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RESEARCH ARTICLE

Optical Examination of Pin Insertion Process

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Abstract

In the electronics industry compliant pins are gaining ever more prominence mainly in the automotive industry. In this paper, a new, dedicated optical pin insertion process control method is described. Using a specific automatically synchronized video recording technique, the elimination of the components of a moving mechanical system and minimization of the number of cameras is demonstrated. A simple algorithm is given for the selection of the appropriate pictures for inspection and for pin detection. The reliability and the accuracy of the method and the experimental system are also demonstrated and proved. Significant reduction of failure rate was demonstrated.

Keywords

press-fit pin · compliant pin · automatic optical inspection (AOI)

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1 Introduction

Nowadays, the largest sector of electronics manufacturing which receives the most special attention is the automotive industry. Quality, reliability and environment protection, as well as the sales figures, are significant indicators of this segment. Because of these parameters and the influence of price competition in the market place, innovations in new assembling technologies can be observed from time to time.

On the other hand, to meet the lead-free standards required in the pin insertion process, use of compliant pins (Fig. 1) (also known as press-fit pins) is an enduring alternative [1]. Due to the compliant part of the pin (Fig. 2) – which is slightly larger than the diameter of the through-hole – for assembling purposes, solder alloy is not required. The established connection is resistant against mechanical, thermal, climatic, and atmospheric effects [1]-[2].

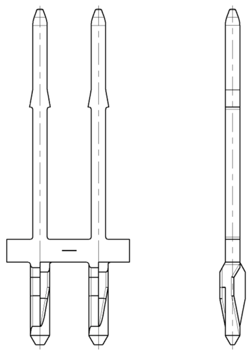

Fig. 1. Example of a compliant pin [3]

2 Assembling technology of compliant pins at a glance

Press-fit pins are usually shipped in reels and inserted into printed wiring boards (PWB) by means of insertion machines. Insertion machines can contain more than one insertion heads to increase the number of different types of pins that can be inserted by a single machine.

Even more flexibility is given by rotary insertion fingers which can apply pins at different angles thus eliminating PWB rotation.

For the highest quality of assembly, the higher quality inser-

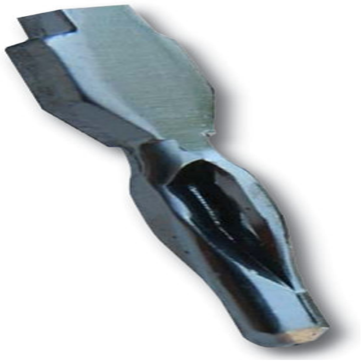

Fig. 2. Compliant part of a press-fit pin

tion machines can be fitted with penetration sensing and/or the ability to measure electrical continuity. Both methods are used for real time verification of the insertion process.

3 Existing inspection possibilities for assembled press-fit pins

In some cases when the previously mentioned verification methods are not adaptable, Automatic Optical Inspection (AOI) would be the best choice to achieve the quality requirements of assembly.

For press-fit pin inspection, for example Automatic Placement Inspection Machines (API) or Universal Automatic Optical Inspection Machines (UAOI) can be used. The main difference between the two machines is their field of applicability. UAOI machines can be positioned following the paste printing, placement or solder reflow; API machines can only be placed after placement.

With both machines the same lighting method and image processing algorithms can be deployed to detect missing or deviated pins. To take full advantage of the production line, the obvious solution is to use top viewed orthogonal cameras to detect failures (Fig. 3).

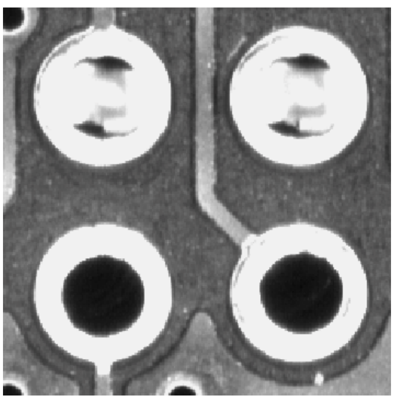

Fig. 3. Top viewed perpendicular images of compliant pins

In the usual build-up of inspection machines – where the illumination and image capturing system is placed above the object to be inspected – for underside inspection of compliant pins (Fig. 4), PWB flipping is required. Therefore a flipping station has to be positioned in the production line before API or UAOI.

