Getting the most out of mini-wave selective soldering machines - Are Two Heads better than One!

This article will examine the flexibility and advantages of selective mini-wave soldering including dual functioning nozzles and how to get the most from them.

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Why selective mini-wave soldering
The idea of mini-wave soldering is to replace hand soldering or traditional wave soldering which often ends up needing hand touch up/repair.

There are many other factors for considering selective mini-wave soldering. We all know about the deadline for switching to Pb free solder. The deadline came and went but the percentage of people that have fully made this transition is really quite low. The Pb free transition has resulted in a new level of interest in selective mini-wave soldering and there are many reasons NOT to buy another traditional wave machine:

1) Start up cost is expensive. In addition to the cost of the machine, the cost to fill it is very expensive. It could realistically cost 40K to fill some new wave machines, depending on the type of alloy and the price of silver at that time.

2) Operating cost are also higher e.g. N2 usage, Power consumption, more dross, more maintenance.

3) More floor space required.

4) There are more and more double sided reflow PCB's with less and less through-hole components so why not get something you have full control over?

Advantage of mini-wave selective soldering
The first advantage of selective soldering with a selective mini-wave is the quality of solder joints you can achieve with this process. Since you can control the process down to pin level versus PCB level you can expect a much higher FPY compared to traditional wave soldering. At each soldering location you can control the dwell time, peel off direction, nozzle height, drag speed, and more. This means even with densely populated PCB's you will have complete control over each area individually. In traditional wave soldering your parameter set is limited. With traditional wave soldering there is also the thermal shock risk on sensitive components.

When using a mini-wave selective solder process you do not need specially designed pallets like those you would need to have when soldering in a traditional wave machine. These can cost thousands of dollars by time you by the quantity needed for the process. You are also limited in keep out areas and component height using this process. On double sided reflow PCB's you may also need to glue and cure which is an additional process which cost time and money.

Key factors when selecting the best solution for your application

Is it true? Are 2 heads really better than 1?

Dual nozzles are an option that is offered only by a few suppliers and most of these only offer dual nozzles that can operate simultaneously using the same size nozzle. While this is good for running multiple panels at the same time, it doesn't really give you the ultimate flexibility you may be looking for.

Imagine having to solder a densely populated PCB with some very tight areas - pins that are 1mm away from other SMD devices - but on the same PCB. Imagine also that the board has some large connectors and other large devices. With a single nozzle it is possible to hit the tight areas, but not possible to properly solder the large connectors or other larger devices. The small nozzles are very good for tight areas but the thermal energy is not as much as it is on a larger nozzle. So there are 2 problems when using a small nozzle:

1) The thermal energy often is not enough for very difficult soldering points which means you will need to keep it in the solder longer which causes copper dissolution and board delamination.

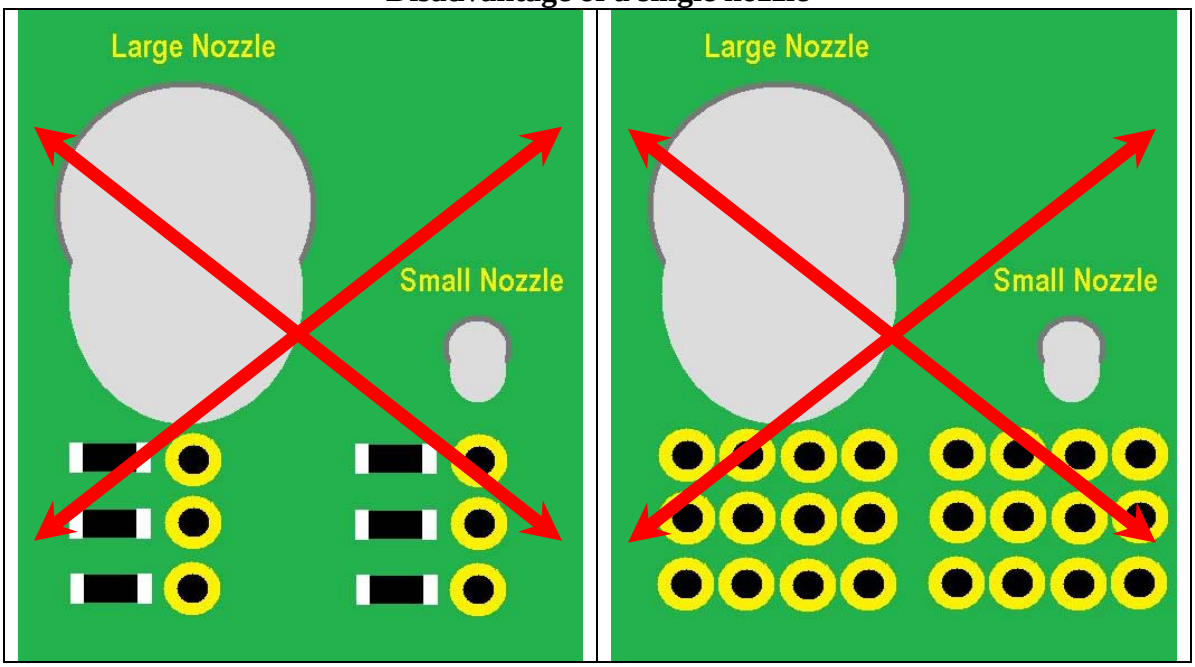
2) If you are soldering a large connector with 5 or more rows of pins that require soldering up and down each row this will dramatically increase the cycle time.

