Optimization of Detection Strategy in Electronics Assembly

Jiang Jianguo, Liu Chunyan, Cheng cheng
Computer School, Xidian University, Xi'an, Shanxi, 710071, China
jjg3306@126.com, lcy3306 @126.com, cc3306@126.com

ABSTRACT: ***The requirements of the electronic equipment in high-quality, high reliability and easy maintenance are more and more high, and, the request of the detection technology is increasingly strict, but, with the restriction of the detection capability and detection range, the single detection technology can not meet the above requirements. In order to solve those problems, the purpose of this paper is to improve the quality and efficiency of the high-density electronic circuit module. For the existing problems and deficiency of the detection technology in electronic assembly industry, the detection process is deeply researched and the combinatorial optimization algorithm is proposed, meanwhile, the optimization of detection strategy distributes the usage process of the equipment effectively and the purpose of comprehensive and cost-effective combination detection is achieved.***

KEYWORDS: ***high-density electronic circuits;single detection;combined detection;optimization algorithm***

I. INTRODUCTION

With the electronic technology and information technology being the main driving force and the digital technology being the core, the requirement of the electronic components in high-quality, high reliability and easy maintainability are more and more high. Moreover, those components needs to face complex and atrocious climatic and environment. Therefore, the reliability and security of the equipment have become a core factor in protecting the battle effectiveness of the weaponry[1].

With the development of scientific and technological, the electronic circuit module production trends to variable volume, high reliability and short cycle, the hysteresis of the detection methods and efficiency are more and more serious. Although the single detection method take continual innovation in technology, the functionality and efficiency of which are insufficient to meet the needs of the production of electronic circuits. How to optimize the combination of the existing detection technology and form an efficient, stable and accurate detection optimization strategy has become an urgent task, with this strategy, it can cope with variable production conditions, reduce the time consumed by the middle process, improve the quality and reliability of the product and meet the urgent needs of the detection.

At home and abroad, the PCB auto-detection technology has developed from the reorganization phase to the research and application phase, but the detection of electronic circuit mainly focus on the single detection technology, the combinatorial optimization technology used to accelerate the detection speed, improve the detection quality has not relevant reports[1]. For the existing detection technology problems and deficiencies in electronic assembly industry, this paper optimizes the detection process with combination the optimization algorithm and achieves comprehensive and efficient combination of detection.

II. ANALYSIS OF SINGLE-DETECTION METHODS AND THEIR LIMITATIONS

The current detection tecnology in popular are AOI（Automatic Optical Inspection，AOI）, AXI (Automatic X-ray Inspectio，AXI)[2], ICT (In-Circuit Tester，ICT) and EMScan (Electro Magnetic Interference，EMScan)[3] and so on.

A. Four Kinds of DetectionTechnology

AOI means that when it auto-detects, the camera automatically scans the PCB（Printed Circuit Board，PCB）and captures the images, then ,the detected solder joint will be compared with the qualified parameters in database, with image processing, the defects of the PCB will be checked out and displayed by monitors or marked for maintenance. The defect types that AOI can detect are elements missing, parts wrong, components offset, components polarity errors, components interchangeable, the monument legislation checking, solder insufficient, solder excessive, legs upturned, and even welding and so on.

AXI adopts cross-section X-ray detection system, and it conducts omnibearing data acquisition and detection by use of stratified cross-section scanning. The defect types that AXI can detect are solder short-circuit, bridging, solder insufficient, chips lost, components bad alignment and so on. Meanwhile, AXI has high fault coverage in the weld interface of the electronics, electrical appliances, wires and cable connector, the nondestructive detection of the kim, insurance tubes and plastic casting, specially, the invisible situation of that the solder joints set under the device.

ICT adopts the probe to replace the needle bed. It conducts electrical measurement by using electrical probe that driven by multiple motors and be able to fast-move in contact with the device pins. ICT can automatically generate the appropriate detecting procedure by directly accepting PCB design data from CAD system, which is more suitable for assembly welding detection; This detection technology can accurately measure the containers leaking, equipments wrong, parameter deviation, solder joints with solder, circuit boards to open short-circuit of the general and special components such as the resistors, inductors, capacitors, diodes, transistors, SCR, FET, integrated block and so on. Meanwhile it can accurately feedback the fault points.

The electromagnetic scanning equipment is formed by a precise electromagnetic probe arrays, and thousands of electromagnetic probes are arranged by people cross-shaped. EMScan is able to detect the magnetic field information in all directions, which has a unique spectral / spatial scanning

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feature; it can scan a frequency range for the selected region and measure the radiation situation in the whole frequency band of each spatial location to get the full electromagnetic information.

Therefore, with obtaining the complete electro-magnetic information of the normal board and fault board, compare the data of those by computer and find the abnormal spectrum, the component or circuit causes failure will be found by effective localization algorithm. So the detection efficiency in electromagnetic spectrum analysis has substantial increase than manual analysis.