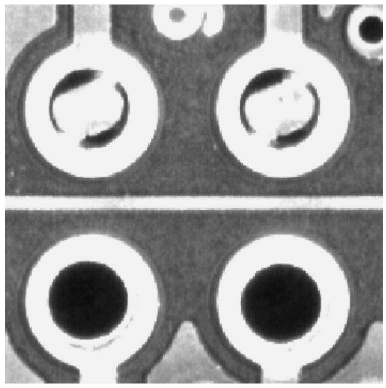

Fig. 4. Bottom viewed perpendicular images of compliant pins

For presence, absence and reliable deviation detection with angle viewed cameras of API or UAOI, at least two different images are needed which requires extensive distance PWB movement to be carried out. Numerous PWB positioning inevitably results in an increased cycle time hence this inspection method is not feasible.

Advantages and disadvantages of the introduced inspection technologies for press-fit pin inspection are summarized as follows:

Advantages:

- The required technology is available in store.
- It is existing, proven hardware with well-known testing algorithms.
- The possession of ‘know how’.

Disadvantages:

- Expensive.
- In-line inspection requires increased investment into more inspection machines.
- Robust machines, with less mobility.

4 Proposed automatic optical inspection method

4.1 Design considerations

The goal of our development is to produce a cheap, lightweight, mobile, in-line, automatic, reliable and traceable inspection system dedicated to inspection of press-fit pin insertion, which is fast, not product-specific and easy to use.

Mobility and lightweight construction is achieved making use of the inherent capabilities of the production line. Each insertion machine is followed by a conveyor. The movement of the PWB on the conveyor can be used as a translation stage. By using this method movement mechanics and heavy, robust build-ups are not needed.

4.2 Scheme of the automatic optical compliant pin inspection system

Our automatic optical compliant pin inspection system (PinAOI) consists of three main parts:

- The most important part of PinAOI is the illumination system which is located under the conveyor belt and under the printing wiring board.
- The image capturing system is located above the conveyor belt.
- The personal computer, the main controller unit.

4.3 Image capturing and illumination system

Images are captured by an Imaging Source DMK41BF02 FireWire CCD monochrome camera.

For adequate homogeneous illumination a LED-based lighting unit was made (Fig. 5) consisting of 484 red LEDs in a component size of 1206, and a clouded sandblasted plexiglass.

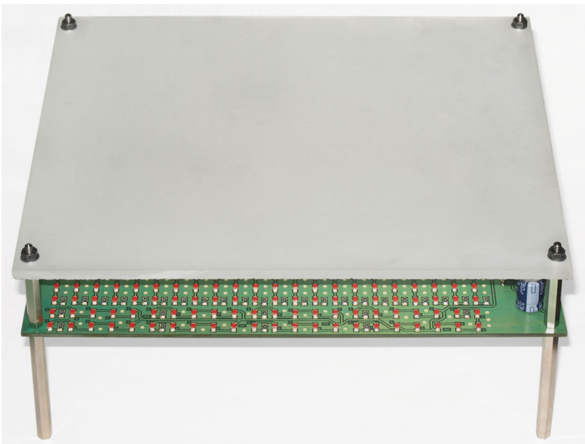

Fig. 5. LED-based lighting unit

The LEDs are controlled by an optical gate which detects the arrival of a printed wiring board.

4.4 Software

The block diagram of the control software can be seen in Fig. 6.

After program startup, parameters are loaded into the main program by the "Camera handling" module and then the "Monitoring" module is started.

As soon as a PWB arrives, images are taken by the "Capturing images" module. Around 20 frames (Fig. 7) are acquired during the movement of the PWB.

Images of the connectors to be inspected are redundantly preset in the captured 20 frames, but there is only time to analyze two or three images of the captured ones, therefore the most relevant images are selected (Fig. 8)

The relevant three frames are selected based on the fiducial points. Using the coordinate system which is set up by the fiducial points, the pins of the connectors can be easily localized in each picture.

