Increase Production Yield by Investing in Leading-Edge Equipment

Feature Article by Brent Fischthal
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As we wind down 2021, we eagerly anticipate the new year, which should bring new opportunities. With the start of the new year, we often see new capital equipment budgets roll out, and production engineers and operations managers begin to evaluate how to best spend their newfound resources to improve the processes. There are multiple papers readily available from industry experts like Chrys Shea of Shea Engineering about the significance of solder paste inspection (SPI) equipment. Therein, you can find justification about why adding a solder paste inspection machine should be the first piece of inspection equipment considered. SPI will immediately reduce assembly defects.

Therefore, let us consider automated optical inspection (AOI). AOI technology has been available for decades, but only since the introduction and industry adoption of real 3D measurement has it emerged as a major area of focus to prevent defects and improve production yields in pre-reflow and post-reflow positions. Yet, many manufacturers are using antiquated 2D or quasi-3D systems that increase false calls and escapes.

In the early days of optical inspection, SPI and AOI systems were based on 2D inspection technology. These 2D systems were looking at different grey levels for solder joint and component detection. Most decisions were made by a "good/bad" comparison to reference images or "golden boards." While many 2D AOI systems remain in use, the effort needed to keep this technology at a low level of escape and false-call rates can be exceptionally high. These antiquated 2D systems facilitate false calls and failure escapes. This is because the concept of comparing reference images is still the main technique applied in 2D systems. To help the situation, some equipment manufacturers have added additional cameras and projectors to create a "quasi 3D" or "2.5D" inspection technology, but it is still based on the same inadequate concept of comparison or color assessment.

Now, after the introduction of 3D AOI, a transition to true 3D measurement is taking place. The benefits are clear: rock-solid


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threshold and inspection tolerances that minimize escape and false-call rates with minimum debugging effort. If you are facing production quality challenges due to your old 2D AOI equipment, it may be time to upgrade.

Measurement-based Inspection

Process optimization is desired by every manufacturer, as well as equipment suppliers. However, it has been difficult to realize due to the limitation of two-dimensional (2D) imaging, which was the de facto standard for the past decades. Not only it is difficult for 2D automated optical inspection (AOI) systems to identify defects on curved and reflective solder joint, 2D AOI systems do not generate reliable data. Every aspect of the 2D inspection process relies on contrast, not quantitative measurement. As such, 2D AOI users must either scrap or repair defective boards, which increases costs and eliminates process improvement opportunities.

The introduction of 3D imaging to the inspection market solved some of the problems. By measuring components and solder joints, and then offering critical height information to the inspection algorithms, users could locate errors like pad overhang and insufficient soldering. However, the validity of the measurement data remained questionable as most of the 3D AOI systems use "blob detection" to find the component body; but, this technique is susceptible to external factors like board warpage and component proximity. Since finding the component body is the critical first step in the inspection process, it can negatively affect the whole inspection sequence if inaccurate.

Koh Young technology has overcome this challenge by using 3D technology for all component types to extract their bodies (Figure 1). True 3D measurement is processed by a parallel computing engine. While 2D inspection technologies are combined with real-time PCB warp compensation to offer accurate inspection data, the new platform goes much further. Using patented shadow-free 3D technology, we provide improved results by measuring every aspect of the component and solder joint in accordance with the IPC-A-610 standard. This system's ability to generate a significant set of reliable measurement data can be found, for example, in our KSMART analysis and optimization solutions.

Ground-breaking Transparency

In this hyper-competitive world, manufacturers place ever-challenging demands on process solutions. Manufacturers want to monitor and adapt the process to achieve zero defects by accessing all the data at anytime, anywhere. They must also cope with shorter life cycles, so

