



Thin Wall Nozzles for Automated Fluid Dispensing

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Precision thin wall nozzles make many applications practical for high volume manufacturing while reducing unwanted variables. Thin wall nozzles enhance placement precision, improve deposit accuracy and increase flow rate repeatability — wringing additional capability from new and existing dispensing equipment. Implementation of a thin wall nozzle system will enable process possibilities that were not feasible before this technology was developed.

Nozzles are manufactured using the deep drawing process. Deep drawing forces a malleable metallic disk into a series of cavities in progression, using punches to draw down a formed section so metal can be pulled into the shape of the next cavity in the series. Each cavity differs in size and shape.

Progression of the nozzle to the next cavity occurs until the metal is incrementally work-hardened by each step in the progression and the desired shape is formed. Wall thickness of the nozzle can be selectively varied in each section drawn down or pulled.

The combination of a thin wall coupled with a monolithic design is a metallurgical marvel made possible by appropriate material selection. The copper alloys used to construct the nozzle exhibit an innate propensity to work harden at a rate that is substantially less than stainless steel. Two copper alloys that are well suited to meet the requirements of this process are nickel silver and phosphor bronze. This is an important aspect of a monolithic design for a nozzle produced by

the deep drawing process. More progressions can be used to draw the metal down to produce finer detail with a thinner wall and optimized geometry for fluid transmission that is generally more rigid and able to handle higher pressures.

The surface finish of the metal is very smooth, dimensionally accurate and highly polished entering the first progression in the deep drawing process. Thin walls of the nozzle retain the surface finish because the metal is stretched instead of cut.

Nozzle Comparison

Medical gage tubing used for standard needle gages sold by most manufacturers is sized by the outside diameter of the tube. As a result of the extremely thin wall, the exit aperture for a given gage size is much larger in deep drawn nozzles in comparison to cannula based on medical gage tubing dimensions.

Conventional needles used for robotic dispensing systems adopted the medical gage tubing standard long ago. Medical needles require high column strength to resist failure from buckling since they are heavily loaded in compression. High compressive loads are required in order to pierce the epidermis of a patient to administer a subcutaneous injection of low viscosity fluid. Robotic dispensing of higher viscosity fluid does not require large compressive loads to be applied axially to the nozzle. Forces are applied differently in these applications. Gravity, pressure and small tensile forces are the most common loads applied. A very thin



Assortment of nozzles with different size openings.

rigid wall can be produced by cold working the material to the extent that it is able to resist high pressure without substantial deflection of the nozzle wall, contributing to a change in volume. Volumetric change increases variability in the fluid deposit. It can be caused by deflection of the nozzle wall or deflection of other components behind the nozzle in the fluid path. After fluid flow is terminated, pressure is relieved and relaxation can cause extrication of an additional bolus of unwanted fluid to the work piece.

Nozzle Design

Smooth surface finish decreases the thickness of the boundary layer at the fluid-wall interface, further alleviating obstruction and reducing the propensity to clog with filled fluids. A rough interior surface increases the width of the boundary layer at the fluid-wall interface, effectively acting to impede flow to some extent and encourage communication between particles in filled fluids. Filled fluids in an environment where communication is encouraged have a much greater propensity to agglomerate and clog the exit aperture. Thin walls with smooth surfaces are advantageous features in nozzles produced with this process.

This is an important consideration when the intent is to target difficult applications that require precise exit apertures with minimum facial area exposure. Minimizing facial area exposure reduces the fluid's ability to cling and allows cleaner break-off of the fluid stream. Thin vertical walls around the circumference of the exit aperture, coupled with a dramatic reduction in run-out tolerance made possible by monolithic construction, minimizes proximity to the target by enabling closer place-



Reusable hub fitting for nozzles.

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ment. Monolithic construction also provides a more contiguous flow channel and completely blocks exposure to ambient ultra violet light that can cause problems with curing of adhesives in the nozzle. Vertical walls make it difficult for fluids to climb up the side of the nozzle because the full effect of the force of gravity is exerted on the fluid. This inhibits migration or wicking up the exterior wall and keeps the fluid located at the exit aperture.

Some manufacturers employ exterior chamfers to thin the cross section around the outside diameter of the exit aperture to aid fluid break off. This practice dilutes the influence of gravity and aids fluid migration.

Nozzle cores can be used uncoated or coated. Nickel silver is generally used in uncoated core applications, usually for adhesives. Phosphor bronze or nickel silver base metals may be used for coated nozzle cores. Either can have electroless nickel or entecoat applied; both coatings are hard and resistant to abrasion. Entecoat is a nickel alloy composite with a matrix comprised of nickel and polytetrafluoroethylene (PTFE). Entecoat combined with phosphor bronze base metal is preferred for biomedical applications. This coating can be deposit-

ed with extreme accuracy. Coverage is completely uniform on all surfaces of the nozzle core, and is non-stick with hydrophobic properties that can further alleviate effects from wicking. Entecoat exhibits the greatest beneficial effect when used with aqueous-based fluids.

Nozzle Geometry

Nozzle geometry is selected to achieve maximum pressure reduction at a selected flow rate while minimizing the volume of fluid retained ahead of the luer taper. Fluid volume ahead of the luer taper exacerbates any propensity of the system to drip or entertain the presence of a droplet or buildup that could transfer to the work piece in an uncontrolled fashion or detach unintentionally en route to the location of the next target. Directing the delivery system to act by pull back of the excess fluid can compensate for the additional volume. Excess volume ahead of the luer taper also inhibits response time by introducing lag due to compensation and risk of viscosity change and eventual solidification if the fluid rapidly cures. Selection of a conically shaped geometry achieves considerable pressure reduction. Pressure is reduced by approximately three times at equivalent flow rate or flow rate is increased by three times at equivalent pressure. The conical shape is rigid which results in a high propensity to resist bending in contrast to

conventional needles made from straight tubular cross sections. Transitions between cross sectional changes can have an adverse or beneficial influence on pressure and flow rate; to be of benefit, they are kept gradual and generous.

Thin wall nozzles are connected to the fluid delivery system through a hub with twin helix acme threads that mate to the luer connection and provide full luer thread compatibility. The hub serves to lock the nozzle core to a luer taper to prevent separation from the taper under pressure, resulting from transmission of liquid. A hub can be made separable or attached permanently to the thin wall nozzle core. Molded color-coded polypropylene hubs are permanently attached. Reusable hubs are separable and lower disposable core cost. They reduce waste, as only the wetted core is disposed, retaining the hub for reuse.

This hub type is currently manufactured by machining from stainless steel or tellurium copper. A very short straight section, approximately one millimeter (0.039-in.) culminates in an exit aperture that provides the best detail for access into confined areas. Standard medical gage tubing size is based on outside diameter of the needle; deep drawn nozzles in standard gage sizes are based on this as well. However, nozzles designed specifically for robotic dispensing of fluids have a considerably thinner wall, enabling a significantly larger inside diameter for a given gage size to be produced. Deep drawing of the metal makes exit apertures as small as 50 microns (0.002-in.) with thin rigid walls of about 0.05 millimeter (0.002-in.) or less, a cost efficient reality for promulgation of the technology in the industry.

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