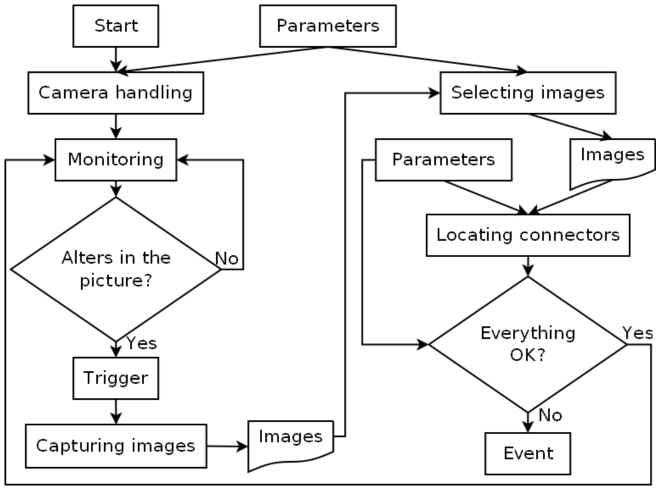

Fig. 6. Block diagram of the control software

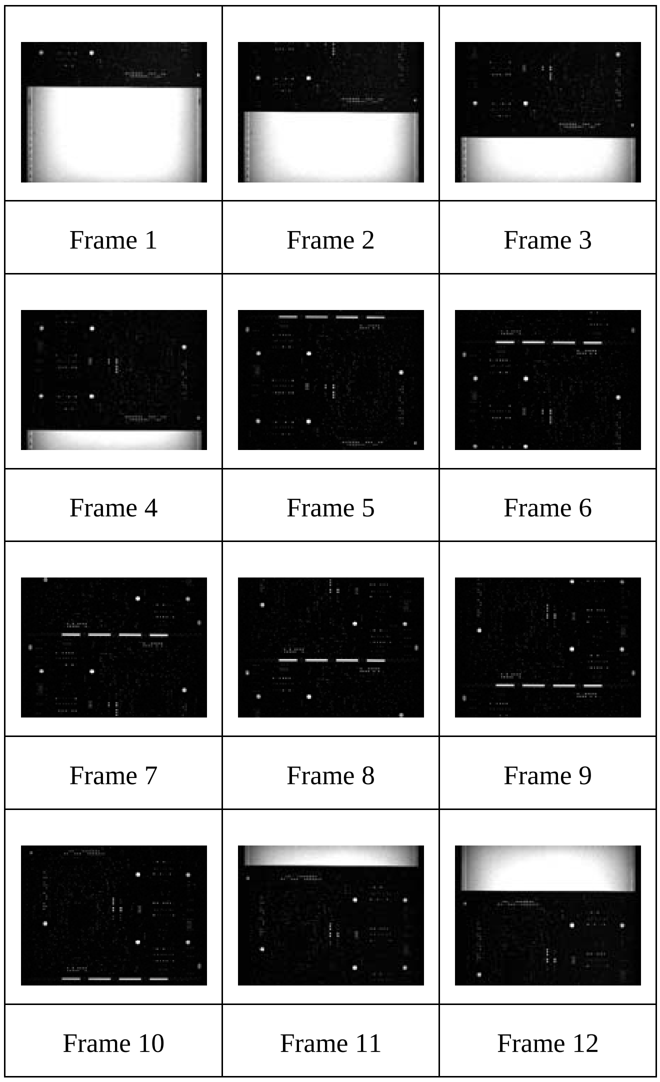

Fig. 7. Example frames about the movement of the PWB

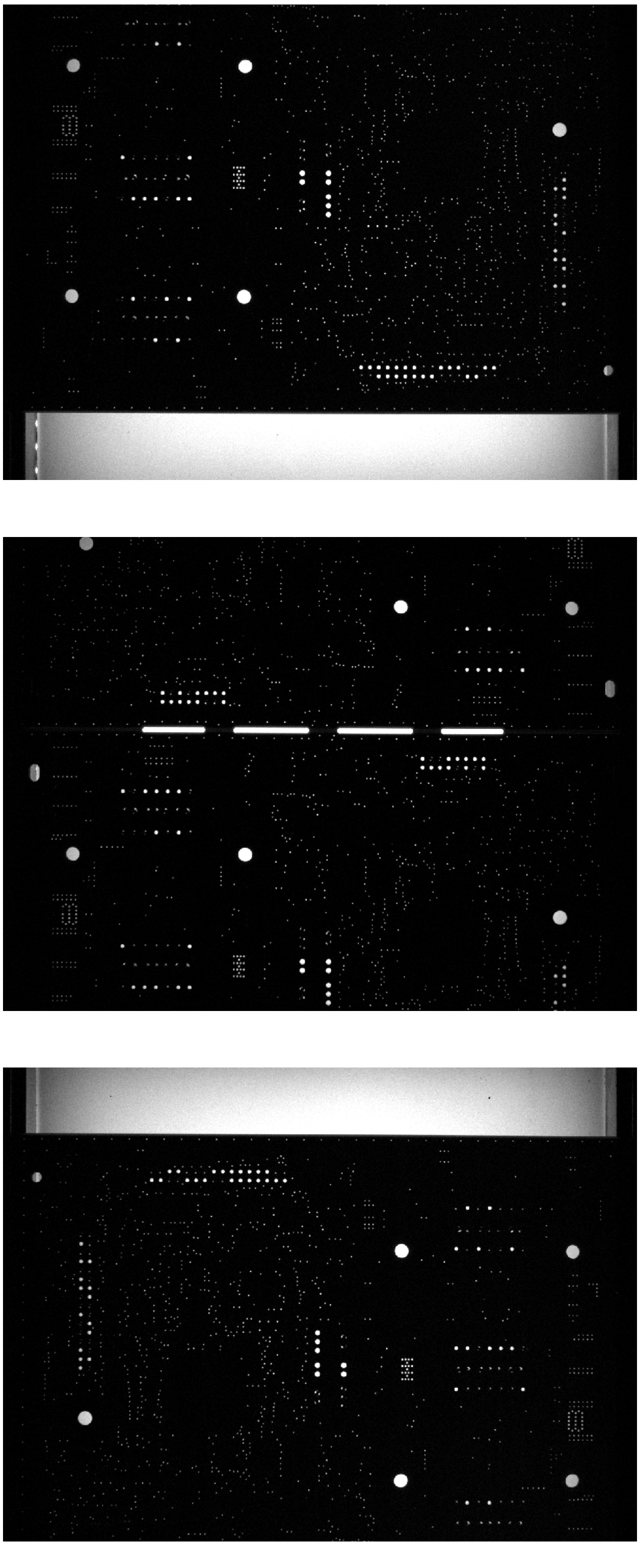

Fig. 8. The most relevant three frames

To enable the detecting of the presence of the pins, the pictures are binarized. The next step is to count white pixels. If the number of white pixels exceed a predefined threshold, this means that there is no obstacle to the path of light (especially in the through-hole) thus the pin is missing (Fig. 9). The image processing algorithm was developed using Matlab.

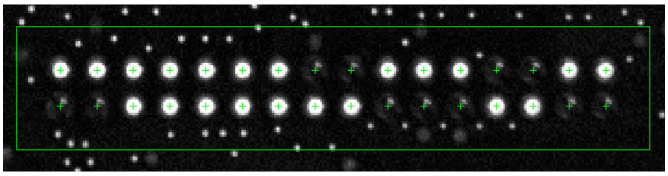

Fig. 9. Example of a connector after examination

4.5 Hardware realization

An experimental setup of the PinAOI system was set up on an Asys conveyor (Fig. 10) in an automotive factory.

Fig. 10. Experimental setup

5 Experimental results

Our experimental system was used to detect missing press-fit pins.

In a three month period without PinAOI, the manufacturing line (with a capacity of 4800 pieces of PWB per day) produced around 120 faulty units which were revealed only after the FT (Final Test).

