

Quality throughout the entire line

A paradigm shift: From defect detection to process control

When you walk into a modern SMT production facility today, at first glance there's little that looks new. Printers, placement machines, and inspection systems are in the same places they've been for years. The real change is less visible — and that's precisely why it's so significant. It's taking place behind the scenes — where individual process steps are being transformed into a seamless, intelligently controlled manufacturing process.

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For a long time, final inspection was the focus of quality assurance. Defects were identified, analyzed, and then corrected. However, this approach is increasingly reaching its limits. Modern AI servers, high-performance computing systems, and safety-critical electronics — such as those used in the automotive industry — combine large-format printed circuit boards and ball grid arrays (BGAs) with thousands of different, sometimes highly miniaturized components in various orientations. Even the smallest process deviations can necessitate rework or, in the worst case, result in the scrapping of an entire printed circuit board.

While material costs and manufacturing expenses are rising significantly, electronics manufacturers are facing growing competitive pressure. Maximum productivity and capacity utilization must go hand in hand with the highest level of process reliability. What was once often considered a conflict of objectives is now evolving into a common challenge.

It is precisely this shift in perspective that is transforming modern SMT lines. Instead of detecting errors only after they occur, machines, sensors, and software continuously monitor the manufacturing process in a closed-loop control system. Process data is evaluated in real time, deviations are detected early, and — where possible — corrected immediately and automatically.

The Foundation Is Laid During Solder Paste Printing

Many quality issues originate as early as the first process step. Fluctuations in solder paste volume, even the slightest positional deviations in the solder paste deposit, or unstable printing parameters can compromise the quality of the entire printed circuit board and

later lead, among other things, to solder bridges, open solder joints, or “head-in-pillow” defects in BGAs.

Modern printing platforms such as the DEK TQ therefore continuously monitor all quality-relevant process parameters and ensure high process stability even in high-mix manufacturing environments. With an alignment accuracy of $\pm 12.5 \mu\text{m}$ at 2 cmk and a wet printing accuracy of $\pm 17 \mu\text{m}$ at 2 cpk, the platform lays the foundation for the highest print quality. Numerous automation functions for Smart Pin Support, cleaning the undersides of stencils, solder paste transfer, and stencil and squeegee changes reduce manual intervention and thus also potential sources of error.

In combination with the SPI system Process Lens and the WORKS Optimization application from ASMPT, printing and inspection data are continuously cross-referenced in a closed-loop control system, and printing parameter corrections are automatically applied before they can affect the quality of the printed circuit board.

End-to-end quality assurance — from pickup to assembly

Modern AI servers, high-performance computing systems, and demanding automotive and industrial applications place ever-increasing demands on electronics manufacturing. On complex printed circuit boards, thousands of components come together — ranging from the smallest passive components to large processors and connectors. Different component sizes, weights, package types, and materials each present unique challenges for pickup, alignment, and assembly. Especially in high-mix production environments with frequently changing products, the assembly platform must automatically account for these differences without compromising speed or quality. In addition, as the value of modern printed circuit boards increases, so do the demands on placement quality. That is why quality assurance for innovative placement machines from ASMPT — such as the SIPLACE V platform, which combines up to 30% higher actual throughput with maximum precision — begins long before the actual placement of the components.

The highly integrated CP20 placement head processes standard components at a rate of up to 52,000 components per hour with an accuracy of $\pm 25 \mu\text{m}$ @ 3 sigma. Despite the high speed, this precision is only possible

through a multitude of coordinated quality controls — the first of which takes place right at the pipette. The system automatically checks their condition, approves clean pipettes for production, sends contaminated ones for cleaning, and rejects damaged ones.

Even before pickup, any misalignment of the component in the belt pocket can be detected and compensated for by the PCB camera. An integrated component sensor also monitors every single step. It checks whether the component is present or absent before and after pickup, as well as before and after placement. At the same time, it measures the component height down to 50 µm. The measured values are fed directly into the placement process. In this way, even the smallest components can be reliably detected and safely processed.

Precise alignment is ensured by the placement head with 20 independently driven segments. Each segment can individually rotate and position the picked component during movement. Together with the component camera and sensor, this ensures seamless quality control throughout the entire placement process. As a result, components ranging from 016008M to 8.2 × 8.2 mm can be reliably placed in any required angular position within a single head cycle.

