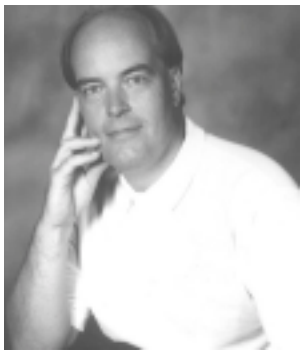
Hot Air Knifes (HAK) Eliminates Wave Soldering Defects



Wave Soldering is still one of the most widely uses automatic soldering processes used in electronic assembly operations. The soldering system is often the first automatic machine a company purchases as their production volume of printed boards assembled increases. It is also the first piece of capital equipment as it is one of the easiest to cost justify to management. Care needs to be taken as many boards designed for manual assembly do not necessarily solder that well during wave soldering.

During the original introduction of mass soldering in the mid 1950's the most demanding component pitch to be soldered was 0.1 but that has now changed with surface mount to 0.050" on small outline devices (SOIC) or even 0.025" on quad flat packages. Leaded integrated circuits are available below 0.050" as are IDC post header terminals for ribbon cables. Increasingly the use of three and four rows of termination on input and output connectors are proving difficult to the soldering engineer. This is particularly true as they are positioned at the entry and exit from the wave when the most disturbance to the solder wave formation takes place.

In real terms the only functional defects we have to overcome on good quality boards and a reasonably well set-up wave soldering system are solder shorts and solder skips. Hot Air Knife Technology can not eliminate skipped joints but it can remove solder shorts. A solder short is a conductive link between two or more pins on a board assembly. It is due to excessive solder remaining on the base of the board between terminations. The excess solder has not drained fully back into the wave before the start of solder solidification.

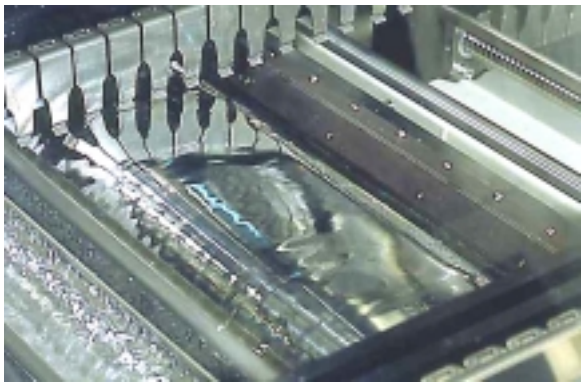
A solder skip is a total lack of solder on one or more pads. Normally this is specific to surface mount components on the bottom of the board. Solder skips are caused by either the solder waves are not at the right height and not contacting the board surface fully or they are caused by gassing from the flux during wave contact. All other skipping faults are a result of design, PCB or process stages before the soldering process. Interactive CD ROMs on Wave Soldering and Surface Mount problems are available from the SMART Group www.smartgroup.org

Any other problems seen during machine soldering are cosmetic issues which can be easily eliminated from the process if a little time is spent with the process or the materials being used. After fifteen years of practical shop floor experience and running training courses on wave soldering for much of that time there are few problems that have not been seen before. In most cases faults are caused by the machine being incorrectly set-up or a fault of the product design being processed.

"It is fair to say that most modern soldering systems used in industry can be set-up and operated to solder to a satisfactory standard without an air knife. That is dependent on the level of process training staff and engineers have received and the quality of the designs being processed. The air knife is that little bit extra to over come that problem board assembly that we all face from time to time. Unfortunately many people use the hot air knife to overcome poor initial set-up of the machine or use it when not required, then say it does not work or its not needed"

Bob Willis Process Guides

There will always be designs that stretch a wave soldering systems capability and that is why back in 1977 the Hot Air Knife (HAK) was originally designed by Hollis Engineering to remove solder shorts from closely spaced terminals. HAK Technology was an now is a method of projecting a thin sheet of hot air approximately 0.018", at the base of the printed board assembly as it exits the solder wave. As the joints leave the solder wave and when they are still in a liquid state a HAK removes the excess solder from the terminals.



