Graham Engineering Corporation (GEC), located in York, Pennsylvania, specializes in high-end blow molding machinery and equipment for the non-PET segment of the fluid bottling and packaging market. Their machines are widely used at plants that manufacture bottles to be filled with automotive fluids, household detergents and cleansers, and beverages that are marketed in non-transparent bottles. By using the PC-based control system from Beckhoff and the ultra fast EtherCAT fieldbus system, they were able to significantly increase the productivity of the machines and the quality of the molded bottles.

Performance and efficiency greatly increased for blow molding machinery

The Graham Wheel product was GEC's first major product entry into the blow molding machine market. Graham Wheels have been made for over 30 years with installations worldwide – they now represent a dominant technology in the production of high output blow molding systems. The main component spins around a horizontally driven rotary table carrying the molds. The "Graham Wheel" rotates around a horizontal axis. Up to six extruders feed plastic into a component known as a flow head to quickly form bottles in virtually any type of thermoplastic to the perfect shape and highest quality available.
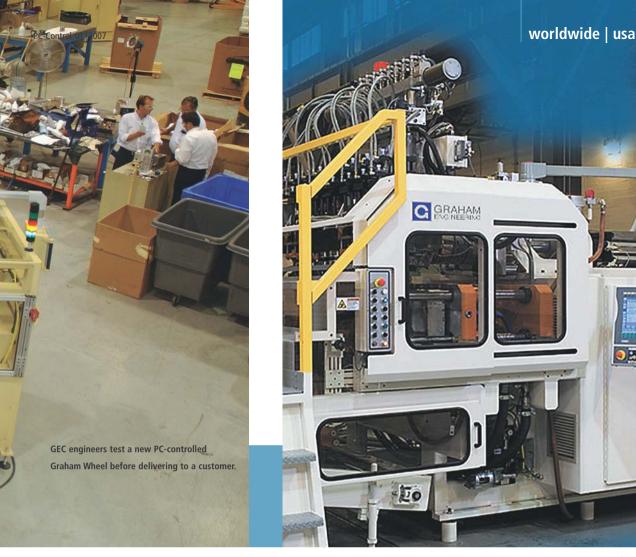
In the fast lane with PC control

"GEC uses their automation and controls expertise to help their customers surpass the competition in production output, reliability, cost efficiency and safety. GEC has heavily adopted PC-based controls, which have been our main controls platform for over five years", Dave Fiorani, Engineering Manager, Graham Engineering said. "True to our company motto 'Innovation Taking Shape,' GEC

machines are under a perpetual state of improvement to ensure that our customers' machines will be world class, yet integrate seamlessly with existing line components."

Control PC must meet the most demanding requirements

"In 2003 GEC had determined that our existing PC hardware platform wasn't going to keep up with our machine design migration so we needed to find a successor", Fiorani said. We then completed an exhaustive evaluation of Industrial PCs from five major vendors. Over 20 critical performance criteria were evaluated in each vendor's product offering. We found that only Beckhoff Automation was able to meet every single item on our list, which included:
| Highest speed processors currently available on the Industrial PC market
| Openness: control software should run on any standard PC
| Capable of direct communication to HMI – no OPC server required
| Integrated UPS function blocks to handle proper PC shutdown

GEC engineers test a new PC-controlled
Graham Wheel before delivering to a customer.

GEC has heavily adopted PC-based controls, which have been their main controls platform for over five years.

| Ability to offer an operator station with fully integrated push buttons
| Software updates available to download from Internet – upgrades available at no charge after initial license purchase
| Ability to buy Commercial Off-the-Shelf (COTS) components from any PC store to replace failed components, adhering to ATX Open Standards

GEC chose Beckhoff C6140 PCs with 2.4 GHz Pentium® 4 processors running TwinCAT software as the control centerpiece for Graham Wheel machines. "Most of our machines could be controlled using TwinCAT PLC, but for a few specialized machine types, we need NC functionality so we use TwinCAT NC across the board to use a standard software package," Justin Kilgore, Senior Electrical Engineer, Graham Engineering, said.