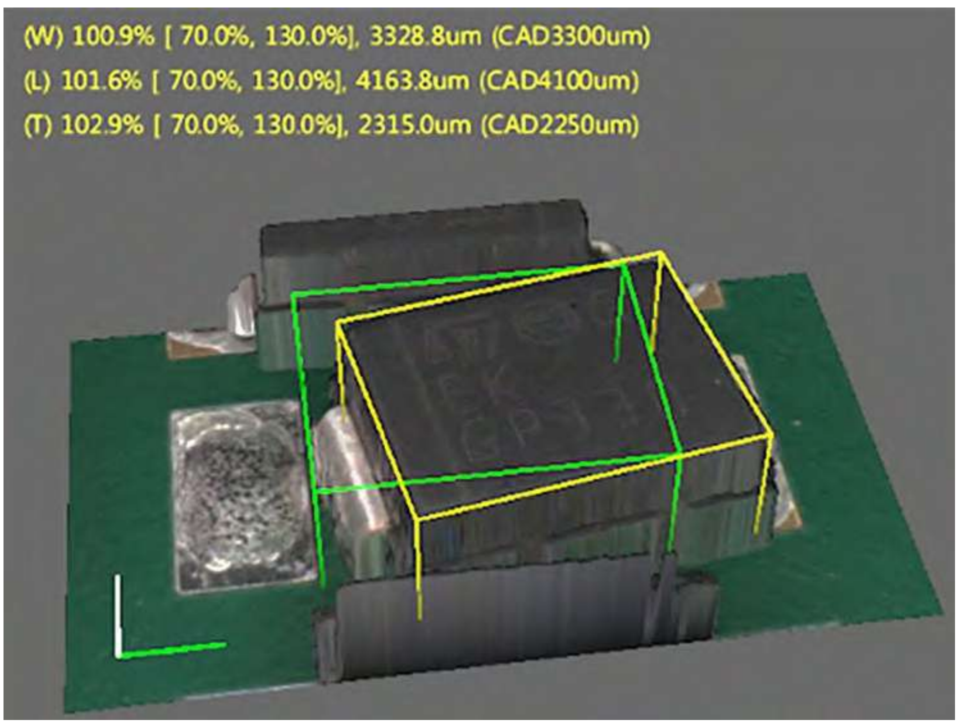

Figure 1: Mapping the component body by using 3D measurement technology.

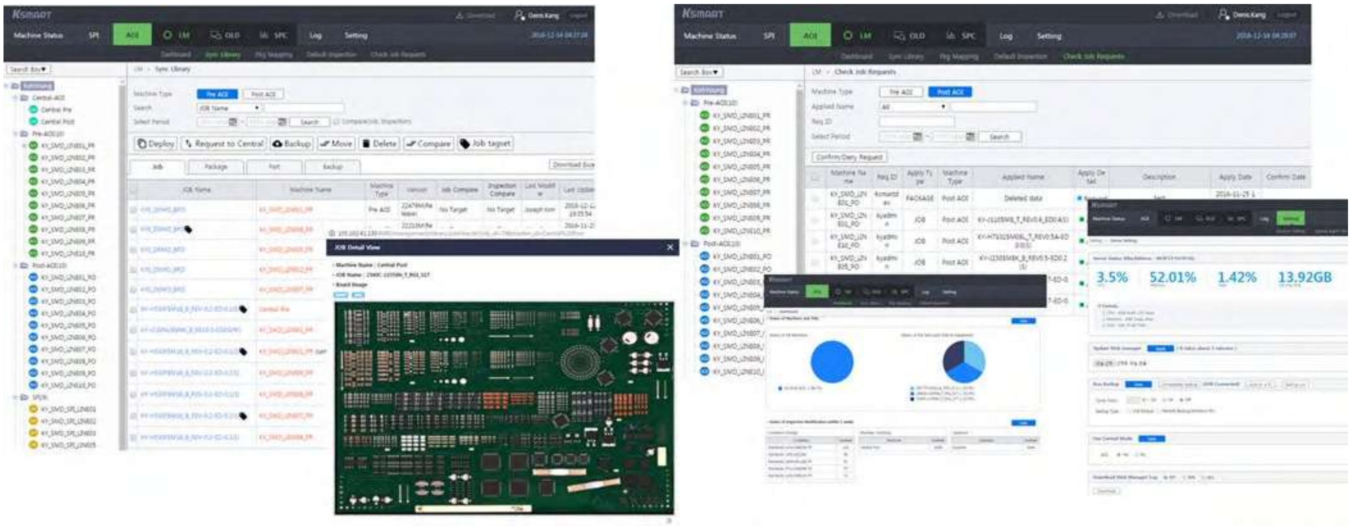

Figure 2: KSMART Library Manager module on web interface.

inspection solutions should be able to collect and analyze a large amount of data to produce traceable results.

Our approach to the analysis solution is to collect all inspection and measurement data from all equipment via a hub, and then provide the data anywhere within the network through a web-based application. Big data is a foundation for Industry 4.0, so advanced inspection systems must evolve from simply judging "pass/fail" tools into highly intuitive, dynamic decision-making systems, which emphasizes the need for reliable, traceable data.

