Hot nitrogen for wave soldering

A new innovation for increasing quality & productivity of wave soldering machines

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- Wave soldering - background situation
- Local Nitrogen inerting system
- Important operating parameters
- Why preheat N2 ?
- How to preheat N2 ?
- Impact on soldering quality - fields results
- Conclusions
Wave soldering - Background situation

- Main solder alloys for Tin Lead substitution
  - SAC 305, SAC 405, SN100C, SACX 0307, Sn99.3Cu0.7

- Solder pot temperature: 250 - 265°C
  - Solder melting temperature: 183 -217°C (SAC 305)

- Inert atmosphere now becomes very common, and is recommended by the main OEMs
  - Better wetting
  - Less dross
  - Use of less actives fluxes, and less flux consumption
  - Higher reliability and reproducibility
  - Less maintenance

- Inerting technologies for waves soldering machines:
  - Full tunnel
  - Local inerting system (original equipment or retrofit)
Typical layout of a local Nitrogen inerting system

System showed: ALIX Inertwave equipment - Air Liquide
Important parameters for wave soldering

- Heat transfer and contact time between solder alloy and PCB
  - 2 most important criteria for quality of soldering joints

- All other operating parameters have to be set accordingly:
  - Preheating and solder bath temperatures, wave nozzles geometry, rotating speed of the pumps, conveyor speed

- Need to increase heat-transfer and contact time on PCBs
  - Why? Lead free solder and massive PTH components
  - Possible solutions:
    - Reduce conveyor speed 😞
    - Increase overall length of solder nozzles geometry (laminar wave): limited effect!
  - Temperature drop between the 2 waves is critical
    - Intermediate solidification of the solder joints
    - Possible increase of intermetallics layer
Why preheat nitrogen?
1st reason

- Increase heat transfer and contact times
  - Thanks to the convection effect given by hot nitrogen, the temperature drop between the 2 waves is reduced
    - solder joints remain at higher temperature between the two waves.
  - And the equivalent contact time* is longer
    - The conveyor speed can be increased (higher production capacity)
    - Defects rate is reduced significantly
    - The solder joints quality is increased

(* Time above liquidus temperature)
Temperature profiles

Solidus liquidus

217° C

+36,3° C

hot nitrogen

air

+37,6° C

hot nitrogen

air

Temperature measurement on small diode pin

Temperature measurement on triac SMD
Equivalent contact times

Temperature measurement on small diode pin (+ 25% equivalent contact time)

Temperature measurement on triac SMD (+ 60% equivalent contact time)

(conveyor speed: 1,30 m/min)
Why preheat nitrogen?

2nd reason

- Reduce maintenance
  - Avoid clogging of the N2 diffusers
    - High speed of the pumps for powerful solder flow due to the mask technology (selective soldering).
      Solder is often over flowing and can easily hit the surroundings and solidify on the N2 diffusers
    - With hot Nitrogen, the solidification can not occur
  - Avoid condensation of flux vapors on the N2 diffusers
How to preheat nitrogen?

- A heat exchanger is necessary:
  - Use the enthalpy of the solder pot is easier and less expensive than an external heating
  - N2 temperature must reach at least the solidification temperature of the solder alloy
    - (217°C for SAC305 – 227°C for Sn100C)
  - Possible to reach nitrogen temperature of 230°C.
  - Design is adapted to the machine geometry and available space
Hot nitrogen for local N2 inerting system - principle

System showed: ALIX Inertwave equipment - Air Liquide
Example of implementation
Impact of hot Nitrogen on soldering quality

Case 1: power supplies - Lead free

<table>
<thead>
<tr>
<th></th>
<th>Cold nitrogen local inerting</th>
<th>Hot nitrogen local inerting</th>
<th>Delta</th>
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</thead>
<tbody>
<tr>
<td>Defects total</td>
<td>793 dppm</td>
<td>522 dppm</td>
<td>- 34%</td>
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<tr>
<td>missing solder</td>
<td>364 dppm</td>
<td>183 dppm</td>
<td>- 50%</td>
</tr>
<tr>
<td>bridges</td>
<td>277 dppm</td>
<td>183 dppm</td>
<td>- 34%</td>
</tr>
<tr>
<td>icicles</td>
<td>41 dppm</td>
<td>43 dppm</td>
<td>+ 5%</td>
</tr>
<tr>
<td>others</td>
<td>111 dppm</td>
<td>113 dppm</td>
<td>+ 2%</td>
</tr>
<tr>
<td>Dross</td>
<td></td>
<td></td>
<td>- 10%</td>
</tr>
<tr>
<td>N2</td>
<td>18 Nm3/h</td>
<td>18 Nm3/h</td>
<td>0 %</td>
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</table>
Impact of hot Nitrogen on soldering quality

- Case 2: power supplies for computer - Lead free

<table>
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<th>Reference</th>
<th>Hot nitrogen local inerting</th>
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<tbody>
<tr>
<td>PCB A - Defects total</td>
<td>1765 dppm</td>
<td>1247 dppm</td>
<td>- 30%</td>
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<tr>
<td>missing solder</td>
<td>665 dppm</td>
<td>477 dppm</td>
<td>- 28%</td>
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<tr>
<td>shorts-bridges</td>
<td>950 dppm</td>
<td>640 dppm</td>
<td>- 33%</td>
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<tr>
<td>Total PCB joints</td>
<td>147420</td>
<td>68880</td>
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<tr>
<td>PCB X - Defects total</td>
<td>6313 dppm</td>
<td>3297 dppm</td>
<td>- 48%</td>
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<tr>
<td>missing solder</td>
<td>2512 dppm</td>
<td>386 dppm</td>
<td>- 85%</td>
</tr>
<tr>
<td>shorts-bridges</td>
<td>3756 dppm</td>
<td>1949 dppm</td>
<td>- 48%</td>
</tr>
<tr>
<td>Total PCB joints</td>
<td>86800</td>
<td>157 850</td>
<td></td>
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<tr>
<td>Dross</td>
<td>0,4 kg/h</td>
<td>0,03 kg/h</td>
<td>- 93%</td>
</tr>
<tr>
<td>N2</td>
<td>-</td>
<td>19 Nm3/h</td>
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</table>
## Impact of hot Nitrogen on soldering quality

- Case 3: EMS - data center I/O connectivity products - Lead free

<table>
<thead>
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<th></th>
<th>Reference</th>
<th>Hot nitrogen local inerting</th>
<th>Delta</th>
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<tbody>
<tr>
<td>Defects</td>
<td>8900 dppm</td>
<td>2600 dppm</td>
<td>-67%</td>
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<tr>
<td>Dross</td>
<td>1.5kg/hr</td>
<td>0.06kg/hr</td>
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<tr>
<td>Flux</td>
<td>1.16kg/hr</td>
<td>0.78kg/hr</td>
<td>-33%</td>
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<tr>
<td>N2</td>
<td>-</td>
<td>17.2Nm3/hr</td>
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Conclusions

- Hot nitrogen technology for local inerting system of wave soldering machines has proved to give significant advantages with Tin Lead or Lead free solders:

  ✓ Better heat transfer on the PCBs, especially between the 2 waves (very important for lead free)

  ✓ Longer equivalent contact time (up to +60% for massive components), allowing a higher conveyor speed

  ✓ Better soldering quality, less joints defects: average -40% (up to -80% in some cases)

  ✓ Almost maintenance-free system: no solder clogging and no flux vapors residues on the N2 diffusers (cleaning effect)

- Already more than 100 field references with ALIX Inertwave HT system of Air Liquide (patent apply for design)