B. The Limitation of The Single Detection Method

Although AOI system is powerful in detection, yet also has some shortcomings, such as limitation of detecting circuit fault and restrictions of inspecting invisible solder joint. In addition, AOI system require higher detect condition, such as when there is PCB warpage, it may be led to detect failure duo to the variation of the focus, while, the test purpose can no be met, if the detect condition is relaxed. Meanwhile, AOI determines whether the components past wrong by recognition element shape or text, the constantly variation of component type make it frequently change the components parameter, which lead to miscarriage of justice.

AXI technology is currently a relative mature detecting technology, which processes high fault coverage, usually up to 97%. The process defects are generally accounted for 80% -90%, and it can detect the invisible solder joints, but the AXI technology can not detect the deficiencies and failure of the circuit electrical performance.

ICT technology is very convenient and fast for the manufacturers of high-volume and product-stereotype. However, as the line becomes increasingly complex, the product increasingly rich and the development cycle of new product becomes increasingly shorter, the traditional circuit-contact detecting has been extremely limited, and, it is difficult to diagnose defects through the ICT and functional detecting. In addition, the increase in the number of ICT contact will lead to ICT detecting fault and the number of re-measured increasing.

In order to accurately detect electromagnetic field problem by EMScan, it is necessary to use SPICE (Simulation program with integrated circuit emphasis) model[4], but almost all of the IC are unable to provide SPICE model, EMScan will not be able to take into account the radiation of the device itself (the radiation of devices is much greater than the radiation transmission line).

Those detection methods can achieve their own specific detect effects for their respective detection object, for different circuit products, the demand of detecting are different and the commonly problem and fault type are varies. Usually, the single detect equipment does not guarantee the requirement of the detection quality and speed.

III. THE STRATEGY OF COLLOCATION

In order to improve the product quality and reliability, meet the production and detection standard of the electronic circuits, it is necessary to optimize the detection methods. There is certain complementary among various detection methods, normally, each technology compensates for the shortcomings of another technology, collocation with each other can achieve high fault coverage and low defect spread.

A. The Collocation of AOI and ICT

AOI has become an effective tool to control the production process, with adopting AOI, it can improve the yield of the ICT, reduce the labor cost of visual inspection and ICT detection, avoid that the ICT becomes the capacity bottleneck or even be canceled and shorten the ramp-cycle of the new product. While, ICT plays an important role in electrical performance which AOI can not involve.

B. TheCollocation of AXI and ICT

It can be seen from the combination of the AXI technology and ICT technology, on one hand, AXI mainly focuses on the quality of the solder joint[5], it may confirm the existence of the components, but can not confirm whether the component, direction and value are correct. On the other hand, ICT can determine the direction and value, but can not check whether the weld is acceptable, especially, the joints set under the package components, such as BGA, CSP and so on.

C. The collocation of AOI and AXI

AOI systems are used to check the visible solder joints [4], which obtain the optical image through a high-pixel camera within a few milliseconds. Meanwhile, it can check double-sided PCB on both sides quickly. AXI systems are generally used in the original that AOI can not detect, that is, the internal structural characteristics can only observe by AXI, including the solder joint shape of BGA and the fill situation of the hole in the solder joints of the plug-in component. These two technologies combined into a system (AOXI)[6] will be able to reduce the overall costs. Some sophisticated systems can even use AOI and X-ray examination the double-sided PCB at the same time; significantly increase the production rate of PCB.

The experimental results has shown the detection fault coverage of various detection methods, detect by single ICT can only detect 22% of all defects of the SMT line, with increasing AOI system, the fault coverage can rise to 46%, and then add AXI system, the coverage can reach 95%, and then increase the EMScan, the defect detection rate can reach 98% -99%. The complementary of four detect methods are shown in Fig1.

