Jet Technology: Advancements in Fluid Dispensing

By Can La, Product Manager, Techcon Systems, OK International Inc.

Electronic devices are growing in demand and shrinking in size, requiring manufacturing and packaging technologies to dispense new varieties of materials in microscopic amounts with ever-increasing speed and accuracy. As a result, fluid dispensing has grown from the early use of a small plunger manually pushing fluid out of a syringe to today's sophisticated computer-controlled devices. Traditional fluid dispensing methods are hampered by slow speed. Non-contact jet dispensing offers speed, precision and a lower cost of ownership. While the best method is ultimately determined by the material and application at hand, jetting provides a superior technology and a wide process window.

Common Dispensing Methods and Techniques

Time/Pressure Dispensing: Time/Pressure Dispensing (TPD) methods use a syringe and a pneumatic valve. The TPD Syringe method utilizes controlled and timed air pressure, producing a measured shot of air that forces fluid out of a syringe, through the dispensing needle, and onto the work surface. Due to its simplicity and low cost, this method is widely used in bench top applications. To achieve more repeatable results, TPD valve methods incorporate a pneumatic valve to better control the volume of fluid being dispensed. For low to medium viscosity fluids, a Needle valve or a Diaphragm valve is recommended. An automated controller opens a piston/needle assembly or diaphragm, which in turn opens a path for the fluid to flow through. When the air signal stops, the piston returns to the original position and closes the valve. Time and pressure can be precisely controlled to dispense dots or continuous beads of fluid. Higher viscosity fluids often require a Spool Valve, where the piston drives down to open the fluid path. When the dispense cycle is completed, the spring of internal compression lifts the piston up to close the valve, creating a natural back-suction feature that prevents drips.

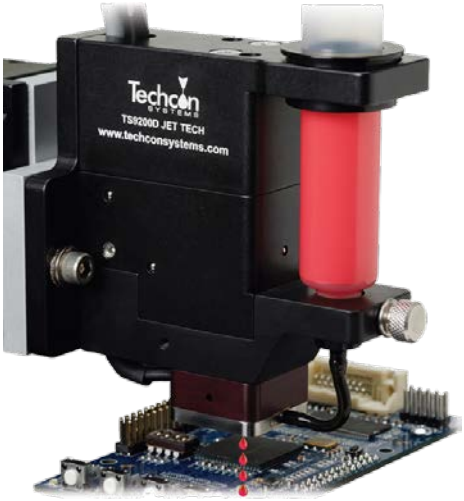
Positive Displacement Methods: A common weakness of time/pressure dispensing is its susceptibility to fluctuations in the dispensed fluid's viscosity. If the fluid becomes thicker or thinner, pressure must be adjusted accordingly to maintain repeatability. One way to avoid this problem is to use a Semi-Positive Displacement Method such as a Rotary or Auger pump. The auger pump uses a rotary feed screw (auger) that rotates inside a fluid chamber to push fluid from the auger inlet to the dispense tip. A better way to control repeatability of the dispense process is with a True Positive Displacement Method. As the name suggests, pushing down in a displacement chamber pumps an identical volume of fluid out of a matching dispensing chamber. Displacement pumps vary by the type of mechanical action used, such as the Progressive Cavity Pump, Piston Pump, and Peristaltic Pump.

Common Disadvantages to Common Methods: TPD and Positive Displacement dispensing methods have an inherent disadvantage: slow dispensing speed. This is because they are both contact dispensing methods and thus require repetitive Z-axis motion—move down to place the fluid, then move up to break away. As it retracts, the dispense head sometime leave behind strings or tails that can contaminate the work surface or create unwanted interconnections. Programming special maneuvers to reduce stringing/tailing is only moderately effective and adds even more time. To produce today's microelectronic assemblies, surface mount technology (SMT) requires increasingly smaller and tighter dispensing at faster speeds, and with greater accuracy and higher yield, posing a challenge for traditional dispense methods.

Jet Technology: Fluid Dispensing at Jet Speed

Jet Technology represents a paradigm shift in precision dispensing. With traditional contact methods, a needle touches down and physically applies the fluid; with non-contact dispensing, a jet hovers over and shoots fluid at the work surface without ever touching it. The difference is like a fountain pen versus an inkjet printer.

