Practical Issues Concerning Dispensing End Effectors

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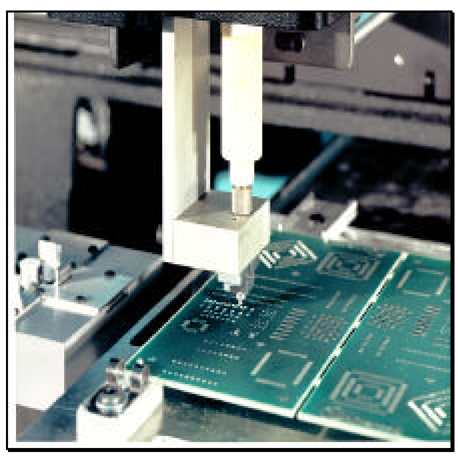
Dispensing is often overlooked as a process. The process engineer faces a lack of good information about dispensing because very little attention has been paid to the topic over the past few years. This paper explores some of the lesser known aspects of the end effectors or pump technologies.

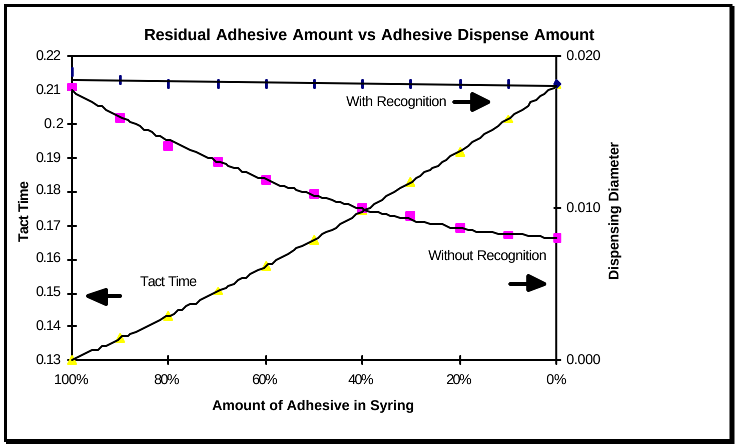
Chip placement technology and placement speeds drive high speed dispensing. This direct link to the chip shooter determines the required specification for speed in the dispensing process. Over the past 15 years the placement rates have increased from 10,000 chips per hour (cph) to over 40,000 cph. While chip shooter speeds have increased over time the average size of components have been decreasing from 1210 and 1206 (about 40 mils in diameter or more) to 0805 and 0603 (around 20 mils in diameter or less). These changes in speeds and component size reduction have redefined the dispensing requirements. Universal Instruments has had 5 distinct dispensing models introduced to the market to mirror 5 chip placement models sense 1989.

Time Pressure

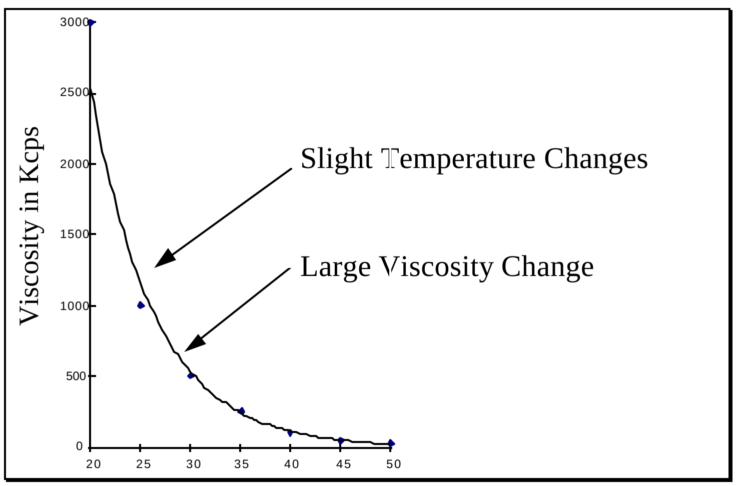
Time Pressure dispensing is the oldest and best understood dispensing method. About 70% of all dispensers currently in the market today are Time Pressure. New machine sales for the high end market with Time Pressure dispensing are rapidly declining. The reasons for this fall out is due to the limited capability of dispensing small dots at high rates of speed. Time Pressure as a technology is going through a series of challenges as technology and industry are changing.. The older generations of the time pressure systems were matched in speed and ability with the chip shooters they supported. This centered around larger chip placement and slower rates. An example of this technology is shown in Figure #1.



The syringe level VS dot size. There are very dramatic effects on dispensing with Time Pressure systems related to the syringe level or the amount of material left in the syringe. As the material level decreases within the syringe the amount of air is increasing. A pulse of air transfers energy in 2 ways. One, the pressure forces the stopper down and two, the energy compresses the air. As the syringe level goes down, air compresses and absorbs the shock. The stopper moves less and less in the same amount of time. The response rate, the rate at which it takes a set amount of material to move out the nozzle tip is derating over the entire syringe. The continuous pulsing of air (compressing and relaxing) within the syringe an internal friction producing heat. These two factors syringe level and heat have several interacting process challenges that make the Time Pressure systems complex. Figure #2 shows a decreasing dot diameter as the syringe level drops. This is labeled "without recognition". It a camera is used and the dot diameter is held constant (the flat line labeled "with recognition") then the tact time, the time required to achieve this dot size, grows longer and longer.

