Practical Thermal Profile Expectations in a Dual-Lane, Dual-Speed Reflow Oven

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Will MY products run on a Dual-Lane Dual-Speed reflow oven?

Fred Dimock  Manager Process Technology
What is a Dual Lane Dual Speed Oven?

- Two Lanes
- Two Speeds

Process two different products in the oven at the same time.
Profile vs. Recipe

- **Profile** is the targeted thermal process
- **Recipe** is the oven/furnace settings to obtain the profile
SMT Profile / Thermal Target

- Peak Temperature
- Time to Peak
- Time Over Liquidus (TAL)
- Soak time & temperature (FAT)
- Heating-Cooling rates

- Max/Min °C
- Minutes – Max
- Range - Sec
- Ranges
- °C/Sec
Typical Solder Reflow Profile Target

- Peak temperature = 240 ± 10 °C
- Time to peak = 3 minutes Max
- TAL = 60 ± 15 seconds
- Soak = 160 to 190°C for 60 to 90 sec
- Ramps =
  - +2.0 °C/sec Max
  - -1.5 °C/sec Min

6 items
Recipe

Oven Settings

• Zone set points
• Belt speed
• Static pressure

3 Control Knobs

Dual Lane
Dual Speed
Shared
Heating (and cooling) is transferring **BTUs / Calories** in a controlled manner.

\[ Q = h \cdot A \cdot t \cdot \Delta T \]

**Q** = the amount of heat being transferred
- (positive/heating or negative/cooling)

**h** = the heat capacity of the product
- (the ability of the product to absorb or give up heat)
  - (part is product weight)

**A** = the surface area of the product

**t** = time

**\( \Delta T \)** = the temperature differential between the material and the heat source.
Boards with Different Weight and Size

Board 1
\[ Q = h \cdot A \cdot t \cdot \Delta T \]

Board 2
\[ Q = h \cdot A \cdot t \cdot \Delta T \]

different time

Belt speed

Same
Boards with Different Weight

We can regain the TAL and Peak by changing the belt speed

Peak 225.5 vs. 231.6 °C
TAL 25.1 vs. 33.2 sec
Due to higher weight

<table>
<thead>
<tr>
<th>Weight (gm)</th>
<th>Peak</th>
<th>Total Time Above 217</th>
</tr>
</thead>
<tbody>
<tr>
<td>230</td>
<td>232.6</td>
<td>34.25</td>
</tr>
<tr>
<td>250</td>
<td>226.2</td>
<td>25.06</td>
</tr>
<tr>
<td>28 IPM</td>
<td>225.5</td>
<td>25.07</td>
</tr>
<tr>
<td>1.0 IWC</td>
<td>224.7</td>
<td>23.02</td>
</tr>
</tbody>
</table>
Approaches to Determining the Recipe

Fully Manual and Prediction Assisted

The methods are described in a paper that was published in Printer Circuits Design & Fab / Circuits Assembly - March of 2011
And featured in EM Asia - in May 2011

It is also available on the BTU website at

http://www.btu.com/support-knowledge-center.htm

Additional information is available in the white paper section of the KIC Thermal web site
To simplify this discussion we will focus on the peak temperature but in practice you will need to take the other profile requirements into account.

We used three boards in this example to cover a wide range of product 75, 360, and 520 grams.

The 360 gm board was used as the starting point.
Step One

Establish a centered Eutectic recipe for the 360 gm board

<table>
<thead>
<tr>
<th>Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top</td>
<td>90</td>
<td>130</td>
<td>165</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>180</td>
<td>200</td>
<td>225</td>
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<td>240</td>
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<tr>
<td>Bottom</td>
<td>90</td>
<td>130</td>
<td>165</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>170</td>
<td>180</td>
<td>200</td>
<td>225</td>
<td>235</td>
<td>240</td>
</tr>
<tr>
<td>Conveyor Speed (inch/min):</td>
<td>44.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Step Two

Profile the 75 and 520 gm boards with the same recipe
Record the Peak temperature TAL, FAT (soak time), etc.

