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Lean Manufacturing and Modern Placement Equipment

Tom Foley and Jeff Rupert

Finding the perfect fit.

Lean manufacturing is more than a buzz phrase. To be truly competitive on a global scale, smart surface-mount equipment suppliers and electronics manufacturers have dedicated their efforts to supporting this concept throughout their facilities. Lean manufacturing is a way of thinking, reacting and conducting business from the top down. From streamlining day-to-day operations, configuring and running production lines, shipping product to after-sale customer service, electronics manufacturing is now striving toward the *lean, mean, production machine* goal. The more perfected the operation, the lower will be the production cost.

A primary part of this concept is the focus on capital equipment flexibility. Having the right equipment in place and in the right line configuration to produce the desired product is today's goal. To compete successfully in the world market, manufacturers must eliminate any restrictions they might have regarding mixed-model production, quick changeover, accurate programming and line balancing.

The Pick-and-Place Fit

Regarding pick and place, the production line configuration of the last decade is being eliminated. Lining up a dedicated chipshooter from Supplier A, followed by a fine-pitch machine from Supplier B, is a costly setup that supports limited product configurations with little flexibility. Today, placement equipment must support a large array of needs and be able to adapt even to the unknown—quickly.

To address the need for flexibility in a lean manufacturing environment, some modern placement equipment designs show a strong trend toward flexible, modular, gantry-style machines that can be deployed as standalone work cells or be combined together for higher throughputs. Machines that have over 150 feeder inputs and are capable of placing the total component spectrum allow almost any product to be built on almost any line. This ability simplifies the job of the production planner and allows all lines to run at higher utilization levels.

Control software is now designed to centralize both individual product/machine programming and optimize the entire production line. Rather than storing programming data in the individual placement machines, centralization of files allows fast downloading of any program to any production line in the factory when required—or even to remote factory locations, as needed. Further, centralizing line optimization streamlines production for true lean manufacturing by reporting and supporting different production scenarios, including shortest possible cycle time or shortest changeover time depending on the batch size being run.

A new option developed specifically to support the lean manufacturing concept in the area of component placement is circuit pre-scanning. Most high-end placement machines are designed to check for skip marks (bad circuits). This practice adds to cycle time since each subpanel on every printed circuit board (PCB) must be

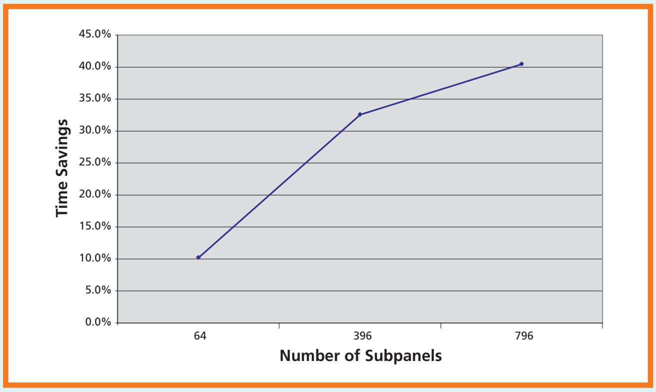

FIGURE 1: Time savings due to off-line skip mark detection.

checked for skips before components are placed. Time spent can run from 0.5 to 1 second per subpanel, and many of today's multilayer PCBs have hundreds of subpanels.

To accelerate the placement cycle and still maintain component/circuit integrity, some placement equipment manufacturers also offer standalone pre-scanning options that integrate with all placement modules. Using a barcode reader and optical flatbed scanner, these systems identify and record skip mark locations on PCB subpanels and pass this information to the placement machine. The placement module simply reads the board barcode, which is matched automatically to its electronic traveler on the fly while placing components.

For example, one company running boards with 396 subpanels saw a 30% decrease in overall cycle time by integrating this step into the placement process. This average is typical, and more savings can be expected as the complexity of the boards increases (Figure 1). Regardless of the production line configuration, this timesaver adds even more value when used in conjunction with some of the more innovative production line setups. The stored information can be passed from machine to machine quickly, so, if a manufacturer is using dual lane setup or parallel placement, one pre-scan for skips can save placement cycle time and help ensure end product quality.

Line Solutions for Specific Challenges

The flexibility provided by the expanded capabilities built into modern modular placement equipment becomes valuable when considering some of the more innovative configuration options that can create truly lean and cost-effective production lines. Two examples that are gaining wide acceptance are flexible dual lane placement setup (Figure 2) and the parallel manufacturing line.

Flexible Dual Lane

Dual lane production is not new; it has just been reinvented. In the past, dual lane manufacturing was typically used only by a few original equipment manufacturers (OEMs) producing smaller boards. Having a production line setup for a board width limit of approximately 8.5 in. is not an option for the vast majority of electronics manufacturing services (EMS) providers. However, today, suppliers of placement machines, ovens and linking conveyors are bringing products to market that offer flexible dual lane transport that helps to eliminate this board width restriction.

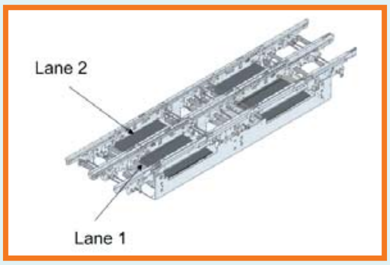

FIGURE 2: Dual lane placement setup.

