Jet Dispensing Technology
Shooting for Perfection

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Abstract

Adhesives play a major role in electronics manufacturing. The trend toward smaller, faster, and more complex electronic devices has driven the industry to develop new adhesive dispensing technologies to solve today's electronics assembly challenges.

This paper compares "contact" and "non-contact" adhesive dispensing systems, examines their advantages and limitations, and discusses history and developments in non-contact dispensing technology.

Introduction: Adhesive Dispensing Methods

Adhesives can be applied in a variety of ways, from mass transfer methods such as screen-printing to handheld and automated selective placement dispensing systems. Mass transfer works well for unpopulated or simple printed circuit board assemblies (PCBAs). However, the trend toward smaller and more complicated PCBAs has made selective placement dispensing, utilizing an X-Y-Z positioning system, essential for today's manufacturers of electronics.

Contact Dispensing vs Non-Contact Jet Dispensing Systems

Selective placement dispensing systems can be characterized as either "contact" or "non-contact." To understand their advantages and limitations, it is important to understand the differences in their methods of dispensing.

Contact Dispensing

In contact dispensing, the applicator tip must get close enough to the target for the adhesive to wet the surface. Wetting is needed to create surface tension between the target and the adhesive. Surface tension, a property of molecular attraction, provides the sticky cohesive forces needed for a dot of adhesive to remain on the worksurface, instead of pulling away with the tip, leaving strings or tails. Wetting takes a great deal of time to achieve as the nozzle must deliberately move in close proximity to the workpiece.

The following three dominant contact dispensing technologies in use today require exacting X-Y-Z positioning:

- **Time/Pressure** systems use a needle valve to control pressure inside the syringe to regulate the amount of adhesive dispensed. Dot sizes tend to vary in these systems, depending upon the amount of adhesive in the syringe.
- **Auger Pump** systems use a feed screw that is turned on and off by a motor. As the screw turns, it forces adhesive through the threads and out the nozzle. These systems produce consistent, repeatable dots.
- **Positive Displacement** systems use a piston pump to displace a volume of adhesive in a reservoir, and push an equivalent amount of adhesive through the nozzle. These systems are more costly, and cleaning is more laborious compared to time/pressure and auger pumps.

Non-Contact Jet Dispensing

Non-contact jet dispensers do not rely on surface tension to pull the adhesive from the applicator tip. Instead, they utilize high fluid momentum created in the jet valve to rapidly eject a discrete volume of adhesive onto its target. These systems do not move in the Z-axis direction, and are capable of dispensing adhesive dots at much faster speeds than their contact dispensing counterparts.

Typical jet dispensers use a ball and seat mechanism. As the ball retracts from its seat, adhesive fills a reservoir. As the ball returns, it strikes the reservoir with an acceleration force that dispenses a controlled amount of adhesive through the nozzle and onto the substrate.

Jet dispensers are capable of creating a variety of dot diameters, and dispensing patterns from a single dispense head, by jetting multiple shots in rapid succession until the desired dot size or pattern is created.

There are two varieties of non-contact jet dispensing technologies in use today:

- **Pneumatic Pressure** systems utilize air pressure to control the valve mechanism.
- **Piezoelectric Actuated** systems are relatively new and utilize a piezoelectric crystal to convert electrical energy into mechanical displacement, making them ultra-fast and high precision.

History of Non-Contact Jet Dispensing Technology

Jet dispensing of fluids has been around for over four decades and was first used in inkjet printing. Inkjet printers create images by propelling very small droplets of ink onto paper or plastic substrates. The concept of inkjet printing developed over a span of about 20 years, from the 1950s to the 1970s. There was no single inventor of inkjet technology, but it is often attributed to both Ichiro Endo, who worked at Canon in Japan, and John Vaught, who worked at Hewlett Packard in the United States. Ichiro was inspired when he saw a syringe full of ink accidentally touched with a hot soldering iron. The heat caused the ink to increase in volume and spurt out. Ichiro refined the concept, and his work became the Canon Bubble jet printer. By the late 1980s, inkjet technology had matured, and a number of companies joined Canon and Hewlett-Packard in the inkjet printer market.

In the 1980s, the electronics manufacturing industry began investigating jet dispensing as a way to increase adhesive dispensing speed. One of the first applications of jet dispensing in electronics manufacturing was to dispense non-conductive surface mount adhesives onto PCBAs to keep surface mount devices in place before and during wave or reflow soldering processes.

The ongoing trend toward smaller, more complex electronic devices imposes the need to accurately dispense smaller amounts of adhesive into tight spaces, and has spurred developments in non-contact jet dispensing technology. Today, jet dispensing has been validated for a number of different adhesive formulations and assembly applications.

Advantages of Non-Contact Jet Dispensing

Jet dispensers move in the X-Y plane above their targets, accurately shooting precise amounts of adhesive from a distance without contacting the PCBA. This gives them a number of advantages:

- **Speed** - Because jet dispensing doesn't require Z-axis movements, the system can focus on rapid X-Y movements. For example, the **Techcon TS9800 Piezo Jet Valve** is capable of achieving upwards of 1,500 dots per second continuously with maximum bursts of 2,000 dots per second.
- **Less Risk of Damage -** Damage to the dispense tip and the target are virtually eliminated, even when working on uneven surfaces. By eliminating the need to move in the Z-axis, jet dispensers can operate from a distance without risk of scraping or contamination.
- **Reaches Hard to Access Areas -** Operating from a distance makes it easier to dispense between closely arranged components where contact dispensing nozzles and needles cannot enter.

