Advanced Techniques US Inc.

Automating Thermal Stress Reflow Simulation on PCBs

Introduction

The purpose of this paper is to demonstrate the reflow process of thermal stress reflow simulation on bare PCB's per IPC-TM-650 Test Method 2.6.27 (Thermal Stress, Convection Reflow Assembly Simulation). This standard requires PCBs or test coupons to be reflowed six (6) times and then evaluated for quality compliance. Each of the six reflow cycles must be nearly identical to one another in order to maintain the profile tolerances specified in the standard. By automating the six cycles within a reflow oven, consistency is attainable, chance of operator errors that may invalidate the test are eliminated, and efficiency greatly improved.

Set Up

Sample coupons used during the test measure 2.67" x 1.25" and are 0.040" thick (refer to Figure 1). Three coupons were placed onto the oven's loading tray with a 30 AWG K-type thermocouple attached to the surface of each coupon (refer to Figure 2). Thermocouples will provide feedback of actual surface temperature on each coupon throughout each of the 6 reflow cycles.

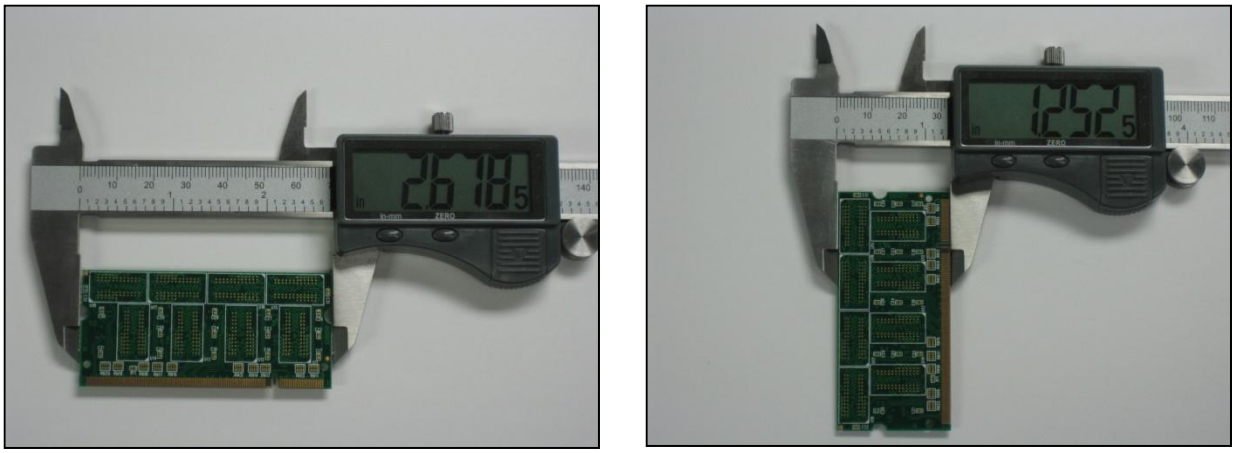

Figure 1: Test Coupons

