Software PLC/NC and Hydraulics:

TwinCAT for Control of Plastics Processing Machinery

Totally PC-Based Control

In planning their new Controls generation, Husky - global supplier of injection molding systems to the plastics industry- have embarked on an integral approach based on an Industrial PC, fieldbus components and software from Beckhoff's product portfolio. The challenge to be met by Beckhoff's solution included a software PLC for machine control and a software NC for electrical axes as well as integrated hydraulic drive and temperature control.

Plastic products have become so familiar and commonplace that people spend little thought about their production as they use them. Many plastic products are manufactured by injection molding. The list of end-products is as endless as unspectacular: Dowels, yoghurt cups, ballpoint pen housings, beverage bottles, automotive rear lenses and bumpers, laundry baskets, buckets, containers for use in medical engineering to name just a few of the vast array of more or less important things in our daily life. However, there is an obvious difference in the sizes of these end-products, from very small (e.g. model making components) to very large (e.g. automotive bonnets), and subsequently also in the size ranges of plastics injection molding machines. A distinctive feature is the clamp tonnage required to operate the mold from which a plastic application springs.

Plastics Injection Molding Machines with a TwinCAT Heart

In order to provide the required clamp forces, machine manufacturers employ either hydraulic units or mechanically sophisticated, electrically driven clamp mechanisms. However, the functional principle of an injection molding machine is the same across all sizes: Through a feed hopper the pelletized plastic material enters a plasticizing barrel where it is melted under the influence of a rotating screw and the temperature exerted by band heaters around the barrel. As the melt compresses in front of the screw, the mold (at left) is closed and then locked by applying a nominal force which must be precisely maintained and controlled to prevent the hot melt from escaping at high pressure. Once sufficient melt has collected in front of the screw, the screw is used as a piston to inject

the material through the machine nozzle into the mold cavities, and to keep the melt under pressure. After a specific mold cooling time, the screw piston is pulled back. The mold is opened, and the molded parts are removed from the mold cores either by means of an ejection mechanism or by a robot. The machine cycle can then be resumed anew. Suitable machines for this process must meet a whole set of requirements, importantly:

1. High part quality: The optimized process and its parameters must ensure a consistent production of good parts, i.e. with consistent physical properties (size, weight, density distribution, color, and even odor). Repeatability of the machine's mechanisms and control are key.

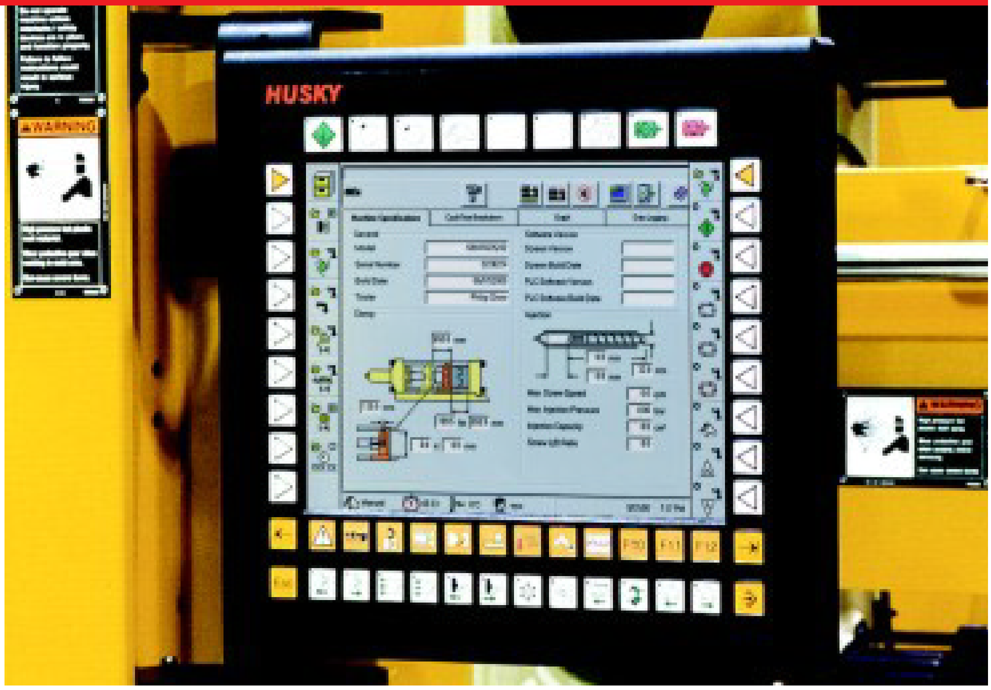
2. Short machine cycles: As the machines frequently run in unattended 24 hours operation, every tenth of a second saved in the manufacturing cycle results in increased part output.

