

The Case for Upgrading the Reflow Process

by Philip Kazmierowicz

For the majority of assemblers, the solder reflow process has been free of innovation since the use of forced-air convection ovens more than 10 years ago. This status quo approach to management may have been adequate when the economy was booming and assembly capacity shortage was the order of the day. Now, however, in an industry displaying a plethora of idle lines, manufacturers must compete not just on price but also in process capability and final product quality. Hence, true upgrading of thermal processes requires not only new machinery but new methodologies as well.

Automating and using readily available and affordable solutions can yield significant gains in quality and productivity.

increase in the price of the services or a reduction in the cost of providing them.

Perfect Every Time — This can be the philosophy of small or large assemblers. The common factor is that they all share high risks (i.e., costs) for manufacturing failures for such products as airbags, pacemakers or missile-guidance systems. Thus, they spend significantly more on equipment and manpower to keep their processes controlled and to document that every product is manufactured within specification.

A Question of Quality

Several issues have surfaced recently concerning work problems at contract assembly houses. While rumors have major OEMs pulling production back to in-house facilities for various reasons, there are increasing accounts of contract manufacturers (CM) losing jobs based on quality problems. Whereas the key to survival in contract assembly had been cost cutting, in the current market a second concern has seemed to focus on quality. As a result, for a CM to stay in business it must be able to guarantee its customers high-quality work at the best price. While still a challenge, the overall task is reasonable, requiring process improvements and greater control of all steps on the line.

For example, for the solder reflow step, one may divide processors into three types:

“Just Run It” — Assemblers with this approach typically are smaller shops whose focus is simply getting the product out the door. Most do not own oven profilers, but even if they are on-line it is unlikely that anyone in house will have the skills to use them. Rather, the thermal process is checked by looking at the solder joints of the finished printed circuit board (PCB). Often, however, a significant percentage of the product must be reworked at a cost that does not appear to be as high as that for improving the process to make it right the first time.

Efficient Quality — Product assemblers in this class often are medium to large contract houses that have found that increasing quality (i.e., building it right the first time) makes sense economically. However, cost rather than quality is still king here and improvements only are implemented if they affect the bottom line favorably. This generally is manifested by an

solder reflow step. This means that for the “just run it” type, the oven is set to previously determined temperature setpoints and conveyor speeds. When the oven controller indicates that such points have been reached, production is begun. The assumption is that temperature setpoints and conveyor speeds that provided an in-spec profile in the past will do so again.

The longer since the oven was last profiled, however, the less likely it still will be in spec. Even though Efficient Quality and Perfect Every Time processors will verify the profile on a regular basis, including once a month, week, or day or even as often as once a shift, the problem with this method is that profile drift remains possible. In fact, every product manufactured since the last in-spec profile was implemented is suspect. Worse, if a catastrophic process change occurs, it is unlikely that periodic profiling will catch it. Instead, catastrophes generally are discovered at final inspection, inevitably causing some product reworking or scrapping.

For each assembler type, the problem can be defined as having two aspects: convincing a customer that the facility can produce quality assemblies and, once a contract is signed, actually producing them. The implementation of advanced reflow process technology can provide such assurances. On the cost side, it can open the way to get more out of existing equipment by increasing uptime, improving equipment use and reducing labor costs through automating certain tasks. To improve and ensure quality, continuous real-time process monitoring is coupled with a proactive statistical process control (SPC) system while additional benefits in customer relations can be realized with automated process documentation and product traceability.

Advanced Reflow Process Technology

With the majority of existing assembly facilities, upgrading the thermal process means purchasing a new, perhaps larger forced-air convection reflow oven. This is misleading. Almost all convection ovens can satisfy most process requirements if their setups are optimized, and high-quality yields can be realized if the process is kept in control. New technologies can automate the tasks required for improved equipment use, process and line optimization, continuous monitoring (vs. sample checks), SPC charting, process documentation, and production traceability. The following examines the functionality of the advanced technologies in the context of three key issues:

Process Development — The first step is to define the specifications (i.e., process window). For the reflow process, the suppliers of solder, flux, solder paste and components generally set the specs. The process window index (PWI) is a statistical tool that provides an objective means to define the specifications and determine the process’ “fit” (Figure 1).

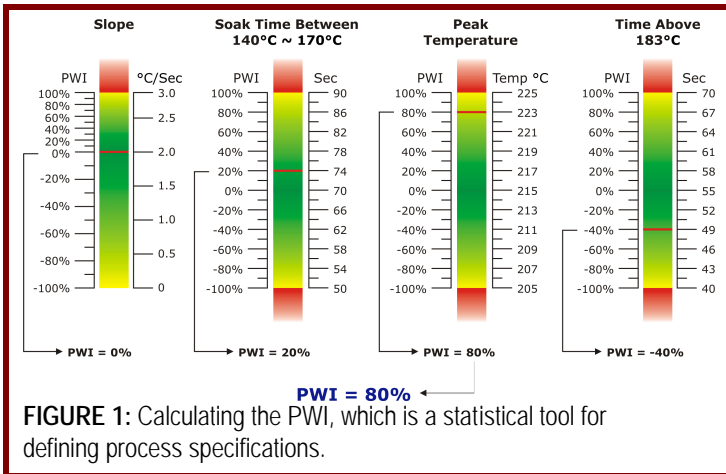


FIGURE 1: Calculating the PWI, which is a statistical tool for defining process specifications.