Immediately after pickup, the system aligns each component to the specified placement angle. In the next step, the integrated component camera captures each component using individually adjusted lighting and image processing parameters. The images are compared in real time with the stored reference data. The system automatically corrects X, Y, and angular misalignments, taking into account the detected Pin 1 marker. Even components that are upside down are reliably detected.

The challenge is particularly great with large processor BGAs: With package dimensions of up to 150 × 150 mm, weights exceeding 500 g, and several thousand balls, they place exceptionally high demands on process reliability. For this application, ASMPT has optimized the TWIN VHF placement head with specially designed pipettes. Before placement, the coplanarity of the BGA balls is optically checked. For BGAs with a uniform ball pattern, it is also essential to verify the correct orientation using the pin-1 mark. This check is performed by the stationary camera.

To prevent solder bridges, so-called spacers — thin separators — are typically used with large BGAs to ensure a defined distance between the component and the printed circuit board. An optional 3D coplanarity measurement based on laser triangulation, with a height resolution of up to 0.5 µm, is used to check the coplanarity of the balls. Especially with large processor BGAs, even the slightest deviations in flatness can prevent individual balls from making reliable contact with the solder paste during the reflow process. Such defects often go unnoticed at first but can later lead to

open solder joints or failures during operation. For this reason, coplanarity testing and the inspection of existing spacers are now among the critical prerequisites for reliable assembly of large AI server BGAs. Integrated PCB inspection (on-board PCB inspection) provides additional assurance. It detects contaminants and foreign objects in critical areas as well as missing components.

At the same time, the placement machine continuously measures the PCB, takes any warping into account during the placement process, and compensates for it individually for each placement position. In addition, software-controlled force profiles ensure that each component is placed with the optimal force.

For passive components, the SIPLACE Measuring Feeder provides an additional level of setup verification directly within the machine. At the start of production and after splicing — the process of attaching a new component reel to an empty one — it checks whether the correct component is present in the respective feeder. To do this, it measures the electrical value of the component and validates it against a stored reference value. If a measured value falls outside the tolerance limit, the feeder prevents incorrect components from being used for placement. Random measurements are also possible at regular intervals during ongoing production. The measurement results are simultaneously documented in the traceability data.

Why Quality Today Means Process Quality

The real progress in modern SMT manufacturing lies not only in individual quality functions but in their intelligent integration. Many deviations are already detected and corrected during the printing and placement process before they affect subsequent manufacturing steps. The downstream AOI remains an important final inspection stage and simultaneously confirms the stability of the overall process. Quality is no longer ensured at individual inspection stations, but is integrated throughout the entire manufacturing process.

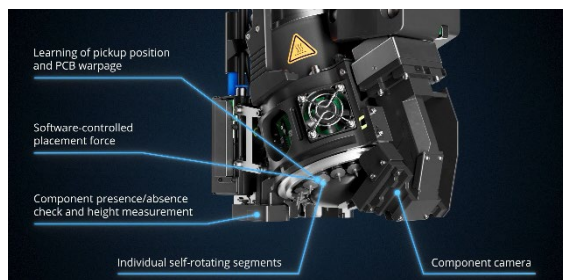
The Big Picture

The next leap in quality will not be achieved solely through even more precise machines. The key lies in the increasingly tight integration of hardware, software, and artificial intelligence. Only through this integration can the vast amount of individual data collected along the SMT line be transformed into actionable insights for achieving 0 DPMO (Defects per Million Opportunities).

This is where ASMPT's WORKS Software Suite comes in. It consolidates process and quality data from printing, placement, and inspection into a single database. Through the standardized IPC-2591-CFX interface, machines and inspection systems from other manufacturers can also be integrated. This creates a comprehensive understanding of the process across

the entire SMT line. While WORKS Monitoring provides transparency into the ongoing manufacturing process, WORKS Optimization analyzes quality and process data using AI, recognizes correlations, and identifies opportunities for optimization. The continuous exchange of data between the networked systems within an SMT line already makes it possible today to automatically correct process deviations before they lead to quality issues.

