Breaking the Bottleneck: Electrical Test Cycle Time Reduction

by Todd Kolmodin
GARDIEN SERVICES USA

As with many manufacturing theatres there is a stream of additive processes that combine to create the finished product. The manufacture of printed circuits is no different. From the conception of the design and issuance of the procurement document, dozens of processes must take place before the PCB is shipped for assembly. Each of these processes takes time and the additive result of all these steps results in the manufacturing cycle, or lead time. Almost always, the customer just wants to know the lead time, or "When do I get my boards?"

However, in the manufacturing process steps leading to the final shipped product, there are individual cycle times within each process. From imaging all the way through final packaging, each process is allotted a predetermined amount of time to complete a given piece or full production order. In a perfect world, all individual process steps or cycle times will be completed early or on-time with the result being on-time delivery (OTD).

But, let's face it, many times Murphy makes an appearance and cycle times may increase. If this happens early in the manufacturing cycle, then the predetermined, gauged cycle time for subsequent processes is out the window. The time for those processes is now compressed or disregarded entirely and the order becomes ASAP. Did the time it took to effectively process that part miraculously compress as well? No, it did not. Now this order is competing with other orders in the same process step that were originally on-time, causing them to delay and WIP (work in process) to climb, thus resulting in the dreaded bottleneck! This is a term that sends chills through production managers and sales forces alike.

With that said, how do we combat this scenario? We streamline the process step by fine-tuning the attributes within that process. The result is reduced or optimized cycle time. This can result in the process step having "sprint capacity" to combat Mr. Murphy when he decides to make a visit. (However, in reality, once production planning finds out the process has reduced its cycle time…well you know what happens.)

Since I'm focused on quality assurance and electrical testing (ET), we will look at this scenario in the electrical test theatre.

BREAKING THE BOTTLENECK: ELECTRICAL TEST CYCLE TIME REDUCTION

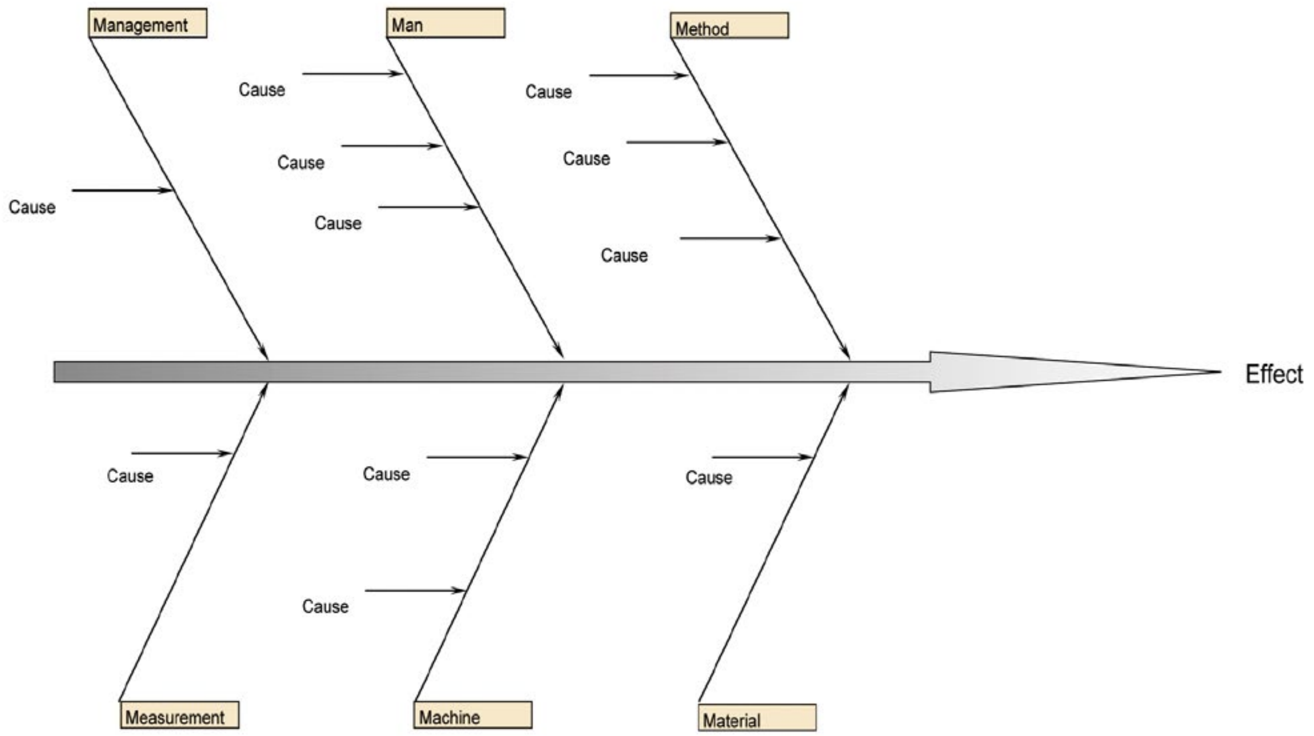

Figure 1: Ishikawa's Fishbone diagram.