Applying our PinAOI, also in a three month period on the same production line, the number of non-functional units decreased to only 10 pieces. These units had also been revealed after the FT.

In other words, by using the PinAOI system the original 278 ppm fault rate of the production line was reduced to 23 ppm only, the non-fuctional units from 120 to only 10 (Fig. 11).

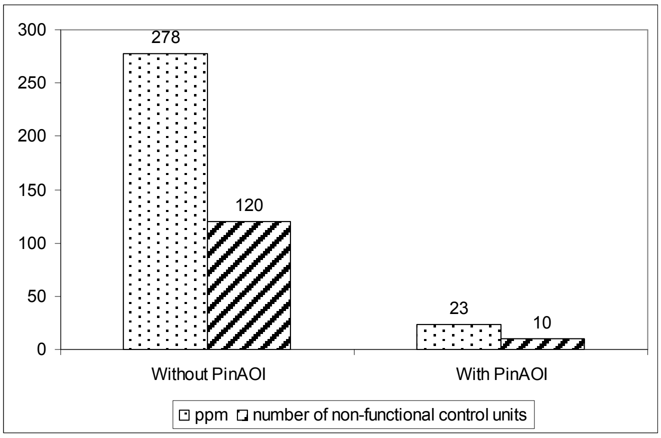

Fig. 11. Alters in ppm and the number of non-functional units

6 Conclusion

In this paper, a new optical pin insertion process control method is described. In addition to the typical and standard advantages of such an automatic optical inspection system, our method fully eliminates the components of a moving mechanical system and minimizes the number of cameras. A simple algorithm is given for the selection of the necessary pictures for inspection from an automatically synchronized video recorder. The reliability and the accuracy of the experimental system has also been demonstrated and proved.

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