今天回流炉的三个调整允许对回流焊温度曲线进行参数设定。如果重量或设计相当不同，特别是当焊料从共晶焊转为无铅，适合一块电路板的参数设定未必适合另一块电路板。在三个调整中，区定值对峰值温度和液相线上时间的影响最大。改变带速也在较小程度上影响峰值温度和TAL。但静压不只影响峰值温度和TAL，对峰值温度的一致性有最大的影响。

Oven Adjustment Effects on a Solder Reflow Profile

Belt speed, zone temperatures and static pressure all impact peak temperature.

By Fred Dimock

The change from eutectic to Pb-free solder has required new recipes for reflow ovens. Solder paste manufacturers have developed profile parameters, but it remains the responsibility of the assembly engineer to find the correct control settings with a limited number of reflow oven adjustments. Additional complications exist because the liquidus temperatures of the new solders require peak temperatures close to the point at which components are damaged. Thus, the importance of accurate recipes and precision oven control is amplified.

Conventional reflow ovens have two adjustments for profile development. One is the zone set points and the other is belt speed. Some oven manufacturers have added high, medium and low fan speeds as an additional adjustment, and one manufacturer has a closed-loop pressure control.

Given the three possible adjustments, a study was undertaken to determine the effects varied belt speeds, static pressures and zone temperatures have on the peak temperature, time above liquidus (TAL) and temperature uniformity of a 100 and 230 g populated surface mount board.

Experimental

A Pyramax 98 N reflow oven with edge rails, fine mesh belt, and closed loop pressure control was used for this experiment. A recipe that produced a Pb-free ramp-to-peak profile with a belt speed of 28 IPM and static pressure of 1.0 IWC was chosen as a baseline (**Table 1**).

The plan was to individually vary each parameter (high and low) and record its effect on the TAL, peak temperature and uniformity of each board. An additional run was performed with all variables at the high and low settings to see the combined effect.

High and low ranges were established for each of the variables, as outlined in **Table 2**. Data were gathered with a SlimKIC II profiler.

Table 1. Baseline Recipe

E	Set Points
Z1	100 °C
Z2	125 °C
Z3	150 °C
Z4	175 °C
Z5	200 °C
Z6	225 °C
Z7	250 °C
BS	28 IPM
SP	1.0 IWC

Table 2. Variable Experimental Ranges

E	Ranges
Static pressure	±0.3 IWC
Belt speed	± 4 IPM
Z5 and Z6 Set point	±10 °C

Table 3. Board Weight Results

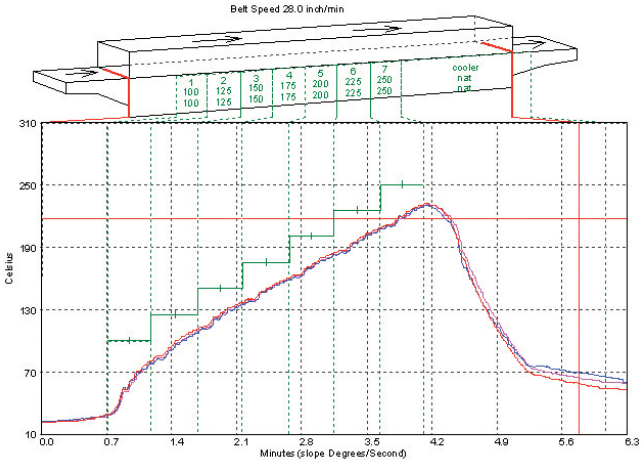
E	100 G	250 G
Peak (°C)	231.6	225.5
TAL (sec.)	33.18	25.07

Table 4. Belt Speed Changes

E	100 G		250 G	
BS - IPM	24	32	24	32
Peak (°C)	234.8	229.1	229.3	222.2
TAL (sec.)	39.61	25.59	35.72	17.19
Uniformity	1.7	1.8	1.5	1.6

