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BETTER PRACTICES IN IMPLEMENTING PB FREE ASSEMBLY

SOLDER PASTE INSPECTION - ORGANIZE THE PIECES

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Solder paste inspection - organize the pieces

Countless publications and examples are available showing the various benefits of doing 2D and/or 3D solder paste inspection to control print processes and eliminate or identify paste printing errors. Most companies and people agree that an inspection plan of some sort is a must in today's manufacturing arena with challenging chip scale packages (CSP's) and devices down to 0201's.

However, one of the biggest problems with developing a use model for solder paste inspection (SPI) is that each process has it's own set of variables to be considered when developing a robust process and subsequently controlling that process. A common difficulty found in the industry for SPI is that users want a formula or process control model to use to establish a successful SPI plan. Unlike electrical test and other pass/fail testing strategies the SPI use model is very user specific and requires work up front, by the SPI user, to establish the best process control methods.

This article serves to outline a methodology, or thought process, that can be used to successfully implement SPI. This methodology helps with identifying the SPI use model and for moving forward with sensible and robust implementations of SPI inspection plans.

Stacy Kalisz Johnson
Agilent Technologies
Gilbert, AZ, USA
stacy_johnson@agilent.com

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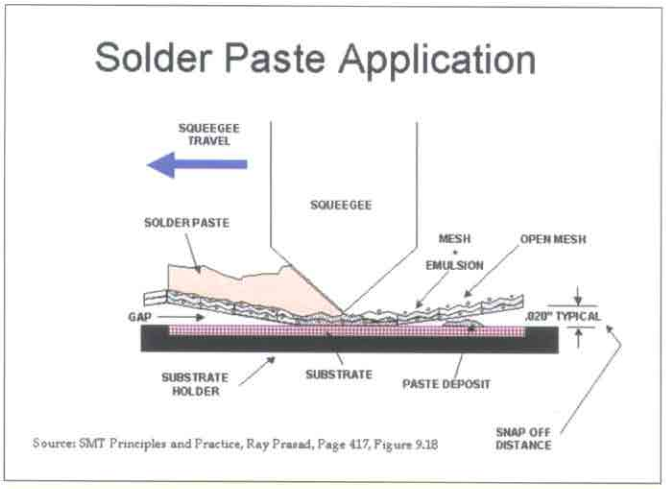
Introduction

The solder paste printing process can be illustrated in one picture as shown in *Figure 1*. If the individual variables that contribute to the simplified illustration of the process in *Figure 1* are actually considered, the paste printing process unravels into a very puzzling process to master. Despite the fact that the solder paste printing process has been around for several decades, it is considered a black art[1], rather than a science, by some.

Understanding any process begins with understanding the contributing variables. There are many factors that affect the quality of solder paste printing. The main factors can be found in *Figure 2*. These factors, unlike some processes are inter-related and affect one another. Therefore, establishing a robust solder paste printing process is a puzzle that can be assembled one piece at a time.

The solder paste printing process is comprised of eight pieces. Understanding and managing these categories will produce an optimum print process:

- People
- Environment
- Printed Circuit Board (PCB)
- Screen Printer
- Stencil
- Squeegee
- Solder Paste Material
- Print Parameters



Source: SMT Principles and Practice, Ray Prasad, Page 417, Figure 9.18

Figure 1. Schematic illustration of the solder paste printing process[2].

