process. The investigation required finding a feeding solution where through-hole components could be fed and trimmed for the robot to pick and place and then forming of the leads could occur (Figure 5). Creating a nozzle to pick the component from the feeder, and finally a method to clinch the leads on the underside of the board was the key to the vendor's solution. A small machine with a camera system to identify through-hole leads accurately and a feedback system indicating proper insertion matched with the feeding system were an ideal solution for this customer (Figures 6 and 7).

Figure 5 - Radial Cut Feeder

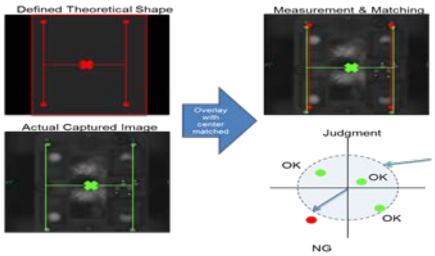

Figure 6 - Vision system for Through Hole Parts

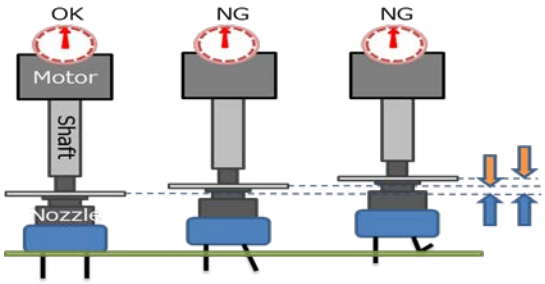

Figure 7 - Ensuring Proper insertion

Case Study 2

A customer had a mass production requirement of placing many connectors on a board of the same size and shape but different colors (Figure 8). The customer was experiencing many problems with this process. Manual operator stations were being used and the quality was not to standard. The operators for this station did not stay long so newly employed persons were making mistakes and having to be trained. If the product was changed many accidents by the operator occurred with incorrect placement. The proposed solution was to replace the manual operator station with a flexible robot that could have many different component inputs, and high quantity supply. A stacking stick feeder that allowed for adjustment to varying sizes of sticks was provided (Figure 9). A robot that could accept multiple stick feeders and was flexible enough to handle many variations and could be quickly programmed with offline software was proposed to the customer. The result of this proposal was the customer saw productivity increase, quality increase, and costs were contained to the cost of the robot and the feeders.

Figure 8 - Problem board and components

Figure 9 - Adjustable Stack tube feeder

Case Study 3

A customer had a process where a very large metal jig needed to be attached to the PCB (Figures 10 and 11). Accurate placement of this jig was critical. Based on the size of this jig the customer always assumed that it needed to be manually processed by a human, and suffered slow production and poor quality results. A proposal for an accurate robot capable of handling this large size jig and communicating with the SMT line was submitted. The resulting solution was a robot being placed in the SMT line that accurately placed the large jig with a human only needing to supply the jigs to the robot in quantity (Figure 12). The customer saw that automation of this process was not only possible but resulted in higher productivity and higher quality for the product. A side benefit was later realized that the robot was also capable of placing SMT components and could help speed up other production needs.

Figure 10 - Blurred Image of Jig on PCB

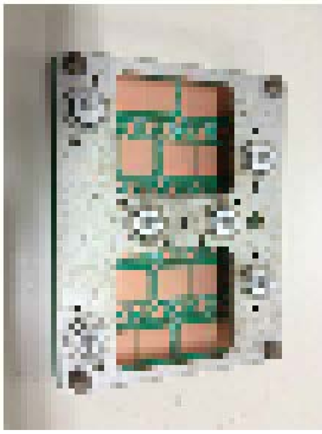

Figure 11 - Blurred Image of completed Assembly

Figure 12 - Operator Preparing Jigs for the Robot

Conclusions

SMT machines are robots, but normally with a very specific set of specifications, allowing the machine to be fast enough for SMT production. These specifications keep SMT robots from being able to do the "out of spec." processes. The robots that have been discussed are robots that have very large component range, specialized software that allow them to be used for hybrid uses and many variable component inputs. Robots have shown the ability to increase production and increase quality of many processes; still human operators will be needed to supply the components to the robot. Robots have a place in SMT production and with increased capabilities being innovated; many companies can begin to see the reduction in overhead costs, the increased production, and the increase in quality. Robots have a "correct" place in SMT.