Automated High Volume Consumables Production

From Tool to Blister

Pipette tips are small and relatively simple components that are now in high demand. One might think producing large quantities of these products is a simple task. It is not. The requested high quality can only be reached by using complex automation. To meet these challenging requirements, MA micro automation has developed a modular solution: Centauri IVD.

The Centauri IVD production system can be adapted to meet specific pipette tip manufacturing requirements. © MA micro automation

With the onset and spread of the coronavirus, pipette tips were suddenly seen in print media and on television news shows. To combat the pandemic, routine sample testing increased to an incredible scale. Mandates for in-vitro diagnostic testing increased demand for these disposable components with new production plants being brought online globally. Total pipette tip manufacturing requirements are significantly greater than before. What makes pipette tip manufacturing so challenging? Wall thicknesses of these molded parts are about 0.3 mm and tip bores are sometimes only tenths of a millimeter in diameter. Aspirated liquid fill volumes must be exact and repeatable as they are critical to the accuracy of test analysis results. Internal geometries and other critical to quality features of these parts must be tightly controlled to support reliable testing.

This is why high-quality injection molding machines, tools and process controls are required for manufacturing. What happens after a mold cycle is complete and the mold opens is decisive. MA micro automation developed the modular Centauri IVD automation solution to enable all post molding process automation including packaging. With an installed base of many systems in Europe, several more of these high-performance production systems will soon be delivered to customers in the USA and Asia.

The pipette tip manufacturing process begins with component removal from the molding tool. A side takeout robotic actuator is located adjacent to an injection molding machine. The actuator, driven by linear servo motor technology, is used to rapidly advance a custom end of arm tool (EOAT) into and out of open mold halves (**Fig. 1**). The EOAT is configured to receive pipette tips from a horizontal array of delicate core pins in the mold. Part tips face toward the gripper, instrument bore ends face out. MA micro automation is the only supplier in Europe to produce these high-speed robotic units in-house.

Centauri IVD equipment provides automated handling of parts transferred from the mold. Post molding operations include a variety of non-contact quality inspections, re-pitching of parts to different arrays and management of rejects prior to loading of racks and packaging. Immediately after the pipette tips have been transferred from the mold to the EOAT, the process begins. Through-beam laser sensors are used to monitor successful part transfers. Additional sensors are used to monitor the gap between parts and gripper sleeves to ensure complete transfers. Any missing part would be considered a critical fault and the system stopped to prevent damage to mold cores.

The side takeout actuator and loaded EOAT retracts away from the injection molding machine and then rapidly travels to position parts adjacent to a tilting station. This station is designed to perform two tasks. One is to receive parts with axes horizontal and transfer them down through an optical inspection station. The second is to pivot all parts from horizontal to vertical orientation with tips pointing down.

Inspection On-the-Fly

Multiple cameras, optics and light sources are positioned within a protective enclosure. Using a sophisticated array of first surface mirrors, lighting and high-definition cameras are used to capture images of all 64 pipette tip geometries. The entire inspection process is performed on-the-fly with all parts entering and exiting the inspection station without stopping. Full 360° inspection enables detection of burrs, short shots, and other defects. Test results for each part passing through the station are used to coordinate downline QC station NOK removal and replacement with OK parts. Data from these inspections are also tied to injection molding machine controls for continuous adjustment of parameters required to maintain optimal performance.

Inspected parts are reoriented to present axes vertical, tips down. The array of parts can be unloaded directly into product carrier fixtures or into re-pitch tooling. The initial transfer of parts coming from QC inspection requires re-pitching from injection mold cavity positions to an array suitable for subsequent reject part refill operations. Parts are loaded into precision pockets of an array of rails. Populated rails are then moved to compress the array before another transfer gripper acquires parts for transfer to workpiece carriers. While being transferred to each workpiece carrier, individual grippers are compressed in another axis to create a tight array of parts matching centers of racks to be loaded downline.