Reducing Cycle Time in Electrical Test

In most manufacturing plants the back-end struggles with the additive cycle time violations of all previous processes. Everything is "hot" and cycle time is of the utmost importance. Extreme pressure is put on these late stage processes to make up lost time and attempt to ship the product on-time or as close as possible. Unfortunately, many of these latter processes are the most important. In final inspection and test, all of the prior processes are inspected and validated against the customer requirements and industry specifications.

Many tools and disciplines are used to help analyze a process to gauge its effectiveness and identify areas of concern or targets for improvement. Some examples are Kaizen and 5 Ys. Kaoru Ishikawa, a Japanese quality pioneer, introduced a highly visual diagram to illustrate cause and effect attributes that result in the undesirable outcome. It is known as the Fishbone. In general terms, with regard to ET, the basic diagram is outlined in Figure 1.

Now, using the diagram in Figure 1, we must identify the attributes affecting cycle time in ET. Some immediate items come to mind:

- Yield
- Production issues
- Excessive rework
- Misleading or confusing fabrication drawings/requirements
- Incorrect ET tooling
- Missing information
- Machine downtime
- Human error
- Load balancing

Using the above diagram, we can extrapolate these items into the Fishbone. Figure 2 summarizes our list.

From that diagram, we can now see the causes that can affect cycle time in electrical test. Let's first look at the cause attributes in manufacturing. As I stated earlier, planning and scheduling are extremely important. We see it is one of the attributes listed. In many cases production planners put a fixed time allotment for electrical test. However, this can be a problem. Dependent on whether the job is tested on a flying probe or a grid test machine may influence the time it would take the same

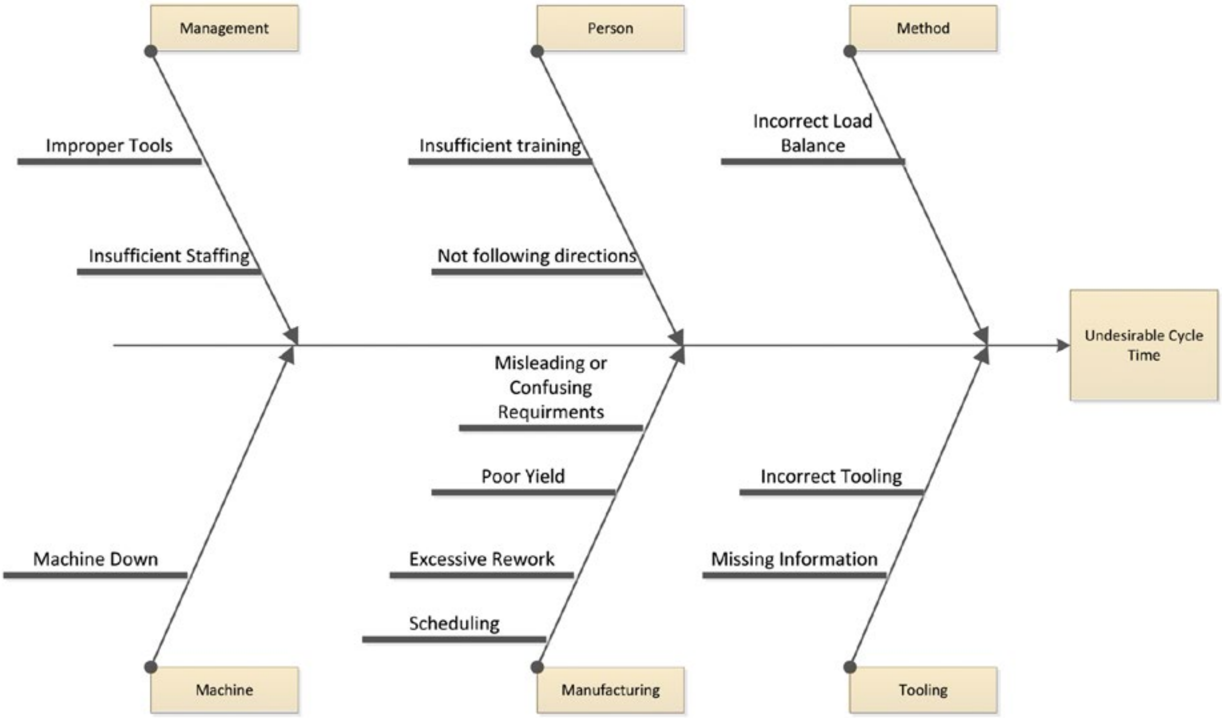

Figure 2: Populated Fishbone diagram.