This traceable data can then ensure the highest levels of transparency by showing all conditions of the lines, including machine configuration and software version, while providing the required documentation for changes to the job file, package, part, and more. Users can quickly verify whether all lines are within the ideal conditions. If a variance occurs, the user can instantly upload optimized programs and inspection conditions without fine tuning with the Library Manager module (Figure 2). The software module provides a complete central management solution for component libraries, programs, inspection conditions, and more. Library Manager combines all equipment into a single centralized library. All changes are traceable and manageable by user level Identification. Such controlled data management allows continuous analysis of the raw data and helps guide experts towards the right direction.

Eliminates the Bottleneck

Of course, maintaining quality, repeatable measurement data is not enough to realize a smart factory. Instead, analyzed data needs to be instantly visualized with relevant indicators like yield rate, NG analysis, PPM analysis, Gage R&R, offset analysis, and more to allow users to compare board performance and identify process deviations. Using the real-time statistical process control module, users can identify the exact defect origin by checking false calls and NG parts from the dashboard, as well as evaluate, and optimize default settings.

For instance, if the thickness was the major problem in a worst-case part, users can click the part to view analysis result and find the root cause. An X-bar chart of measured thickness of the part will be shown across time with average, minimum, and maximum values, plus tolerance levels (Figure 3). If values frequently deviated from average values and tolerances are too tight, users can adjust the tolerance levels to minimize false calls. On the other hand, if the process was stable, operators can tighten the tolerance to prevent

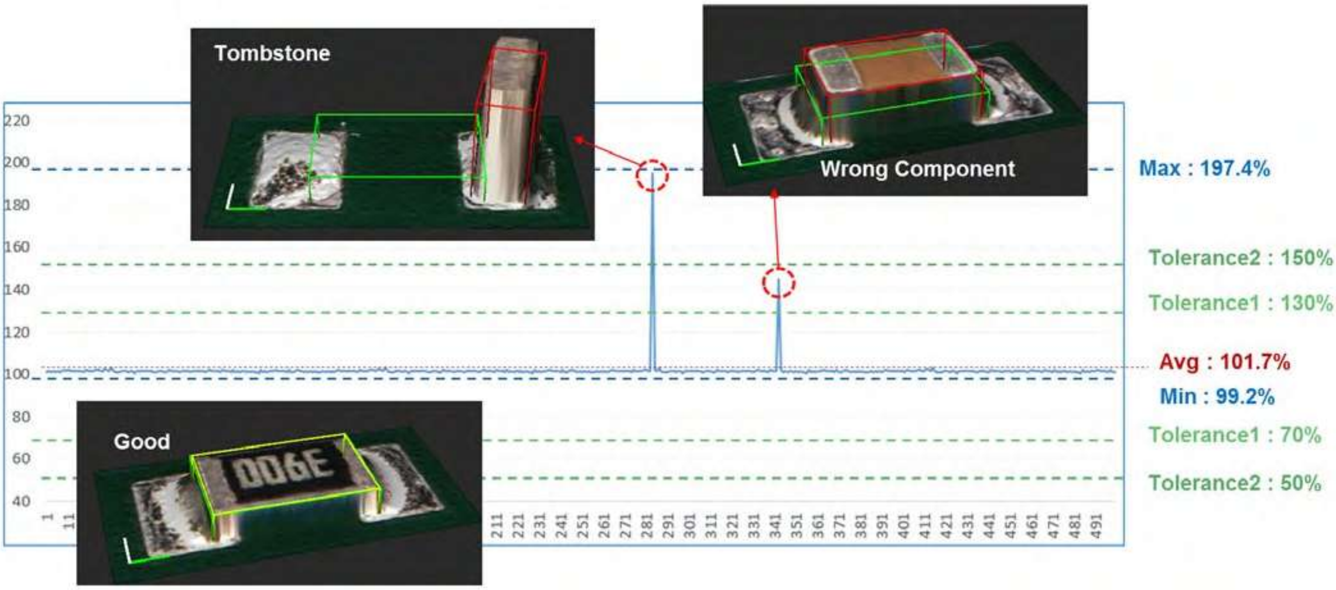

Figure 3: X-bar chart for thickness of R1005 part.

future escapes. The measurable data helps improve the process.

In the meantime, operators have the ability to load and debug identified defects with accumulated historical real data from all lines and simulate the results of any adjustments without affecting production. Users verify if the adjusted setting is "suitable," then, deploy new, optimized programs and inspection conditions to all production. These iterative actions optimize processes based on objective, real measurement data, not merely by a user's experience. In some use cases, we see users achieve as much as a 98% false call reduction.