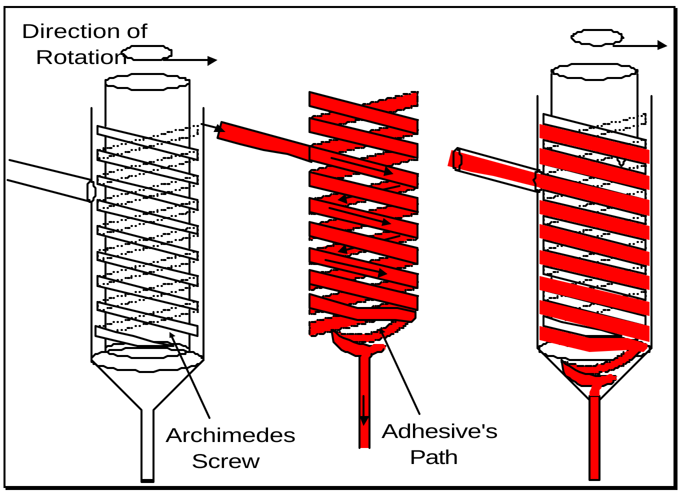


Heat generation through the rapid pulse rates of compressed air transfers heat into the adhesive. This heat comes from the internal friction caused when air is compressed against air. Adhesives are extremely sensitive to heat. Figure #3 shows the viscosity (the resistance to flow) over a temperature range. This is not linear, and it varies greatly around room temperature. Random temperature variations around room temperatures alter the flow dynamics of the adhesives dramatically. One way to lessen these effects is through intentionally heating the adhesive into a flatter part of the curve. This is the reason for temperature control (heaters and coolers) in dispensing machines. Adhesives are cured by heating and have a trigger point which is the point where the hardener starts to react with the polymer and starts the process of crosslinking. Unfortunately once started this process continues until the adhesive is fully cured. This can occur as low as 40C in some adhesives.



Inspection. To overcome these challenges of dot consistency inspection of the dot is normally required. These inspection systems work by letting the line operators know when the dots inspected with the camera vision system fall out of an acceptable range of diameters. The line operator or the machine will have to make necessary adjustments by either changing the time pulse or increasing the air pressure. These changes can happen several times over one syringe.

Archimedes

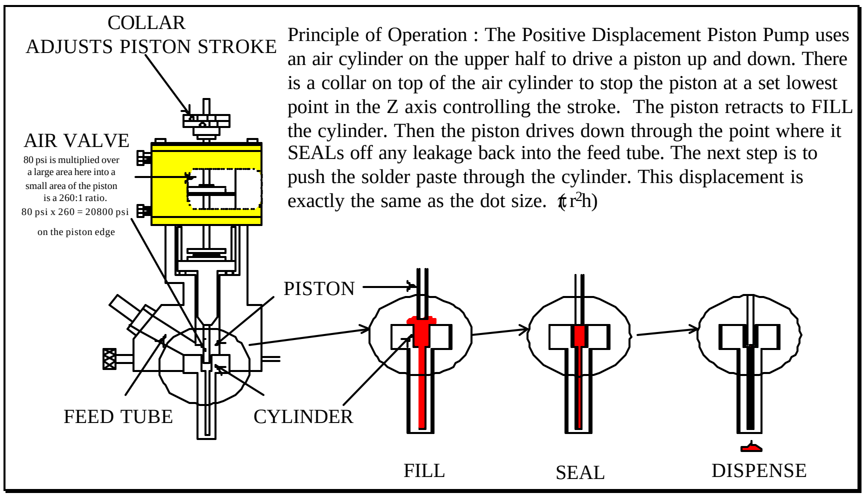


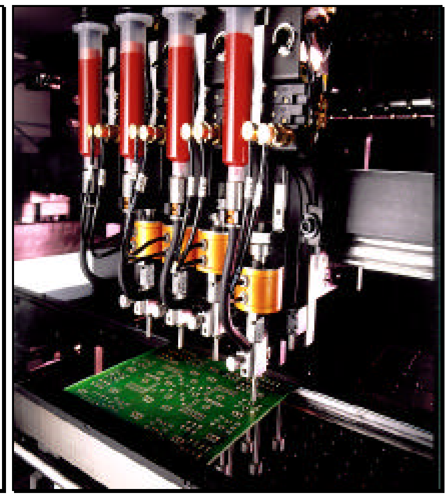
Archimedes metering valves utilize a screw to turn material down a cylinder. The rotation of the screw creates a shearing force on the material which forces the material down the threads of the screw. Constant air pressure is applied to a syringe which forces material down a material feed tube. The material is introduced to the screw which turns for a set length of time or rotational distance. As the material reaches the needle hub it encounters a resistance to flow due the restriction in area at the needle shaft. The screw will continue to turn creating a needle pressure which is high enough to force material through the needle. Any area restriction such as the needle at the output of the auger will create back flow. The amount of back flow is proportional to the pressure drop from the needle hub to the syringe. The flow out the needle is equal to the pump shear flow minus the back flow. If the needle requires a higher pressure to flow than the screw can deliver then back pressure is created and material will not flow out the needle. This phenomena can be characterized with material flow rates which are dependent on needle ID and screw characteristics. One of the biggest misconceptions about the Archimedes metering valves is that it is a positive displacement pump. While very effective and a major improvement over time pressure technology output is directly effected by viscosity. Positive displacement directly indicates that a set mechanical movement relates to a set volume this mechanical movement is not viscosity dependent.