3. Ease of parameterizing and maintenance: In the event of problems, the operator must be able to troubleshoot them as fast as possible, supported by convenient error messages and additional online tools, such as repair work videos. Machine visualizing software at the HMI (Human Machine Interface) plays a major role in

Husky Injection Molding Systems Ltd.

Husky was founded in 1953, and has emerged as the world's largest single-brand manufacturer of injection molding machines. With production sites at Bolton (Ontario, Canada, Milton (Vermont, U.S.A.) and Dudelange (Luxembourg), Husky employs 3,000 people worldwide who realized sales worth US$ 708 millions in the past fiscal year. Products include hydraulic injection molding machines with clamp forces from 50 to 8,000 metric tons, molds, hot runners, and removal robots.

Control Panel with TFT display, touch screen, softkeys, and user ID system



meeting this requirement.

4. Effective operator protection: Hot melt and high pressures present a potential risk of injury which must be addressed both by design and by engineering control.

5. Effective system protection: Jammed, sticking or partially removed moldings can damage the most expensive component on the injection molding machine - the mold. The slightest scratch in the cavity or core surfaces will be well visible on the molded product and can render it unusable.

6. Efficient use of resources: This includes reducing the environmental impact of the machine by minimizing start-up and production scrap (material consumption) as well as power and water consumption during production.

Husky machines have hydromechanical clamps. The screws of the injection units are driven by a hydraulic radial piston or servo motor. Servo motor drives are also used on the removal robots.

One Industrial PC Replaces 4 Conventional Controls

Two years ago, in response to the rising requirements in the plastics injection molding markets, Husky decided to make plans for introducing a new PC based generation of machine controls. A comparison between traditional control architecture in plastics injection molding and advanced PC based control reveals the differences: Conventional concepts in this application area are based on numerous specialized controllers and hardware PLC. The PLC governs the global machine process and - on hydraulically driven machines - communicates with an injection controller (IC), a clamp controller (CC), and a temperature controller (TC). On electrical injection molding machines there are further controllers for operating the individual servo axes. The traditional HMI is based on an Industrial PC still without any controller functions. And everything is wired in parallel in the control cabinet.

Husky‘s new control concept combines all of these functions in an Industrial PC installed in the control cabinet, where it replaces all former controllers and the hardware PLC. The machine signals are collected and transmitted by way of a Profibus master card and Beckhoff Bus Terminals connected to the fieldbus. Also connected decentrally to the Profibus, non-contacting transducers provide the positioning information of the individual hydraulic cylinders.The operating unit is another Beckhoff standard product, a Control Panel without any intelligence of its own, linked to the PC by means of two coaxial cables and featuring a TFT touch screen, softkeys, and a user ID system. Industrial PC, fieldbus, electronic terminal block - that‘s all. The hardware has been reduced to the essential. The separate electrical cabinet for the servo motor power components has been eliminated, since these parts can now be installed in the free space gained in the central control cabinet.

Equally integrated, the software platform is based on the languages defined in the IEC 61131-3 standard and has been designed as a software PLC in TwinCAT. It serves for close loop control of all hydraulic cylinders and also for controlling the robot sequences, with a TwinCAT software NC for numerical robot control. The key software components for controlling a Husky machine can be organized in four task areas, further explained on the following pages:

- Hydraulics
- Temperatures
- Robotics
- Visualization

Husky has many years of experience in close loop control of hydraulically operated machine axes (typically at least 8 per machine). In contrast to the past, the individual controls are no „black boxes“ anymore but can be

From dowels to bumpers - a wide range of plastic products are injection molded on Husky machines available in a complete portfolio of different tonnages

conveniently generated and adapted under the IEC 61131-3 standard by Husky's hydraulics and control specialists. Motion control of a hydraulically operated positioning axis is not a trivial job. The control profile is non-linear and also subject to limitations governed by the process technology. During injection, for instance, the injection piston follows a multi-step forward speed profile while at the same time limiting the injection pressure. As the piston advances, the control must provide for smooth transition to hold pressure depending on piston position, injection pressure in the barrel, or mold cavity pressure. For suckback, the system must again switch over to speed control with subsequent positioning control on the starting position for the next injection cycle.
The scalability of the CPUs in an Industrial PC helps to minimize response times to milliseconds as needed to control the high piston speeds during injection.