Jetting is primarily a valve-based technology. In piezoelectric systems such as Techcon's TS9000, voltage is applied to a piezoceramic stack which then expands/contracts to operate the valve. In air-actuated systems such as Techcon's TS9200D, air pressure operates the valve. However, instead of the large sliding valve stem in conventional needle valves, the TS9200D utilizes a very low mass diaphragm, which requires less energy and speeds up the process. In jet dispensing, the fluid is separated from the applicator using droplet momentum and the result is a perfectly round dot. Jetting produces dots of extremely small size, low volume and high consistency. Also, jet dispensing's positive shut-off can execute precise lines and sharp corners. By incorporating a multi-function process controller such as Techcon's TS920, dispensing results can be perfected by fine-tuning jet and fluid pressures, drop size, drop rate, and dispensing parameters such as refill and dwell time.



TS9200D Jet Tech requires less energy and speeds up the process

Jet technology is perhaps best defined by what does not happen during jetting: There is no contact with the work surface. There is no needle, and there is no Z-axis motion required to dispense. These distinguishing features provide advantages in dispensing speed and agility, dot capability and quality, maintenance, throughput, and cost of ownership.

Jet Tech Advantage: Speed. A significant advantage of jet dispensing comes from the elimination of Z-axis motion. By removing the stop-down-up motion required for contact dispensing and adhesion, jets can dispense "on the fly," greatly increasing speed. Techcon's TS9000 is capable of very high frequency dispensing (short bursts up to 1000 Hz at full stroke). Also, since jetting takes place above the work surface, it eliminates the time-consuming requirement of constantly monitoring the Z-axis position. Finally, non-contact dispensing leaves behind no strings or tails, thereby eliminating the additional time/motion required to prevent/correct them.

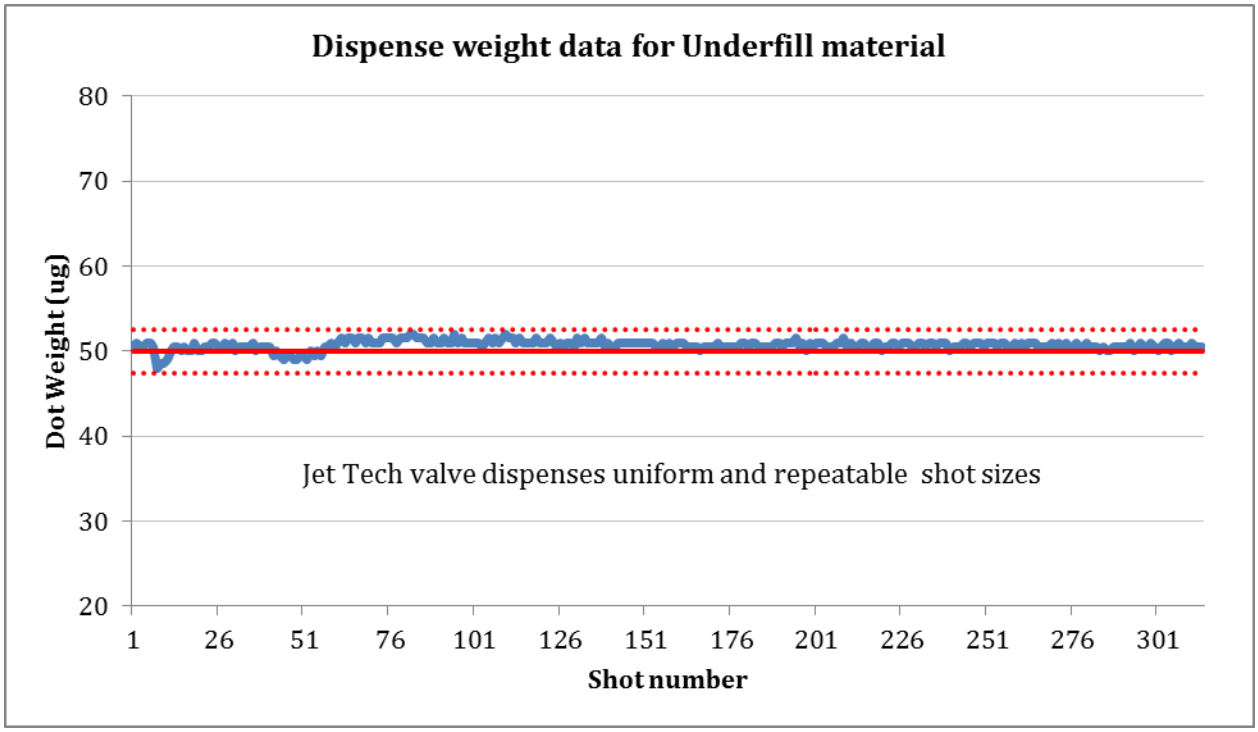
TS9200 Jet Tech offers extremely high speed dispensing