A rule of thumb is to always use the largest nozzle possible even if it's a single pin. With a larger nozzle the process window opens up quite a bit. They are easier to control and most importantly it means less time in the solder because of the thermal energy coming from it.

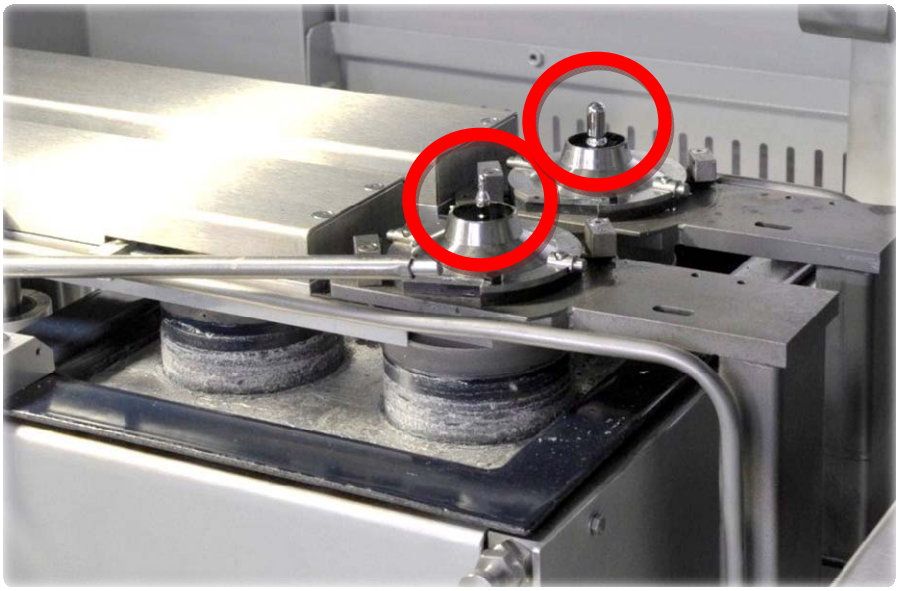
On the other hand, when using a very large single nozzle to increase the speed and generate more thermal energy for soldering the large connectors it will not be possible to solder the very small areas that require a smaller nozzle.

In the diagram below you can see what happens if you try to use a large nozzle in a tight area. The wave solder will reflow the SMD's around the area to be soldered causing them to fall off into the pot. The small nozzle will be able to solder without touching the SMD's. On the other hand, if you have large connectors you can make a single pass with the large nozzle before automatically switching to the small nozzle for the tight areas. The small nozzle will be much too slow for soldering these large connectors.

Disadvantage of a single nozzle

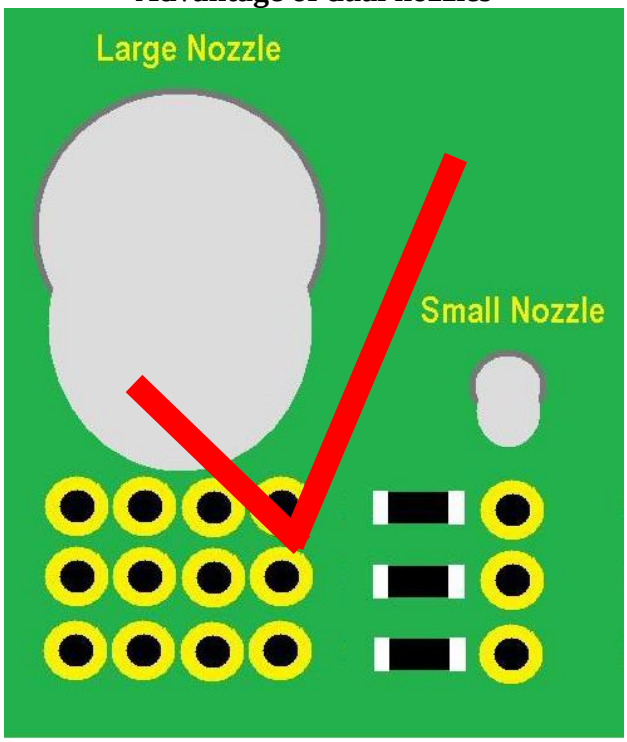


The ultimate solution is a dual operating nozzle system on a single machine that can use 2 different sizes nozzles that are controlled individually for every soldering location on the PCB.