Flexible dual lane equipment can quickly change from dual lane to single lane mode and back again. The latest flexible dual lane equipment can process up to two 10 in. wide boards in dual lane mode or switch to single lane mode for boards up to 17.5 in. Ideally, all conveyor rails would be motor-driven with encoder positioning to enable the change to take just a few minutes for the entire line.

Dual lane mode fits into lean production by providing:

• quick reaction to customer demand. No waiting is needed for the line to finish with Product A before starting Product B. Both products can be built simultaneously.

• downstream production optimization. End products that require a mother/daughter board combination can be produced concurrently, simplifying the manufacturing process downstream.

• assembly of the top and bottom-side of a board at the same time. In lane one the board topside is processed and fed into a magazine at the end of the line. Full magazines are then immediately brought to the beginning of the line for processing down lane two. Completely finished boards come off the line sooner without producing large amounts of uncompleted product.

When operating in dual lane mode, secondary non-productive times in the placement process are significantly reduced. As the machine populates the board in lane one, a board can be moving into the processing area in lane two, which is referred to as *asynchronous transport*. Approximately two seconds of non-productive, board transport time are eliminated, which allows the placement head to immediately begin placement upon fiducial reading. For a short cycle time product, two seconds per board savings has resulted in lines that produce 5 to 10% more product by the end of the shift.

Serial vs. Parallel Manufacturing

Serial or parallel manufacturing involves restructuring the production line based on specific needs. One North American manufacturer was able to significantly improve its surface-mount line output and utilization by changing its line layout from serial mode to parallel mode manufacturing. This change did not result in the need for new surface-mount assembly equipment; it only required reallocation of existing machines.

Figure 3 shows this manufacturer's past typical line, which was three placement machines operating in serial mode. Process steps before and after placement were left out to simplify the description. The component placement workload was divided across the three machines: A, B and C. The overall objective was to find the shortest possible cycle time, which was the job of the line optimization software. Because the

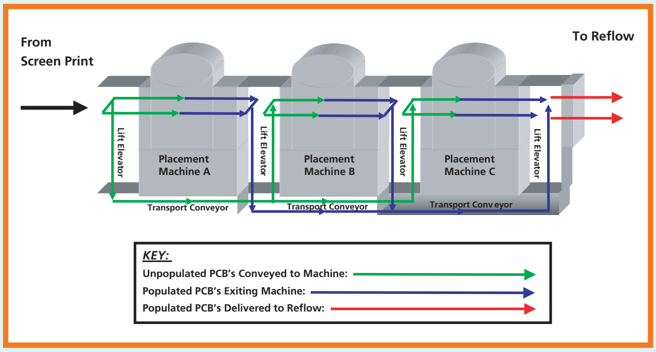

FIGURE 3: Parallel process flow diagram.

manufacturer had a large number of boards that required the reading of both local and secondary global fiducials, non-productive fiducial read time was causing the boards to spend too much time in each placement machine for fiducial reading.

By changing the line configuration slightly, these same machines were set up to operate in parallel mode (Figure 4). This setup greatly reduced the percentage of the non-productive fiducial read time and resulted in additional line productivity. These changes included:

- A conveyor lift was located before each placement machine.
- Underneath each placement machine was a board conveyor that connected between the conveyor lifts. (The connecting board conveyor could also have been located above the line depending on preference.)

As boards arrived from the screen printer, they traveled to only one placement machine for 100% of the placements instead of through all three machines. If the first machine was busy processing and had a board in the input buffer, subsequent boards traveled down the first lift, beneath the first machine, up the second lift and into the second machine for processing. When Machines A and B were busy, then Machine C was put into use. Following placement, the boards traveled into the downstream lift and were conveyed underneath the line and up again to feed into the reflow oven.

In this example the placement cycle time in serial mode was 30 seconds, while the cycle time in parallel mode was increased to 90 seconds. However, by operating in parallel mode, three boards were processed in 90 seconds, and non-productive fiducial read time became a smaller percentage of productive time, resulting in a 15% jump in line productivity. The same line configuration can be operated in serial mode for products that would not benefit from parallel processing.

Upon making the change to parallel processing, the manufacturer realized another important benefit as well. Should one of the placement machines require maintenance, the complete line does not need to stop. Boards would naturally flow to the available placement machines, and production would continue.

Conclusion

Operating in a lean manufacturing mode means the pursuit of continuous improvement. The electronics manufacturing community, especially in North America, must continually look for ways to reduce waste and cost from the moment materials are

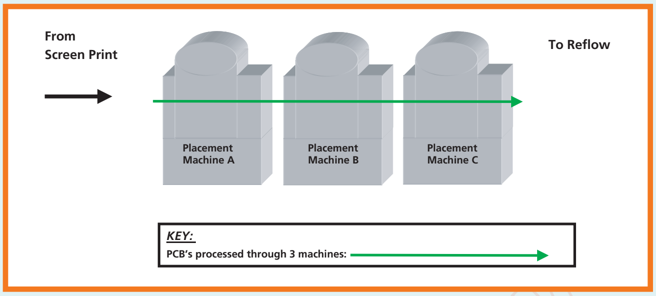

FIGURE 4: Serial process flow diagram.

procured to the time the product is shipped. The right placement equipment for specific production requirements must be selected, and the lines selected must be configured for optimal value.

Implementing what worked well for another company does not mean the exact setup will work for every manufacturer. Thoroughly studying production needs and then setting up the line with the optimal configuration pays off in the long run. Every aspect of a manufacturing operation that encompasses people and processes, including placement equipment configurations, must be scrutinized to determine if value is added. ■

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