- **Small Dot Sizes –** Although dependent upon nozzle size and material properties, jet dispensers such as the Techcon TS9800 Piezo Jet Valve can produce micro dots as small as 0.5nL with extreme precision and repeatability.
- **Cleaner Process –** Without contact between the applicator tip and the target, adhesive is deposited without drips, strings, or tails. This means less waste, reduced downtime, and easier maintenance.

Limitations of Non-Contact Jet Dispensing

While jetting has become prominent in electronics manufacturing, it is important to note that the valve must be configured for the application and material properties. For example:

- **Low Viscosity Materials** require nozzles with smaller orifices to help control material flow.
- **High Viscosity Materials** may need to be heated to improve flow.
- **Type of Filler** in the adhesive will affect the process. Adhesives with coarse and highly abrasive fillers may not be conducive to jet dispensing.
- **Splashing** occurs with higher propensity in jet dispensing, and requires fine-tuning of the dispensing parameters. Once correct parameters are determined, jet dispensing is extremely accurate and consistent.

Because many factors influence any dispensing process, it is important to consult an experienced fluid dispensing specialist to help guide you to the best solution for your dispensing application.

Non-Contact Jet Dispensing Materials and Applications

Jet dispensers have been validated for a number of different adhesive formulations and assembly applications, including but not limited to the following:

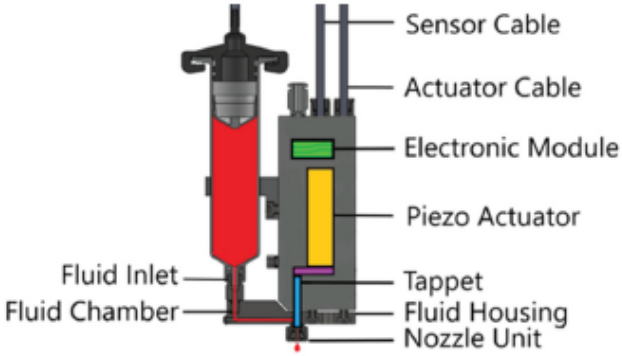
- **Die Attach Adhesives** for semiconductor wire bonding packaging
- **Conductive Adhesives** for solder replacement in SMT assemblies
- **Surface Mount Adhesive** (SMA) for wave solder processes
- **Underfills and Encapsulants** reinforcement for CSP, BGA type SMT components
- **UV-Cure Adhesives** for displays and structural bonding
- **Low Viscosity Fluids** like liquid flux
- **Thermal Interface Materials** (TIMs) for heatsinks

Recent Developments in Non-Contact Jet Dispensing: Piezo-Actuated Jet Valve

A relatively new method of non-contact jet dispensing utilizes a piezoelectric actuator to convert electrical energy into mechanical displacement, making piezo-actuated systems ultra-fast and high precision.

In piezo jet valves, an electronic piezo crystal oscillates up and down at a high rate of speed, generating kinetic energy that moves a tappet (also called a valve lifter). The tappet opens and closes the valve, and forces the adhesive to shoot out under precisely controlled pressure, to form a perfect dot on the target.

Piezo jet systems can shoot dots continuously up to 1,500 times per second, and up to 2,000 times per second in bursts. Under similar conditions, such as similar material viscosity and X-Y movements, piezo jet valves dispense about 20 times faster than any contact dispense system, and two times faster than pneumatic jet valves. For speed-sensitive, high-volume, high-throughput applications, the increase in yield can be extraordinary and highly profitable.



A number of manufacturers provide piezo jet dispensing solutions. However, valve and controller designs can differ significantly. When selecting any dispensing technology to best fit a specific application, it is important to consider the following:

- **Adhesive Properties** such as viscosity, fillers, and cure times
- **Desired Cycle Time** or how many parts per hour you want to produce
- **Ease of Adjusting Dispense Parameters** to ensure correct placement and correct amount of material is dispensed
- **Controller Capabilities** of some systems require manual tweaking while others provide software allowing the operator to easily fine-tune and optimize the process for different materials
- **Training and Technical Support** available from the manufacturer

Conclusion: Jet Dispensing, the TS9800, and Techcon

Jet dispensing technology has evolved since its early beginnings with inkjet printing. In the electronics manufacturing industry, non-contact jet dispensing technology offers a number of advantages over contact dispensing systems. Non-contact jet dispensing systems move only in the X-Y plane, and are capable of dispensing adhesive dots at much faster speeds than their contact dispensing counterparts, with less waste, reduced downtime, easier maintenance, and improved profitability.

As more materials and applications are validated for jet dispensing, new jet valve systems are being developed, including piezoelectric-actuated jet valve systems. Piezo jet valves further increase dispense rates and are about 20 times faster than any contact dispense system, and two times faster than pneumatic jet valves.

Because many factors influence any dispensing process, it is important to consult an experienced fluid dispensing specialist to help guide you toward the best solution for your application. Getting an expert involved early in a project can help you develop the right process and avoid potential problems.

Techcon, a leader in precision fluid dispensing technologies, and creator of the Techcon TS9800 Series Piezo Jet Valve, brings digital intelligence to their controllers for ease of use. And Techcon's global support team is available to provide technical assistance, training, and material validation for even the most challenging dispensing applications.

Techcon TS9800 Series Jet Valve

- **Fastest Non-Contact Dispense Time on the Market**
- **Compatible with a Wide Range of Materials**
- **Remote Access and Control over Ethernet Networks**
- **Rated at 1 BILLION CYCLES**

Techcon TS9800 Series Jet Valve Dispensing System

Future papers will explore statistical data using automated optical inspection (AOI) machines to measure consistency, repeatability, and quality for various materials used in the electronics manufacturing industry.