AOI-AXI Duo Improves Product Yield

by David Upton, YESTech, a Nordson Company

Automated optical inspection (AOI) and automated X-ray inspection (AXI) have been around for some time in various configurations and both have played a role in improving the quality of circuit boards. While some companies opt for one technology over the other, each form of inspection contributes its own unique benefit to the manufacturing process.

As board densities increase and component sizes decrease, the need for a fast, accurate, and more efficient inspection process is critical. A growing number of electronics assemblers have integrated AOI and AXI into their quality-control inspection processes.

Biamp Surface-Mount Assembly With AOI Inspection

Opting for both types of inspection can provide even greater benefits and return on investment as has been found by Biamp Systems, an international provider of professional installed audio electronics. The company, headquartered in Beaverton, OR, with additional engineering operations in Brisbane, Australia, delivers high-quality and innovative professional electronic products designed to meet the audio requirements of corporate boardrooms, theater complexes, courtrooms, public venues, and other installed audio applications.

In March 2005, Biamp was looking for ways to make the inspection process on a surface-mount line more efficient. Several inspectors would visually check the circuit boards with the aid of template overlays and paper documentation, such as drawings and the bill of materials. Visual inspection consumed a good part of the operators' time, and in many cases, there was a lag between the time boards were processed and inspected.

When comparing the speed, efficiency, and flexibility of other test and inspection methods, the benefits of AOI were clear. A typical manufacturing line, for example, may have two to four

inspectors to visually identify and repair component and solder defects. By contrast, an AOI system requires only one operator to detect and repair defects as well as collect all necessary data for yield improvements. This can reduce the per-shift requirement for labor or enable reallocation of resources to another part of the manufacturing process.

Biamp purchased an AOI machine to better utilize operator time and automate quality data collection. Ease of use is one important but often overlooked factor to consider when implementing AOI. For dedicated higher volume production lines, some systems are better suited than others, which often are programming-intensive and do not lend themselves to line changeover.

Other types of systems are designed to provide the flexibility needed to match production throughput on multiple line configurations. Biamp was looking for something simple to program, easy to operate, and available at a competitive price. The company selected the YESTech YTV-2050 AOI machine.

The YTV-2050 is a high-speed, high-defect coverage AOI system. Image processing technology integrates several techniques including color, normalized correlation, and rule-based algorithms to provide inspection coverage with a low false failure rate. It uses Thin Camera™ technology and has up to four top-down viewing cameras and four side-viewing cameras to inspect solder joints and verify correct part assembly.

Technicians typically take less than 45 minutes to create a complete program including solder inspection. A standard package library simplifies training and ensures program portability across manufacturing lines. Off-line programming maximizes machine utilization, and real-time statistical process control monitoring provides a valuable yield enhancement solution.

With Biamp's commitment to comply with the European restriction of hazardous substances (RoHS) initiative in 2006, the company added a second surface-mount line along with a newly released YESTech F1S AOI machine. The new platform could better accommodate Biamp's higher speed line with faster inspection time, more accurate motion control, and LED lighting. The system's four oblique viewing cameras offered inspection capabilities for R-nets and other difficult-to-inspect parts.

Upon analysis, Biamp decided it would be beneficial to incorporate X-ray inspection in its process.

A YESTech YTX-3000 AXI System was purchased.

AXI is becoming increasingly popular because, like its counterpart AOI, it is a noninvasive inspection solution that provides real-time process data and can be used effectively for defect detection and yield improvements. X-ray images of solder joints can be analyzed automatically to detect structural defects such as insufficient solder, voiding shorts, opens, and other defects that can account for upwards of 90% of the total defects on a complex board.

But unlike AOI, X-ray imaging is not hindered by hidden solder joints, component shields, and high-density double-sided boards, making AXI the logical choice for inspection of complex boards with BGAs, CGAs, CSPs, or components that are under RF shields. This is a critical advantage since a significantly larger number of boards fall into this category with the increasing popularity of array-style packaging. In addition, many cell phones and wireless communications products call for placing RF shields over unsoldered components at pick-and-place, using the reflow process to solder the shields to the board.

The company always had high confidence in the proven leaded solders and had very few test failures due to solder defects on BGA components. However, since the lead-free solder process was new to Biamp, the company felt it was important to have the capability to inspect BGAs via X-ray.

