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Reflow profile

During reflow heating process, state and action of solder paste changes more or less like the below indicated.

1. First ramp-up :

By elevation of temperature, solvents start evaporating.　Evaporation rate differs depending on boiling point of each solvent employed.
In the same way, rosins and thixotropic materials start getting softer.　How each material becomes soft depends on its softening point.　In general, softening point of solder paste is at around 100°C.

Thus, when ramp-up rate is too steep, it softens solids of flux while large portion of solvent is remained and makes the solder paste watery, and can be causes of slumping → solder beading and bridging.

2. Pre-heat stage :

This stage is required to get rid of solvent completely and distribute the heat uniformly to the substrate.

The flux becomes soft like liquid, and uniformly encapsulates solder particles and spread over substrate, preventing them from being re-oxidized.

Also, along with elevation of temperature and liquefaction of flux, each activator and rosin get activated and start eliminating oxide film formed on the surface of each solder particle and substrate.

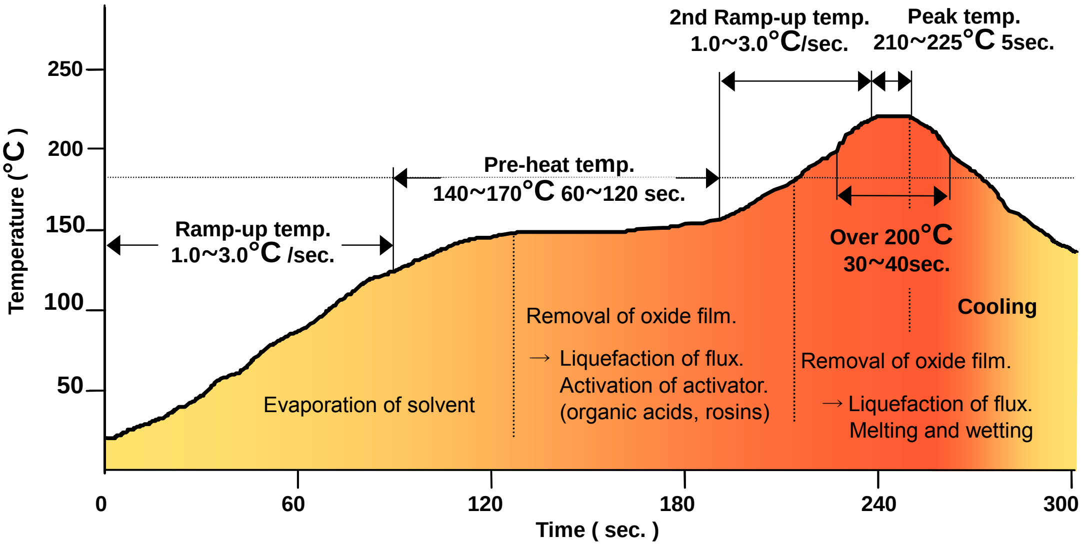
3. Over 200°C :

When solder particles melt by reaching melting point, in reaction with flux medium, oxide gets eliminated and soldering takes place.

A reason why the condition '*over 200*°C *30~40sec.*' is recommended is to secure complete melting of solder and certain wetting time in case some high heat capacity components are mounted.

Whether bridging by heat slumping happens is to be determined at first ramp-up to early soaking stage. What causes bridging here is inadequate heat distribution to each pad and lead wire.

When temperature of lead wire becomes higher faster than that of pad, then molten solder tends to be sacked up to the lead wire.　An excess molten solder swells at heel of the lead comes in contact with the solder of the neighboring lead wire.　Thus, in case bridging occurs, it is important to figure out very carefully how it happened.



** This reflow profile is recommended for most of Koki no-clean solder pastes, such as SE(S)48-M954 series, M1000-2, M855, M600 and CA and CH series solder pastes.*

In general, typically two different types of reflow profile have been popularly used, ‘linear’ type and ‘saddle’ type. Though we normally recommend the above ‘saddle’ type profile, let’s think how each profile has been created.

When surface mount components reflow assembly process was started to be used, population of components was not high and heat capacity difference among components was relatively small. Such simple board configuration had allowed to apply a easy-to-design gradual ramp-up/no-soaking zone profile without major problems.

Advancement of downsizing of PC board design started to require dense population of components and accelerated implementation of high heat capacity package components such as ICs and QFPs.

Increased heat capacity difference among components made it difficult to achieve good thermal equilibrium by using the gradual type profile (or even the saddle type profile) in combination with the conventional far IR reflow oven due to uneven heat mass distribution, different heating efficiency depending on color of components and shadow effect.