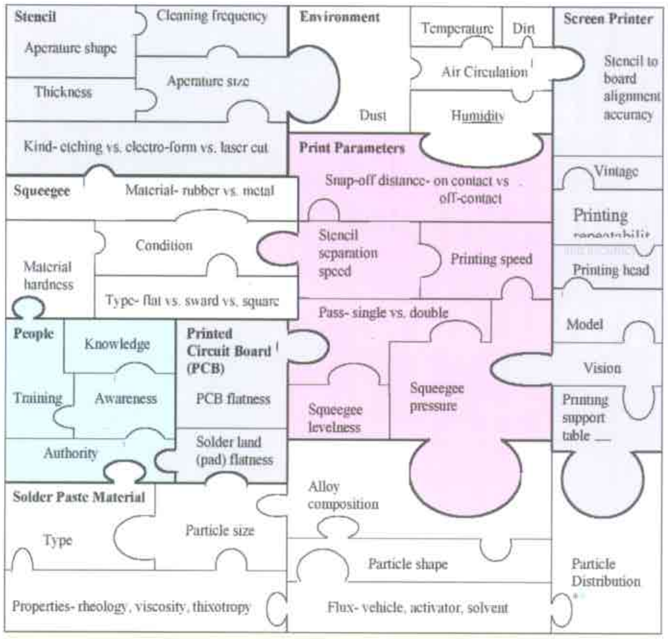


Figure 2. Solder Paste Printing Variables [2, 3, 4, 5, 6, 7, 8, 9].

The reality is that some of these factors cannot be managed by a process engineer or can only be impacted in a limited way. For example, the process engineer will only have limited influence over the people involved with the process. Most likely, the process engineer will not be able to hire new people to support a process but rather will have to work with existing staff. The process engineer could (and should) make every effort to educate and train all level of operators, technicians and other engineers associated with the process in order to achieve the best process results however, reality is the overall impact will not be controllable, consistent or measurable. Chances are, the factory will have a predefined environment and although a process engineer can recommend changes to the cleaning procedures, humidity or temperature control; most likely the environmental conditions will be out of the control of the process engineer.

The PCB design usually happens further upstream and will not be influenced, in most cases, by the process engineer. Therefore the engineer must work with what crosses his or her line. In an ideal situation a process engineer will be able to evaluate and choose a screen printer specifically for a product but in most cases, new processes require the use of an existing screen printer or of a standard printer that has been evaluated and incorporated company wide. Generally speaking, the same applies to stencils, squeegees and solder paste material. Standards are usually developed through prior studies, vendor recommendations, manufacturing technology task forces, etc.

These recommendations may change over time but extensive experimentation and evaluation of these parameters is unlikely when rolling out a new process. In fact, many factories develop processes in one location and transfer the equipment and materials set with the new processes. Therefore, the path of least resistance with maximum impact, minimum cost of evaluation, overall benefit for a company and specifically a process engineer is to optimize the print parameters. Recommended print parameters may be available when a process is established or transferred but other line and factory specific variables will impact these parameters therefore, they need to be optimized for each line. The results obtained from solder paste inspection can be used to evaluate, measure, baseline and characterize the print parameters.

Ask the right questions

A misconception in the solder paste inspection (SPI) marketplace is that once an SPI system is purchased, process control can begin. Partnering with the SPI provider and spending time to evaluate the process the SPI will be monitoring is the first step toward achieving process control. Study the process by asking and answering the following questions about your process:

- What are the contributing variables?
- Which of these can be controlled?
- Which of these will your factory allow you to change?

The answers to these questions cannot be supplied by the SPI supplier. These are product specific, company specific, line specific, etc. However, by understanding what options are available, studies can be done to establish baselines, solidify optimums and begin the process control process. The user will know what processes and variables to control.

Therefore, once the questions are answered, the following course of action is recommended.

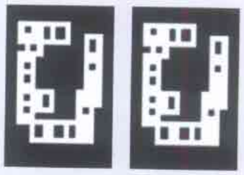
- Run screening experiment(s) with those variables.
- Use data to identify how the variables impact the process outputs.
- Solidify optimum or baseline settings.

Identifying the critical variables, studying them and using the data to verify the optimum settings to yield good parts (or establishing a process baseline) will be the first step in SPI implementation. The SPI system can be utilized to assist with identifying the baseline, without it a true baseline would be difficult to establish. Once the baseline is established a method for root cause or assignable cause analysis when an SPI flagged error occurs can be easily implemented.

