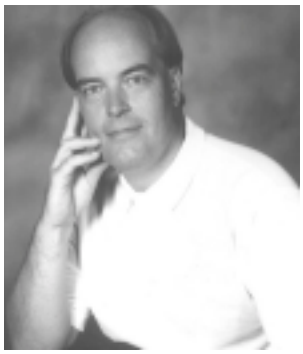
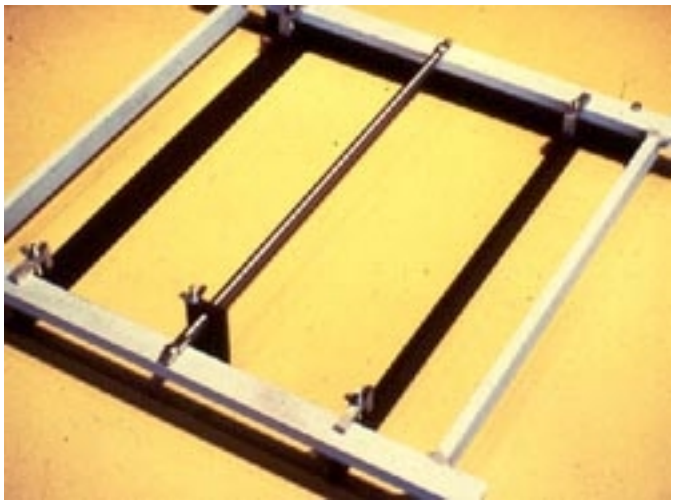
Guide to Soldering Jigs and Pallets



By Bob Willis and Peter Swanson

Despite the advances in electronic manufacturing which drive companies to the use of reflow soldering, wave soldering will be with us for many years to come. There are still many through hole components which can not be converted to surface mount and many products which do not benefit from changing to SMT. Wave soldering is a simple process for through hole parts and less demanding than alternative like intrusive pin in hole reflow techniques.

The soldering pallet, carrier or jig has been used for many years. Initially, a carrier was needed with fixed width chain conveyors to allow different board widths to be soldered. These early carriers were made from stainless steel or titanium, and were adjustable to allow operators to load different width and different size boards. Some of these fixtures were specifically designed to protect the leading edge of the board and prevent solder flowing on to the topside of the board. The front deflectors also provided support for the board during pre-heat and wave contact to minimise warpage. Often the deflector is used to mask the edge of the board when it features a series of gold edge contacts. These are normally used for interconnection to sockets on other boards, typical examples are PC graphic cards or boards for telephone exchanges.

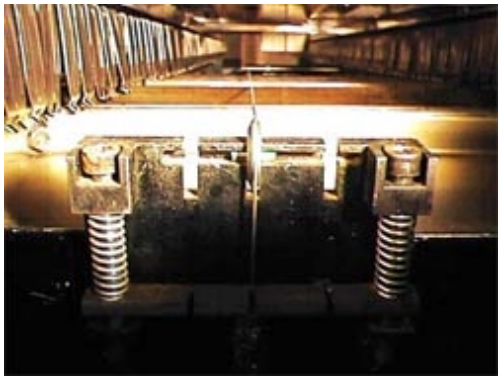


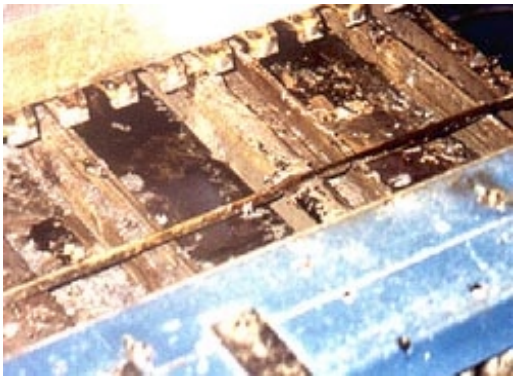
Example of front supports

Unfortunately many design engineers continue to produce layouts which do not allow the correct support for wave soldering hence the need for soldering pallets. It is fair to say that if more consideration was given at the front end of the design cycle many products would not require traditional solder jigs. This in turn would reduce the cost of manufacture.

Today, the most common type of wave soldering conveyor is the finger system. Although more expensive than the chain system, finger conveyors are more versatile as the conveyor may be opened and closed for different board widths. They also allow direct and automatic loading of boards from an in-line feed conveyor helping to automate the wave soldering process. With many companies trying to reduce time during machine set up jigs and pallets can over come the issue of different width boards without introducing standard width multi panels.

In many cases at the design stage jigs can be eliminated if the board is narrow less than 100mm or if a mechanical wave support is used and provision has been left in the layout of the base of the board. A wave support is a titanium knife edge which is positioned in the centre of the wave. The knife is supported on two adjustable rods at the front and rear of the solder pot. This allows the knife to be re-positioned for different board types. A further alternative is a support wire which is again fixed to the rear of the solder pot and can be stretched through the machine to the fluxer Thus supporting boards right through the process.