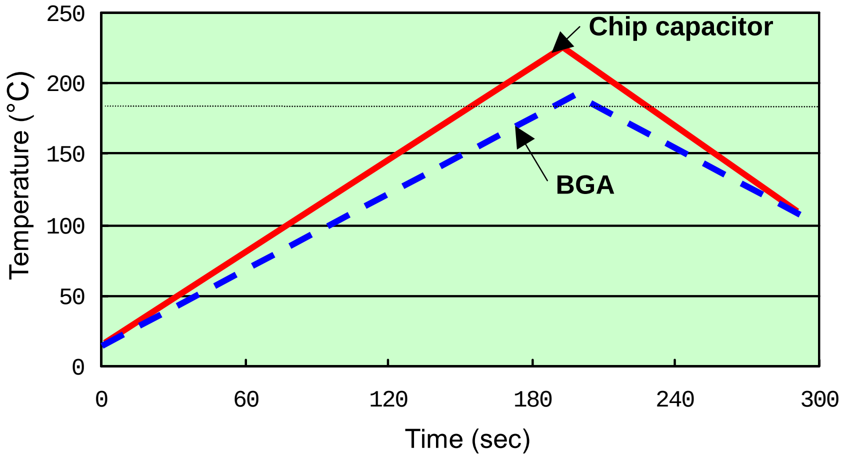
Then, vapor phase refow process, which is capable to realize extremely good thermal equilibrium, had once become popular. But, due to several problems, such as cracking and tombstoning of components by abrupt heat elevation, toxicity of solvent, abolition of CFC solvent and etc., this process became less popular quickly.

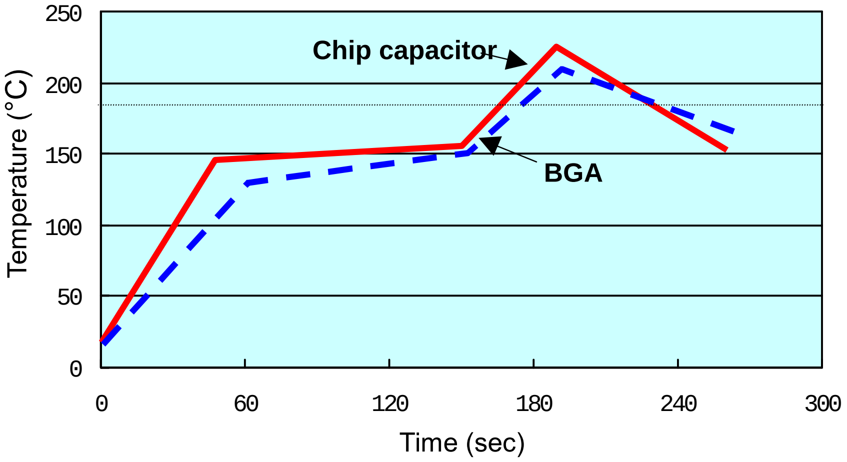
Forced air convection reflow process developed in turn, has won a large popularity because of far better heating uniformity in comparison with far IR reflow.

Now, a reason why the saddle type reflow profile has been widely used is mainly and simply for the purpose to achieve by having a soaking zone as similar thermal equilibrium at peak reflow zone to vapor phase process as possible with the help of forced convection reflow process.

We believe it is very important for better production yield as a whole that the priority of how reflow profile to be designed shall always be given to consideration of kinds of components and design of substrate itself, rather than how solder paste behaves during heating process.

For example, when temperature of soldering point of two different components, say chip capacitor and BGA is measured, peak temperature difference between these components shall be large as the temperature elevation rate of each component is different according to their heat capacity.