Example of one air knife produced and supplied by Invicta Engineering in the UK

A system consists of a control unit that feeds air through to the air knife at very low flow and then at high flow when required to remove solder shorts. This reduces the drop in temperature if the system was simply switched on and off as required. The air passes through a tube and out through a series of holes into the head through a screen which produces a more even pressure as it exits the slot aperture. Thermocouples monitor the air and heater temperature which will be monitored at the control panel.

The process works due to the wetting forces which form a reliable solder fillet. At the solder to pin/pad interface the wetting forces are at their highest. As we move away from the pads the forces acting on the solder between the pins are weaker.

"Remember the totally unorthodox method of removing excess solder from a board assembly when a de-soldering tool is not available. We have all done it or seen test engineers do it ! Heating the solder with an iron and then quickly knocking the board on the side of a bench removes the solder short but not the solder from the joint areas. An air knife is a more elegant and non destructive technique to remove shorts".

The correct set-up of a HAK requires the knife to be positioned as close to the underside of the board as possible and as close to the wave exit. When this is achieved the air pressure and temperature required can be at its minimum. The greater the distance from the board the higher the air pressure required. As the distance is increased and the air increased the temperature will also need to be raised as it will drop at the point where contact is made with the joints. A typical air knife temperature would be 390oC with a pressure between 9-15psi. It's also common to see cavitation on the surface of the solder when too higher pressure is used.

The angle set for air contact will depend on type of board surface mount, plated through hole or single sided assembly. The angle of the air knife can range between 45-80deg. All plated through hole boards are less sensitive to set-up than single sided boards as the volume of solder on the joint section is much less between the lead and the pad. It is slightly more difficult to set the process for single side boards than for plated through circuits. With plated through boards the solder at the top of the hole can be seen to shimmer as the air contacts the base of the board directly after separation from the last wave.

Care should be taken during initial design to make the air knife more effective as a process aid. Although all the following are good design for manufacture rules for any circuit design:

No tooling holes or large holes with plating. These would normally require masking to prevent solder fill. In the case of a HAK the solder will be removed by the air, unfortunately on to the top of the board. All surface mount component terminations should be parallel to the direction of travel. This is normal for the parts to obtain the best soldering yields.

No large cut-outs, always use a routed plug in the PCB to blank the hole which is easily pushed out after soldering. Manual masking is time consuming for application and removal during production. Any masking and de-masking operation is not the most favoured job by production staff and a defeat for a production engineer.

Always support the board to prevent sag during passage through the solder wave, either using a blade or wire centre support. When using pallets make the PCB support edge as thin as possible to allow close positioning of the HAK. Always control lead length from the base of the board which should not be greater than 3mm.

As a practical example working for a contract manufacturer on a high volume product line he was experiencing two shorts on every board produced. After trying every trick in the book the shorts still remained on two rows of pins in the centre of the board on 0.025" pitch connector. Conducting a short trial with an air knife eliminated the shorts and the contractor purchased a new machine with an air knife.

An air knife is like any process tool it must be correctly set for a product or optimised for a group of different boards. If it is switched on and let to operate who is to say if it is working and justifying its cost. Correct set up for an air knife is through experience and production trials. Incorrect set up will not remove solder shorts it can even create soldering defects by blowing solder onto the top of the board.

During the description of the knife and its operation we have referred to it solely as an air system. Today it is also used with nitrogen when associated with a nitrogen soldering process. In a sealed unit where the wave has a hood the knife is also used to introduce nitrogen in to the system. During operation the flow rate is but only a small bleed of gas is introduced through the knife when boards are not being processed. The same technique is also used when the knife is used in an open nitrogen wave like the ConTour supplied by Electrovert. Nitrogen must be used in either application through the knife or it would defeat the benefits of the nitrogen if it were introduced in any other way.

If you have great designs and design engineers willing to make changes to continually improve yield, customers willing to listen to contractors, no leading edge fine pitch technology and a stable low defect <100PPM (Parts Per Million) defects you don't need an air knife. If you don't have the above or you are a contractor often not in control of the designs then try it out it can eliminate solder shorts it certainly has for me.

Bob Willis is a process engineer working in the electronics industry, providing training, consultancy and product failure analysis. He runs production lines for suppliers at exhibitions and also provides seminar and workshops world wide. Bob has one of the largest collection of training videos, interactive CD-ROMs and training material in the industry. Contact him via his web site **www.bobwillis.co.uk**