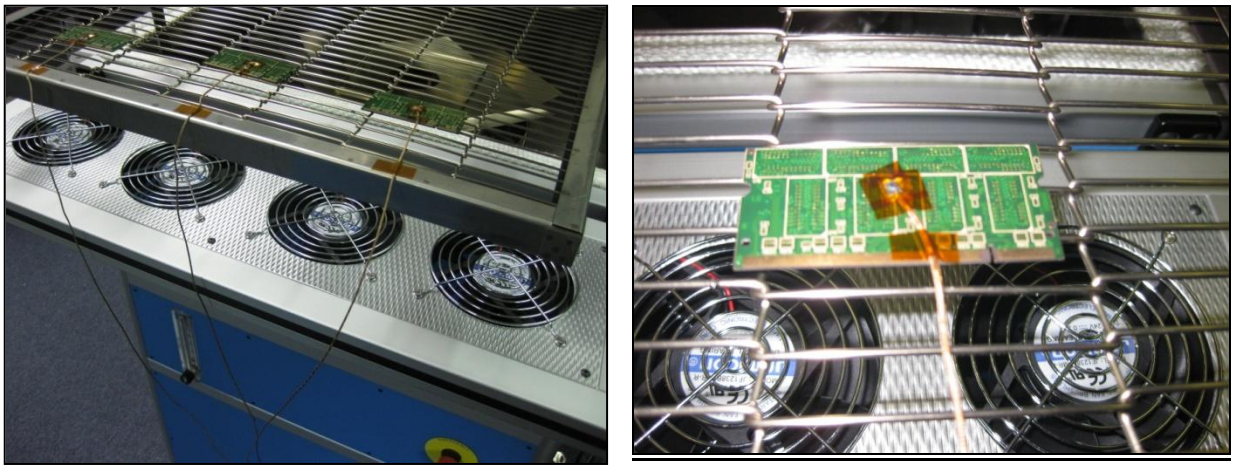

Figure 2: Test Coupons on Loading Tray

Process

Once test coupons have been placed on the loading tray, the operator selects a preset profile within the oven's software screen and clicks "Start" to begin reflow. Loading tray automatically moves inside the oven's heating chamber and heating is initiated. From this point on, PRO 1600 Reflow Oven would automatically cycle the coupons 6 times without operator intervention. Data from each cycle is recorded into a raw data file as well as a graph on the software screen. Figure 3 below represents the oven's software generated graph of all 6 reflow cycles.

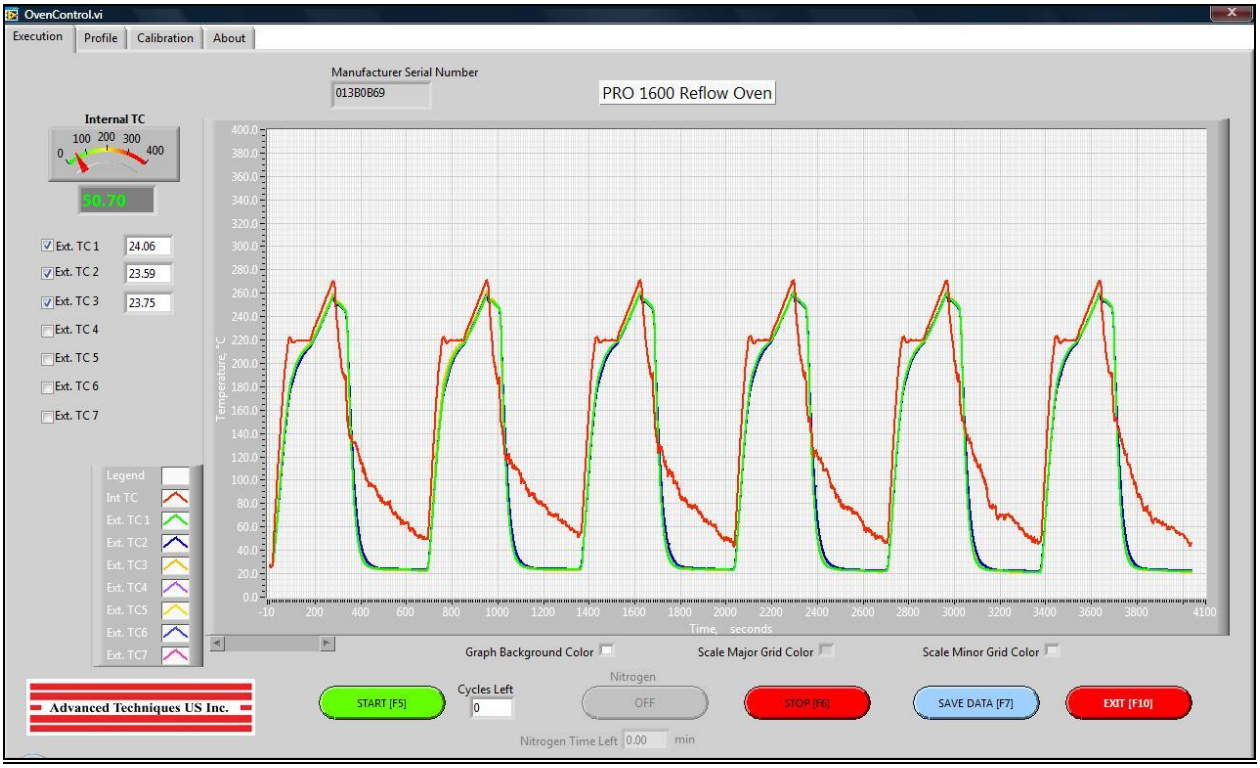

Figure 3: Software's Screenshot After Completion of 6 Reflow Cycles

Screenshots of each of the 6 individual reflow cycles are outlined below. Referring to Figure 4 -9: Reflow Cycle 1-6, red line (Int. TC) on the graph represents air temperature inside an oven while green (Ext. TC1), blue (Ext. TC2), and yellow lines (Ext. TC3) that are graphed close together represent the surface temperature of each of the three test coupons. Graph's Y-axis represents temperature in Celsius and X-axis represents time in seconds.