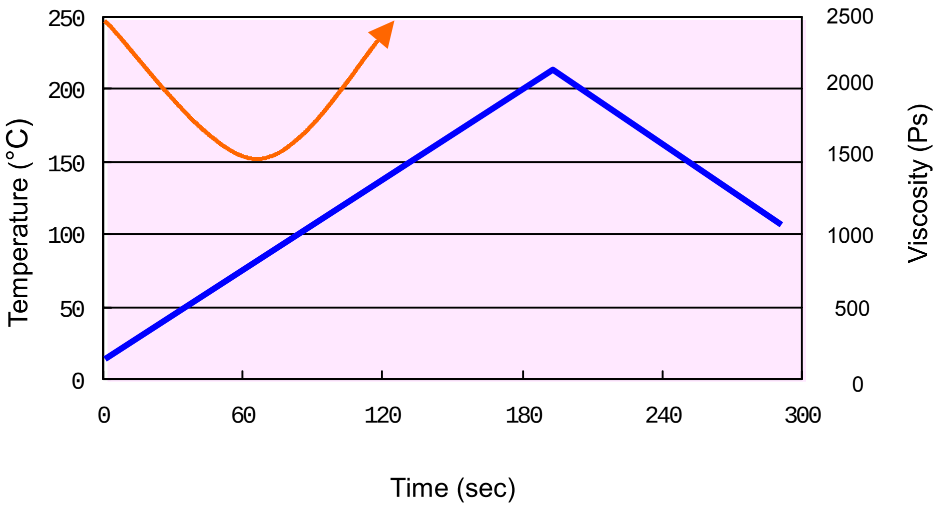
A soaking zone of the saddle type reflow profile, on the contrary, allows temperature of relatively large heat capacity components to catch up with that of the rest of components before the second ramp-up starts, and it makes temp. difference of each component at the soldering temperature much smaller.

Therefore, in terms of realizing better equilibrium among components, it should be desirable to have the saddle type reflow profile.

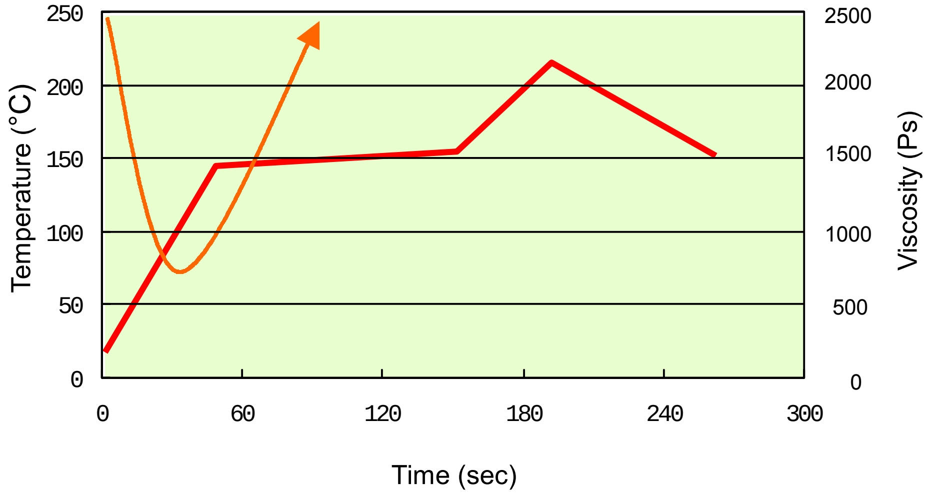
From solder paste point of view, it is correct that as temperature elevates, solder paste tends to become soft and can cause slumping and result in solder beads, bridging and other soldering defects if the first ramp-up is too steep and/or flux formulation is not proper.

Slow ramp-up helps evaporate solvents while making softening pace of rosins and thixotropic materials slower, and eventually, helps to prevent solder beads, bridging and other defects.

Graph-I



Graph-II



As the above Graph-II indicates, the steep ramp-up can create steep drop in solder paste viscosity. Therefore, what has been done conventionally for solder pastes to prevent this is to formulate lower boiling point solvent so that majority of solvent can evaporate before the temperature reaches softening point of rosins and other solids materials. This, however, could turn out to be short stencil and tack life of the pastes.

Having in mind that the saddle type reflow profile shall be desirable to ensure good solder joints quality regardless of size/heat capacity of components, we have developed a special thixotropic formulation which ensures extremely high slump resistivity even under relatively steep ramp-up, and made it possible to adopt high boiling point solvents for extended stencil and tack life at a same time. This new thixotropic formulation has been applied to most of Koki solder pastes since SE(S)-M953i was developed. (ex. M850, M954)

Such a flux formulation has succeeded to make the solder pastes much less dependent on design of reflow profile, and as a result, to widen process window of soldering process.

Our conclusion is that customers can adopt either type of profile, gradual or saddle type, so far as Koki solder pastes and most of solder pastes are concerned, and a certain level of heat energy to evaporate all solvents is ensured. But our recommendation is what design of reflow profile to apply shall be determined from the full respect of heat equilibrium of substrate and components to secure quality solder joints on every component, rather than worrying to much about how solder paste behaves during reflow process.

In fact, as you have experienced, there are quite large number of users are using the saddle type profile without any soldering problems.

According to our experiences, how to design stencil apertures shall have more practical influence over prevention of soldering defects such as solder beading and bridging, than spending a lot of time in changing design of the profile.

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