

SPEED and THROUGHPUT in NEXT-GENERATION STENCIL PRINTING

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Introduction

In simplest terms, a faster printer logically means higher throughput. Overall speed, however, is dependent upon a number of factors including the individual cycle times for various steps in the print cycle (e.g., stencil wiping frequency, board separation and printing speed). A stencil printer's overall throughput speed, per board printed, must also be tied to the capabilities of the line; in other words, there is no benefit in having a fast printer and/or high-speed placement machine if line speed is governed by the reflow oven at the end of the line, with a fixed time/temperature profile that is significantly slower. Line configuration and balancing, and thus overall line optimization, is therefore an essential part of realizing the maximum benefit from a high-speed, printer capable of handling volume production.

Benefits of Higher Throughput

Line configuration and balancing is an essential part of realizing the maximum benefit from all stations in the line, from material handling systems (buffers, loaders, etc.) to the machines handling different process steps. A printer with high throughput capability, however, is 'fast' by design; the mechanical systems, software, stability of the frame, and motion control and sequencing all contribute to the overall operational speed of the individual machine. A thorough and comprehensive understanding of a printer's throughput capabilities gives the production engineer maximum flexibility in utilizing that piece of equipment to advantage in any number of line settings, configuration, or scenarios. A single printer may have sufficient throughput capability to handle two manufacturing lines and thus be fully utilized while sparing the facility the investment of purchasing printers for both lines, with the possibility that both would be under-utilized.

When we talk about 'speed', we really mean 'throughput', i.e., the time it takes for a single PCB to enter the printer, be printed, and exit the machine. This is not the same as 'cycle' time. Overall throughput is the *SUM* of various cycle times for such processes as the print stroke, stencil wiping, PCB indexing, alignment, etc. Some can be shortened; some cannot, such as the print stroke, which will have an optimum speed (which cannot be exceeded, usually) depending on the type of paste used, stencil, aperture sizes, etc. The advantage to higher throughput is not only greater volume of product, but also to the process. Higher throughput provides a comfortable margin of more time for key overhead functions that have the biggest impact on print quality.

With Higher Speed, You Can Now:

- Print at slower speeds;
- Utilize slow stencil separation for optimal print definition;
- Wipe more frequently (if needed) with the MPM Edison high efficiency wiper;

- Double print stroke after wipe.

Having time left over to optimize settings provides maximum possible yields!

What is a 'Fast' Printer?

A printer's mechanical systems, software, stability of the frame, and motion control and sequencing all contribute to the overall operational speed of the individual machine. 'Total Throughput' time, from the moment that a PCB is indexed into the machine until it exits the machine, is the true measurement of speed. For example, a machine with a total throughput time of 15 seconds would be considered a fast machine. Total throughput time is the sum of the various steps that the machine takes to print a board, and the cumulative cycle times of each step, whether it is alignment, print stroke, stencil underside wiping, indexing, or others.

Simply speeding up the print stroke, i.e. the speed at which the squeegee or print blade moves across the stencil is not an option.

Depending on the application, e.g. fine pitch or standard pitch, aperture size and shape, solder

paste thixotropy and other issues such as 'broadband printing', every application will have an 'ideal' print speed to obtain highest yields and defect-free paste transfer to the PCB. Good printing results are in part a function of the paste 'rolling' in front of the printing blade and being pressurized to fill the apertures completely. Too fast a print stroke will leave some apertures only partially filled, and could also hasten the viscosity breakdown of the paste through shearing. So if the ideal stroke speed for an application requires a print stroke lasting x number of seconds, then cutting time off of the overall print cycle will have to occur elsewhere.

Cycle Time

Multiple processes are involved in the printing of a single PCB, and yet not every process is part of the printing of every board. For example, one of the processes might be under-stencil wiping with an automatic wiping system. The manufacturing process engineer may choose to set the wiper to engage one in every ten boards; or every three, depending on many factors, but ultimately determined by how soon the underside of the stencil sees solder paste bleed around the apertures. Obviously, the process engineer wants to minimize the frequency of the wipe cycles, because a wipe cycle takes time away



Figure 1. MPM Edison printer with 15-second throughput.

from throughput speed, and because it costs in terms of lost solder paste. But the vagaries of the printing process, i.e., paste type, viscosity, aperture size, board topography and gasketing, etc., affect this frequency. But when it is required, depending upon the type of wiping system used, there is a specific wipe cycle interval time, and this cycle must be added to the others, such as PCB alignment, board handling, paste replenishment, print stroke, and others, to establish or calculate the 'true' throughput rate or speed. For example, the newly-released MPM Edison printer platform achieves an average throughput speed of 15 seconds per PCB printed, including the print stroke and stencil wiping; and this can be shortened even further, on average, the less frequently that stencil wiping is required.

