Control Rework in the same Way as Production Process

Automatic and reliable Rework Process

The evolution of electronic components and the change-over to lead-free is a challenge for production. In addition, we need to focus on these issues in the rework process. In the field of automated rework, it is necessary to understand certain important process parameters if one is to get reliable and repeatable results.

*Bruno Affolter**

Very often, rework is understood as repair. Even though repair is significant in the production process with consideration of the costs of individual components and boards, it represents just part of the overall field of rework. Other processes need to be mentioned as well. Some examples:

- New products face frequent changes during development as well as during the introduction phase to mass production. Prototypes and small series production have the same requirements in process quality as the main production.
- There are occasional applications where one or more components cannot be assembled on the main production line. There can be limitations with odd-shaped packages, component dimensions, component weight, different placement heights, required accuracy or due to the relative proximity of adjacent components. Sometimes components are not delivered in tape reels or similar packaging that can be handled by pick-and-place machines. In these cases it is helpful to have a system available that allows flexible assembly alongside of the production line.
- Rework can help to understand the effect of process parameters set in production, especially during the change-over to lead-free. It can be used to investigate the cause of production errors and optimize production parameters rather than adopt a "trial and error" approach.

Electronic modules are automatically reworked in series today. Capable systems are available, allowing repeatable and reliable processes.

Evolution of packaging

Moore's law is well known [1] and is applicable to the evolution of component packages. Today's packages are often no larger than the silicon die that is inside them. Dice are even mounted on top of each other and thus we enter the third dimension in packaging. The proximity of connections no longer allows manual assembly and manual rework as the required accuracies are outside of human capabilities.

The faults experienced in reworking are the same as in the initial soldering process: There are "popcorn" and "tombstone" effects, shorted or open solder joints, insufficient solder paste volume or wetting and many more. The electronics manufacturing industry is faced with the interaction of chemical, mechanical and thermal parameters, all of which need to be taken into account.

Once the process is established, the goal is to maintain it through many cycles, independent from environmental conditions. What is a matter of routine in manufacturing, is often neglected in rework. It's our considered opinion that we need to control and master the rework process in the same way as we do with the production process.

Changeover to lead-free technology

In addition to all of the above challenges raised by the evolution in packaging, we are now faced with more hurdles to overcome. Crucially, lead-free technology requires higher process temperatures with a typical increase of 35 °C. The physical condition and thermal limits of the components however, are still more or less the same. This means, the process window is reduced and we need to be careful to precisely follow the specified soldering profile. With the higher temperatures involved, lead-free solder has a tendency to create more oxidation and more dross. A consequence of this is that BGAs have a lesser self-centering effect than when soldered in a leaded environment.

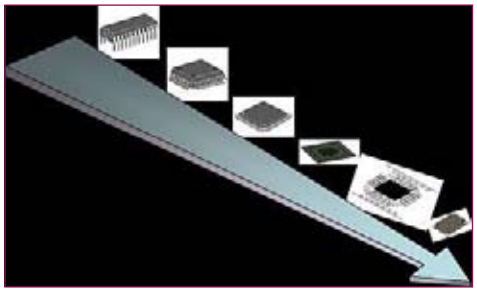
The major rework parameters

In order to make rework reliable, automated and repeatable, the following basic parameters need to be controlled.

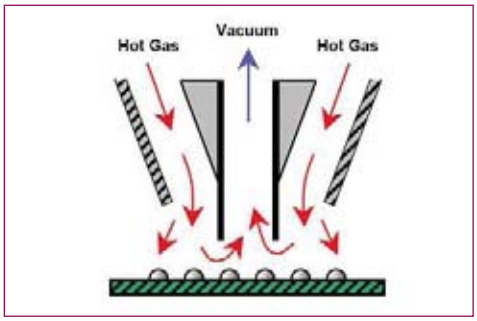
Heating Power: Bottom heater

In rework, we are selectively desoldering and soldering. This means that the board is partially heated. To prevent the board from warping, buckling and thermal damage (delaminating), it must be uniformly preheated up to 150 °C for a lead-free environment. Also, the temperature difference between the board and the component that is to be reworked (not to be confused with the component ΔT) must be minimized.

