SolderPlus®

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Air Powered Dispensing

Summary

In this paper, EFD explains the most critical variables affecting air-powered dispensing of solder pastes and shows how to manage those variables to your advantage.

- Solder Paste
- Tip Type
- Air Pressure
- Dispense Cycle Duration
- Temperature
- Fixturing
- Reservoir size

Introduction

Air-powered dispensing systems use controlled pulses of air pressure to dispense solder paste from syringe reservoirs in uniform amounts.

Air-powered dispensing equipment comes in many shapes and sizes. Each and every unit has at least two characteristics in common with all the rest: air pressure regulation and dispense cycle control.

Compared to the use of wire solder and solder preforms, dispensing solder paste with air pressure is a relatively simple and much more flexible option. One would think that with only two machine variables needed to control dispensing, air-powered application of solder paste would be foolproof, but this is not the case.

Each section of this paper addresses a process variable and provides an explanation of successful and unsuccessful implementation for each.

Solder Paste

Solder paste is a mixture of spherical solder alloy particles (called "solder powder") and a gel-like flux medium. The flux medium coats all the particles to protect them from oxidation and holds them in suspension.

Solder paste is not a fluid. When pressure is applied to solder paste, it is actually applied to the flux medium that contains all the solder powder. The flux medium picks up and carries the solder powder, much like grapes in Jell-O, as the flux medium is put into motion.

The better the flux medium, the shorter the delay between when the flux starts to move and the solder powder starts to move with it. This characteristic determines both how well the solder paste dispenses and the rate at which the flux medium can separate from the solder powder.

Tip Type

For every dispensing application, there is an optimal tip style and size. The trick is to identify which one is the best for your process.

When choosing a tip, do not expect to produce a deposit with a diameter smaller than 1½ times the ID of the tip. Although it is technically possible to produce smaller deposits, it is very difficult to do so in a real-world environment.

As a rule, you should use the least restrictive dispense tip that will meet your deposit size requirements. Larger gage tips allow for faster flow and produce less backpressure on the solder paste

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during the dispense cycle. Shorter shank steel tips have less flow resistance than longer ones. Tapered tips produce less backpressure than straight-walled tips. Rigid-walled tapered tips, as opposed to the more flexible regular tapered tips, resist deformation and produce more consistent deposits.

A tip that is too restrictive for the type of paste in use will cause excessive backpressure and foster tip clogging.

¼"Stainless ½" Stainless Tapered

Longer tips are useful for reaching out-of-the- way deposit locations. Paste will dispense more slowly from a smaller tip, allowing smaller increments in deposit size per unit of time.

These effects may be used to meet tight deposit size tolerances by combining a more restrictive tip with a longer cycle time. In any case, tip choice can make or break a dispensing process.

Air Pressure

With air-powered dispensing systems, air is used to transmit force to the material to be dispensed. Choosing a pressure setting for an application requires an understanding of how solder paste reacts when put under pressure.

Apply too little force, and the material will not dispense fast enough or even not at all. Apply too much force, and the flux is forced out of the paste; a phenomenon referred to as "separation."

For most applications, a pressure range of 20psi to 40psi is appropriate, but this is not a hard and fast rule. Higher or lower pressure may be required, depending upon tip type, package type and solder paste formulation.

Start out in the 20psi to 40psi range. If you think you need higher or lower pressure to reach your process goals, consult your solder paste manufacturer to help identify possible hazards.

Dispense Cycle Duration

The length of the dispense cycle determines how much material is dispensed for any combination of pressure and tip type. Problems related to dispense cycle duration arise only when the cycle is too short. It is almost always possible to avoid "too short" pulse durations, and it is useful to know why. During each pressure cycle, the system undergoes a series of six ordered steps:

1) The air hose and empty volume of the reservoir are pressurized.
2) The flux is pressurized and begins moving towards the reservoir exit.
3) The accelerating flux overcomes the resistance in the system, picking up and carrying the solder powder as it moves.
4) The paste shear thins (viscosity drops) as it accelerates until achieving a steady flow state where the flux and solder powder are moving together at the same rate.
5) Pressure is removed and the solder paste decelerates to a stop.
6) Over the next few seconds it thickens back to the pre-shear thin viscosity.

Note: If the dispenser has a barrel vacuum feature, it should be disabled when dispensing solder paste.

Keep in mind that there is a minimum time required to execute each step. This time is influenced strongly by the tip type and the amount of material in the reservoir. The lower the flow resistance of the dispense tip, the shorter the time required to reach Step 4. The time requirement also changes as the reservoir empties, lengthening in relation to the increasing volume of air requiring pressurization.

For each solder paste there is a minimum cycle time below which paste separation is greatly accelerated. When cycle time is shorter than the minimum, the process will barely reach Step 3 and a steady flow state will not be achieved.

Instead, flux is moved and pushed out of the reservoir in too high a proportion. As the flux separates from the solder powder, the powder will pack closer and closer together until it forms a powdered metal "filter" at the reservoir exit or in the dispense tip. While flux is able to pass through this filter, solder particles will not.

For consistent results and to avoid separation, cycle time must be long enough to reach step 4. For many pastes this cycle time is less than 0.25 seconds, but some solder pastes require as much as 0.50 seconds to reach Step 4.

