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Auger Valve Dispensing

Summary

In this paper, EFD identifies the most critical variables affecting auger valve use and explains how to use those variables to your advantage.

- Deposit Size
- Tip Type
- Air Pressure
- Auger Speed
- Auger Screw Selection
- Temperature
- Fixturing
- Tip Position
- Reservoir size
- Care & Maintenance

When tuned well, auger valves are capable of making sub-milligram size deposits with less than 5% variability from deposit to deposit. When tuned poorly, a variety of problems can result, all of which may cause unacceptable deposit size variation.

Introduction

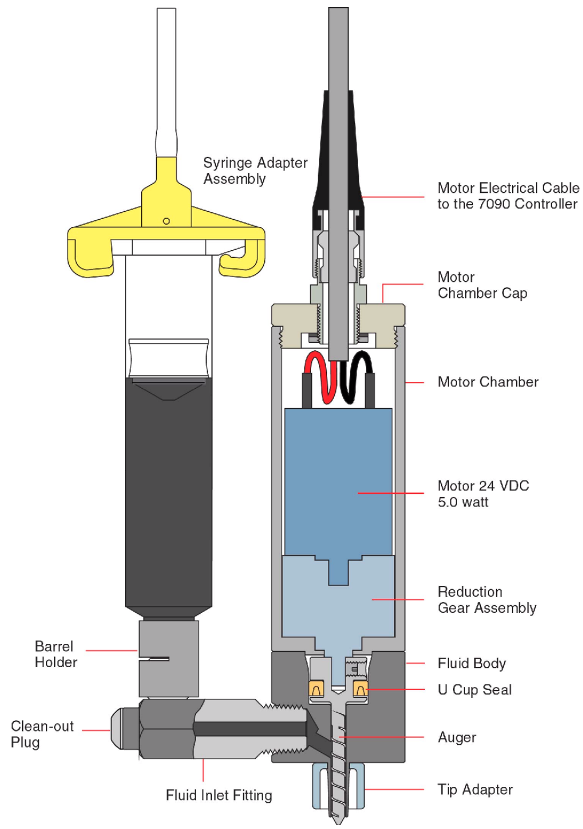
The use of auger valves for high accuracy dispensing of solder paste has been accepted as the method of choice for over a decade. The speed, flexibility, and cost of auger valves have kept them a step ahead of the alternatives.

Auger valves are wonderful tools for placing small to moderate sized solder deposits. But, as with many other flexible systems, there exists room for use and abuse of the features available.

It is worth noting here, in the introduction that while highly accurate and rapid in response, auger valves do not dispense material quickly. If cycle time is critical and deposit size is moderate to large, an auger valve may not be quick enough. Under these condition, pulsed air dispensing or a spool valve may be a more effective option.

Deposit Size

The first step in developing a dispensing process is identifying the size deposit required. In some cases, the criteria for deposit size and shape may be purely visual but many cases require a repeatable measurement technique.



In the cases where “by eye” is adequate, the tried and true trial-and-error method is applied to identify the size required. You rely on the value judgment of an operator to maintain process control.

For processes demanding a finer degree of control, deposit size requirements are still developed using trial-and-error but this is followed by the implementation of process controls driven by measurement or calculation.

In such cases, a method for measurement capable of identifying changes in performance is required. A “best” solution is one that produces the desired deposit while staying within the recommended range defined for the process control variables addressed in this paper.

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Tip Type

As a rule, you should choose to use the least restrictive type of dispense tip that will meet your deposit size requirements. Larger gage tips allow for faster paste flow and produce less backpressure on the solder paste during the dispense cycle. As a consequence, they are also less resistant to paste drool under constant pressure. Shorter shank tips have less flow resistance than longer ones. Tapered tips produce less backpressure than straight walled stainless steel tips but are vulnerable to process variation, as they are more flexible and can expand and contract due to auger induced pressures. Rigid tapered tips, as opposed to "regular" tapered tips, deform much less and produce more consistent deposits.

¼" GP ½" GP TT

The determination of the correct tip size and type for each application is one of the most critical steps in the design of an optimized solder paste dispensing process.

Using too restrictive of a tip for the paste type in use will cause excessive backpressure and foster tip clogging. Using too large a tip for the deposit size can interfere with deposit size control within established tolerances.

Gage	EFD Tip Color	Tip ID	Minimum Dot Diameter
14	Olive	0.060"	0.090"
15	Amber	0.054"	0.081"
16	Grey	0.047"	0.071"
18	Green	0.033"	0.050"
20	Pink	0.023"	0.035"
21	Purple	0.020"	0.030"
22	Blue	0.016"	0.024"
23	Orange	0.013"	0.020"
25	Red	0.010"	0.015"
27	Clear	0.008"	0.012"
30	Lavender	0.006"	0.009"

When choosing a tip, the rule of thumb is you may not expect to produce a deposit with a diameter less than 1½ times the tip ID. It is technically possible to do so but is difficult.