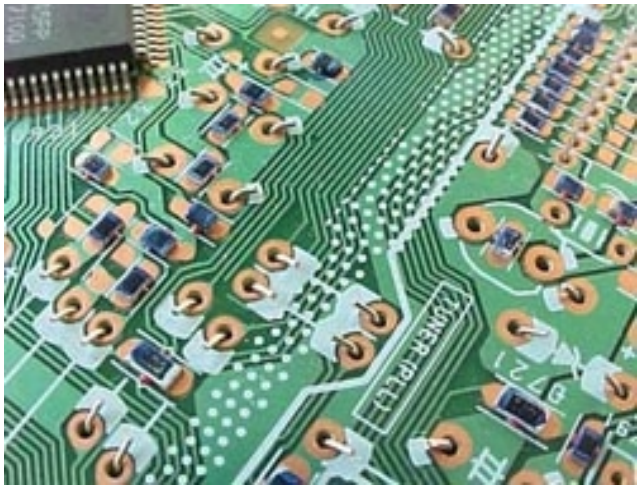
Wire support and knife support both can eliminate the need for jigs

Warpage

During soldering, the PCB substrate rises in temperature above its glass transition temperature (Tg). 120-135oC even if a jig supports a board on all four sides the board will still tend to sag in the centre. This will always increase the possibility of shorting in the centre and back portion of the board. The degree to which sagging will occur will be influenced by the following:

Type of board, single double sided or multilayer
Loading of components
Copper balance of the circuit pattern
Pre heat and wave temperature

A simple way of reducing this is to use a wire fixed and recessed on the underside of the jig. This will support the board during processing and minimise distortion. Support wires like wave supports need to be considered at the (Printed Circuit Board) PCB design stage. During layout a no-go area should be placed along the centre of the board on its longest dimension. This no-go area should be 3mm wide and should not allow any component termination points or component bodies on the base of the board.



It is perfectly acceptable for circuit tracking to be placed across this area as the tracking will be protected by the solder mask. If possible it is also good practice to have an indicator to the position of the no go area on the top side of the board either in the etched copper, legend or an image in the resist. This mark should be on the back and the front of the panel and makes positioning of the wire or knife support easy during wave set-up. If the support is not positioned correctly it could interfere with other parts on the base of the board.

A common problem with pallets is shorting of connector terminations in dense areas. This may be caused during initial wave contact or when leaving the wave as it causes a change in the normal flow pattern of the solder. A useful modification is to insert solderable metallic strips in to the carrier; these can act just like solder drainage pads on surface mount ICs and help drain the solder away eliminating shorting. As the solder drains off the underside of the board and jig the flow is disrupted and smooth separation is not always possible. If a solder drain is positioned in the pallet just behind the connector pins the solder is literally pulled off the board.

Advantages of Pallets

1) Masking

Dedicated pallets allow masking of selected areas of the board during wave soldering. This eliminates the time consuming task of manually masking the board. Pallet material is left in selected positions during profile routing. Many areas can be masked in this way, but the most common are gold edge connector fingers and corner tooling and mounting holes. An alternative is to fix small pieces of material to the underside of the jig to act as temporary masks. These may be screwed to the jig and moved or replaced when necessary. This eliminates temporary manual masking using tape or dispensed compounds.

2) Fixturing

A common requirement for printed board assemblies is the consistent positioning of connectors, LEDs (Light Emitting Diodes) and sockets. This is a necessary so that a mating part or enclosure can be positioned correctly at final assembly. It is inevitable that all components move during soldering. It is poor design and engineering practice to hope that parts will align correctly. When using pallets, special clamps and support arms may be fitted to the top of the jig to guarantee correct positioning during soldering.

3) Processing Multiple Assemblies

Jigs can be designed to hold more than one assembly at a time, thus giving increased efficiency through the soldering process. Handling of small boards or a couple of different sized boards in a jig is simple and it eliminates board break out after the soldering operation.

4) Soldering Surface Mount

It is possible to wave solder some larger surface mount devices, like QFPs. The results are better if this component is presented to the wave at a 45o degree angle, which can be achieved by PCB layout, or by presentation of the board in the jig at 45o. The only issue with having the board at a angle in the jig is that the size of the jig will increase and the width of the conveyor will need adjustment.

(Wave Soldering of any four sided surface mount device should be avoided if possible due to the poor yields that will be experienced).

Pallet Design Rules

Modern solder pallets are made from various materials, including FR4 and various high temperature glass composites. It is very important to choose one which provides a very stable support during pre-heat and wave contact. Composite materials are generally better wearing than laminates which, like PCBs themselves, will tend to de-laminate with repeated heat cycles. Material varieties include conductive or semi- conductive static safe versions. One company has produced injection moulded pallets from high temperature plastic.

A good quality pallet should not sag during the soldering process by more that 1-2 mm. The amount of sag is governed by the type and thickness of the material, the temperature of the process, the weight of board and components and the width of the pallet. To asses the pallet's ability to stay flat during processing place a steel ruler on the surface of the pallet so that it can be seen from the unload end of the machine. Pass the pallet through the machine and use the ruler as a reference as it passes through the pre heat and finally over the wave. To measure the sag simply hold a ruler vertically against the pallet.

