Precise Timing and Synchronization Drives Thermoformer Performance

Servo system on thermoformers uses PLSs to achieve precise multi-axis synchronization, reliability and throughput.

Thermoforming plastic product packaging, plastic cups, lids, foam plates, deli pieces, horticulture components and berry box products used in supermarkets requires highly precise, synchronized motion. And with inline, continuous thermoformers performance requirements go even higher, and require precise timing and repeatable sub-millisecond level synchronization between multiple axes.

Brown Machine (www.brown-machine.com) has improved the performance of its inline, continuous thermoformers by coordinating motion with a series of high-speed programmable limit switches (PLSs) that coordinate motion based on the position of the thermoformer's main drive. Brown Machine utilized a PC-based motion controller from ORMEC Systems (www.ormec.com) and high-speed PLS outputs on the system's axis modules to increase performance and reliability.

Brown Machine is a leading manufacturer of thermoformers used not only to produce a wide variety of plastic disposable and food packaging products – but also clamshells for hardware products such as doorknobs and blister components used to package razor blades with cardboard inserts.

Continuous Thermoformer Process

With a continuous thermoformer, the material is delivered as a sheet from roll stock, or it is fed in directly from an extruder. The sheet goes through an oven where it is brought it to its final forming temperature, and then into a form station where vacuum and pressure are used to shape the material in the mold and form the product into a "skeletal web".

The web is then moved, in most applications, to a separate trim station where the product is trimmed from the web with matched metal punches and dies (some systems used steel-ruled dies for cutting). Once the product is separated from the skeletal web, the scrap is re-granulated and put back into the system.

On the form station, servos are utilized to drive the upper and lower platens which correspondingly hold the upper and lower segments of the mold. In most applications, there is a process called “plug-assist” which is used to help distribute the material properly in the mold. With a plastic cup, for example, the plug-assist moves down into the mold cavity to help form the cup and optimally distribute the plastic material.

The result for proper machine operation is that timing, speed and movement of the mold, as well as platen position where various form functions are turned on and off, all become critically important. Maintaining product quality and optimizing machine performance is difficult since, as the platen is traveling up or down, precisely synchronized process actions need to be coordinated.

Brown Machine manufactures a variety of configurations of its line of thermoformers. With a B-Line hot sheet thermoformer, the typical configuration is up to nine-axis. With a trim press, servos are used on the ejectors and the feed system. A vertical trim press is typically a five-axis system.

Continuous Formers & Vertical Trim Presses

Brown Machine experience some feed problems on a redesign of its vertical trim presses. The system wasn’t accurate enough, and the servo loops weren’t tight enough to maintain position properly – which caused other problems downstream with counters, baggers and other processes.

“The majority of system improvements related to achieving higher speeds and accelerations, how fast the system could get to proper position and overall system accuracy,” said Matt Salgat, an electrical engineer at Brown Machine. Salgat said that the main drive, based on its position, needed to precisely initiate motions on other axes, and the group together would perform a camming function.

The system utilized programmable limit switches on the DSP axis module of the ORION motion controller to produce closely coordinated motion on the trim presses. The axis module provides three optically isolated PLS outputs that respond at the position loop update. Each PLS can be independently driven with actual or commanded position of an axis, or through MotionData communications which provides tightly coordinated, multi-axis electronic gearing.

“We also noticed a performance improvement on the forming stations where the PLSs fire the plug-assist,” Salgat said. “On most machines, the mold would come in first and, based on mold position, the plug-assist motion would be initiated. When the plug is moving toward the sheet, you are also firing a variety of valves based on plug position. All of that closely-coordinated, synchronized motion is done through using the programmable limit switches, and it is done very effectively,” he added.

Utilizing the PLSs dramatically improved the accuracy of the system, and repeatable performance as well. Brown Machine noted that the vertical trim presses could now achieve a running speed of 160 shots per minute – which required highly accurate, repeatable performance to coordinate the precise timing needed to synchronize multi-axis motion. Previously, Brown had a machine running at 140 shots per minute but could not achieve reliable accuracies.

Customers benefited from the ability to increase speeds but, more commonly, set the machine to run at a 3:1 or 4:1 ratio between the form station and trim press to achieve maximum machine throughput and product quality.

In a previous attempt to implement a similar system, Brown Machine tested a board-level motion controller. But unlike the robust, industrial performance and reliability of a standalone, integrated motion controller, Brown experienced problems with system reliability, power supply issues and inconsistent software performance.

Once the PLSs had been implemented properly in the ORMEC system, the performance and reliability improved dramatically. For Brown Machines customers, the performance of the system has improved and there have been fewer service calls and overall reliability has been higher. "You always notice when you get calls back," Salgat said.

Not the Limiting Factor

A key advantage for Brown Machines' customers is that the systems perform consistently up to expectations.

"The process has to be the limitation on productivity and throughput rather than the machine itself," said Jim Robbins, VP at Brown Machine. "As materials and technology have gotten better, increasing the capabilities of the machines to maximize the process of forming the material is always the goal of this machine supplier."

Salgat said that the new system allows customers the option to heat the sheet up faster, increase the speed of the former or ability to change process parameters on the mold, but adequate cooling time is always critical to consistently producing high quality parts. But customers can also run parts more confidently – as long as they maintain a proper ratio between the forming station and trim press – and there has been less scrap and less downtime.

Remote Support & Maintenance

Brown Machine has used modem communications and PCAnywhere software to perform remote support, diagnostics and maintenance on its machines for three years. Engineering and service personnel can dial-up directly into machines, and use development software provided by vendors to support the Lookout HMI, Allen-Bradley PLC and ORMEC motion control software used on the machine. Brown Machine can modify and support control software and perform machine diagnostics through the modem.

"That's been saving us time and money, but has also contributed to machine uptime," Robbins said. He added that the ability to diagnose problems via modem dramatically improves service response – typically faster than service personnel could travel to the airport.