TECHtips

Electronics Manufacturing Insights from ACI Technologies, Inc.

Experimentation for Success

The technical tips have offered valuable details and techniques into various aspects of electronics manufacturing. This has been validated by the reader responses concurring with our assessments, offering additional insight, or in some rare cases, stating divergent points of view on any particular matter. In a bit of a strategic departure from the normal range of electronic manufacturing topics, ACI Technologies, Inc. would like our readers to consider the importance of being well prepared in the arena of designed experiments in order to properly qualify a manufacturing process. This particular topic has relevance because of the associated scope of work ACI Technologies encounters in numerous projects from material R&D to manufacturing process optimization, which require appropriate experimental designs to ascertain the significant data.

Following are the three important design of experimentation (DOE) rules of engagement.

1. Plan the experiment with a realistic goal in mind.

One experiment may not reveal all the pertinent information needed to optimize the manufacturing process.

This diagram (Figure 1) reflects a process to build a printed circuit board that may contain as many as 200 sub-steps to manufacture. The practicality of a full blown experiment incorporating all the subsequent processes is unrealistic. Breaking down the individual areas into manageable experimental units is more practical in assessing where the greatest variability in the manufacturing process occurs. The type of experiment that is used will also depend on the type of data required and the stage of development the manufacturing process has achieved. One possible approach indicates that a screening experiment may be appropriate for a number of processes that are relational or sequentially adjacent to each other. An optimization should occur at each process to properly determine relationships without introducing excess variability that would mask true variability between processes. Finally, a nested analysis of variance models (ANOVA) may be used to determine where the variability in the larger manufacturing flow occurs. Whatever experimental methodology is utilized, many smaller experiments will yield greater information and prevent the costly mistakes frequently encountered in one grand experiment.

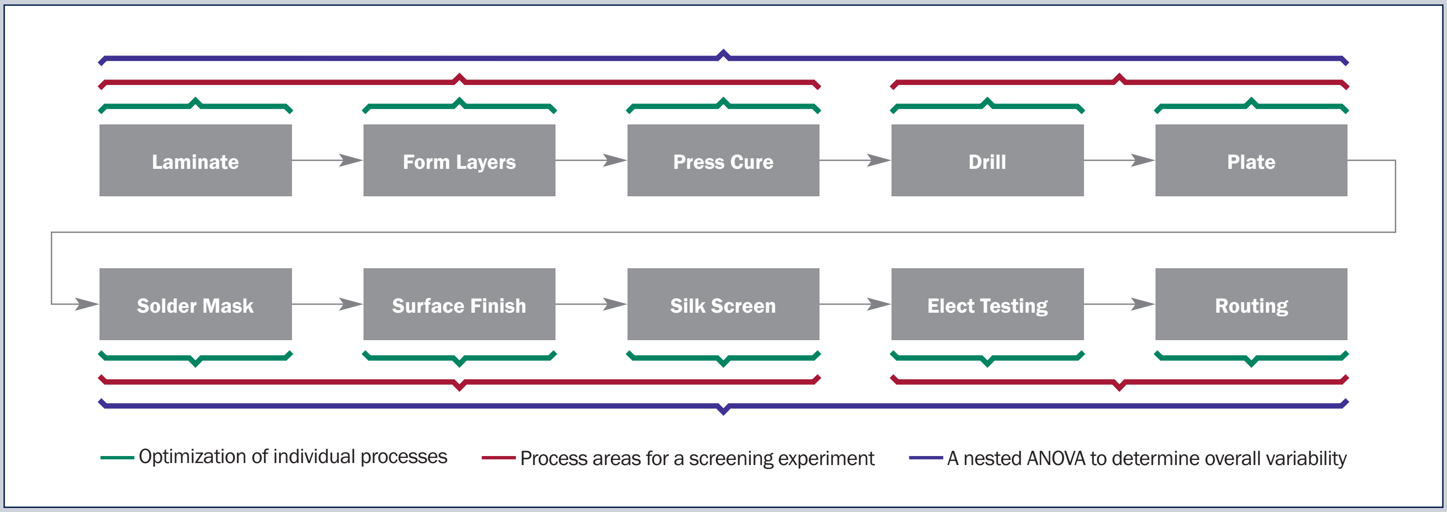

Figure 1: Diagram of a possible printed circuit board build process.

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2. Define the factors that are constraining and block where appropriate.

Experiments are costly and it is not always possible to run the experimental unit in a totally random fashion. A recent example of this occurred when cost and time precluded running a solder paste experiment with four different paste types, two different panel finishes, four atmospheric oven conditions, and two peak reflow temperatures. Even with a fractional factorial design, the practicality of running each board in randomization was prohibitive. In these cases - and they are more common than not - it is advisable to incorporate a blocking scheme that can be used to effectively monitor the effects of process sequence and bias on the experimental results. This may require more than one block. For example, noting the day the experimental runs were conducted. It could be that all runs with high peak reflow temperatures and a specific solder paste were processed on Day 1. If those blocks are not incorporated into your data, any effects from those conditions will be confounded an unreliable. It must be proven that on Day 1, there were no anomalies that would skew the results, such as the oven temperature was recorded accurately and the solder paste was not mishandled or given any extra-ordinary treatment that the other pastes would not receive.

3. Replicate.

It is better to replicate experimental runs than to expand the experimental factors and levels with no replication. Replicating runs will generally increase the statistical significance of your data. A rule of thumb is to incorporate 25% of the experimental runs as replicates. Randomize the sequence of the experiment (this can be done in Excel very effectively) and select the first 25% of the runs that are sequenced. Please note that the replicates are a representation of the experimental unit, and are not siblings. An example of a sibling is running an experimental unit (i.e., having the same factors) concurrently under the same conditions. A true replication is run as a randomized and independent event, having the same experimental levels and conditions.

Experimental design can be a costly and inconclusive process if the proper precautions are not taken to ensure that a statistically sound probability of detecting true variability or causation exists. When DOE is properly implemented, process improvements can be instituted that will help decrease cost and improve product reliability. It is our goal at ACI Technologies to help facilitate process improvements for our valued customers, by using the tools available to make the right experimental choices.

Carmine Meola
Technical Director
ACI Technologies, Inc.