All printed board materials expand during heating, so any design should allow for this. The pallet design should also allow for the common tolerances of the PCB length and width. A routed board will have far tighter tolerance than a blanked board profile. As a guide, a 0.25mm (0.010") clearance should be left around each edge. This will allow for expansion during soldering and will not cause the board to jam in the jig. A common cause of chip capacitor cracking is board flexure; this can occur during removal of the board from a tight fixture.

It is good design practice to leave a clearance of 4-5mm from the edge of the board to the first component termination. In practice, many designs do not, and soldering components right at the edge can be difficult. To help, the edges of the pallet which support the board should be chamfered or relieved to minimise the solder deflection which will occur during soldering. As the jig material is not solderable, it tends to cause a local meniscus, depressing the wave. The chamfer reduces the possibility of skipped joints around the edge of the board.

The edge surface used to support the board during soldering should be as small as possible 2-3mm. If it is a large area flux will seep into this gap and will tend to spit during soldering possibly causing solder balls. This is a problem with foam fluxing but not with spray application. A wide edge support also causes flux residues to be left on the edge after soldering. In cases where boards and pallets are being cleaned it is not a problem. With no clean the temperature at the point of contact is lower so the solvent does not vaporise; there is also no opportunity for the wave to displace the flux. With no clean fluxes residues may be visible around the edge of the PCB.

It is recommended that all pallets are supplied by one company and common rules applied to pallet thickness, height of board in the jig and position of edge for conveyor finger location. If this does not occur then many of the pallets will position the boards at different heights relative to the solder wave. This will undoubtedly increase soldering defects. A further recommendation is for one engineer in the company to be responsible for jig design, or a detailed procedure be written. It is a common problem in large companies where engineers are split into project teams and procure all tooling for their own board, hence the potential problem of inconsistent jig design. The problem also occurs in sub contract when a customer supplies his own pallets; when moving from a previous vendor the pallets may need modification.

Processing Considerations

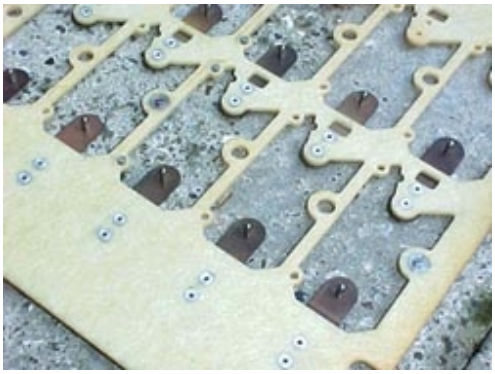
When setting up any solder wave it should be remembered that soldering in pallets does affect the process parameters. The relative height of the wave may be different to soldering boards directly on the machine, although better pallet designs will compensate for this by careful layout of supports and outside edges. The wave may need to be adjusted. Care should be taken to measure the clearance for the jig on the solder ducting. The use of a glass plate or Lev Check is a common way of setting up a solder wave; it should be mounted in a jig to make sure that the wave is consistent with the boards being processed in the pallets.

Double Sided Reflow

Double sided reflow products can also benefit from jigs. Pallets have been made which support double sided boards on belt conveyors during reflow, keeping the bottom side components off the belt.

Often there are still through hole connectors on these products which produce a problem during manual soldering, when it is difficult to consistently obtain complete through hole fill and achieve consistent joint formation. A jig can be produced with routed recesses, allowing the double sided product to be wave soldered while the reflowed components are protected from the solder wave. Apertures in the jig are left exposed for the through hole components only. This type of jig will tend to be thicker than normal and will require a higher wave and/or depth of immersion to provide satisfactory soldering performance. This does provide an unstable solder wave and a lot more dross in a air environment.

It is important that temperature profiles be conducted on the base of the board in the protected areas for possible secondary reflow. This will occur if the solder wave temperature is too high, too long is spent in the contact with the wave or the material separation from the components is too small. An alternative technique to selective soldering with double sided reflow is to reflow solder all the through hole components during second side reflow.



Example of double sided fixture for selective soldering through hole parts and example of reflow fixture for thin laminate materials

Use and Care

A jig or carrier plate is a precision tool designed to maintain the board at specific height above the wave. It is also designed to minimise sagging and twisting of the board during soldering. Any clips fitted to the top side are positioned to maintain the board in position not allowing the board to lift during wave contact. The cost of pallets is an investment to improve the quality of the soldering operation so why do companies not look after them? If the wave soldering system is correctly set up a jig can become the weak link in the chain. Consider the small investment in a trolley or rack for jig storage to protect these valuable assets.

It is good practice to periodically monitor the flatness and squares of your pallets using a flat surface. Taking a set number of pallets every week/month and examining their condition is common sense. It is recommended that they be numbered so that the same pallets are not always selected for test. This is also a good opportunity to replace any broken or damaged clips and clean the exposed surfaces particularly the board mounting face. If flux builds up or solder balls are on this face then the board will not sit flat and the process will be out of control.

Finally an example of a high temperature injection moulded wave soldering fixture

Bob Willis is also a process engineer providing engineering support in conventional and surface mount assembly processes. 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. 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**