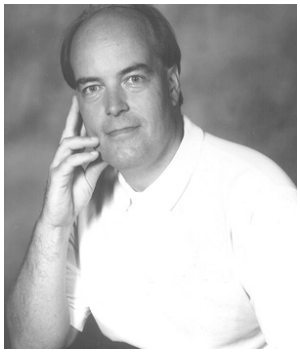
Setting Up Reflow Soldering Parameters

Bob Willis



Bob Willis Process Guides

Reflow soldering is a relatively simple process. Solder in the form of solder paste is heated along with component and printed circuit terminations. Depending on the alloy, the solder paste particles become a liquid at either 179°C or 184°C. When the solder is in the liquid state a solder joint will form between the two surfaces.

The speed of wetting will depend on the lead and PCB coating and the solderability of that coating. It is necessary to heat up and cool down the assembly in a controlled manner. It is also necessary to maintain the solder joints in a liquid state to eliminate voiding and form a true intermetallic bond with the base materials. Further details on reflow and profiling are contained on the Bob Willis video tapes and CD ROMs on profiling reflow ovens.

Board Support

The printed circuit board should remain as flat as possible throughout the first or second soldering operation. The peak temperature and maximum duration at peak temperature of any component should not be exceeded. Many parts have a peak temperature limit of 220°C.

With modern convection ovens the convected air or nitrogen should not disturb components or cause the printed board to flex. This can occur with thin boards of less than 0.5mm like PCMCIA panels. Ideally all reflow ovens should be able to adjust the level of convection rates to minimise component movement.

The board support should be fully adjusted to meet the board requirements, it should need the minimum clear area on the base of the board. Variation on conveyor width should be checked on entry, exit and in the centre when cold and at operating temperatures to make sure that distortion of the board is not due to conveyor pinching.

Machine Parameters

Initially the temperatures of the separate zones will be based on an existing profile for a similar board design. The speed of the conveyor will be adjusted to the desired assembly throughput of the oven. This may be limited by the type and length of the unit.

Profiles and Thermocouples

Thermocouples will be fixed to the printed board surface and the component terminations ideally directly in contact with the pad surface. If they are placed on the top of terminations it may affect the readings. After any adjustment to the oven it is necessary to wait until the oven stabilises. The speed of stabilisation and its repeatability over a number of profiles is a mark of a good reflow oven. This should be part of the initial oven evaluation and understood by production staff.

Next the first board with thermocouple leads attached may be passed through the oven and the temperature profile analysed. Adjustment may then be made to the zone temperatures and conveyor speed to obtain the correct profile. The desired profile is a combination of recommendations from the solder paste manufacture, the component suppliers guidelines and the printed board solderable finish. All surface finishes are affected to some degree by high temperatures. The correct temperature profile can eliminate solder balls and significantly reduce flux residues on many low residue pastes

To conduct the reflow operation correctly it is important to know what temperatures are being seen by the whole board assembly. This requires the use of thermocouples to monitor selected solder terminations. In the case of surface mount parts the thermocouple beads are soldered directly to the joint surface using high temperature solder.

With Ball Grid Array (BGA) the lead must be positioned under the centre of the device. In most cases these are the last terminations to reflow during soldering. Either thin wire is used or more commonly, a profile board is produced with a thermocouple wire mounted through the board into a ball termination to improve the repeatability of the temperature measurement.

All profiles should be developed on a fully populated board to guarantee that the correct conditions are achieved. If the boards are to be processed in or on support pallets then they should be used during profiling. The pallets will contribute to the mass and hence affect temperature rise on selected areas in contact with the board. It can easily affect the temperature rise by as much as 20^{o}C.

When a profile has been established then the board should be run through the oven again monitoring the profile but load the oven in front and behind the profile board to determine the thermal loading and the degree to which the temperature drops. Final setting changes may then be made to the oven zone temperatures.

Final Trials

When a profile has been established and been run in production with satisfactory soldering results the following information should be retained. The solder temperature in each zone, the speed of the conveyor, the extraction rates and the board loading. A temperature profile should be run on the oven initially each day to build up a picture of the process stability. The frequency may then be adjusted depending on the repeatability of the results.

Further trials should also be run on the desired profile with the production paste to determine the degree of slumping of the paste as it will affect solder shorting. Lower the final zone to just below the reflow temperature of the paste. Pass a fully populated board through to examine the board on exit. Check the amount of slumping on fine pitch, under BGA devices and chip components. This test is very useful to understand many of the causes of solder beading on chip devices.

Even with the best convection oven there is a difference in peak temperature or duration between different board assemblies. So don't be a Lazy Engineer with a single profile be a Great Engineer and learn more about your process.

Process Trials Procedures.

Standard trials are often conducted on reflow ovens by production engineers during product assessment, machine approval or in process set-up. The following trials are also used by machine suppliers during equipment development.

Temperature Uniformity

Measure the surface temperature on an assembly or ideally on a blank laminate test board to obtain any variations across the complete conveyor belt width. This will show any peaks or low points between centre or near the edge of the conveyor.

Test results ideally achieved to be between 5-10^{o}C

Thermal Loading

First a temperature profile is produced as a reference using six thermocouple probes soldered to the assembly, three on the top and three on the bottom. The oven is then thermally loaded with products. Alternatively copper laminate or steel sheets may be substituted to fully load the oven. During loading a further profile is taken to compare the temperatures in this simulated production test. If only top side heating is being considered on the oven all the probes are placed on the top of the board.

Test results achieved ideally less than 10-15^{o}C

Temperature Stability

Measuring surface temperature on an assembly or test board checking variations across the complete belt width. Repeating this trial periodically through out the day in production shows an oven's control system even with a varying environment. The test should be run with one set-up but may be run with different board types.

Test results achieved ideally less than 10-15^{o}C

Throughput Speed

Adjustments are made to the conveyor speed for the maximum envisaged circuit board throughput requirements. The preferred temperature profile for the most complex product is then the goal. Reference must be made to the paste or adhesive requirements when considering these tests.

Evaluating nitrogen usage must be conducted with discussions on existing users of machines for consumption and maintenance. The use of nitrogen has benefits but needs to be justified. Solderability assessment of surface pads is a good measure of the benefits of nitrogen comparing samples before and after reflow in nitrogen.

Bob Willis is a process engineer providing engineering support in conventional and surface mount assembly processes. He runs production lines at exhibitions and also provides reflow soldering seminars and workshops world wide. He is often called to advice suppliers and customers on process issues and is able to undertake process improvement projects on site. He has one of the largest collection of training videos, interactive CD-ROMs and training material in the industry.

Bob will be presenting four Master Classes at APEX in California, he will also be presenting classes at SMT Nuremberg in Germany for those engineers visiting the show. For further information on how Bob may be able to support your staff contact him via his web site **www.bobwillis.co.uk**

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