I/O terminals handle monitoring functions

"Beckhoff remote I/O also replaced expensive PCI I/O cards supplied by their prior PC vendor. GEC now uses special function I/O terminals for their machines' E-stop functions and temperature measurement", Kilgore said. "The KL2692 watchdog terminal eliminated the chance of any possible errors in terms of machine and heater control. The KL2692 monitors a bit that is toggled by the controller during each cycle. If the toggle signal fails, the controller switches off two relays that are integrated in the emergency stop circuit in order to prevent damage to the machine." A KL3352 Strain Gauge Isolator is used to bring in various pressure transducers. Before, GEC needed additional hardware to perform the same function.

"In addition, I/O addressing via TwinCAT's Automation Device Specification (ADS) is highly automated and very simple," Kilgore said. "With our previous PC ven-

dor's software, an engineer had to address all of the I/Os at the bit level. We now save 8 – 16 hours of I/O addressing time on each machine using TwinCAT."
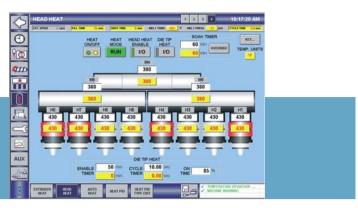
Flexibility on the test machine

In order to test and apply the new controls and major machine components, GEC has a Lab Wheel. GEC tests several different bottle types, mold sets and head configurations so the Lab Wheel needs extremely high flexibility to change. "With the Lab Wheel's old PLC system we lacked changeover flexibility, which became a source of headaches when testing newly designed machine components," Rolf Weingardt, R&D Manager, Graham Engineering, said. "We've had a Beckhoff PC running on the Lab Wheel for over a year and a half now with none of the flexibility concerns we experienced in the past."

The PLC racks were also replaced with Bus Terminals. "We didn't have to do any internal wiring changes on the Lab Wheel and were able to use all our existing wires," Paul Klinedinst, Senior Development Engineer, Graham Engineering, said. "We saved over 200 hours of I/O wiring time because of the Bus Terminal I/O flexibility."

EtherCAT meets Graham Engineering's need for productivity and parts quality

Some of the I/Os still use traditional fieldbus technology. An FM3332 thermocouple module is used over PROFIBUS to monitor 32 thermocouple channels. Variable Frequency AC drives on the machine are also networked via PROFIBUS. For performance and cost reasons, GEC uses EtherCAT, the real-time Ethernet fieldbus, for ultra fast I/O communication.

GEC required new PC hardware that would allow direct communication to their HMI without an OPC server.

Graham Wheels feature parison programmers – devices used to precisely control the wall thickness at various sections of each bottle. For the parison programmer, high speed analog I/O was required to very quickly control the motion of this molding process within a few thousandths of an inch. "GEC selected EtherCAT from Beckhoff", Kilgore said: "EtherCAT is the fastest Ethernet-based remote I/O available today and is as easily implemented as standard Bus Terminal I/O". GEC was able to eliminate the parison programmer's previous controller – a custom high-speed I/O circuit board – after implementing EtherCAT.

"The fastest we were able to close the loop on the parison programmers used on our previous machines was 1 ms," Klinedinst said. "With EtherCAT, we can close the loop on the Lab Wheel as fast as 150 µs. We're getting better performance with more control over the parison programmer now than with any of our previous systems. The bottles-per-minute rate on our machines is basically fixed due to the cooling stage of the bottles; however we are capable of making higher quality bottles today because we've adopted EtherCAT technology."

Customers jump on the controls upgrade bandwagon

GEC quickly fitted all new machines undergoing assembly with Beckhoff C6140 PCs. "Once we upgraded our Industrial PCs with Beckhoff hardware, our control reliability immediately increased," Dave Yenor, Vice President of Global Business Development, Graham Engineering said. "Also, because of Beckhoff's remote I/O flexibility, any required retrofits in the field have become much faster and easier."

Today, GEC has standardized Beckhoff PC-based controls across all product lines. "With the occasional exception of determined customer specifications for traditional PLCs, all machines that leave Graham Engineering's assembly facility will now have Beckhoff controls on them," Fiorani said. "Because of the smartly designed Beckhoff PCs, special function I/O and automated E-stop features, GEC machines are safer and more reliable than ever," Yenor said. As a result of the technology GEC has utilized, "we're seeing many of our end-user customers eliminating 'hard specs' for big name PLCs and actively retrofitting their older machines with similar Beckhoff control systems."

→ Graham Engineering Corporation
www.grahamengineering.com
→ Beckhoff USA **www.beckhoffautomation.com**