The image above shows 1 machine with dual nozzles utilizing a 1.8mm nozzle on 1 location and a larger 8mm on another location. In this configuration you could then run all of the tight areas with the small nozzle setting the machine to switch over automatically and then run the large connectors. The programming is done at the same time and the program does the work from the moment the operator presses the start button.

Advantage of dual nozzles



Other determining factors when deciding which machine is best for your process
When determining what the best solution is for your process there are several factors you must consider:

1) **What are the cycle time requirements?** If the need is for a very fast, high volume machine you may need to consider High-Speed Stamp Soldering as discussed in a previous white paper. Selective mini-wave soldering is made to be very flexible, easy and fast to setup and change-over but it's not meant to be as fast as a traditional wave soldering machine. Most people understand this but it must be stated as a fact. The question often asked is, "what is the average cycle time with selective mini-wave soldering"? There is not really a good answer for that but it's probably true that most boards run between 2 and 5 minutes. Of course there are some faster and some slower.

2) **What is the largest PCB you plan to run in the machine?** There are machines available that handle boards with maximum sizes of 10" and machines that can handle boards up to 24". When running very large PCB's you must think about how you will keep these PCB's flat during the soldering process. The best and most proven method is always a mechanical solution. Some machines offer laser or other types of systems to detect board warpage but it is not a guaranteed method. Components, flux residue, and other variations on the board can affect the results.

3) **What type of pre-heating is required?** People are often surprised to find that many times NO pre-heating is required with selective soldering, but at the same time it is often extremely critical depending on many factors.

    a. Thickness of the PCB
    b. How many layers
    c. How much copper is built into the PCB
    d. Heat sinks
    e. Pb free or not

For these reasons and more, various options for pre-heating such as Radiant IR, Ceramic IR, convection, quartz, and Nitrogen are available from some manufacturers. Most of the time several types of pre-heating methods can be combined if needed. The method for pre-heating can be determined by the type of flux to be used and characteristics of the PCB but in most cases an IR style pre-heat can be used. Pre-heating is something that should be discussed in detail prior to making a decision with the purchase of selective soldering equipment.

As stated above, it is sometimes surprising to people when they find out a very high percentage of PCB's can be selectively soldered with no top or bottom pre-heat. Having controlled heated Nitrogen at the nozzle is a very good method for constant process heat which in most cases is more important than pre-heat while selective soldering. In the image below it shows how the heated Nitrogen comes straight out of the nozzle and is directly applied to the lead and barrel to be soldered. This heated Nitrogen can be controlled to 220° C and can be turned off and on when needed. Although this can be used as a pre-heat, the main purpose of it is to have constant heat on the soldering area during the process. This is especially helpful when soldering with Pb free alloys. One of the main problems when soldering with Pb free alloy is copper dissolution and PCB delamination. What causes this is the solder pot temperature is very high, and in order to get good barrel fill sometimes you need to stay in the solder for too long. When using this heated N2 you can lower the solder pot temperature which causes less dross. It gives better Inertion around the wave (less oxidation), heats the pin and the barrel directly, and the results from this are better FPY.

Heated N2 at the mini-wave nozzles

The process order for pre-heating it is also very critical. The accepted method is to flux first and then pre-heat. Some manufacturers may do the pre-heat prior to fluxing but this is widely not accepted due to improper flux activation.

How much flexibility do you need now and in the future?

The key to mini-wave selective soldering is fast setup, fast change over, and ultimate flexibility not only when you buy the machine but also in the future if you wish to add more options. One of the first things to consider is whether or not you want an inline or batch solution.
It's not very common that the "in-line" version of selective solder machines actually go in line. They are usually standing alone with an operator that is loading the PCB's into the carrier/gripper. Often times too much emphasis and money are spent on this option and it is not used, but in-line is certainly an option you should consider.

Future growth is very important. You may not want to buy more than you need at this time but you also do not want to be stuck with something that will not work for you in the future. Therefore, it becomes extremely important to know exactly what the machine is capable of handling and what type of upgrades can be added. Another thing to consider is the ability to do these upgrades on your own versus having to pay someone to do the installation.

Conclusion

Since the bottom line for selective solder is to achieve high-quality soldering joints that are repeatable, you need to select a system that is going to give the best results. But with many options to consider it is best to partner with a vendor that that provides both high-quality soldering equipment that offers the ultimate in flexibility. The vendor that can offer a large and experienced service organization and good supply of spare parts is a strong plus.