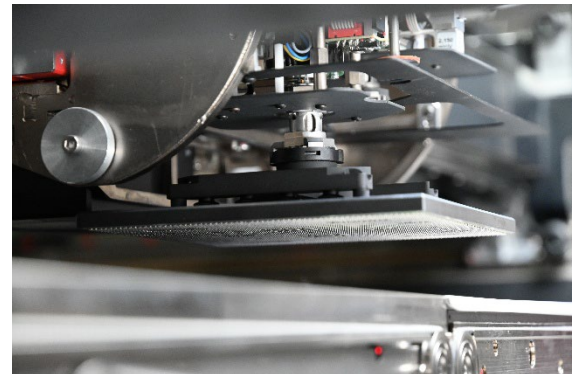
As a result, quality is increasingly becoming the outcome of a self-learning and continuously self-stabilizing manufacturing process. This is precisely where the true paradigm shift in modern SMT manufacturing lies.



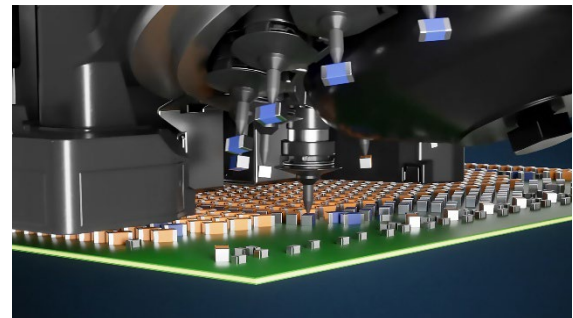
Innovative SIPLACE placement heads monitor every placement operation with integrated sensors and image processing — from pipette inspection and component recognition to precise placement. (Image: ASMPT)



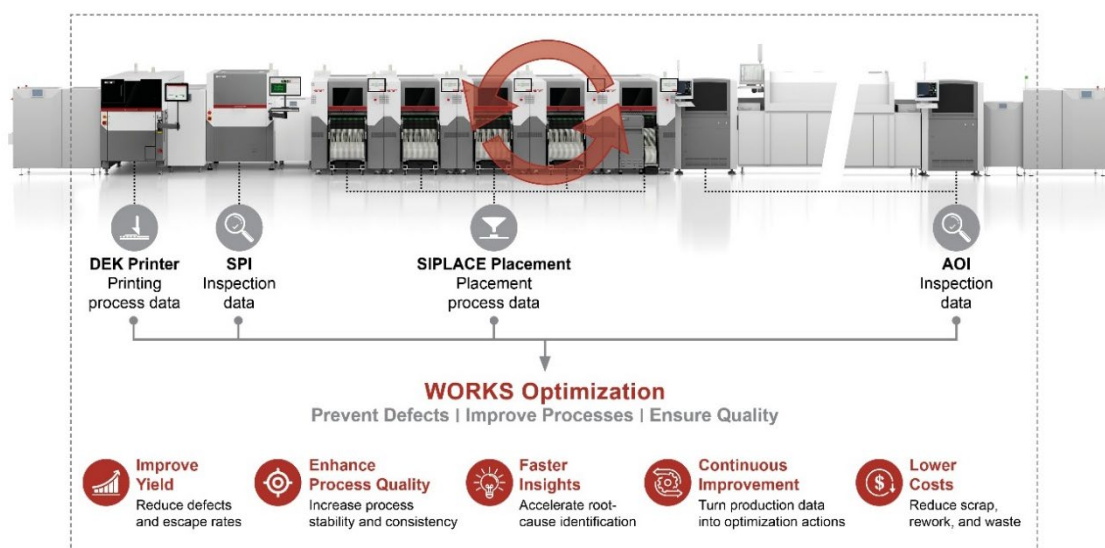
With integrated sensors, image processing, and automated quality functions, DEK TQ, Process Lens SPI, and SIPLACE V provide the foundation for consistently quality-oriented and intelligent SMT manufacturing. (Image: ASMPT)



For large processor BGAs, reliable pick-up, precise alignment, and the coplanarity of the balls determine the quality of the resulting solder joints. (Image: ASMPT)



The Collect&Place placement head, with 20 independently driven segments, aligns each component individually and enables the reliable placement of a wide variety of components in any required angular position. (Image: ASMPT)



Integrated communication between the DEK TQ solder paste printer, the Process Lens SPI system, and SIPLACE placement machines stabilizes the manufacturing process and detects deviations even during production. (Image: ASMPT)