Every tip size and type is the best choice for some application. The trick is identifying which is the best for your application. Longer tips are useful for reaching out of the way deposit locations and can add resistance to keep paste from drooling from large gage tips. Paste dispenses more slowly from a smaller tip, allowing for smaller increments in deposit size per unit time. When deposit size consistency is of primary importance, cycle time can be sacrificed for tolerance by using a smaller gage tip. In any case, tip choice can make or break a dispense process.

Air Pressure

Auger valves are intended for use with constant pressure when dispensing solder paste. The system relies on the inherent resistance to flow provided by the auger screw and the dispense tip to prevent constant material flow out of the tip (tastefully called drool). The air pressure should only be high enough to maintain material flow, keeping the auger cavity filled. Pressure typically ranges from 4psi to 10psi but both higher and lower values have been required for particular valve models unusual applications.

Even with a "correct" pressure setting, there may be an unacceptable quantity of drool during extended pauses between dispense cycles. Programmed removal of pressure from the solder paste reservoir is recommended in this situation.

Auger valves are not intended for use with pulsed pressure but pulsed pressure can be used. When in need of using pulsed pressure, specialized paste formulations may be required to handle the aggressive processing conditions. Typically, pulsed pressure is thought of as a solution to a cycle time problem.

Example: "The valve does not dispense fast enough at the recommended pressure setting so a higher pressure is used to increase flow. The higher pressure results in unacceptable drool so the air feed is switched from constant to pulsed, eliminating the drool in between deposits. Pulsing the pressure adds energy to the paste in the form of heat, *accelerating flux decomposition, and causes paste separation. The eventual failure mode is deposit size reduction followed by flux rich deposits until the valve and/or tip becomes completely blocked. The paste manufacturer is then called in to fix the perceived paste problem."*

If an application has a cycle time that seems to necessitate the use of pulsed pressure, then an auger valve may not be the best solution. Contact your paste and valve manufacturers before using pulsed pressure with an auger valve to see if they have a better alternative.

Auger Speed

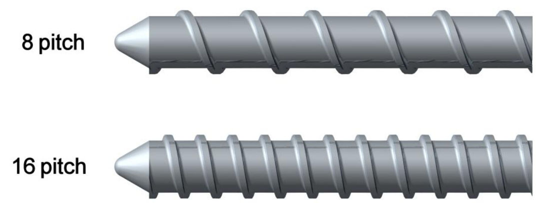
After defining the tip and pressure that gives the best performance, deposit size should be fine tuned with auger speed and time. The pressure generated by the spinning auger is a product of rotational speed. Auger speed is defined in revolutions per minute. To a point the more revolutions per unit time, the more material the valve will dispense per unit time.

For any combination of valve, paste, and tip types, there are maximum and minimum achievable flow rates at the maximum recommended pressure. This means that beyond a certain point, higher valve speed does nothing to change dispense rate. The amount of pressure required to overcome the inherent resistance in the dispense tip reaches the stress level at which two things happen. The alloy particles start to cold-weld together causing valve blockage and paste temperature is elevated by the combination of friction and pressure. At the low end, either the auger motor fails to turn or the pressure generated by the spinning auger goes below the threshold required to overcome the inherent tip resistance resulting in no flow.

To achieve the most precise control, combine slower speed with longer time. To maximize dispense rate, run the valve at the highest speed possible without damaging the paste.

Auger Screw Selection

There is a second variable, beside speed, which can have a profound affect on dispense control: the screw design. Most auger valves have two auger styles: eight threads-per-inch (sometimes referred to as flights) and sixteen threads-per-inch. They also come in a variety of thread depths. As usual, there are tradeoffs associated with each of the available auger screw options.



The eight thread-per-inch auger screw is a standard among valve manufacturers, and is appropriate for most applications. Inherent resistance is moderate and paste flow is fastest.

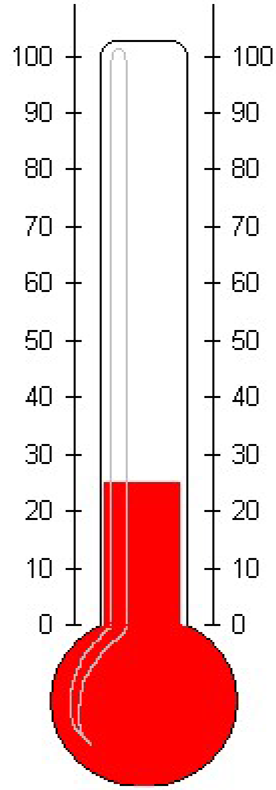
The sixteen thread-per-inch auger screw is used when either additional inherent resistance is required and/or finer deposit size control is required. With the distance between threads halved, the total distance paste must travel around the screw is doubled while the amount of material exiting the screw per revolution is halved.

If the most appropriate screw type can be identified early in the process development cycle, time and effort can be saved.

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 valve cycles.

Fixture

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

The single most frequent fixture 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. Shielding and improved airflow can both 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.

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.

