One of the last step in the PCB production process, following the screen printing and component placement, is reflow. Like we have discussed in the previous two articles, each process comes with its own set of challenges and the reflow stage is no exception.

The reflow process has taken on a life of its own with the evolution of changes in technology, impacted by environmental factors and the demand for greater accuracy with tighter tolerances.

Two of the main technologies deployed on the shop floor are either based on convection or vapor phase technology. In this article we look at both technologies and compare the advantages and disadvantages, with the aim of helping you to make an informed decision, if you are looking to invest in a solution.

One consideration is the minimisation of voids. For some engineers, filling the void and ensuring there is sufficient solder around the solder joint becomes a balancing act of several factors. These consist of variables such as the type of solder utilised i.e. no clean and water soluble lead-free solder, the manufacturer of the solder paste, stencil design, as well as the reflow process used - convection and vapor phase reflow.

Reflow: convection oven method

Typically, the convection method consists of four heat phases: preheat, thermal soak, reflow and cooling. These phases are depicted as zones within the convection oven, where the PCB passes through on a conveyer belt. However, some convection ovens consist of additional reflow zones and one advantage of additional heating zones is it gives you greater process control.

As the convection process is ‘in-line’ with the rest of the assembly process, greater throughput can be achieved because it integrates with the other SMT systems, automating the entire process. The conveyer belt is key to driving the boards through the system and adjusting the speed of the belt can help to refine the reflow process without having to manipulate the temperature of the different zones. If you start adjusting the temperature of one of
the zones, it will adjust the other zones to compensate which could lead to undesirable consequences.

One of the potential consequences can be the insufficient wetting of the boards. Ensuring the boards achieve sufficient wetting, especially when they are densely populated, can be a challenge. Often with a diverse range of components sizes, ranging from anywhere between 0201 to 2920 chips sizes, all with a different thermal mass. Irrelevant of the chip range and size you are utilising on the board, you may still find that the board consists of voiding in some of the solder joints. According to findings from T. Lentz & G. Smith (2016), two out of three solder pastes in their investigation gave higher levels of voiding in the vapor phase reflow without vacuum compared to RTS convection reflow. The solder include both water soluble and no clean lead-free paste.

Reflow: vapor phase method

Ultimately, whichever solder paste is utilised, both the reflow solution and the paste needs to be configured to minimise both voiding and insufficient wetting. Therefore it’s important to consider the process holistically, rather than each element of the process separately.

Vapor phase solutions often require more investment than convection ovens, both from the initial investment of the system, but also from the operational perspective i.e. Galden® PFPE - Perfluoropolyether Fluorinated Fluids. With its high thermal stability and wide operating temperature range makes it ideal for the reflow of PCBs.

The perfluoropolyether is heated to create vapor which provides the temperatures to create the wetting required for reflow of the board. It provides efficient energy transfer and is relatively safe process meeting the FM approved 6930 standard.

The vapor phase method is ideal for PCBs mounted with a range of chip sizes because there is minor temperature fluctuations between components differing in thermal mass.

In addition to vapor phase providing the inert atmosphere, resulting in temperature consistency for efficient wetting, the potential of overheating the PCB is eradicated because the temperature is restricted to the maximum temperature of the vapor, which is around 230°C for lead free.

However, vapor phase tends to be more of a manual process and is usually associated with batch production, which impacts the potential throughput. Although there are vapor phase systems that do cater for large volume production, they come at a significant cost compared to most convection solutions.

Equally, convection solutions don’t lend themselves well to organisations that have space restrictions because they tend to be considerably larger than vapor phase ovens.

Interestingly, T. Lentz & G. Smith (2016) found that both water soluble and no clean pastes demonstrated a statistical significance with voiding levels, with the no clean solder showing a mean level of voiding a low 1.4% in the RTS (convection) method, compared with a much larger 14.1% with the vapor phase method. However, they did document that vapor phase with vacuum did reduce levels of voiding.

Making an informed decision

Ultimately, the reflow method that is right for your business will depend on a range of factors including:

Design

The design of the board and the range of components including the size of the chips, can have a bearing on what method is utilised. i.e. if the board is densely populated you might want to consider the vapor phase option, where you benefit from inert atmosphere.
Volume
If you require high volume, then you need to consider that some vapor phase solutions can be provide only a batch reflow process. Convection ovens have been designed to automate with the rest of the SMT line and typically provide higher throughput. However, some vapor phase systems have been developed to offer increased automation, delivering greater throughput, but the technology comes with a requirement for significant investment. It should be noted that throughput volume depends on numerous variables including the solder profile.

Range
When you manufacture a range of boards, there are additional factors that need to be considered such as how many different boards you need to process through the system. Typically, you’d need to allow for the zones to reset if you were utilising convection ovens which could impact turnaround times.

Application
If the PCBs are critical and are utilised in applications such as aerospace, defence, or medical, the vapor phase solution provides the benefit of PFPE which eradicates the possibility of overheating and provides greater consistency, even with components with greater thermal mass. However, vapor phase requires significant investment which is not going +to pay dividends if the boards are going to end up in consumables of low value.

Voiding
Aspandiar, R. (2019) suggests that the size of the void is less critical than the location because if the void is located on the solder joint, it is more likely to impact the reliability than a larger void situated away from the joints.

However, with some methods showing that voiding can be present with a mean value of 14%, with some solders using vapor phase methods, it begs the question how many of those voids are situated on the solder joints themselves.

Quality control and continual improvement
Whether you decide to invest in vapor phase or convection technology, ensuring the systems are configured to meet the correct specifications to accurately reflow your boards is essential. After all, you could have the latest oven on the market with all the technology, but if you don’t configure it properly and setup the profiles correctly, inevitably you’ll end up with insufficient wetting, voids or even overheated boards. Therefore, its imperative that engineers utilise the tools they have at their disposable to configure the ovens (particularly the convection systems) to optimise their performance. Tools such as Thermal Profilers should be utilised pro-actively, rather than just as a trouble shooting aid. Utilised with the AutoSeeker Profile Optimiser software negates the need for balancing the zones, with the aim of achieving the gold standard for every profile.

Thermal Profilers
Thermal profiler systems such as the PRO thermal profiler from SolderStar include insulated micro dataloggers which can be utilised with a range of accessories, capturing comprehensive data for profiling the oven to optimise the reflow process.

The AutoSeeker Profile Optimiser, unique to SolderStar can be added to the system where it searches through millions of combinations of oven set points, to provide suggested settings for both temperature and speed. This solution is not restricted to convection ovens, it can be utilised with selective wave and vapor phase reflow methods.