<table>
<thead>
<tr>
<th>Board gm</th>
<th>Peak ºC</th>
<th>TAL sec</th>
<th>Soak sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>224</td>
<td>65</td>
<td>75</td>
</tr>
<tr>
<td>360</td>
<td>219</td>
<td>64</td>
<td>72</td>
</tr>
<tr>
<td>520</td>
<td>215</td>
<td>61</td>
<td>70</td>
</tr>
</tbody>
</table>
Step Three

Profile all three boards with increased and decreased belt speeds (We used ± 5 and 10 IPM increments)

Record the Peak temperature TAL, FAT (soak time), etc.
Step Four and Analysis

Step four: Plot the data

Equal Peak Temperature
360 and 520 gm board

Equal Peak Temperature
360 and 75 gm board
Other Eutectic Data

If this is unacceptable you will need to modify the zone set points.

You can estimate the change in TAL etc.
Lead Free Profile 360 gm Board

### Setpoints (Celsius)

<table>
<thead>
<tr>
<th>Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
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<tbody>
<tr>
<td>Top</td>
<td>95</td>
<td>102</td>
<td>120</td>
<td>140</td>
<td>160</td>
<td>180</td>
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<td>Bottom</td>
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<td>120</td>
<td>140</td>
<td>160</td>
<td>180</td>
<td>200</td>
<td>220</td>
<td>240</td>
<td>245</td>
<td>250</td>
<td>255</td>
</tr>
</tbody>
</table>

Conveyor Speed (inch/min): 44.0
Lead Free Data

**Peak LF Profile**

- Centigrade vs. Belt Speed
- Lines for 75 gm, 360 gm, 520 gm
- Starting Target Point

**TAL LF Profile**

- Graph showing time vs. belt speed
- Lines for 75 gm, 360 gm, 520 gm

**Soak LF Profile**

- Graph showing soak time vs. belt speed
- Lines for 75 gm, 360 gm, 520 gm
How can we eliminate some of the data runs?

Eutectic 6 times 3 boards = 18 runs

Lead Free 5 times 3 boards = 15 runs

With 2 Boards
2 times 3 = 6 runs

Since the data is liner
3 times 3 boards = 9 runs
will be enough
Is there an easier way?

The KIC Explorer and 2000 software we used can predict the affect of changing the belt speed on a profile.

Thus we modified the belt speed in the starting point profiles of the three boards and it predicted new profile data without our having to make additional runs.

Then we compared it to the actual results.
The Actual vs. Predicted Peak temperatures were within 2 - 2.5°C

Thus we can get the data we need with one run for each board and a bit of time on the computer!
A major step in determining the recipe is finding the zone temperatures and static pressure settings that will work for both boards.

Predictive profiling software such as KIC Navigator can help establish the base recipe.

You can do this on a standard reflow oven.
Prediction Assisted

Start by attaching TCs to important places on both boards and plug them into a single profiler.

The number of TCs on each board will be limited so choose their locations carefully.

Then run the boards thru an oven together (one behind the other is OK) and allow the software to find the best belt speed and set points for the combination.

Note: All the criteria might not be in specification.
Then turn off the TCs that are on board #2 and tell the software to give you a prediction by only changing the belt speed. This will predict the belt speed for board #1.
Do the same thing for Board #2.

Turn off the TCs for board #1, tell the software to only change the belt speed and it will predict the belt speed needed for Board #2.
CONCLUSIONS

• There are numerous ways to predict if your combination of products will run on a Dual-Lane Duel-Speed reflow oven without actually having a DL – DS oven.

• It can be done with standard profilers but predictive software can save significant engineering time.
http://www.btu.com/support-knowledge-center.htm

“Oven Adjustment Effects on a Solder Reflow Profile”
Circuits Assembly – “Getting the Recipe Right”
EM – Asia  EPP Germany

Maximizing Process Control with Controlled Convection Rates
Global SMT & Packaging

Oven Selection and Lead-Free Solder  Global SMT & Packaging

Effect of High-Temperature Requirements for Lead-Free Solder
Circuits Assembly

Practical Thermal Profile Expectations in a Dual-Lane, Dual-Speed, Reflow Oven  Circuits Assembly, EM-Asia

Experiences in Transferring Recipes from an 8-Zone Reflow Oven
Global SMT & Packaging

Improving Reflow w SPC Part I, 2 and 3  Circuits Assembly
THANK YOU