Connecting Big Data

A single inspection system has limits and cannot manage and optimize a complete line while in isolation. Working with our partners, we are developing connectivity solutions that optimize the process by exchanging real-time measurement data from SPI and AOI systems with every machine on the production line, feeding real measurement data such as offset, volume, height, area, and warnings to other systems, while analyzing trends for process optimization and traceability. When this solution is combined with CFX and HERMES, it can help manufacturers define correlations between distinct processes (Figure 4).

Using this advanced communication, the AOI can feed correct mounting position values to mounters, which ensures components are mounted in the targeted position. This feature improves process repeatability by automatically adjusting component placements and catching the shifting trend to make further position corrections.

Autonomous Process Optimization

Understanding the increasing importance of networked intelligent systems in the smart factory, the modular platform is designed for future growth and expansion. When new modules are released, a manufacturer can implement the upgrades as needed, extending capabilities beyond automated adjustment toward a comprehensive infrastructure for autonomous process optimization.

Budgeting for Capital Equipment

Clearly, the capabilities of leading edge AOI equipment will help manufacturers improve their electronics manufacturing process, and just like SPI equipment, the benefits will be immediate. Now, it's time to consider the in-

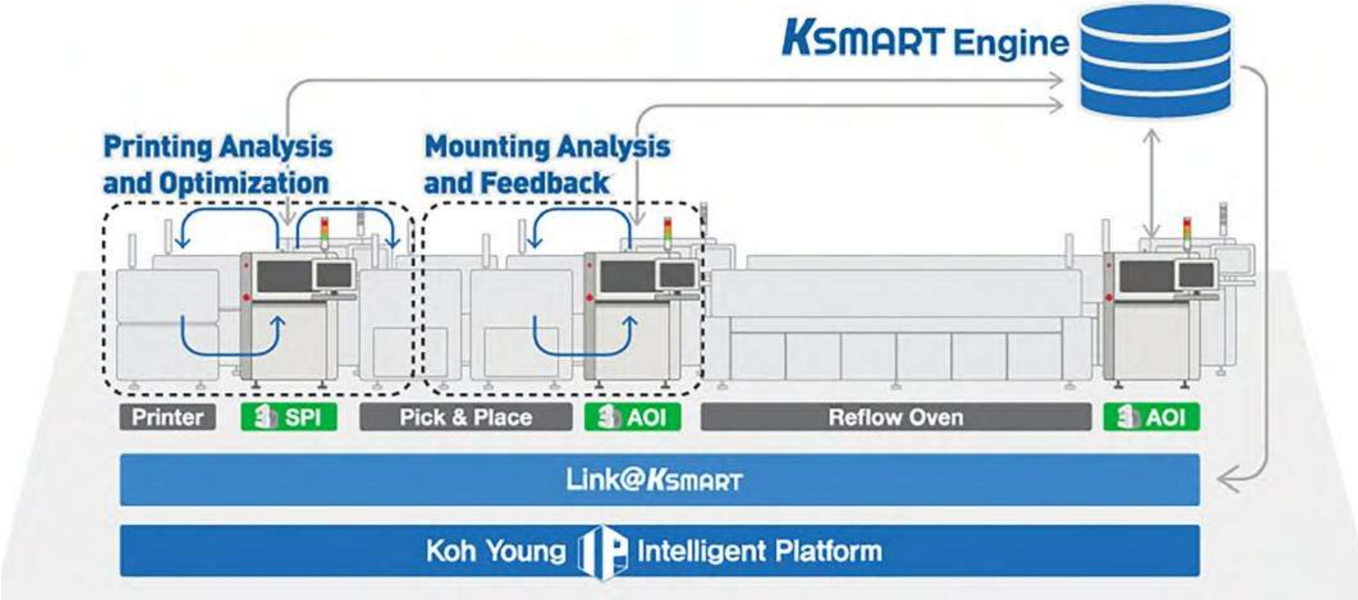

Figure 4: Achieving a smart factory by using 3D inspection process information.

vestment. Of course, many companies opt to purchase the equipment.

Owning the equipment your business uses to operate gives you the highest degree of control over how you manage your resources. You can sell the equipment at any time or continue to use the equipment for years if that use remains productive. When you buy capital equipment for your business, you own the equipment, get the use of the equipment for as long as it lasts and can depreciate the cost on your taxes.

With a lease, you trade some of that control for more simplicity in the operation of your business. With a lease, the equipment is delivered, you make the payments, and the equipment is either purchased or removed at the end of the lease. You spend little or no time managing the equipment compared to if you owned the equipment. Leasing the equipment instead of buying might cost more in terms of cash flow, but leasing comes with its own set of advantages.