Calculating a '15-second' Throughput

Naturally, every application will have a different throughput speed, depending upon a number of factors including (and especially) the type of solder paste used, the size of the PCB, the size of the apertures, and other variables. So in arriving at the 15 second time for the new MPM Edison printer, it was decided to use as standard or commonplace a board and print routine as possible, one that would serve to be a benchmark for most PCB printing scenarios. As such, the following parameters were used to achieve a 15 second throughput including print stroke and wipe stroke:

- 8" x 5" board size
- Maximum speed on transport
- 2 fiducials for alignment
- 2"/second print stroke
- 2"/second wipe stroke (One dry wipe only)

Stencil Wiping – Less is Faster

The stencil wiping process can be one of the biggest contributors to added cycle time. It can be minimized in at least three ways:

1. Reduce the number of wiping steps by using an optimized solvent-based system; e.g., reduce from 3 wipe strokes to 2 for a solvent, vacuum and dry cycle which is the most effective cleaning sequence;
2. Optimize the print cycle so that needed wipes are less frequent, e.g., 1 wipe every 5 prints instead of 1 every 3 prints, when possible; change print pressure, paste type, improve gasketing;
3. Opt for a system with a larger roll of wipe material (**Figure 2**) so that change-outs are less frequent.

Less Wiping = Higher Overall Throughput Speed.

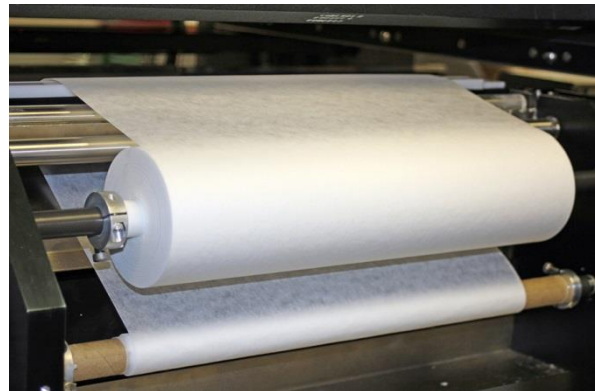


Figure 2. Larger wiping rolls require less frequent change-outs.

Minimizing Motion

Much of the overall throughput time for processing any PCB is consumed, cumulatively, by travel of various components within the machine. By studying the motion of different components, time-consuming travel can be minimized. Sometimes it requires out-of-the-box thinking and revision of cherished concepts, when 'we've always done it that way' can no longer be defended. Ask, "Do we really need that much Z-travel for this part nowadays?" "Does the gantry really need to be parked back there between cycles?" And there are others. For example, if it takes x amount of time for a module to index back to a 'park' position and in doing so travel the length of the print area, and an examination of the sequence shows that the module doesn't need to go back there at all, wouldn't it save time to leave the module in its current position, provided that it did not create an interference? This type of re-thinking can help eliminate unnecessary movements and thus trim cycle time; and we must always remember that all time savings, no matter how brief, are cumulative. Improvements in individual components, modules, or systems can also enhance throughput; for example, a more efficient stencil wiping system such as a solvent based system that gets the same job done in a shorter cycle time; or a better vision alignment system that's faster; a smaller board handling size (do we really need that much board size capacity these days?) and other considerations can trim cycle times. Of course, even more dramatic results can be obtained when certain cycles can be eliminated altogether, or their frequency reduced, as in the aforementioned stencil wiping frequency reduction.

Additionally:

- Use "Parallel Processing" to manage the entire system;
- CANopen control architecture allows axes to move at the same time without electrical or mechanical limitations;
- Design and configure systems for Back-to-Back (BTB) orientation to create a flexible dual lane solution to maximize productivity on a dual lane line;
- Use High Speed Vision Alignment with 'on the fly' fast 'POE' (Power Over Ethernet) camera whereby power and communication utilize the same cable and single CCD split field allows simultaneous up-down image acquisition.

Conclusion

Higher stencil printer throughput (total speed) characterizes next-generation SMT stencil printers, and is achieved by advances in mechanical design of the basic machine as well as its features and software. Higher throughput is in demand by the surge in automotive and smart device electronics manufacturing. A printer's 'throughput' is a cumulative sum of the cycle times of each part of the printing process, which can be reduced through a thorough study of system design, motion efficiencies, and reductions in frequency of necessary cycles such as stencil wiping. A printer has already been developed that realizes a 15-second throughput; such capabilities will be necessary going forward to satisfy the needs of the smart device and automotive markets and future demands in SMT PCB assembly.

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