job to test on either machine. Today it still remains that the most expedient way to test a PCB is using a well manufactured fixture on a grid test machine. However, there are increased costs with fixtures. There is the actual fixture cost, maintenance of the fixture itself and also the storage. Poor yield and excessive rework are two of the other main attributes that increase cycle time in ET. Although these are causes on the diagram they are not specifics that can be solved in ET.

As briefly stated earlier, load balancing is a large contributor to cycle time. We see this listed in Figure 2 under Method. Both flying probes with automation and grid test machines can be used. However, with flying probes there can be an indirect or direct method to the test. Using the indirect method does provide a faster test but some customer/industry standards do not allow this on some product. Direct method testing, albeit favored by some customers, is a slower test. These variables can cause a wide range in cycle time for specific product.

Drawing some conclusions for the above exercise, we can see that manufacturing and methodology are the two largest "bones" that have the highest impact on cycle time in ET. While in manufacturing, ET cannot influence the yield and rework attributes but the other two, scheduling and requirement, it can. This goes along with the attribute in methodology. The solution here is…communication! Communication of requirements, expected volume, layout, and requirements for TDR/HiPot all come in to play when going through ET. Knowing well in advance can influence whether grid test fixturing should be used or flying probe. Also, should manual HiPot testing be used or a multi-channel fixture? Here alone, significant time can be saved if this is known in advance. Many times a first time build is only a few panels with no visibility for the future. Generally, flying probe is used. It is now tooled and forgotten. Two months down the road volume is manufactured and arrives with only flying probe tooled as the solution. Cycle time skyrockets as the test solution is no longer correct.

Scanner/flying probe combinations can also significantly reduce cycle time on flying probe orders. Favorable selections are most double-sided product, LED product and multitude of multilayer builds.

With correct scheduling, load balancing the management attribute solves itself. With proper future foresight, staffing can be adjusted to process varying loading cycles. Strong maintenance/PM programs attack the machine attribute while a strong training/cross-training program attacks the "person" attribute.

Communication, scheduling and proper loading in our exercise are the main influences in ET cycle time. Keeping these variables under control can reduce ET cycle time measurably while also providing the needed sprint when Mr. Murphy makes a visit upstream. **PCB**

Todd Kolmodin is the vice president of quality for Gardien Services USA, and an expert in electrical test and reliability issues. To read past columns, or to contact the author, click here.

4-D Technology Allows Self-folding of Complex Objects

Using components made from smart shape-memory materials with slightly different responses to heat, researchers have demonstrated a four-dimensional printing technology that allowed creation of complex self-folding structures.

The technology, developed by researchers at the Georgia Institute of Technology and the Singapore University of Technology and Design (SUTD), could be used to create 3-D structures that sequentially fold themselves from components that had been flat or rolled into a tube for shipment. The components could respond to stimuli such as temperature, moisture or light in a way that is precisely timed to create space structures, deployable medical devices, robots, toys and range of other structures.

The researchers used smart shape memory polymers (SMPs) with the ability to remember one shape and change to another programmed shape when uniform heat is applied. The ability to create objects that change shape in a controlled sequence over time is enabled by printing multiple materials with different dynamic mechanical properties in prescribed patterns throughout the 3-D object. When these components are then heated, each SMP responds at a different rate to change its shape, depending on its own internal clock. By carefully timing these changes, 3-D objects can be programmed to self-assemble.

The research creates self-folding structures from 3-D printed patterns containing varying amounts of different smart shape-memory polymers. The patterning, done with a 3-D printer, allows the resulting flat components to have varying temporal response to the same stimuli. Earlier methods required application of differential heating at specific locations in the flat structure to stimulate the shape changes.

The research was reported September 8 in the journal *Scientific Reports,* which is published by Nature Publishing. The work is funded by the U.S. Air Force Office of Scientific Research, the U.S. National Science Foundation and the Singapore National Research Foundation through the SUTD DManD Centre.