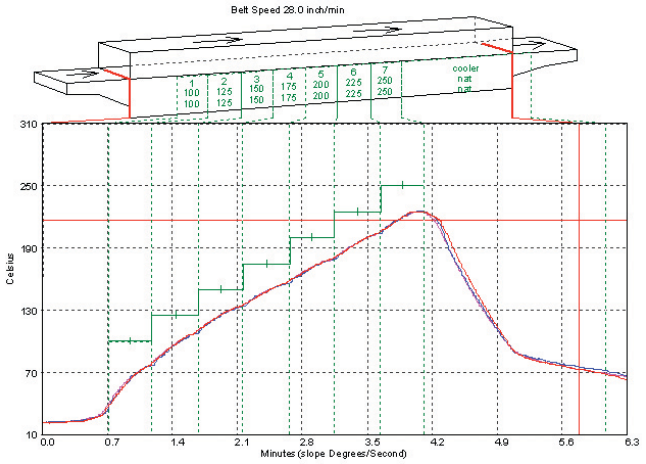
Table 5. Zone Temperature Changes

E	100 G		250 G	
Zone temp.	240	260	240	260
Peak (°C)	223.4	240.9	217.7	233.2
TAL (sec.)	20.48	42.24	6.16	35.03
Uniformity	2.1	2.2	1.6	1.8



	Peak	Total Time Above 217
1 1	231.5	34.67
2 2	230.8	30.63
3 3	232.6	34.25
TC Mean	231.6	33.18

Figure 1. SlimKIC II profile of the 100 g board.



	Peak	Total Time Above 217
1 1	224.7	23.02
2 2	226.2	25.06
3 3	225.5	27.12
TC Mean	225.5	25.07

Figure 2. SlimKIC II profile of the 230 g board.

Results

The 100 and 230 g boards were run at the baseline operating parameters of 28 IPM, 1.0 IWC and zone 7 set points of 250°C. **Figures 1** and **2** show the resultant profiles for the 100 and 230 g boards, respectively. **Table 3** shows the peak temperature and TAL data for the boards. There was a difference of about 5°C at the peak and 8 sec. in the TAL between the two boards because of weight and board design.

Belt speed. Belt speed was varied from 24 to 32 IPM with the static pressure and zone set points at the baseline settings. **Table 4** shows the peak temperature, TAL and uniformity data for each board. The increased belt speed lowered the peak temperature and TAL, and slightly decreased the temperature uniformity at the peak.

Zone temperature. The oven was reset to the baseline parameters, and the temperatures in zones 6 and 7 were increased and decreased by 10°C. Peak temperature and TAL increased with the higher zone temperature settings and the uniformity decreased (**Table 5**).

Static pressure. The oven was reset to the baseline parameters and the pressure varied from 0.7 to 1.3 IWC. The increased static pressure increased the peak temperature by about 5°C and TAL by about 10 sec. (**Table 6**). The uniformity at peak was significantly better with the higher static pressure.

High and low interactions. Next, the combination of all the high temperature parameters (low belt speed, high zone set points, and high static pressure) and low temperature parameters (high belt speed, low zone set points, and low static pressure) was used to determine the interactions on each board. There were significant changes in all the profile attributes, with about 30°C differences in peak temperature and close to 50 sec. in TAL (**Table 7**). Uniformity was considerably better with the high oven parameters. In the case of the heavy board, the peak temperature did not reach the liquidus when all the settings were set low.

Today's high performance reflow ovens have three adjustments that permit recipes for solder reflow profiles. A recipe that works for one board won't necessarily work for another board if the weight or design is significantly different.

Of the three oven adjustments, the zone set points have the biggest effect on the peak temperature and TAL. Changing the belt speed also affects the peak temperature and TAL, to a lesser degree. But the static pressure not only affects the peak temperature and TAL, it has the biggest impact on uniformity at peak temperature.

Pb-free solder's more stringent process requirements make it important that all three adjustments – zone temperature set points, belt speed and static pressure – be used when developing recipes. ■

Table 6. Static Pressure Changes

E	100 G		250 G	
Pressure	0.7	1.3	0.7	1.3
Peak (°C)	229.2	234.0	222.0	227.3
TAL (sec.)	26.94	35.79	18.12	29.20
Uniformity	2.3	1.7	2.3	1.5

Table 7. Interactions

E	100 G		250 G	
	low	high	low	high
Peak (°C)	218.4	245.7	210.6	240.2
TAL (sec.)	4.21	59.36	0	49.25
Uniformity	2.7	1.6	2.6	1.5

Fred Dimock is senior process engineer at BTU International (btu.com); fdimock@btu.com.