A Ten Minutes Buffer Prevents Production Downtimes

A modular and scalable production system provides NOK and OK part management to separate stations within a larger manufacturing system. For end-to-end production within a single system, a decoupling buffer is required. The buffer is used to "decouple" serial process of the injection molding machine from the parallel processes of inspection and refill operations downline. With an injection mold machine cycling at 5.8 seconds, the Centauri IVD system is configured to provide a buffer capacity of ten minutes. Delays due to load faults or other throughput issues downline will not require the molding machine to stop. A first in first out (FIFO) methodology is used to maintain the good parts queue.

A programmable servo driven circuit of workpiece carriers is used to transfer oriented parts between stations. Carriers, configured to hold an 8 x 8 array of pipette tips, are used to transport parts through QC check and refill stations.

RFID tags on each carrier enable local data management for each set of fixtured parts. Molded parts can also be unloaded for manual quality inspection at dedicated collection stations. This portion of the Centauri IVD line can also include filter loading and insertion. Filters are sometimes used to prevent aerosols in sample collection that may affect test results. If included, a height adjustable servo actuated tool is used to press and seat previously loaded filters.

100 percent inline checking of all parts follows. A filter presence check if required, presence of particulate, measurement of overall length (OAL), check of tip and hub bore dimensions are all processed. These critical to quality vision inspection tasks require expertise with lighting, camera selection, optics, and image processing. MA micro automation has in-house capability with high precision vision inspection work. Opto-engineers and software development specialists are constantly workin g on developping new and better systems to meet customer inspection requirements.

NOK Parts Are Replaced by NO Parts Before the Packaging Starts

A Scara robot mounted vacuum gripper is used to transfer a single component from the array of parts within a stationary carrier. The sample part is moved to a test fixture where it is pressed over a receptacle with force monitoring used to confirm concentricity with respect to the injection gate feature. Outputs from this analysis allow injection molding equipment to be adjusted to maintain optimal performance. The robot can also transfer sample parts to a drawer for manual retrieval and further analysis.

Carriers with parts advance to a blow-off reject removal station. NOK parts are blown up and out of carrier nests and discharged to an offline receptacle. Carriers then advance to a refill station where known OK parts from a previously populated queue of good parts have been loaded. Those parts were loaded at the start of the batch production run. Known OK parts are retrieved from the good parts buffer and loaded into any open positions of the carrier to replace previously removed NOK parts.

Last Steps to the Final Packaging and Delivery

The carrier then advances to an unload station where the full complement of pipette tips is removed and transferred to plastic Racks. A thermal transfer printer is used to mark and apply a barcode label to each Rack. Vision inspection of the label verifies data accuracy, correct color coding and presence of all pipette tips. Any faulty rack is flagged and removed at an unload station. Good racks advance to a blister packaging module where covers can be added. Finished racks with covers can also be marked with lot number, expiry date and other variable data using inkjet printers. Finally, racks of pipette tips with covers are loaded into blisters, heat stake sealed and discharged to final packaging operations.

The modular design of Centauri IVD equipment makes it possible to customize elements of the system to meet the unique requirements of different manufacturers. MA micro automation has established a growing installed base of these machines and demonstrated their reliability and high performance. ■

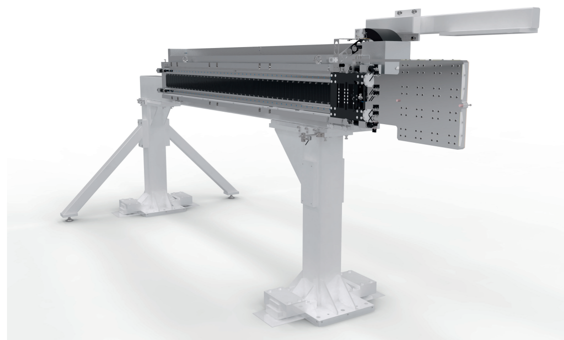

Fig. 1. A high-speed single axis robotic handler utilizes a linear servo motor to deliver unparalleled speed and positioning accuracy.

Info

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