Efficiently securing THT quality

Technologies and concepts for the optimal use of AOI and AXI in THT production

In the course of green energy and electromobility development, power electronics are becoming increasingly important in our environment. However, the integrated version in the form of IGBTs is not used in every case - conventional THT technology is still in use in many cases and a replacement for this component type is not currently in sight. Compared to the SMD process, the production of such mounted PCBs is much more complex and thus also offers a great deal of design freedom for assembly, handling and testing.
In the following article, based on the different types of defects on THT PCB-As, the inspection technologies are presented and their efficient placement in the manufacturing process is explained.

Considering a PCB-A with THT power electronics, its quality criteria can be divided into 3 categories: the components on the top side, the pins with solder joints on the bottom side and the barrel fill through the PCB. Here, too, a serious difference to the SMD process can be seen: the features to be inspected are formed at different production steps of the manufacturing process and, in addition, the use of different inspection technologies is required for the reliable detection of faults. The result is the need for integration of specifically configured inspection systems that are tailored to the respective production step and the types of defects to be detected.

Typically, the manufacturing process of THT power electronics begins at assembly workstations where the THT components are manually mounted on the PCB. An early automatic inspection at this process step offers the highest efficiency through a short quality control loop, as detected failures, e.g. a wrong polarised electrolytic capacitor, can be corrected immediately, and before being soldered, by repositioning without a soldering iron. Camera modules are available for this inspection task that can be mounted directly above the assembly workstation (Fig. 1) and which carry out the inspection almost without the worker noticing. Another advantage of the quality check in this production step is that if down holders are used for the PCB-A, there is still a clear view of the components at this workstation. Whereas in the subsequent steps the test objects may be covered.
Typical test tasks for component inspection in this production step are: Presence, polarity, labelling (OCR), colour as well as reading the serial number of the individual PCB.

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Figure 1: AOI module for component inspection at the assembly workstation

After the defect-free mounted PCB has left this combined assembly and inspection workstation, it can be fed into the soldering process. To detect defects in this production step, AOI systems are typically used to inspect the THT solder joints on the underside of the soldered PCB. The faults that can be detected are shown in Fig. 2: not soldered, pin not completely wetted, pin too short, missing pin (legend: 1.=PCB, 2.=pin, 3.=solder).

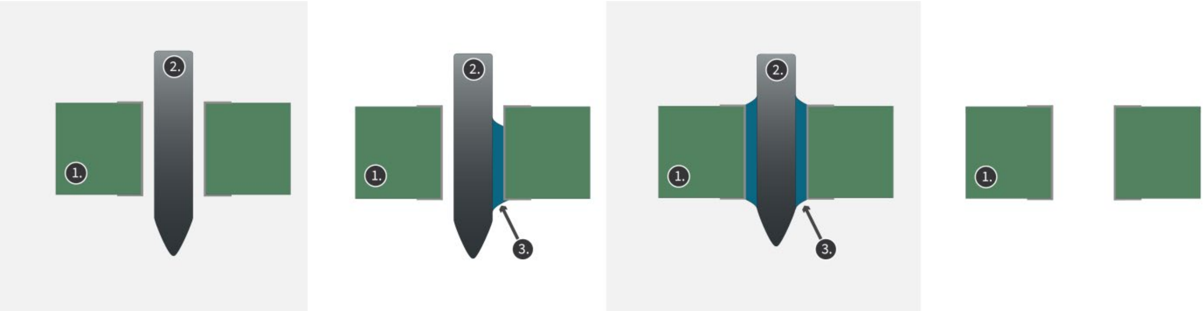

Figure 2: THT solder joint defect

Two main requirements for the AOI system can be identified from these circumstances: Firstly, it must inspect the PCB-A from below, as turning would mean an enormous additional effort, and secondly, a 3D system is necessary in order to measure solder volume and pin length.

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Depending on the process sequence, the product variety and the planned budget, the component inspection mentioned at the beginning can of course also be integrated directly into the production line independently of the placement workstation. This can be done, for example, in the manner of a double-sided AOI system after the soldering oven. The integration variant of such a system is shown in Fig. 3. However, possible disadvantages are the more costly repair of component defects as well as the possible covering of parts of the PCB-A by down holders.