Jet Tech Advantage: Agility. Since there is no needle, fitting into tight spaces or disturbing other parts is not an issue. Jetting can deposit fluid in spaces where needles cannot fit—a common dilemma when dispensing between closely arranged

components. Also, since there is no touching down to dispense, there is no need to accommodate work surface topography.

Jet Tech Advantage: Capability. Compared to traditional dispensing, jetting produces dots of smaller size and volume. Dots as small as 10 nl can be achieved with Techcon's TS9200D (high-viscosity fluids) and 2 nl with the TS9000 (low- to medium-viscosity). Since dispense tip build-up is not a concern, multiple dots can be stacked to form larger dots. A line, circle, or any shape or solid is a simple matter of jetting dots shoulder-to-shoulder—without changing the tooling or slowing down to guarantee surface adhesion. Sharp lines can meet at corners without a pool of media building up while the needle changes directions.

Jet Tech Advantage: Quality. By definition, non-contact dispensing means that no applicator touches the work surface. Eliminating work surface contact means no drips, strings or tails. Since only the dispensed fluid touches the work surface, surface adhesion is undisturbed. Dot size remains consistent because there is no wicking to the needle, no fluid build-up on the needle, and no dripping from the needle. Since fluid is dispensed from above the work surface rather than pressed onto it, adhesion quality does not suffer from work surface irregularities such as inconsistent cleanliness, warping, or non-flatness.



Jet Tech Advantage: Maintenance. In fluid dispensing, clean is good, but cleaning time is down time. Conventional dispensers have a fluid ejection device to purge and as many as eight dynamic fluid seals to disassemble and clean. With jet dispensing, cleaning is quick and tool-free. For example, a key component of the Jet Tech 9200D is its valve—a single diaphragm and nozzle plate. Only these two parts contact the fluid, so only these two parts need cleaning. The jet can remain on the robot, clean parts are reinstalled immediately, and since no special off-line cleaner is required, there is no need to re-calibrate the system.

Jet Tech Advantage: Throughput. As described above, the easy maintenance of jet dispensers results in less down-time. Non-contact dispensing means the work surface and its components and wires are not damaged if the needle accidentally touches them. Eliminating Z-axis motion also eliminates the use of a Z-axis standoff, which is prone to media buildup and requires constant attention to avoid damaging the work surface. Less damage means less costly and time-consuming rework. Finally, jet dispensing simplifies parts handling, since additional support under the work surface is not necessary.

Jet Tech Advantage: Cost of Ownership. The greatest value to jet technology is fluid dispensing at greater speeds and with higher quality results than with traditional contact dispensing. Additionally, jet methods produce smaller wetted paths and thus waste less fluid, require less down time for cleaning and maintenance, and offer greater yields due to less damage to the customer's product. Process controllers such as the TS920 that offer micro-increment control of key dispense parameters allow dispensing programs to be easily adjusted for batch-to-batch changes in materials or fluid characteristics, reducing time, money and material wasted on trial-and-error tinkering. A single jet dispensing system easily can accommodate multiple applications. As new opportunities and materials arise, dispensing capabilities (and the system's value) can be increased by incorporating a variety of nozzle shapes and sizes (for the TS9000) or diaphragms and nozzle plates (for the TS9200D).

Jetting Applications: Shooting for Perfection

Jet dispensing is common in SMT applications such as silver epoxy for die bonding, adhesive dispensing for component assembly and encapsulant underfill for flip chips. Advancements in jet technology and system design continue to expand the range of jet-able materials, such as jetting silicone phosphor in LED assemblies. Non-contact dispensing also has been the biomedical industry's method of choice. For creating assays and lab-on-a-chip materials, jetting offers a contamination-free method for making tiny deposits of rare, sensitive, or expensive fluids with little waste. Because of its positive shut-off and repeatable shot size, jet dispensing has become a popular method for pipetting in the life sciences. As advancements in technology continue to both miniaturize and multiply the devices that we cannot live without, it is certain that jet technology will make them possible.