Combined with the shock produced by high pressure, short cycle duration can degrade paste beyond the point of dispensability in just a couple hundred cycles.

Temperature

The effects of temperature on solder paste dispensing are generic to most dispense methodologies. Auger valves are not an exception. As temperature changes, three things happen:

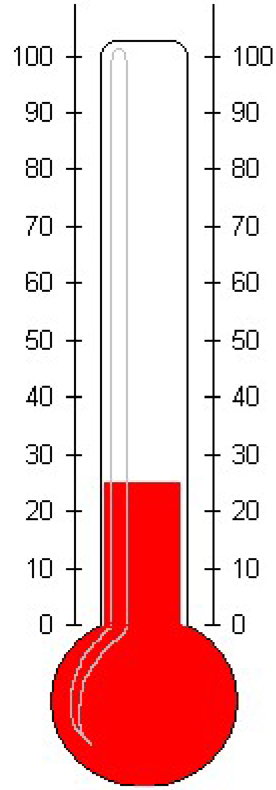
1) The paste changes viscosity. Increases in temperature soften components in the paste making it thinner, less viscous. Decreases in temperature have the inverse affect, thickening the paste.

   Note: Above 27˚C (80˚F), softening can reach the point at which the paste loses the ability to hold the solder alloy in suspension, resulting in paste separation.

2) Deposit size varies as the temperature varies. Changes in viscosity affect flow rate and, therefore, deposit size produced with a particular set of dispense settings. Keep temperature variation to a minimum as a safeguard against temperature related deposit size variation.

3) The flux chemistry reaction rate accelerates with increased temperature. The flux is active to some extent even at low storage temperatures. At temperatures above 27˚C (80˚F) the reaction rate is noticeably faster.

Unless a temperature control system is used, paste temperature is increased by both environmental conditions such as room temperature and localized heat sources as well as the conversion of kinetic energy to heat through friction as the dispenser cycles.



Fixturing

Often overlooked as either a process design consideration or possible cause for problems, syringe fixturing can play a pivotal role. The operating life of dispensable solder paste can be drastically reduced by poor fixturing practices.

The single most frequent fixturing mistake is placement of dispense equipment relative to a heat source used for reflow. Close proximity to heating units can result in elevated solder paste temperatures with attendant affects. Temperature control equipment, shielding and improved airflow can be used to minimize or eliminate such heating affects when close proximity is required.

Physical stress applied to solder paste in the forms of shaking, sharp impacts, and vibration all have degradation effects. The worst of the three is vibration. Equipment that generates strong vibrations, such as vibratory bowl feeders, should be isolated from dispense machinery to avoid rapid paste separation. If the dispense machinery cannot be isolated, smaller reservoirs can be used to match the volume used to the exposure limit imposed by the vibration source.

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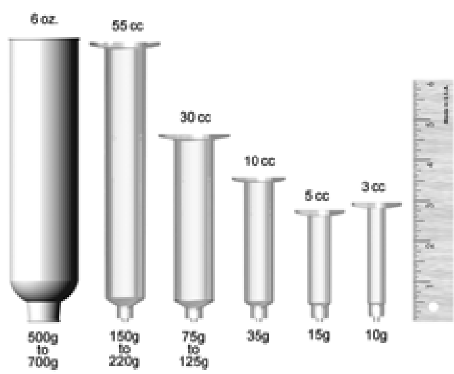
Sharp impacts and vigorous shaking of solder paste by slides and high-speed XYZ positioning systems can have cumulative separations effects over many dispense cycles. In some cases, smaller reservoirs of paste may be used to eliminate paste waste due to scrap by matching the cycle count limit before paste failure to the paste volume dispensed over those cycles.

Reservoir Size

Selecting a reservoir size is a compromise between replacement frequency, temperature, and deposit size.

For example, in applications where solder is consumed at the rate of 10 grams an hour, 3cc syringes would not be a good choice, because they would have to be replaced approximately every hour. For this application, a 30cc syringe containing between 75 and 125 grams would minimize downtime for syringe replacement. However, if 10 grams were being consumed every two days, using a 3 cc syringe would minimize the amount of material wasted because of environmental degradation.



At higher temperatures, the question to consider is how large a reservoir can be used without subjecting an excessive amount of material to environmental degradation.

The size of the deposit determines the number of pressure cycles it takes to empty a given reservoir size. When making smaller deposits, it will take more cycles to empty the barrel, so paste is subjected to agitation (which degrades paste) for a longer time. When making larger deposits, fewer cycles are needed to empty the reservoir and there is less risk of paste degradation.

For most pastes, however, it should be possible to generate at least 10,000 deposits before failure. If using larger reservoirs and generating more than 10,000 deposits, be prepared for marginal results.

Conclusion

Because they are capable of producing such a wide range of deposit sizes, air-powered dispensing systems are the ideal tool for applying solder paste in many different operations.

Air-powered dispensers provide the best performance when used to produce solder paste deposits between 3 milligrams and 0.50 grams. Size-wise, this amounts to deposits between 1 and 10 millimeters in diameter under most conditions.

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