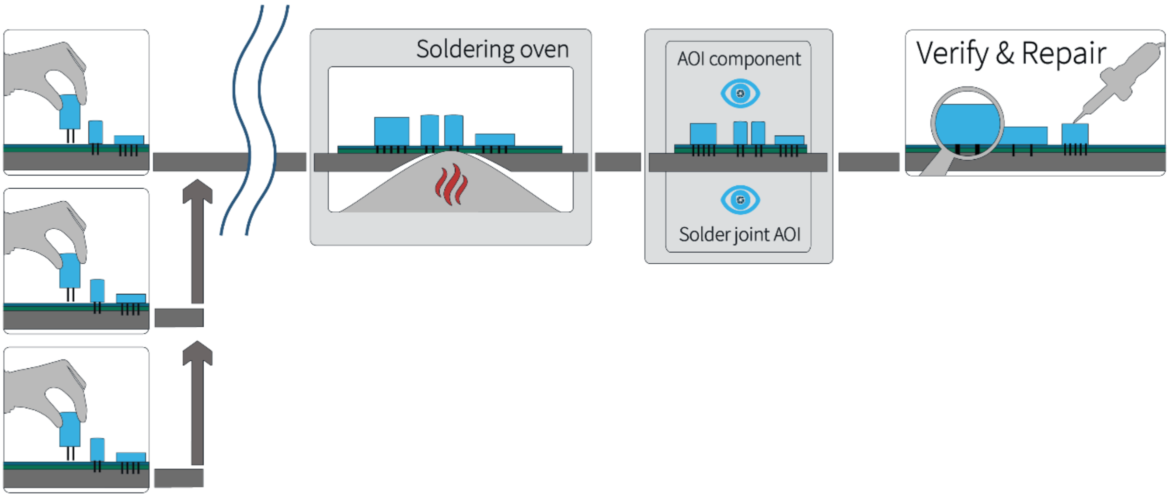

Figure 3: Component and solder joint inspection after soldering

Particularly high efficiency for the use of AOI systems in the THT process can be achieved in production lines that have a return transport of the carriers (incl. PCBs). In addition to the optimised transport sequence of the products, this also offers additional possibilities for the integration of optical inspection technology. For example, two AOI modules can be integrated in one housing in front of the soldering oven in the production line to save space. Detected component defects can be redirected and repaired "cold" before soldering. In this case, the solder joint inspection takes place in the same basic system with a time delay in the lower return transport of the PCB-A (Fig. 4).

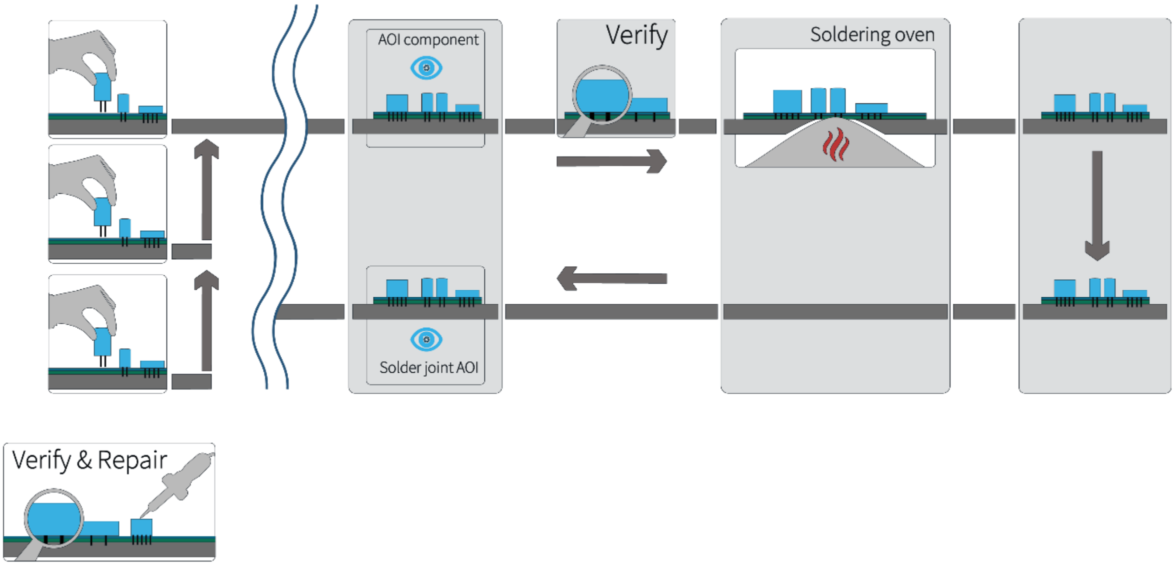

Figure 4: Component and solder joint inspection at different transport levels

These integration options are possible with the THT Line 3D AOI system (Fig. 5), which offers configuration options for different AOI modules in both the upper and lower transport module. Thus, different inspection programmes can be executed simultaneously with the system. Depending on the requirements, orthogonal inspection modules with or without angle view cameras as well as 3D measurement modules are available.

Figure 5: 3D AOI system for component and solder joint inspection of THT PCB-As

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The integration of verification and repair stations contributes to the efficiency of the overall process in a way that should not be underestimated. In conventional arrangements, these are often located directly behind the respective inspection system. Even though in such a case the evaluation or further processing of the PCB-A takes place immediately after the AOI inspection without any loss of time, this approach also has some disadvantages: For example, an additional person is necessary for the verification at this central point or "jumpers" from the respective assembly stations are utilized for this task. Both cases are associated with an expenditure of resources.
A solution for reducing these expeditures is a decentralised verification of the faults detected by the AOI systems from the respective manufacturing steps for all lines. This is possible by presenting the faults from the currently inspected PCB-A at the workstation. The PCB-A remains in the AOI system or on a subsequent conveyor module until the complete classification of all faults has been carried out "remotely". Only then is it transferred to the next process step along with the inspection result (pass or fail). In addition to saving resources, this kind of decentralised classification, which can now performed by the assembly station operator, has a learning effect that is very valuable for continued quality improvement, since with this concept each operator is presented with their "own" errors (Fig. 6). The PILOT Connect communication system offers such convenient verification via an Ethernet connection to the respective position in the production line. Depending on the existing line control system, a faulty PCB-A can then also be transported directly to the respective workstation for rework.

