AOI for Process Control

The PCB industry's not-so-great escape.

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Though it's been part of the PCB industry for roughly a decade, automatic optical inspection (AOI) technology is still frequently misunderstood. In this article, I'll attempt to clear up some of the confusion surrounding this tomplex process.

The fact that AOI can fail to detect defects is troubling for those depending on expensive inspection machines to do what they were purchased to do—find flaws! Why do some defects escape detection? AOI refers to a system that contains four main components: setup, scanning, verification, and repair. Each of these stages presents an opportunity for a flaw to escape, or even to be created.

AOI: The Primary Components

Setup

Setup defines the specific part-dependent parameters that instruct the scanner to perform its inspection. The parameters defined include the areas of the part to be considered or ignored, and line width and spacing requirements.

Setup is performed by an AOI or CAM operator in manual or automated fashion using a processed part or data as the basis for defining what a part should look like. At this stage, the potential to miss flaws during scanning is introduced if improper inspection or exclusion areas are defined. If this occurs, the scanner is prevented from examining the entire part. Any flaws present in uninspected areas are missed.

A poor choice of parameters allows lowcr-than-desired line or spacing widths to be passed. Unrealistically stringent requirements also produce false calls during scanning. The operator may get used to seeing false calls, which increases the probability of missing real flaws at verification. AOI machines typically need a minimum line width or space requirement well below the actual width on the part. This machine-required setting can conflict with a customer specification, resulting in a difficult policy decision. Essentially, an AOI machine is inadequate for detecting subtle reductions in line width or spacing but is effective for detecting gross flaws.

Using corrupt data or an improperly processed part as an input to setup also causes misses. During setup, the AOI machine extracts information from the design. A full-reference AOI machine assumes this is the standard against which all subsequent parts should be compared. Only differences would be highlighted in future inspections; common flaws would never be detected. Design rule-compressed reference- (or netlist-) based machines can't detect perfect shorts during setup. Missing perfect shorts are discovered during scanning but rarely detected at verification. Common perfect shorts arc never detected.

Scanning,

During scanning, an electronic image of a part is collected through a combination of illumination-optical schemes and a sensing mechanism. The sensing mechanism output is fed into electronics that condition it and make decisions about the data collected based on criteria defined during setup. There are several opportunities for error in the scanning stage. If a flaw can't be imaged because it's too small or has a characteristic that the illumination-optical sensing mechanism can't resolve, then it will escape detection. Examples of such defects include low-profile shorts between normal-height features (for reflective-type systems) and copper height reductions (for fluorescence-based systems).

Some machines allow for manual selection of the imaging threshold, which introduces the possibility of improper execution by a poorly trained operator. In this case, most misses occur when the operator is encountering false calls caused by oxidation on copper surfaces or base line scratching on phototools (with reflective-based systems) or improperly stripped photoresist (with fluorescence-based systems). In an attempt to avoid false calls, a poor threshold selection maybe made, resulting in missed true flaws.

Assuming a flaw is properly imaged, the user depends on the system's logic to detect that flaw. Different AOI manufacturers use different approaches to perform this task, many of which have logic holes that allow escapes. Sometimes the system even fails without warning during scanning.

Verification

In verification, the operator examines potential flaws detected during scanning. Even if the setup and scanning operations are performed correctly, an escape can occur due to a verification error. Areas highlighted by the scanning machine's ink marks or brought into position by a motorized verification station or movable light beam are reviewed. Unfortunately, the machine can mark the wrong areas or bring the wrong area into view for consideration. Ink marks can also be missed. The operator may orient the part incorrectly, thereby considering the wrong area or making a bad decision about the flaw's severity. Most misses at this stage are caused by fatigue on the part of operators who must wade through numerous false calls. When a real flaw presents itself, it's often missed as a course of habit.

Repair

Flaw repair is the final stage of AOI. Even defects that are detected during successful implementation of the preceding steps can be improperly repaired, resulting in an AOI escape.

Missed flaws are also caused by handling damage, contaminants, and improper processing of the part after the AOI stage.

Progress Inhibitors

Why hasn't AOI become a process control tool in our industry? The technology has gained industry-wide acceptance as a sorting tool etched copper innerlayer surfaces. Preventing corrupted ted and good innerlayer surfaces from being laminated d together into multilayer envelopes has improved finised part yields at electrical test and dramatically reducet fabrication costs. But few advances have been made in defect prevention.

There are several reasons for this lack of progress. First, most AOI departments are located near the end of the innerlayer process. The processes that influence part integrity at this stage are numerous complicated, interdependent and, in some case: , far removed from inspection. It's often difficult to correlate what's discovered at AOI to the preceding processes. es.

Ambiguity is another barrier. AOI machines that use design rules often detect "laws as a result of several logic violations, but seldom is a defect classified properly. An example is a short that's detected as both a narrower-than-desired line width and a pacing violation because it forms an acute angle with the conductor it's shorted to.

High false alarm rates also make it difficult to use data collected by AOI machines for process control.

Various schemes have been attempted to address these issues, but none has been successful. Proposed solutions center around reclassifying the category of a flaw at verification. Human intervention is currently required for defect reclassification and cause determination. Equipment users would prefer that AOI machines be able to more accurately discriminate between different types of flaws and to more reliably classify these defects.

The lack of adequate tools has made it difficult to implement process control with AOI. Several PC-based programs have been offered in the past, but they used the ambiguous data from the AOI machine or data that had been modified through human reclassification. Because of these drawbacks, these tools were rarely used.

Conclusion

Many use the AOI system as an informal method of process control/defect prevention, but these tend to be isolated cases of severe process problems.

AOI machines that more concisely define flaws and reduce false call levels, and voice interactive systems that allow for painless process came classification, have the potential to improve the use of this technology until more effective systems become available.

An aggressive operator training program, procedural audits, and a commitment to automate error-prone system components will help solve AOI problems. FAB

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