Temperature Control with an IEC 61131-3 Functional Software Block

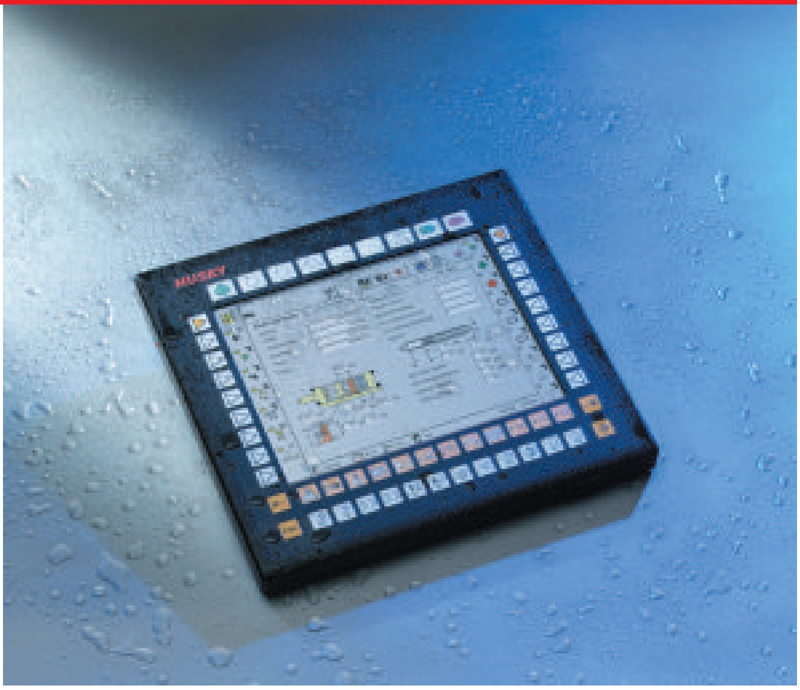
Temperature control is also programmed in the IEC 61131-3 languages. A plastics injection molding system can have more than 100 control zones for heating the machine as well as the mold

Beckhoff TwinCAT: PLC and NC on the PC

The TwinCAT software system (" The Windows Control and Automation Technology") transforms every compatible PC into a real time controller with multi-PLC, NC axis control, programming environment and operating station. TwinCAT replaces conventional PLC and NC controllers as well as operating devices with:

- embedding of Software-PLC and software-NC in Windows 2000/NT, Windows NT Embedded, Windows CE
- efficient multi-PLC with 4 PLC run-time systems per PC and cycle times from 50 us. The programming environment offers all languages of the IEC 61131-3 standard.
- axis control for point-to-point positioning and interpolated path movement. Up to 256 axes can be positioned, dependent only on the efficiency of the PC processor. Special functions such as "cam plate" or "flying saw" are supported.
- connection to all common fieldbusses and PC interfaces for I/O signals: Profibus, CANopen, DeviceNet, Interbus, Sercos, Beckhoff Lightbus and PC-Hardware
- data sharing with user interfaces and other programs by means of open Microsoft standards (OLE, OCX, ActiveX, DCOM+, OPC etc.)

New Automation Technology - based of standard Control Panel from Beckhoff



and its hot runner manifold and nozzles. The temperature control blocks, developed in cooperation by Husky and Beckhoff, provide convenient functions e.g. self-tuning, adaptive power-up, smooth switch-over from manual to automatic mode, predefined response to hardware failures such as thermocouple breakage, open heater, etc. The function blocks can be instantiated. In other words, adding a heating zone is the same as defining a variable.

Control of the electrical robot axes is programmed by using predefined function blocks for axial motion control, available in the TwinCAT NC library. As TwinCAT supports various different fieldbus systems, Husky selected SERCOS for the drives.

The fourth software component - visualization - has been designed by Husky to run under Windows NT. The operating philosophy is focused on touchscreen operation combined with the softkeys of Beckhoff's Control Panel. Critical machine functions, for instance all those involving mechanical movements, are initiated by means of PLC keys below the screen, i.e. for the PLC to check before enabling the requested function. TwinCAT's software interface provides access to control parameters, alarm messages, time records, statistics, etc.

User access is authorized and controlled by means of a memory chip in the size of a keyring pendant. This ID token is plugged into the Control Panel and can store up to 32 kB of data, including e.g. the user's profile.

Cui Bono?

Obviously, important benefits are cost savings derived from the use of a fieldbus system and eliminating specialized control hardware. The control solution can be adapted as required through the performance of the selected Industrial PC. The overall control configuration has become more transparent for Husky and is based on standards e.g. Windows NT/2000 and IEC 61131-3. This means that Husky has complete control of its injection molding as well as the entire engineering control know-how. And while it is not accessible by the regular machine operator, TwinCAT always provides a runtime and programming environment right at every machine. This opens the familiar possibilities of the PC world, such as high-capacity hard disk drives, teleservice by modem and Ethernet, links to further machines by serial interfaces or LAN, communication with SCADA systems, and use of external, Windows-compatible process optimization software.

For the future Husky has recognized a need to focus on modular machine design and „zero engineering“ tools for simplified programming and flexible response to customer and market needs. Beckhoff TwinCAT has become a central pillar in this architecture.