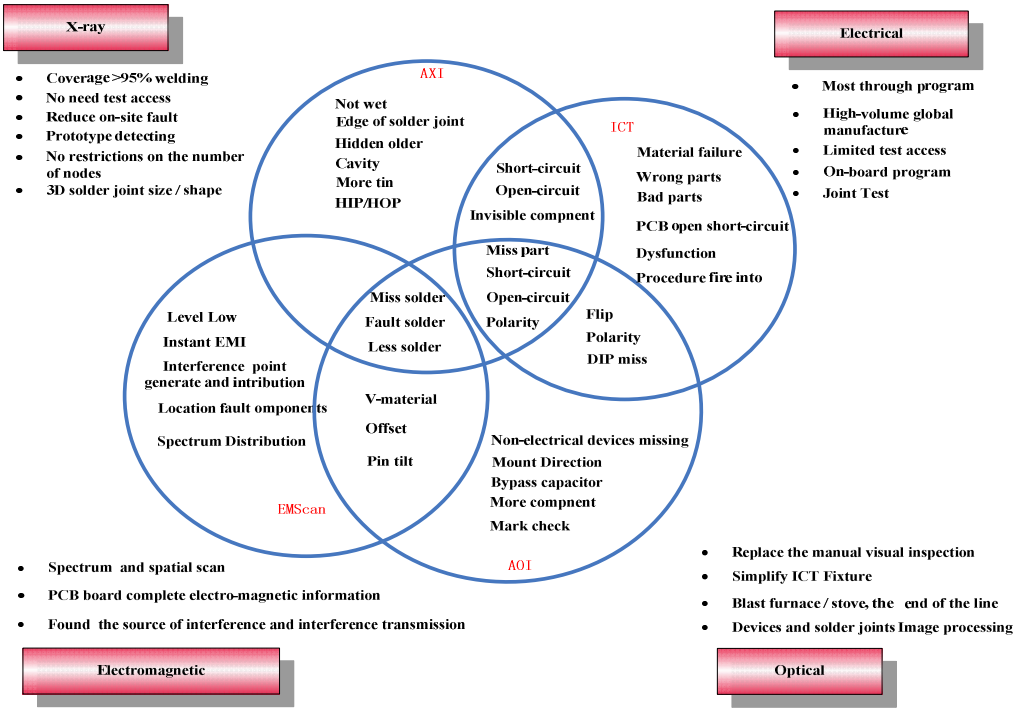

Figure 1. Complementary of AOI,AXI,ICT and EMScan

IV. OPTIMIZATION ALGORITHM

The combination strategies for the mass production stage are deeply researched in this paper. In order to obtain better detect effect, it is necessary to base on the practical and specific defects scope and deficiencies hierarchy. AOI, AXI, ICT and EMScan have certain scope of application, none of them can cover all defect spectrum, the detection process optimization is shown as follows.

- SDT (Shortest Detection Time) rule: the circuit board of short development cycle requires higher detection efficiency, SDT rules give priority to the shortest test equipment. Benefits: enable the average waiting time shortest, and obtain the maximum detection efficiency. Such as: AOI + ICT + EMScan.
- MFTC (Most Fault Coverage) rule: It is important for the high-density circuit board including a large number of advanced packaging devices to consider the additional fault coverage and electromagnetic character, such as: AXI + EMScan + AOI.
- LDC (Lowest Detection Cost) rules: For the mass production stage, the profit and cost are the factors that must be considered, in order to minimize the production cost, it is better to adopt the portfolio strategy as follows: AOI + ICT.

If the main detection objective is to improve the containment degree of the defects, then the optimal strategies should be at the terminal of the detection process. In order to maximize the capacity of the detecting equipment, it is necessary to select the appropriate detecting program.

- SPT (Shortest Processing Time) rule: give priority to the product which needs the shortest detection time. Benefits: enable the average processing time the shortest and obtain the highest utilization ratio of equipment.
- MWKR (Most Work Remaining) rule: give priority to the product which needs the longest detection time, it is suitable for the PCB of a large number that need to check after the producing. Advantages: enable waiting time the shortest and improve the utilization of the equipment.
- EDD (Earliest Due Date) rule: give priority to the product which requires the earliest completion time, it is better to adopt this rule for the product with strict delivery period, Application: make the greatest delay time (delay >= 0) the shortest, advantages: enable the product deliver in time and obtain maximum production efficiency.
- SST (Shortest Slack Time) rule: give priority to the product with the shortest relaxation time.

There are three elements to optimize the detection process of PCB: control the spread of defect, reduce the redundant detection, control the quality[7], therefore, according to the different requires of the circuit assembly quality, we can choose different combination of the priority rules. Such as: MFTC + LDC + SPT, which means, firstly, select MFTC rule to ensure that the products to be detected have high fault coverage; and in this context[8], reduce the production costs. At the terminal of the detection, it is necessary to consider the utilization and the efficiency of the production lines, if there are a number of PCB meets this condition, SPT rule is selected for choosing.

In addition, the thought of parallel detection can be considered in this optimization. Duo to the fact that if the detection objectives of the PCB are different[9], the detection process are different, and the usage of the equipment are also biased, So, in the detection process, it is benefit for the PCB in different to parallel detect by using two or more devices, and the detect results also be comprehensive analyzed. The parallel detection will speed up the detection and improve the efficiency of the production obviously.

V. CONCLUSION

Four kinds of detection technology are introduced and their characteristics, advantages and disadvantages are analyzed in this paper, the complementary and collocation among them are also summarized. The optimization algorithm of detection combination strategy in mass production stage is proposed, which ensure high quality of the products, further accelerate the detection rate, improve the detection fault coverage, reduce the costs, improve the product profitability. Furthermore, the parallel detection thought is proposed to break the limitation of the traditional detection procedures. This paper only researches four separate devices, in further research, the detection equipment can be integrated into the SMT device, with which the solder quality, the mount deviation, the faults and misplacement of the components and the checking new nozzle can be detected while conducting paste. So the system can achieve the purposes of savings equipment investment, reducing occupied space, subtracting the additional cycle time and so on.

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