Ensuring quality and reducing costs through automated inspection during surface-mount assembly are most valuable when used to detect defects close to the fault source. The AOI machines are positioned in the surface-mount lines and used as part of Biamp’s normal production. Every board is fed post reflow into the AOI equipment and inspected. All boards are 100% inspected before moving on to the next process.

Rather than relying on dedicated inspectors, with the incorporation of AOI, Biamp was able to cross-train its operators to run all the machines in the surface-mount line including the AOIs. This gave the company the flexibility to use workers where they were most needed. Most of the programming features could be learned in a couple of weeks, but learning how to properly program the machines is an ongoing process.

The types of PCBs manufactured and inspected by Biamp are mostly mixed surface-mount and

through-hole technology with a few boards that are 100% through-hole. Biamp design engineers try to minimize the amount of through-hole parts on the PCBs although most of the boards have mixed technology with the majority of through-hole parts being connectors. About half of the boards are double sided.

Boards range in size from 16.5 x 11 inches to 2.7 x 1.75 inches. The smaller boards are panelized. There is a wide mixture of component density from six to 2,300 components per panel. The smallest component currently used is 0402 size.

About 50 different types of boards are built, and Biamp produces about 4,000 boards a week. With AOI, speed is not an issue; rather the pick-and-place machines are the bottleneck in the surface-mount process for most of their boards.

In particular, Biamp uses its AOI machine to inspect for the following defects: bent leads, billboard parts, excessive solder, insufficient solder, misaligned parts, missing parts, open solder, solder bridges, tombstones, upside-down parts, wrong parts, wrong polarity, and damaged components. This data helps identify specific defects on Biamp's products and the process where the defect originates, such as the screen printer, pick-and-place, or the reflow process.

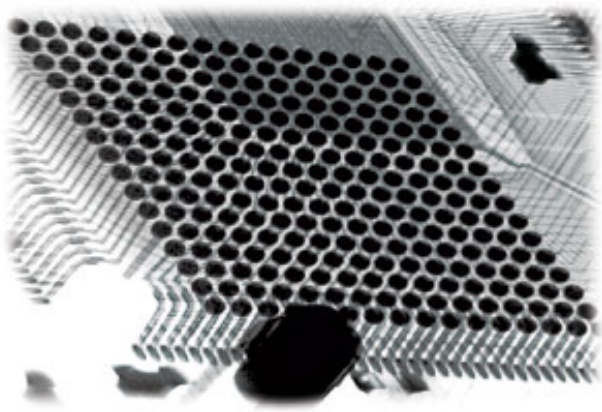

Figure 1. High-Resolution X-Ray Image Taken by YTX-3000

For X-ray inspection, the AXI system is a stand-alone machine used for process development and troubleshooting. The manufacturing engineers use AXI to validate process parameters and board designs, and it helps the test department determine the cause of some test failures. X-ray detects solder voids, solder bridges under components such as BGAs, and raw PCB defects like internal shorts found in product from Biamp's circuit board suppliers (**Figure 1**).

X-rays are generated at a fixed-point source, pass through the PC board assembly, and form an image on an electronic detector. The image is converted into a digital image and transferred to a computer where the analysis takes place. This technology is widely used for single-sided boards in automotive and other high-reliability

applications. Advanced image processing software provides automated inspection of solder defects.

Biamp's operation doesn't change boards frequently, so there is no need to use AXI as part of an automated line. Once the boards have been developed and the processes refined with AXI, AOI verifies the quality of each board, and AXI is used to regularly monitor the manufacturing process.

The YTX-3000 is a high-resolution AXI system in a flexible, compact, maintenance-free configuration. It comes with a 4- or 5-axis sample manipulator and a 15" x 20" X-Y travel for samples up to 5 lb. A full 360 degrees of rotation and 30 degrees of tilt are available. Stepper motor drives provide a range of motion from ultra-slow at high magnifications to high speed for travel over large distances. All systems include a control module and programmable motion for automated inspection.

By using AOI and AXI inspection, Biamp has found many advantages. Although AOI finds the same defects as visual inspection, AOI does 100% inspection on every part and every solder joint. It is impossible for an operator to inspect every component and keep up with the surface-mount production equipment.

