Agilent Process Control Software (APCS) for SP50 Solder Paste Inspection (SPI)

White Paper


This paper addresses the issues that SP50 solder paste inspection (SPI) is facing and how the Agilent Process Control Software (APCS) can be used as a defect prevention tool to strategically feedback output data into the paste printers. This software can be of great help as most of the SMT defects (60 to 70%) are due to solder paste printers.

Solder paste inspection measures the height, area and volume as well as both X and Y offsets to determine the quality of the printed solder paste. While utilizing this information provided by the machine, the APCS can be used to monitor the upper and lower threshold parameters set by the user to determine the result of that particular deposit. Besides that, it can also assess the quality of a single paste printer by determining its process capability ($C_{pk}$) in the event of any abnormality resulted from the printing process. To sum up, the APCS is a process control methodology for the solder paste printers.

Limitations on the current APCS will be acknowledged in this paper to help improve the current software and to make it more user-friendly as a process control software.

The APCS is a process improvement tool which is designed to help manufacturers improve manufacturing process through real time intelligent data collection by the SPI systems. The data collected provides users with the tools necessary to implement closed loop strategies, user defined alarms/charts and manufacturing reports.

APCS encompasses:

- **Inspection Data Storage** in each SP50 machine. It is always on.
- **Process Dashboard** is the GUI for APCS and it runs either on the SP50 machine or on a remote PC
- **Process Monitoring** which is the near real time alarming system
- **Process Review** which offers charting features and data drill down for SP50

The SP50 uses 3D inspection to detect problems with paste deposit height, area, volume, and location. By using the APCS as a process control tool, it helps the user to determine the cause of defects and the action required to eliminate or minimize the problems.
Solder Paste Inspection

Paste inspection process

For paste inspection, boards are never actually repaired after paste printing as compared to component inspection where a review of boards is done and this takes place offline. When a bad board is encountered during paste inspection, there are two choices:

- If the print quality is poor, then board is scrapped (or cleaned to be used again)
- If the inspection results are marginal, board can be released downstream based on the operator’s experience that good joints will be formed.

Process control for solder inspection

- Paste Printer
- SPI
- Inspection Report Files (REP)

*Figure 1. Process Control for Solder Paste Inspection*

Data input

As seen in Figure 1, the SP50 stencil gerber will generally be taken as an input although ECAD can be used where proper deposit naming is required. Paste inspection programs are usually created using a CAD preparation tool.

Data output

The SP50 produces three types of files:

- REP file (per inspection report)
- Errors.log (summary of all errors detected)
- Error images

For solder inspection, the process control loop is significantly shorter than that of component inspection. Solder paste inspection is about control of a single machine with two squeegee directions.
APCS as Defect Prevention for Solder Paste

Requirements

- CPI folder – For APCS to import data from SP50, the CPI folder for that machine must be shared with Read and Write permission. If only Read permission is set, APCS is able to view the inspection data being generated but will not be able to load it into APCS.

- CAD programming for SP – The files required to generate a *plx file are stencil gerber and ECAD files.

- Repair – The error.log file will have the false fail and the true fail results.

Process review for SP50

Understanding zones

For SP50 data, inspection results are presented in a grid form where the inspected board is split into default 5x3 arrays. Each grid layout (or zone) shows the average data for that entire area of the board and can be changed per product. The inspection data is displayed in zone format to make access to large volume of paste inspection data more manageable. Zones are marked according to the scheme shown in Figure 2 with Zone 0,0 being the lowest left corner of the board.

Controlling Worst Chart Display

Process review can display paste inspection data using two modes:

- Attributes
- Measurements

For attribute mode, the Worst Chart Display shows a grid of C-Charts which are control charts that clock error counts. Each chart shows the number of errors produced in each zone.

For measurement mode, it allows the user to visualize three aspects of the paste layout which are the height, area and volume. Measurement data can be viewed as Mean or Sigma (standard deviation).

Figure 2. Zone view for process review
Each of the zone charts can be left mouse clicked on to drill down to a more detailed view of the inspection data. The Worst Chart Display itself does not display the board graphic, thus the user has to click on zone to get Board Graphic displayed for the particular zone as shown in Figure 3.

![Board Graphic for process review](image)

Each deposit in the Board Graphic can be clicked to drill down further to the paste inspection data. This final view shows the selected measurement variable (the paste deposit – Reference Designator) history and the measurement history for the deposit type that the Reference Designator belongs to.
Customizing charts

The APCS offers charting features where users can perform chart customizations according to their preferences. The charting options that comprise frequency, XS, control and pareto charts can be seen in Figure 4. Data can also be viewed over a selected timeframe depending on live or historical settings.

*Figure 4. Charting features*
Limitation

There are few enhancements that can be implemented on the current APCS to make it more robust for users to monitor solder paste printing.

1) X and Y offset

The current limitation of the APCS software is that it does not incorporate X and Y offset measurements which is critical in lead-free environment. Often these offsets should be able to feedback to the user to adjust the offset until it reaches the user specification’s print offset tolerances. When the process falls within the tolerance, then APCS can be used to monitor the print offsets on the SPI.

2) First Pass Yield (FPY) in pre-reflow inspection

A FPY is a good indicator of overall process line performance and process monitoring tool. This chart will help the operator or process engineer to take action if the FPY is out of control.

3) Process capability

There are four variables that can cause the process to be out control; man, method, material and machine. The changes on this variable can improve the process or the other way around. That is why we need capability that can assess the process or machine. A simple way is through the calculation of capability coefficient:

\[ C_{pk} = \text{Min} \left( C_{pu}; C_{pl} \right) \]

Where

\[ C_{pu} = \frac{\text{USL} - \bar{x}}{3\sigma} ; \]

\[ C_{pl} = \frac{\bar{x} - \text{LSL}}{3\sigma} ; \]

\[ \bar{x} = \text{mean value} \]
The current software only displays paste inspection data using two modes:

**Attributes** – the *Worst Chart Display* shows a grid of C-Charts which are control charts that clock error counts. Each chart shows the number of errors produced in each zone.

**Measurements** – it allows the user to visualize three aspects of the paste layout; height, area and volume. Measurement data can be viewed as Mean or Sigma (standard deviation).

A further improvement on data collection is needed for users to understand the whole process of the solder paste printing machine. In particular, the X and Y offset is critical for lead free solder paste because the slightest offset of the printing can cause failure.

A simply measurement is needed to measure the capability of the machine which is Cpk. This is to help users measure the performance of the paste printing machine.

**References**


[4] Zhen (Jane) Feng, Ph.D., Alex Garcia, Thomas Munnerlyn, Walid Meliane, Scott Kingery, and Murad Kurwa, “Solder Paste Inspection Study with SPI and AXI”

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