Figure #3 shows the resistance (viscosity) to the flow as a function of temperature for standard surface mount adhesives. Temperature variations within a manufacturing environment can result in major differences in dispensing results due to changes in an adhesives viscosity. There are also big differences in material viscosity's between different lots of materials and vendors.

Flexibility and control. The Archimedes pump has a larger range of dot sizes and marked improved control over the time pressure dispensers. It is also software controlled making the setup and adjustment of the pump excellent. The software setup advantage has helped this technology carve out a defined presence in dispensing today.

Piston Positive Displacement Valves





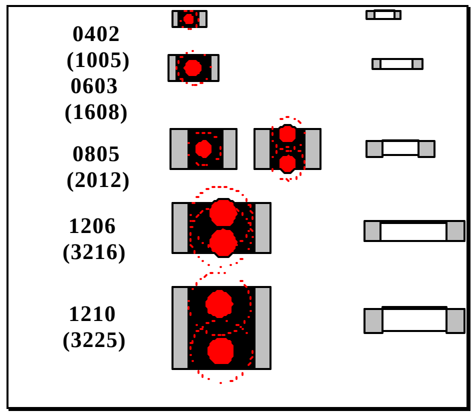
The Piston Positive Displacement Values are widely available. It is analogous to a piston cylinder combination in a car engine. There is a bore and stroke. The combination yield a specific volume displacement of $\pi r^2 h$ where r is the radius or bore and h is the height or stroke. Figure # 3 shows the viscosity changes as a function of temperature. Over this same range the volume or density does not change at all. Thus because Positive displacement directly indicates that a set mechanical movement relates to a set volume this pump type is a Positive Displacement Pump.

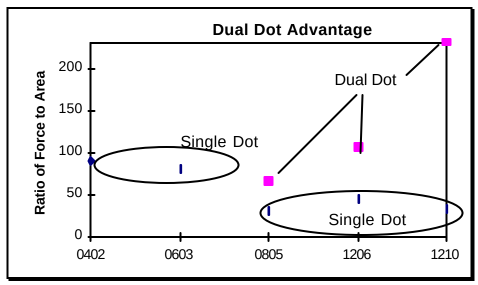
In this pump, shown in figure # 6 and 7 the volume is set mechanically. Both Time Pressure and Archimedes are software delectable. This can be a positive or a negative. When the piston pump is set to the desired dot volume it will run over a wide temperature range and long production times with no adjustments. This is a process engineering advantage because the process in the most stable. The piston pump is closer to fix tooling than the Archimedes or Time Pressure systems more appropriate for high volume usage. Through the use of several pumps fast speeds and consistent output can easily be achieved. The pump operations takes about 3 msec to dispense a large or a small dot. The air valve has a diameter of about 750 mils and the force applied on the piston 40 mil is huge compared to the resistance of the material. The result is that high and low viscosity materials dispense at the same speed, consistently.

Dot consistency. Because this pump is a true positive displacement pump it is the most accurate. This can be statistically proven and becomes increasingly obvious over time with large viscosity shifts caused by temperature, age and differing materials.

Why Dual Dots

From time to time the question comes up about why dual dots are sometimes used and sometimes not. The reasons are very logical but rarely stated. Adhesive adheres to a surface in a way that is directly proportional to its area. The amount of adhesive one can put under a component with a single dot is shown in the figure # 8. This assumes a 3 mil stand off and pad widths matching the component. The mass of each of these common components is also shown. The 0805 and larger components are thicker and therefore have more mass. The amount of adhesion area required increases because of the increase in mass. However the space under the component in limited. The relationship between mass and area is shown in figure #9. The 0805 component is the breaking point where the advantage of using dual dots exists but is not strong. The components larger than 0805s require dual dots. In adition to the increased mass these larger components have higher centers of gravity due to the increased thickness. Naturally the exact point where the area and the green or cured strength balance depends on the specific adhesive and the G forces of the chip shooter. Generally speaking the relative relationships stay the same but the absolute values can vary fairly widely.





Conclusions

While dispensing is often overlooked as a process, it is a process where information can lead to major improvements in yield and ease of use. The above information will give the reader a flavor as to why certain technologies behave in certain ways. The idea situation is to use the technology most suited to the application requirements of the specific situation. In practice many sites will struggle with methods that are not well suited for the requirements at hand. It is hoped that the Process Engineer will benefit from the material presented here. Additional information is available in the form of a white paper on the technology.