Figure 4: Reflow Cycle 1

Figure 5: Reflow Cycle 2

Figure 6: Reflow Cycle 3

Figure 7: Reflow Cycle 4

Figure 8: Reflow Cycle 5

Figure 9: Reflow Cycle 6

Results

Raw data from the 6 reflow cycles is saved in a single file for documentation and analysis. Results of the data show that each of the 3 test coupons were subjected to reflows that met all specifications in Table 5-1 of IPC-TM-650 Test Method 2.6.27. Target parameters were achieved throughout the 6 reflow cycles and are consistent from one cycle to another. Tables 1 – 6 below, compare the desired target parameters listed in Table 5-1 of IPC-TM-650 Test Method 2.6.27 vs. the data measured on each coupon (TC 1-3) during the 6 reflow cycles.

Table 1: Target Preheat time (t1) = 210 +/- 15 seconds

	TC 1	TC 2	TC 3
Reflow Cycle 1	218 seconds	220 seconds	215 seconds
Reflow Cycle 2	213 seconds	214 seconds	206 seconds
Reflow Cycle 3	210 seconds	210 seconds	206 seconds
Reflow Cycle 4	209 seconds	210 seconds	207 seconds
Reflow Cycle 5	212 seconds	211 seconds	207 seconds
Reflow Cycle 6	208 seconds	207 seconds	207 seconds

Table 2: Target peak reflow time (t2) = 270 +/- 10 seconds

	TC 1	TC 2	TC 3
Reflow Cycle 1	280 seconds	279 seconds	280 seconds
Reflow Cycle 2	279 seconds	277 seconds	278 seconds
Reflow Cycle 3	277 seconds	278 seconds	276 seconds
Reflow Cycle 4	277 seconds	277 seconds	276 seconds
Reflow Cycle 5	280 seconds	278 seconds	278 seconds
Reflow Cycle 6	275 seconds	276 seconds	276 seconds

Table 3: Target cool-down start time (t3) = 330 +/- 15 seconds

	TC 1	TC 2	TC 3
Reflow Cycle 1	342 seconds	342 seconds	340 seconds
Reflow Cycle 2	340 seconds	340 seconds	338 seconds
Reflow Cycle 3	341 seconds	340 seconds	338 seconds
Reflow Cycle 4	340 seconds	340 seconds	340 seconds
Reflow Cycle 5	342 seconds	342 seconds	342 seconds
Reflow Cycle 6	338 seconds	338 seconds	338 seconds

Table 4: Target time above T1 (230° Celsius) = 120 +/- 30 seconds

	TC 1	TC 2	TC 3
Reflow Cycle 1	124 seconds	123 seconds	126 seconds
Reflow Cycle 2	127 seconds	128 seconds	133 seconds
Reflow Cycle 3	131 seconds	131 seconds	134 seconds
Reflow Cycle 4	131 seconds	130 seconds	134 seconds
Reflow Cycle 5	130 seconds	132 seconds	135 seconds
Reflow Cycle 6	130 seconds	131 seconds	131 seconds

Table 5: Target reflow temperature T2 = 260° +/- 5° Celsius

	TC 1	TC 2	TC 3
Reflow Cycle 1	258	257	260
Reflow Cycle 2	259	259	262
Reflow Cycle 3	260	260	261
Reflow Cycle 4	260	260	261
Reflow Cycle 5	260	260	261
Reflow Cycle 6	260	260	261

Table 6: Cool-down Rate (maximum -3.0° Celsius/ second, minimum -1.0° Celsius/ second)

	TC 1	TC 2	TC 3
Reflow Cycle 1	-2.85	-2.38	-2.66
Reflow Cycle 2	-2.85	-2.43	-2.70
Reflow Cycle 3	-2.94	-2.35	-2.70
Reflow Cycle 4	-2.98	-2.35	-2.85
Reflow Cycle 5	-2.98	-2.40	-2.81
Reflow Cycle 6	-2.94	-2.46	-2.89

Conclusion

Above data demonstrates repeatability of each reflow cycle to be within the standard's profile tolerances. Substantial variation in lot size may affect results of a profile. Therefore, individual profiles may need to be developed depending on the coupon's thermal mass and lot size. PRO 1600's automated profile repeat function eliminates operator involvement during the 6 reflow cycles. This ensures consistency, prevents operator error that may jeopardize validity of the test, and provides documentation / raw data in a single file for all 6 reflows.

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