Tip Position

A sub-topic of fixture design that deserves attention in its own right is tip position: the relative placement of the dispense tip to the work piece during a dispense cycle.

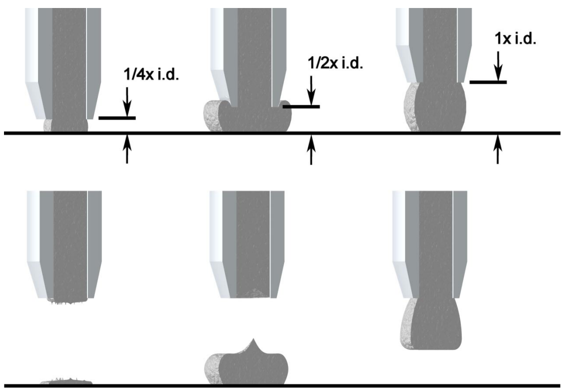
The goals of any tip positioning exercise are to achieve unrestricted paste flow out of the tip during the dispense cycle and a clean paste break-off when the tip separates from the part.

Orientation falls into two categories: perpendicular to the product surface and non-perpendicular. Only perpendicular orientation is addressed in this paper due to the almost infinite variety of outcomes possible with non-perpendicular tip positions. Non-perpendicular tip positions are often a great solution to a difficult dispensing problem but are not easily addressed with general guidelines.

There are two critical variables with regards to tip position: product surface and Z-height.

Dispensable product surfaces come in many flavors: flat, bumpy, smooth, textured, wide, thin, pointy, recessed, and gapped just to name a few. In every case, the goal of tip positioning remains the same; achieve a consistent and clean paste break-off when the tip separates from the part. The surface shape dictates the techniques required for consistent dispense results. Your equipment and paste suppliers should be able to help in identifying solution.

Z-height is the distance from the bottom of the dispense tip to the product surface. If the tip is too close to the surface, paste will exit the tip, hit the part, and backpressure will prevent further paste flow. Continued valve operation without paste flow causes flux separation and cold welding of solder alloy in the valve. If the tip is too far from the surface, paste will have greater adhesion to itself and the dispense tip than the product surface and fail to stay on the product. A "large dot small dot" pattern is likely to emerge and sure sign of too great a Z-height. A good starting point for Z-height is ½ the tip ID.



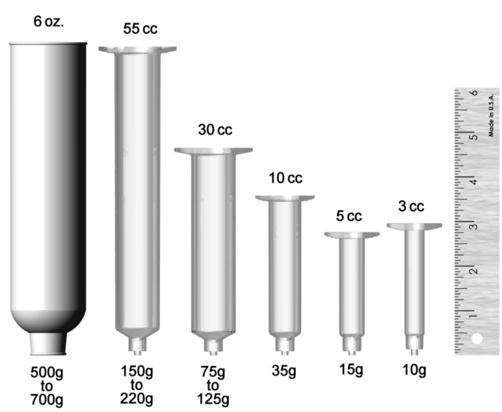
No Dot Good Dot Small dot/ Big dot

Reservoir Size

Reservoir size is rarely a problem with auger valve dispensing applications. Typical deposit sizes allow for thousands of trouble-free deposits per reservoir using standard packaging for the paste type in question.

In vibration rich and high temperature environments, smaller reservoirs may be used to minimize paste waste due to accelerated paste damage.

In vibration free applications where the temperature is within the recommended range, larger reservoirs may often be used without fear of paste yield loss.



Picking a reservoir size that produces the best balance of run time between changeovers and paste yield requires an understanding of the process goals and limitations. Work with your paste supplier to identify the best package for your application.

Care and Maintenance

Care and maintenance requirements for auger valves vary by manufacturer and model but some basic guidelines apply to most.

When idle for more than a few hours, the tip should be removed from the valve and an airtight cap put in place. This will protect paste in the valve from degeneration due to air exposure. Solder paste in tips left on an inactive valve hardens over time. The smaller the tip, the faster it hardens.

The most frequently required maintenance activity is purging of the valve. For best performance, purge a valve after 48 run hours to flush out ageing paste and metal shards. If a valve will be left inactive for a day or more, purging the valve will prevent paste from hardening in the valve if exposed to elevated temperature.

On a weekly basis, disassemble and clean the valve with a manufacturer recommended solvent. Regular cleaning keeps valves performing at their best.

Conclusion

Nobody becomes an expert in auger dispensing over night. It takes a basic education followed by plenty of experimental practice to develop an intuitive understanding of the relationships between the many process control variables.

The same is true of every other soldering process so there are no real shortcuts on the learning curve. Manual methods require the development of control and technique. Automatic and semi-automatic systems have their own sets of process variables to control.

The three most influential, and frequently problematic variables are air pressure, tip type, and environment temperature. Each of these variables can mask a problem with other variables. Elimination of these three as possible causes will narrow down root cause identification dramatically.

Both new and experienced auger valve users have opportunities to extract the best performance from their equipment and material by evaluating their auger valve dispensing process and applying the techniques presented in this paper.

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