PC-based control helps optimize micro injection molding machines

Existing automation platform scales up to increase throughput and maintain improved quality

Based in Georgetown, Ontario, MHS launched its first M3 micro molding machine with the capacity for eight injection molding cavities. The successful solution used PC-based control technology and EtherCAT, along with other Beckhoff components. When MHS decided to scale up to a 32-cavity system in 2020, they found the Beckhoff platform easily scaled with no component upgrades and maintained their innovative process that preserves the working life of the plastic melt.

The M3 micro molding machine is ideal for producing micro parts in medical devices and electronics, among other things.

In front of the M3 injection molding machine: Beckhoff Regional Sales Manager Paul Pierre (left) worked closely with the MHS team, including Design Manager Ryan Craig.

No matter the size or plastic material type, three main factors affect the quality of injection-molded products: pressure, temperature and time. Mold Hotrunner Solutions (MHS) optimized these parameters for the M3 micro molding machine when it launched in 2016. This turnkey, zero-waste injection molding solution provides new capabilities for medical device and electronics manufacturers, among other end users. In-house development of technologies, including hot runner nozzles and molding technology, enabled the M3-D08 machine to produce direct-gated micro parts as light as 1.3 mg with high efficiency and precision.

Combating quality issues with reliable processes

When designing the M3, MHS worked to eliminate the longstanding flaws in injection molding processes. Traditionally, the process begins when plastic pellets drop from a hopper into a pipe-like barrel. A screw feeder moves the pellets forward, and heaters outside the barrel melt them. Based on suitable temperature control procedures, the plastic reaches the required temperature and viscosity before it arrives at the nozzle for injection into the mold. In addition, hot runners like the M3 use valve gates and internal hot sprues to directly inject the material into the mold. In this way it is possible to produce precision

© Beckhoff

MHS selected the 21.5-inch CP3921 multi-touch Control Panel from Beckhoff to provide operators with greater transparency and usability.

© Beckhoff

A Beckhoff C6920 control cabinet IPC delivered ample power to scale the M3 machine from the initial 8-cavity to a 32-cavity system with higher throughput.

parts with spotless surfaces and to reduce the amount of sprue residue that collects at the gating point and has to be removed from manufactured parts post-molding to be recycled or discarded.

To open and close the mold, the machine required coordinated horizontal and vertical motion to shuffle a 500-pound (approx. 900 g) mold in a fraction of a second with an accuracy of 10 µm.

This process resulted in challenges when designing the machine that would ensure high part quality through repeatable control of the injection molding process according to precise pressure, temperature and time specifications.

"Beckhoff has been working with MHS since 2012 when they required greater automation, networking and remote access capabilities," says Paul Pierre, Regional Sales Manager for Beckhoff Canada. So the company turned to Beckhoff again in 2016, when MHS was looking for new control solutions with the initial M3 build. A powerful C6920 control cabinet Industrial PC equipped with a quad-core Intel® Core™ i7 processor was selected as the control platform for the M3. A widescreen CP3921 Control Panel serves as the HMI hardware. This 21.5-inch multi-touch display allowed MHS to reconfigure the control interface to better fit the micro molding process and provide an overview of all process variables.

Real-time networking with EtherCAT is key

EtherCAT provides real-time communication for the complex motion architecture. Because micro parts use so little plastic, maintaining the processing temperature is difficult without affecting the melt quality. The MHS process does not heat the plastic melt to processing temperature until just before it reaches the valve gate, which extends the plasticizing time of the material and reduces waste significantly.

The EL3314 4-channel thermocouple input EtherCAT terminal and the TwinCAT Temperature Controller (TF4110) made the implementation possible. MHS used 14 heaters with tolerance requirements of ± 0.1 °C. The EL3314 and temperature control software gave excellent results. The Beckhoff AX5000 Servo Drives also included AX5721 encoder option cards to support a high-resolution linear encoder. TwinSAFE I/O and drive functions are used to control safety locks, E-stops and safe torque off (STO) options.

To manage motion requirements for opening and closing the mold, AX5000 Servo Drives from Beckhoff power an AL2815 Linear Servomotor for horizontal motion and AL2412 Linear Servomotor for vertical motion. "It would be impossible to achieve the precision of 10 µm at a rapid pace without the real-time capabilities of EtherCAT in the I/O and drives," says Ryan Craig, Design Manager at MHS.

Closing the gap between high throughput and high quality

"PC-based automation from Beckhoff helped us achieve precision with dynamic linear motion profiles, send logs via email to prevent malfunctions, connect to the cloud and communicate with third-party devices, such as cameras and resin dryers," explains Amir Abbas Shoraka, Senior Automation Engineer for MHS.

© Beckhoff

AX5000 series Servo Drives from Beckhoff provide dynamic motion control for the screw, linear mold movement and side-entry robot.

Most importantly, MHS achieved accurate heater control profiles to reach and maintain the plasticizing temperature and cyclic quality control during part injection.

When MHS saw opportunities to increase capabilities further, the company began to scale the M3 from a single module of eight micro part cavities to four modules of eight in 2020. For the resulting 32-cavity version with higher speeds, they were able to use the same controls architecture. The 32-cavity version also adds a side-entry, high-speed robot, which moves 1,000 mm at a rate of 0.4 ms into the cell and another 0.4 ms out. AX5000 drives and two AM8042 servomotors, along with an external brake resistor, make this possible.

In the new Alpha M3-D32, 62 heater controllers are working in the same control platform that controls moving axes and machine sequences in a 5-ms cycle. "In addition to robotics, the M3 offers some intelligent processing on the machine as well as a vision system for part inspection and mold safety, which is networked via EtherCAT. We did this with the same, powerful PC-based machine controller without any loss in performance," Amir Abbas Shoraka says. Based on the success MHS achieved with EtherCAT, the company also joined the EtherCAT Technology Group.

The original M3 machine already exceeded industry standards by producing an average of 170,000 micro parts in one working day with zero waste. If the parts weighed 10 mg, for example, it would require exactly 1 kg of plastic pellets to produce the entire run. The M3 accomplished this efficiency even with PEEK and other high-heat materials while maintaining quality standards. "Starting with the first M3 machine in 2016, the part's prototype parameters remained identical to the processing parameters for high-volume production," MHS Founder Harald Schmidt says.

While the M3-D08 closed the quality gap for micro molding, the Alpha M3-D32 increased this capability to a superior throughput level without affecting its repeatability in terms of pressure, temperature and time. The M3 can achieve a 4-second cycle time or better for machine motion, injection, cooling, ejection and robotics. This brings the scaled-up machine's per-day rate to 690,000 parts on average – more than four times the throughput of the previous system.

More information:
www.moldhotrunnersolutions.com
www.beckhoff.com/plastic