Leasing as a Viable Alternative

Why is it important for electronic manufacturers to have the right financial solution for SMT investments? The world is changing faster than ever before. While some equipment can inherently withstand the pace of change, other equipment cannot keep up with the technological or business challenges. Many equipment suppliers are just not able to provide future-proof equipment solutions, which means many electronics manufacturers are investing in equipment for upward of 10 years with the inherent risk the equipment will not fit their business model or production needs in the future.

Leasing is a solution to overcome this issue. Lease companies can provide 100% financing with a $1 purchase option. This approach allows the manufacturer to pay for equipment as the equipment pays for itself with production runs. Some firms offer options to increase working capital by deferring the initial lease payment for up to 90 days. The application process once deemed complicated and burdensome has evolved. For instance, credit approvals up to $500,000 can be obtained without financial statements for qualified customers. This requires only a one-page credit application; a credit approval can be obtained in only a few days. Manufacturers can lock in low finance rates for as long as seven years. There is a reason equipment leasing has been and will remain a viable option to help acquire capital equipment.

Now let us consider a novel leasing option. What if manufacturers could update the SMT equipment every few years to match the changing production requirements or change equipment simply because equipment suppliers have introduced more capable solutions? Companies like SMT Renting offer a flexible lease concept with service and warranty. Not a traditional financial lease, like banks are offering, but a full operational lease with maximum flexibility, tailor-made towards electronic manufacturers. They focus purely on the electronics manufacturing industry, working closely with the top equipment vendors within the industry to provide manufacturers the option to "stop & swap" equipment regularly—at attractive monthly rates. This gives several benefits to electronics manufacturers such as production flexibility, increased working capital, and faster time to market. Consequently, many electronics manufacturers are changing their financial solution for SMT investments to leasing.

Conclusion

Overall, inspection systems and the exceptional data they produce are making a huge contribution to the digital transformation of the factory floor and the drive to Industry 4.0. AI-engine and deep learning research and development continue to achieve this vision with a focus on next-generation cooperative efforts that expand process capabilities and factory performance. To this end, the company has established three additional R&D centers worldwide to facilitate a quantum leap in technological leadership and competitiveness, even paving the way into new markets and industries beyond SMT. **SMT007**

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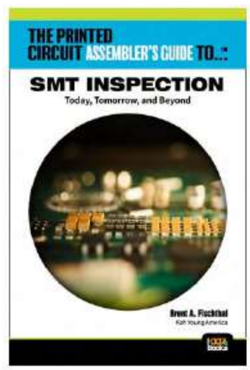
Excerpt: *The Printed Circuit Assembler's Guide to... SMT Inspection: Today, Tomorrow, and Beyond*

Chapter 7: Smarter Manufacturing Enabled by Inspection

There is much that inspection can offer the world of manufacturing, and in this book, we have focused on the current state and the near-term future. Right now, inspection plays an increasingly important role in making manufacturing smarter. Inspection allows us to deliver the quality we know is essential for the products being manufactured right now, and in the future. It is providing the data that allow companies to improve their own performance and efficiency. Data from inspection is contributing to almost every process on the SMT line, providing real insight into faults and their root cause. This inspection data is also providing immediate feedback to other processes in the line, often in real time, making on-the-fly adjustments that reduce scrap, downtime, and even the use of consumables such as solder paste and cleaning materials. Inspection is picking up the slack in terms of skill shortages, allowing lower-skilled operators to manage lines or parts of lines and, thanks to intuitive software, allowing fewer operators to manage more machines and lines. All in all, inspection systems and the exceptional data they produce are making a huge contribution to the digital transformation of the factory floor and the drive to Industry 4.0.



But what of the future beyond the short- and medium-term goals of digitally optimized factories? How far can inspection and data take us?

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Conformal coating protects and isolates electronics from moisture, debris, corrosion and shock, while adding mechanical stability to reduce failures and improve reliability. It is a widely used technique for harsh environments. Yet, most systems use UV light to inspect the surface for presence and only gauges material thickness in a particular spot. Traditional laser-confocal or electron microscope Systems only measure three-dimensional shapes and Inspecting transparent materials is a challenge due to the laser's shallow penetration depth and slow throughput. Koh Young's revolutionary Neptune C+ provides the ultimate solution to these challenges. It represents another innovation and is the industry's first 3D in-line dispense process inspection (DPI) and thickness measurement solution for transparent materials. The system allows you to accurately explore the depths of your process.

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