This is not achieved by merely delivering enough heating power for large or thick boards. We also need to limit the radiated energy by using a closed-loop control system. This will ensure a rapid heat input , maintaining the board at the desired temperature independently of the remaining process. It is also useful to have the ability to individually control multiple heating zones to efficiently heat up small boards conserving both energy and time.



Evolution of packages



Principle of non-contact site cleaning

Hot gas nozzle

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Heating power: top heater

The ability to provide sufficient energy is also true for the top heater when desoldering and soldering components. The use of hot gas as a soldering method has the advantage of excellent heat distribution. Energy is delivered to the solder joints without exposing temperature-sensitive areas to the risk of being overheated. A closed loop control system again ensures that the selected profile is followed precisely and that the results remain constant. The entire soldering process is supported by the motorized X, Y, Z and theta axes of the robot. With lead-free soldering alloys, the use of an inert gas is essential in order to counteract the increasing tendency towards oxidation. High quality rework systems are equipped with multiple gas sources that can be flexibly selected at any stage in the soldering profile.

Cooling

As important as heating, is the requirement for cooling. The energy that we input into the material needs to be rapidly dissipated after the soldering process is completed. It has been proved that faster cooling of the solder joints, the component and the board leads to better soldering results in terms of less sinkholes, stronger joints and a better surface texture.
By cooling, the exposure time at higher temperatures is reduced, providing a positive impact to the lifetime of the module. Cooling can be achieved in two ways. In the bottom heater, an air knife provides a thermal separation of the heater from the board without turning the heater off. In addition, cool ambient air can be blown through the nozzle directly onto the component.

Uniform heat distribution

Hot gas nozzles are widely used in the industry. Using sophisticated nozzle design, heating energy is precisely input to the location where it is required, assuring a rapid melting of the solder. The maximum temperature and exposure time of the component is minimised. Also, custom designed nozzles can be used to insulate any heat-sensitive areas such as the silicon die or adjacent components from the hot gas flow, preventing thermal overload. Zevac offers a wide range of standard and custom designed nozzles.

Site preparation

Before we solder a new component, the site needs to be prepared. Specifically, this means removing residual solder and dirt from the pads and the application of solder paste if required.

Site cleaning

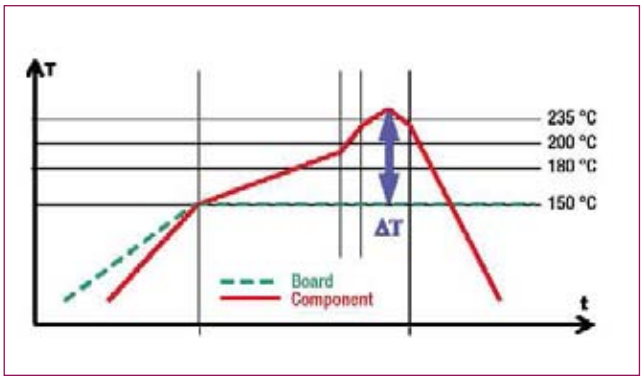
By site cleaning we gain a better wetting of the solder joint. Site cleaning is mandatory for BGA, Micro-BGA and similar components. It is also used as a preparation stage before dispensing. Basically, site cleaning is recommended in most cases in selective soldering.
A non contact method is always preferrable to the manual method of using a solder iron with solder wick. The working height of the site clean nozzle is automatically controlled and maintained to a pre-set level, regardless of any board warping or bending. In this way we can ensure that pads do not become detached. As a bonus, vias are also desoldered.

Applying solder

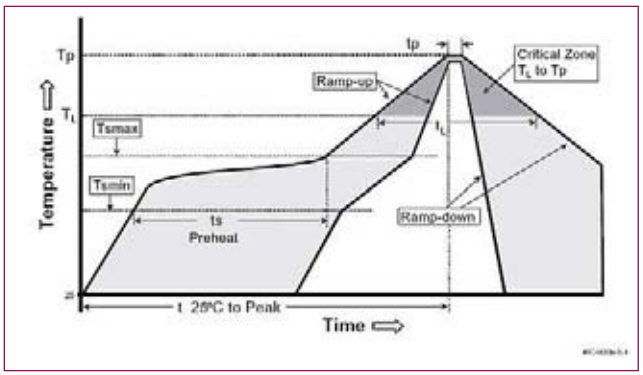
There are many ways to apply fresh solder paste or silver epoxy to the site. As well as paste-on-device, paste-on-substrate,