Examples

After the baseline or optimum print parameters are established (i.e. the process is characterized), errors that solder paste inspection (SPI) flags can be methodically eliminated. For example, after printing solder paste the SPI system flags printing errors *(shown in Figure 3A)*. Something of note is that the blue and green errors are height and volume respectively. Therefore, in this instance the errors, which could result in defects downstream (post-reflow or even later in the process cycle, or even worse at a customer site), would have gone unnoticed had 2D only inspection been in place.

Figure 3A Before.



Pad paste pattern from SPI equipment interface.

Figure 3A Before.

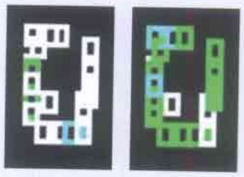


Figure 3. Example 1, effectively using printing baselines and puzzle method to find assignable cause.

After identifying this error the first course of action is to verify that the baseline settings on the printer are untouched *(i.e. pink puzzle piece in Figure 2)*. Once the printer parameters are checked

Figure 4A: Before.

Figure 4B: After.

Figure 4. Example 2, effectively using printing baselines and puzzle method to find assignable cause.

the other printer related item that can be checked is squeegee levelness. In this instance, the squeegee levelness was checked and re-seated and the after image *(Figure 3B)* shows that the paste errors have been eliminated.

Another example from a baselined process is shown in *Figure 4*. The bad print was flagged for area, height and volume errors *(Figure 4A)*. The errors are visually evident, as seen in this photo of the actual pasted pads *(Figure 4A)*. Upon revisiting the baseline printer parameters the print speed had been modified. When the print speed was returned to the baseline setting, the print returns to a good print (visible by eye and no error flag from SPI, *Figure 4B*).

Countless examples such as this can be given. Some cases are not easily solved in the context of the print parameters *(pink, Figure 2)* but if the print parameters are revisited and verified, with a characterized or accurately baselined process the user can then target other potential problem areas to identify what the real issue is. The reality is that errors, which could become downstream defects, failures or field returns, are not caused by any one thing. For example, too much solder volume can be attributed to incorrect snap off, high squeegee pressure, incorrect aperture design or size, a warped stencil, or a stencil that is too thick [1,4,9,10,11]. If the squeegee pressure and snap off have been optimized or baselined then two of the variables can be eliminated from consideration. Following the puzzle methodology, after defeating any contributors from the print parameters *(pink, Figure 2)*, the other areas *(i.e. puzzle pieces, Figure 2)* would be evaluated. In this example we might inspect the stencils for warpage or damage, etc. We eliminate variables until we identify the assignable cause and fix the issue.

Conclusions

Solder paste inspection (SPI) faces a great challenge because in order to effectively use SPI data, a reliable, repeatable and controlled solder paste printing process needs to be in place. However, solder paste inspection is needed to fully characterize a solder paste printing process. Allocating more time to inspection results is a good way to achieve lower defect levels [12]. SPI users should use their inspection results while studying what variables can be changed and controlled and establish baselines for those. This will eliminate many solder paste printing errors and downstream defects putting the print process in a position to accurately be controlled. Specifically, solder paste printing variables can be limited to a manageable number of print parameters that can be optimized therefore eliminating the number of defects attributed to the paste process.

Using the puzzle methodology for identifying and eliminating assignable causes will help the process engineer manage the more than 40 printing variables *(Figure 2)*. SPI users should create their own puzzle of variables, identify what can be affected, baseline, prioritize and use this process of elimination methodology to institute methods of process control. Over time the number of errors will decrease, as they are managed, inherently improving yields and saving money.

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Stacy Johnson

Stacy Johnson holds an MS in mechanical engineering from the Rochester Institute of Technology (NY, USA). During her years at Motorola Stacy worked on several package development projects. With a strong process background, Stacy transitioned to the measurement world in 1999. Stacy is currently a Product Marketing Engineer at Agilent Technologies focusing on the solder paste inspection, SP50 system.