Vitronics Soltec

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Wave solder conveyor angle

Introduction

During the development in wave soldering in the mid sixties of the last century, we have seen wave soldering systems with horizontal conveyor systems and with angled conveyor systems. Finally it came out that the angled conveyor gave the best soldering results.
We will discuss from a process point of view the demands for soldering related to the conveyor angle, such as contact length, dwell time, soldering speed and drainage conditions.

Next a small survey will be given about the pro's and con's of the different systems.

What are the demands for machine soldering

The goal is to get a high output rate combined with a high yield. We like to have a process with a minimum maintenance and a minimal use of consumables.
What we need in a soldering process is that the parts to be connected form sound joints. Further we do not want the solder to stay in between the joints after the solder process.
Also we do not want to overheat components so that their reliability will decrease as a result of the solder process.

With these goals in mind we will discuss the effect of the wave configuration in combination with the conveyor angle.

Limitations in the solder process

Since the thermal load to the PCB must be limited, to prevent thermal damage to the PCB or components, the wave temperature and the dwell time in the wave are also limited. Another reason to limit the dwell time is that the flux activity will be exhausted if the dwell time will become too long. Also a strong washing action of the wave might remove too much flux, which will create solder failures.

Flux

The flux must provide two main functions during the solder process. First it must make the joint area and the solder surface sufficiently clean, to make solder wetting and so joint formation possible. Secondly, at the departure from the solder wave the flux must be able to create an atmosphere were the solder will drain off without too much oxide formation. Oxide formation at this part of the process will create solder bridging between joints, or even solder webbing. If the flux is unable to fulfil these functions, solder problems will be created that can not be fixed by any wave setting.

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Dwell time

The dwell time in the solder is a combination of contact length in the solder wave and conveyor speed. But also the speed has its limitations. It takes a certain time for the solder to separate from the PCB at the wave exit zone. How much time, is very much depending on the joint configuration at the solder side. The drainage conditions will often be improved when we solder under a steeper angle. At a steeper angle the contact length in the solder wave will be reduced. As a result of that we have to reduce the conveyor speed to get to the desired dwell time.

Contact length

For high speeds one needs a longer contact length to get the desired dwell time, which means a larger wave area. This can only be arranged if one solders under a small angle. The solder angle is very much connected to the contact length in the solder wave. The depth of the PCB in the solder wave is limited due to the board thickness, because during the entrance in the wave the solder may not flood the PCB.

General settings

For most practical situations the optimal setting of the conveyor angle, in respect to contact length, dwell time and drainage conditions has been the 7° angle. This is based on a system using SnPb40 solder and a bath temperature between 240 and 260°C and the use of RMA-type fluxes.

Other solutions

Since not every customer uses the same type of PCBs, we offer the possibility in our machines to set the conveyor at different angles. The price one has to pay for this is that the machine must be provided with a nozzle that can create also the long wave area which is needed when one wants to solder under a small angle. Due to its larger surface such a nozzle might create more dross.

Nozzle tuning with the backplate

The tuning of the adjustable backplate is more difficult at longer nozzles when we solder at a steep angle. The solder rise and the velocity of the solder at the wave surface area in front of the PCB, is lower on a wave with a long wave area than with a smaller wave area.
This can be explained by the fact that during the entrance of the PCB in the wave the nozzle will partly be blocked by the PCB, so the solder at the free wave area will rise and get a higher speed. The smaller this free area is, the higher the solder rise and the speed of the solder in this free area will be. With a higher solder rise it is easier to tune the backplate for a correct solder overflow during the passage of the PCB.
This overflow will flood off the remaining oxides from the wave surface and so assist bridge free soldering.

So the best process solution would be to have the nozzle length dedicated to the conveyor angle. This is from the manufacturer point of view however less practical. The best offer we can give is to let the customer make a choise between the 70 mm nozzle and the 120 mm nozzle, in view of the process he wants.

SelectX™

In view of the application of the SelectX™ one needs this debridging tool as close to the PCB wave exit point as possible. This exit point depends very much on the conveyor angle.
At the 'standard' 7° angle this exit zone is at approximately 50 mm from the wave entrance. If we add for long leads an extra 20 mm we find a 70 mm nozzle area sufficient for wave soldering under 7°.

Horizontal conveyor

The benefits of a horizontal conveyor are mainly based on the fact that this system gives the best conveying systems for the PCBs. No special transition changes, or aids to keep the components in position, are necessary during the PCB transport.

The drawbacks are that the solderwave must always have a 'fountain' shape, because it has to flow over to both sides of the nozzle in order to give the protruding leads at the underside of the PCB a free passage over the nozzle. At the backside of the wave a special backplate is often installed to 'tune' the exit point between the wave and the PCB, to reduce unwanted solder bridging as much as possible. Due to this construction of the double flowing wave, more dross is created. The biggest drawback however is that the tuning of the backplate is very critical, so no rubust process can be guaranteed.

Angled conveyor

Although this system has the drawback that in front and behind the soldering machine the conveyor needs a transition area to become inclined and declined, the soldering performance is in general better compared to the soldering systems with the horizontal conveyor. The reason for this is that by increasing the separation angle between the PCB and the wave surface, the gravity will assist the drainage of solder from in between the joints.

By having the possibility to set the angle to customers demands, this system offers the greatest flexibility.

Summary

Due to the fact that the optimization of the solder process is very much depending on the PCB-type and consumables used, a precise investigation of the effect of the conveyor angle on the soldering quality is often left to the customer. From the book Soldering in Electronics Second Edition, author R. J. Klein Wassink, chapter 9.5 Wave Soldering, we found the following information.

Experience of Klein Wassink and Verguld at all, showed that solder bridging can be reduced by:

- adjusting the exit part of the wave, to be as smooth and quiet as possible;
- increasing the angle of conveyance;
- reducing the conveyor speed.