Once defined, the second step is to improve the process. A modern reflow oven, for example, may have a dozen or more variables, including zone-temperature settings and conveyor speeds, with a wide range of potential alternates. Manual trial-and-error methods will not identify the best setup even when performed by an experienced process engineer. This is because there simply are too many alternatives to test. The solution is to use an oven-recipe search engine, which can identify a myriad of potential oven setups, analyze their resulting product profiles and PWIs, and then automatically determine the single best setting in less than 90 seconds. The most stable process, i.e., the

profile most centered in the process window, is selected by choosing the profile with the lowest PWI (Figure 2).

Process Control (Cpk) — After setup, what does the process look like one hour or one day later? In a typical facility, nobody will know until a profile is run. A better method is required to achieve the desired results of increased quality at lower cost.

An automated reflow management system can calculate the profile with the corresponding PWI number for each product processed by the oven. It also calculates the real-time Cpk for every product. Thus, the system warns when the Cpk drops below a preset level and alarms any out-of-spec condition (Figure 3). The alarm may turn on a light tower or it may shut down the feed conveyor to the reflow oven automatically. By flagging an out-of-control process before it reaches an out-of-spec situation, the system becomes a “zero-defect” process tool. By operating continuously without interfering with production, the system provides the following manufacturing efficiencies:

- Increased production uptime
- Elimination of periodic profiling
- Faster line troubleshooting (in a yield problem situation)
- Quicker oven changeover
- Reduced cycle time

Process Efficiency — In a typical facility, the process engineer is required to define and develop the procedure, then find a way to keep it in control. This is neither the best use of skill and time nor is it cost-effective. Advanced reflow management technology, on the other hand, permits significantly improved resource allocation. The process engineer still must define the process window and production parameters, but also will be able to delegate all daily tasks to technicians or line operators.

Since process development and control are highly automated and password-protected, the engineer can be assured that production is in control. Another factor is that in the current economy, assembly facilities often experience significant employee turnover rates, resulting in increased training costs. In contrast, the automated systems described require minimal training, reducing the time and cost of that activity.

	P.W.I.	in/min	Zone1	Zone2	Zone3	Zone4	Zone5	Zone6	Zone7	Zone8	Zone9	Zone10
Original	156%	35.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0	230.0	240.0
Predicted	22%	38.0	80.0	100.0	120.0	140.0	159.6	164.3	179.4	223.7	220.3	221.9

FIGURE 2: Oven recipe search engine results. The profile most centered in the process window is generally that of the lowest PWI.

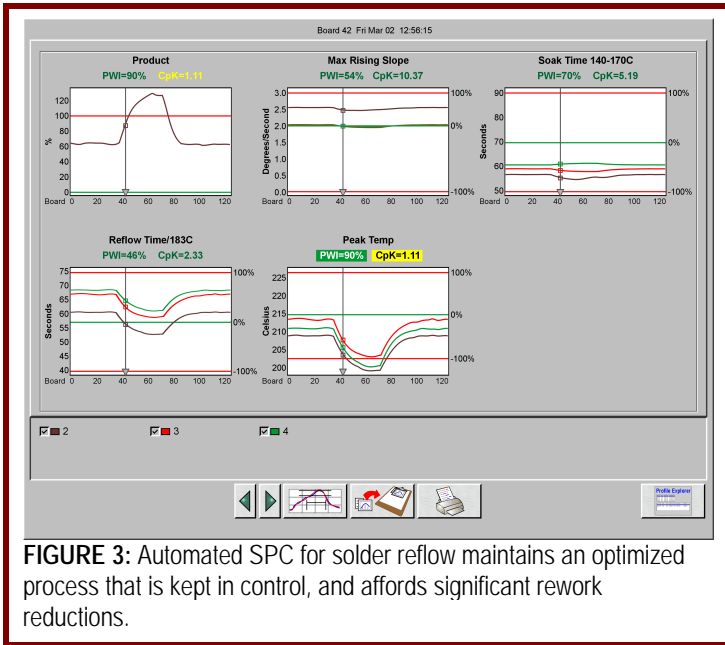


FIGURE 3: Automated SPC for solder reflow maintains an optimized process that is kept in control, and affords significant rework reductions.

quality. Using state-of-the-art profiling technology, an oven recipe search engine and an automated reflow process monitoring system ensures an optimized and automatically controlled operation, including clear benefits for each of the three types of users. The Just Run It processor can reduce rework and prepare to grow the business to the next level; those in the Efficient Quality category, being forced to guarantee quality, will find a state-of-the-art reflow process that delivers high quality results while reducing costs; and for the Perfect Every Time class, benefits include a significant reduction in process monitoring and documentation costs. The benefits of solder reflow automation are clear for all application levels.

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Attitude

Perhaps the most critical component of a reflow process upgrade is “attitude adjustment.” The solder reflow portion of the assembly process generally is taken for granted, with some common assumptions being:

- It is easy and there is no need to focus resources on improvement. (Yet a process failure can be catastrophic.)
- It is a simple process. (But it requires the direct attention of a qualified process engineer.)
- There is no need for advanced tools or automation. (But oven setup can take excessive time, and meaningful process monitoring and control rarely are achieved due to the degree of resources required.)

The contradictions implicit in these statements are obvious, yet they are a fair representation of the responses of people in the field when asked about their reflow processes. The engineer who insists the reflow process is not as important as those of the printer or the pick-and-place equipment usually will admit to a reflow catastrophe incident costing hundreds of dollars -- with nothing being done to prevent future ones. Generally, the same engineer also will admit that oven setup is difficult or complex, and that it would be “nice to know what is going on inside the oven between profiles.”

Clearly, there is a case of industry-wide denial about the importance of the reflow process. The good news is that the solution is simple: Pain-free automation of solder reflow has yielded significant gains in quality and productivity in many facilities with process solutions being readily available to all assemblers.

Conclusion

A true solder reflow process upgrade includes the tools manufacturers need to reduce operation costs while improving