A wide range of rework equipment

Whatever level of automation or process is required by an application, an appropriate solution is available from a wide range of rework equipment.
The ONYX family – **Automated ONYX 32**
Multi-functional positioning system, different application configurations include hot gas, semiconductor and XL.
Options: Dispenser: Time/pressure or auger, Hot gas nozzle changer, SMD tip changer, Die flipper, Height measurement, Fluxing station, Force sensors, Site cleaning, Contact heat tool, Feeder interface, CAD data import, Traceability, Custom specific options.
Ranges of applications include serial rework, prototyping and small series production, micro-mechanics, optics and electronics assembly, hybrid technology, semiconductor packaging, die bonding and many more.
The ONYX family – **Semi-Automated ONYX 29**
Semi-automated high-tech rework equipment. With its open design and its control of seven motorized axes, repeatable results at the highest quality level are ensured.
Options: Multiple pre-heater versions, Infrared temperature sensor, Bridge tray, Fluxing station, Board cooling, Site cleaning, Dispenser: Time/pressure, Pyrometer, Direct view camera, Worktable.
The ONYX 29 is typically used in SMT rework of BGA, mBGA, CSP, flip-chip, LGA, MLF, CCGA, TCP, 0201, HF shielding, connectors, sockets and application specific components on dense boards. Prototyping and post-assembly are additional fields of application.
ONYX 25/ONYX 24
Simple but powerful high-tech equipment, ergonomically designed for today's requirements in the electronics industry.
Options: Enhanced pre-heater (up to 7.5 kW), Site cleaning, Infrared temperature sensor, Pyrometer, Board cooling, Direct view camera, Fume extraction, Worktable
The latest member of the ONYX family principally addresses applications in the field of selective soldering of SMT components, prototyping and post-assembly.



■ Typical profile with board pre-heating



■ IPC/JEDEC standard soldering profile

re-balling and pin print transfer (stamping) a common and flexible method is by dispensing. Zevac's machines can be equipped with time/pressure, auger and piezo-electric valves. The dispensing result is dependent on a variety of parameters. As well as the quality of the dispensing equipment, precise movement of the dispensing needle in all three dimensions is critical to ensure good results. Needle alignment is calibrated by the integrated vision system.
Dispensed line or dot patterns can be created and modified with the built in editor to accommodate a large variety of package types and land patterns.

Accuracy

As an integral component of accuracy and precision in automated rework, Zevac relies on a comprehensive and flexible vision system. It's primary function is the recognition of component-specific features and the accurate alignment of the component to the pads in X, Y, Z and theta. The user is not limited to a pre-defined model library. It is possible to recognize odd shaped components, global or local fiducials, logos, text and other optical objects of any shape and size in the rework process.
In addition, the vision system can be used in the rework process to conduct tasks such as orientation detection, recognition of wrong components, visual inspection or bar-code reading.

Repeatability and reliability

Quality in automatic or semi-automatic rework is ensured by storing any given or evaluated process values in the machine software control. Soldering profiles with all possible settings and parameters may be recalled from a database, allowing every process to run with repeatable results, even under different environmental conditions.
VisualMachinesTM software is developed in-house and is instrumental in the repeatability and reliability of the system with its open approach and user friendliness in the style established with pick-and-place machines. Pre-defined part types and process tasks can be easily and flexibly implemented in main process programs. Every setting, from the machine configuration to process statistics, is controlled by software.
From the considerations discussed above, rework can achieve an improvement in efficiency by

- automation
- reproducibility
- reliability
- traceability
- flexibility

with cost reduction. Zevac has implemented all of these features in one single machine family: ONYX.
Whatever level of automation or process is required by an application, an appropriate solution is available from a wide range of rework equipment. *(cm)*

References
[1] Gordon Moore, "Cramming more components onto integrated circuits" Electronics, Volume 38, Number 8, April 19 1965, pp 114-117
[2] IPC/JEDEC J-STD-020B, "Moisture/Reflow Sensiti-vity Classification for Non-Hermetic Solid State Surface Mount Devices", July 2002