This was especially important for Biamp when company growth required the installation of newer and faster placement machines last year. From June when the new placement equipment was installed to December 2008, the first-pass yield of boards with zero defects improved steadily from 96.96% to 99.12%. This improvement was a result of focusing on where improvements could be made using data from the AOI inspection reports.

Figure 2 shows an example of Biamp's product yield data. The top five defect boards are all products still in development.

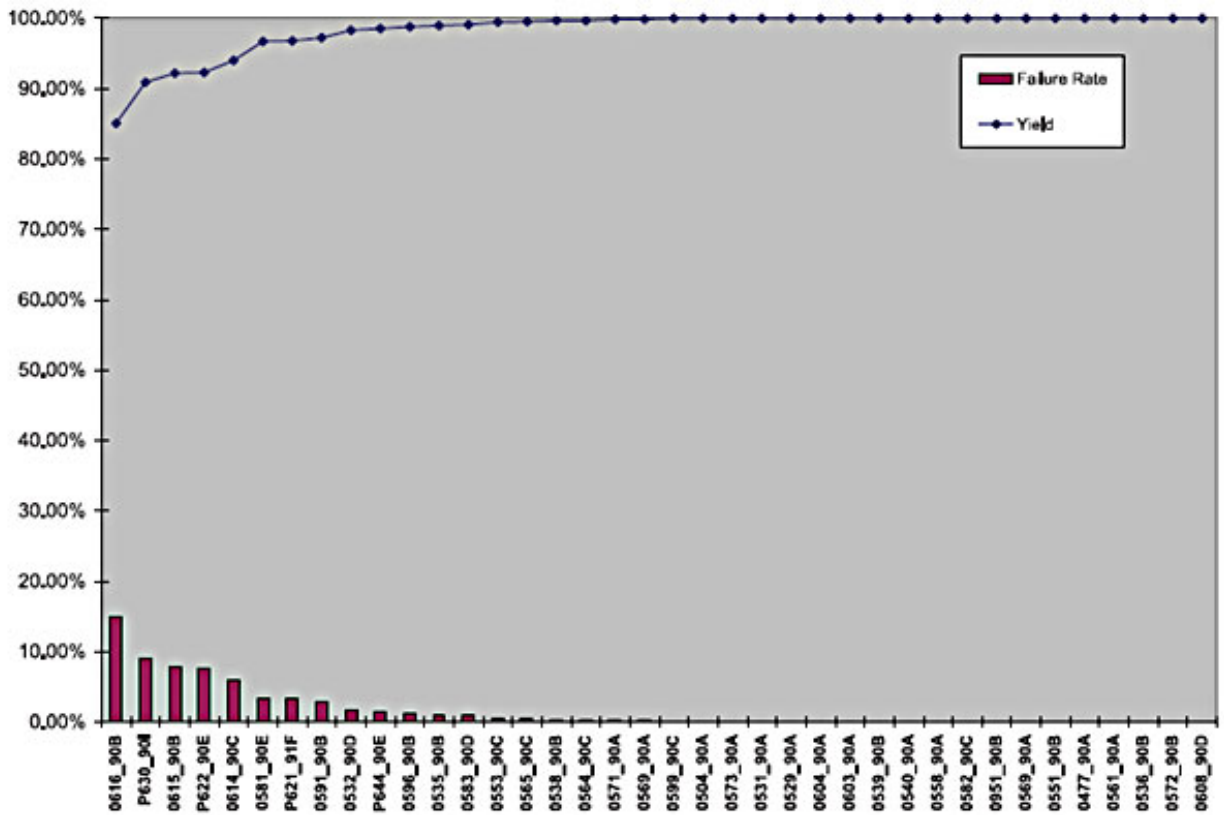

Figure 2. Biamp AOI Product Yield Data

Although exact data for increased throughput is not available, AOI has helped reduce the amount of inspection time and rework. This helps Biamp better use its operators for value-added tasks rather than inspection. Since AOI has helped reduce inspection time and improve quality, more can be done with less people. Other advantages include automated data collection and fast, consistent PCB inspection.

The system is only as good as the program. The programmer can open tolerances to the point where the machine will pass defects. For this reason, engineering keeps control over the AOI programs, and only qualified and trained personnel are allowed to make adjustments to the programs.

About the Author

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