VAPOUR PHASE REFLOW - PROFILING FOR LEAD FREE ALLOYS - ASSCON ADDRESSES THE PROFILING GAP WITH NEW THERMAL CONTROL TECHNIQUES TO ADDRESS THE ISSUE OF PROFILES MEETING PASTE MANUFACTURER RECOMMENDATIONS

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Vapour Phase has seen resurgence in its use recently. In large part this has been a result of new chemistry and the advances in the technology to manage energy flow from the source to the PCB via the vapour. Added the demand from the customer base is again present as we deal with density challenges in PCB design, Parts design as well have to contend with new alloys that are less forgiving than the old traditional 63/37.

Gases as a conductive medium are very poor and while the Reflow process is often described as Convection it is in fact a conduction system. A heat source has a gas passed across it and energy is transferred from the source to the gaseous mass. The gas is directed via a Plenum and other flow control mechanisms to the PCB where the energy is transferred from the gas to the PCB [and everything else it comes into contact with.] The challenge is in maintaining control of the transfer given the overall inefficiencies in the system. If you assume a transfer ratio of energy in a gaseous system that is $1/10^{th}$ of a hot plate then it is reasonable to assume you need to generate 10x the energy at the source that the PCB will require as the gas will not adequately convey the available energy. Added, the inefficiencies at the PCB end of the system are equally poor and further frustrate the control and energy efficiencies of the machines. Hence when we look at power consumed V power used the delta is significant. When you consider the issue of Delta Ts and the higher temperature demands of new alloys – it is obvious the response times in a gaseous system are simply incapable of sensing, providing, transmitting and receiving energy in a real time manner. These issues are exasperated with complex geometries and heavier mass PCBs, stacked parts and PCB to parts gaps that are so fine it is impossible to get gas flow under the parts to carry the heat into the central points of I/O.

Fig 1

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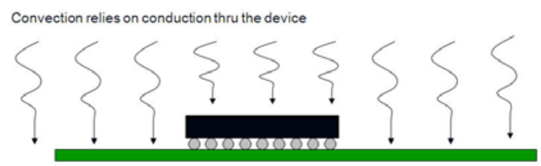
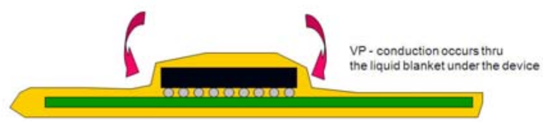


If we again use the Hot Plate analogy and insert a layer of liquid between the hotplate and the PCB. The energy transmission is almost 1-1. There are obviously some losses but coupling of the source to the target via a liquid is a far more effective method of managing energy transference.

A Vapour Phase system enjoys the benefits of capillary action and thus is able to directly carry heat under the device and to the joints directly.

Fig 2



A Vapor Phase system creates a Linear Profile. Linear Profiles [fig 3] are the most logical approach to moving any given mass from ambient to a peak temperature, hold that temperature and return to ambient. The reason simply is the implied stress on the materials is less, once a rise rate is established it makes sense to maintain that rise rate rather than start stop and start again. In consideration of these benefits it would seem Vapour Phase had many significant advantages yet today is still a process used by a minority of manufacturers. However when reference is made to a data sheet from many paste suppliers it suggests the recommended profile for the paste as indicated in Fig 4.

The reasons for the 3 step profile are many and varied and have a long history, but the fact remains this is a difficult profile to create in a vapour phase machine that utilises a single chamber.

Pastes had required a period of "soak" to assist with flux activation and volatile removal before a final push into liquidous. Large mass PCBS with large and small mass components benefitted from the "Catch up" opportunity afforded by holding the PCB at a close to static temperature rise rate for a period of time. This lessens the divergence as reflow temperatures are approached and reduces Delta T at peak.

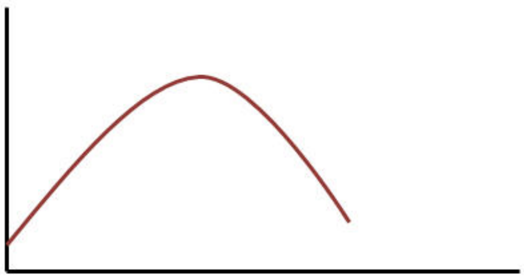


Fig 3 Typical Vapor Phase Profile

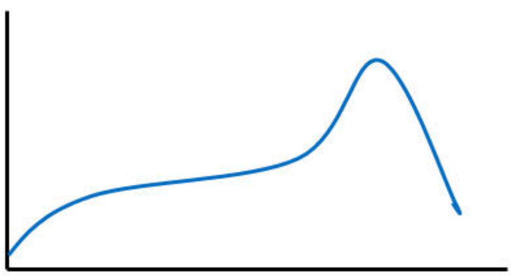
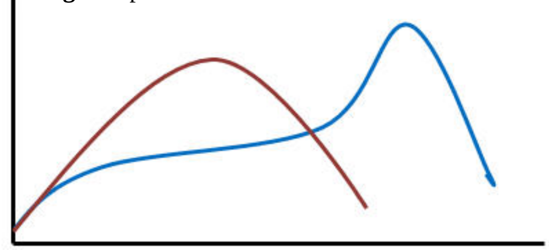