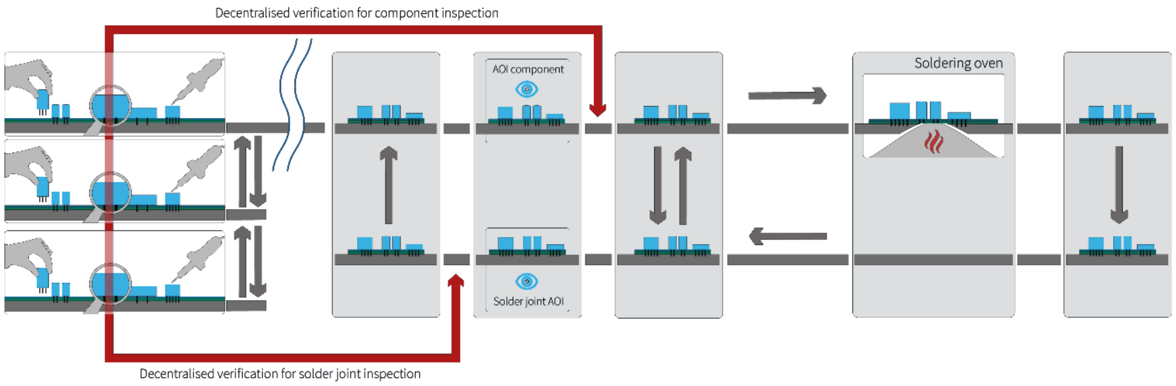

Figure 6: Decentralised verification of component and solder joint defects

The types of faults described so far are are features that are visible on components, pins or the PCB-A. However, the third quality criteria, which evaluates the solder filling from the bottom to the top of the PCB, is critical. Especially in the automotive sector or in safety-relevant applications, this measurement is often an important quality requirement. Figure 7 shows this defect in comparison to a correct example (legend: 1.= PCB, 2.=Pin, 3.=Solder, 4.=Required solder filling).

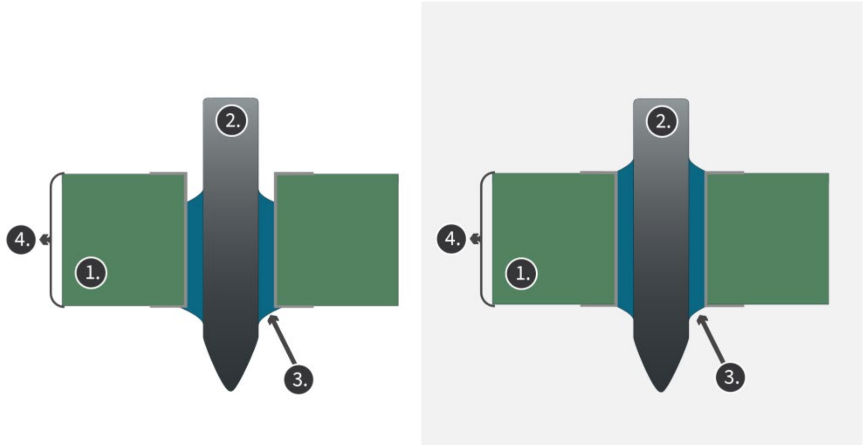

Figure 7: Solder filling at a THT solder joint

With AOI inspection, neither 2D nor 3D technologies can be used to reliably measure the solder filling. The only remedy is the use of X-ray technology. But even with this method, an analysis must be performed to determine whether a required measurement is possible with the chosen technology and what limitations there are. A pure 2D X-ray system is not able to determine the filling of the solder so precisely that a statement according to the requirements (e.g. min. 75%) can be made reliably. X-ray systems with tilt view offer the possibility to get a view of the filling level of the solder joint; however, this can prove to be difficult, especially for connectors with a high number of pins, since overlaps with closed pins are to be expected. In addition, this method results in an increased effort for the test program generation, since the imaging method causes perspective distortion and thus CAD data for the PCB-As cannot be used for the automated program creation. Optimal results for measuring the solder filling, on the other hand, can be achieved with a 3D-AXI system (Fig. 8). Due to the standardised view of the solder joints in the X-ray image, pre-defined inspection functions can be used, which greatly reduces the programming effort. The evaluation of the solder filling in individual layers also guarantees an exact measurement of the fill level as well as the detection of voids.

Figure 8: AXI system for measuring solder filling at THT solder joints

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In conclusion, it can be summarised that the secure and efficient quality assurance of THT power electronics places complex demands on the inspection systems in terms of technology and flexibility. In addition to this inspection technology, the integration of verification and repair stations also plays an important role. For process planning, the suppliers for handling and inspection technology should also be involved at an early stage in order to jointly develop the optimal line concept.

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