Fig 4 Typical Convection Profile

Many paste manufacturers today have pastes for leaded and lead free applications that do work well with a linear profile.

However, for many companies the ability to simply choose a new paste or paste vendor is out of the question. Whether it is an OEM or a governmental edict the paste is a significant part of an approved process and to change the way it is treated would demand a whole new characterisation of the process and an audit. Changing the machine type is likely acceptable but changing the thermal profile infers many potential issues. Not something many desire to undertake.

Fig 5 Vapor Phase v Convection



When the two profiles are matched alongside each other the differences are significant. Fig. 3:

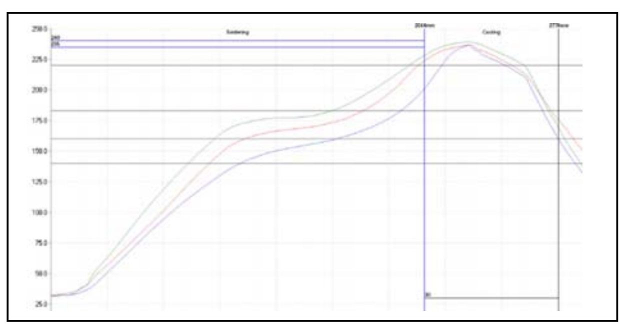
1. Overall saturation time is less.
2. Peak Temperature when looking at ALL components is less.
3. Ramp rates are typically linear

While these facets for many would be advantageous the challenge when changing a proven process is expense and time.

Profiling in a Vapour Phase system in the manner of replicating a 3 stage profile is difficult. The issue is in the vapour blanket acting as a reservoir of thermal energy, and depleting [sucking it out] without losing the vapour has been the problem.

Various approaches have been tried and today many companies have a "partial solution" by either changing the relationship of the PCB to the Vapour blanket – its height in the tank. Or, heaters are switched to minimal levels and so a slow vapour reduction takes place affecting the rate of temperature rise, this exhibits itself as a flattening of the profile Fig 4. All of these tactics are marginal when trying to emulate a profile designed for a convection system.

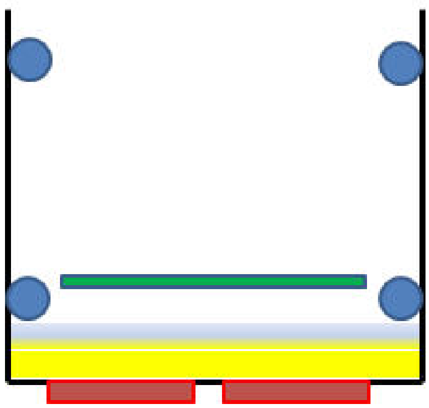
Fig 6. Profile created by switching down heater power



Today the most aggressive temperature changes in a profile can be accommodated in a single chamber Vapour Phase machine. This is accomplished with Active Vapour Cooling [AVC].

Extremely simple but effective it utilises a second set of cooling coils positioned on the walls of the thermal chamber at a point similar to that of the PCB. Fig 7. As the PCB reaches a suggested inflection point slowing in the rate of rise [soak phase] water is circulated briefly through the lower cooling coils at the same time power to the heaters is reduced. The effect is to create a cooler component within the system than the PCB and draw the vapour blanket away from the PCB, condense the vapour out on the cooling coils returning the fluid to the tank.

Fig 7



This instantly reduces the heating rate and allows for a rapid change facilitating the soak period of a 3 stage profile. Fig 8. After a pre determined period, the heaters are again ramped up feeding the fluid reservoir and creating vapour, which again provides the energy transfer to the PCB and it rises in temperature to the Peak temperature.

Fig 8

The end result of such a mechanism is the freedom to create any shape recommended profile and retain the extremely beneficial characteristics that Vapour Phase offers.

1. O2 free environment
2. Controlled ramp rates
3. Low or zero delta Ts at peak
4. Direct thermal communication with I/O under array packages.
5. Lower power consumption