Connecting and Controlling the Food and Beverage Industries

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The food and beverage industries have a history of manual operations, from one end of the plant to the other, including lab and quality operations. In order to improve productivity and quality control, many food and beverage operations have begun integrating these operations and making them conform to automation standards.

One of the problems these industries have is the heterogeneity of processes in the plant. For example, there are both discrete and continuous automation applications in receiving, warehousing raw materials, and getting the raw materials to the process. Processes may be batch, continuous, or a hybrid of the two.

For example, look at a simple brewery operation. Raw materials include hops, barley malt, flavorings and pure water. Each of these must be handled differently. The hops and barley malt are solids, and are handled by solids handling equipment such as hoppers, pneumatic or vacuum flow systems, and belt and bucket conveyors. Water and other liquid flavorings are handled in conventional liquid flow pipelines. Beer is made in batch kettles, so there are batch control steps including developing a recipe and programming the recipe, and then following the steps in the recipe, which can include automated and manual steps. Finally, beer storage is handled like any other tank storage application, with pumps, controls, flow and level indication.

In addition, the packaging part of the brewery uses discrete machine control and packaging systems which pull bottles and cans and packing materials together, fill the bottles and cans with beer, inspect them for damage and FOD (found object debris) and then put the bottles and cans in the boxes, palletize them and get them ready to ship.

Other beverage plants operate somewhat similarly, but there can be wide variation.

Food processing plants range from meat and poultry processing to prepared soups and other foods. The requirements for control in all of these plants vary enormously, and can even vary enormously within a single plant.

Ever since the advent of the PAC (Programmable Automation Controller) and the dramatically increased use of Ethernet in the office space, which migrated to the factory floor in the 1990s, there has been a trend toward producing control and automation products that can be used in a wide variety of applications throughout a food or beverage plant, rather than mixing and matching systems and vendors from one part of the plant to another. These products include I/O, controllers, HMIs and graphic control panels, machine vision systems and industrial networking products.

Islands of Automation

In many food and beverage plants, each portion of the process is built by a machine builder, and is often furnished fully constructed on a skid. Even when the process is not skid-built, the machine builder provides controls as he sees fit. Sometimes the controls include control panels which are made with hardwired lights, switches, and relays inside a NEMA 4 or NEMA 12 control panel. Sometimes the control panels are entirely different than similar function panels in other locations in the plant or in the company. This requires more training for operators, and in emergency situations

this can pose an increased safety hazard as an operator tries to learn to use an unknown control panel.

Using the latest automation and communication tools, food and beverage plants are able to eliminate many of these potential safety issues by implementing common user interfaces, common recipe and standards-based batch programming, and relying on standards-based industrial Ethernet networking for data collection and transfer.

Common Graphical Interfaces: HMIs

From the smallest H-O-A (Hand-Off-Auto) station to the most complicated batch programming station, touchscreen LCDs are easy to mount, use and interface directly via Ethernet or serial interconnection with controllers and I/O.

As an example of a replacement for all those lights and switches, here is an Advantech TPC with a 3.5 inch display.

This touch panel computer can be used to replace all the lights, buttons, relays, and wiring of the old style machine or process control panel, and is flexible enough to handle any control panel application on the plant floor. These HMIs are embedded computers, complete with networking and sometimes serial interfaces for legacy machines and controllers. Using an HMI, libraries of faceplates, indicators, widgets and objects can be pulled together simply on an editing screen. This replaces the sourcing, purchasing, pulling from inventory, kitting, assembling and testing procedure that was used with hardwired operator panels in the past. Even a relatively complex batching procedure can be designed on an HMI panel in a matter of days, where the old procedure might take weeks or more. This is a huge cost saving, and also is an enhancement of safety, since a common HMI interface only needs to be learned once by the operator.

HMIs have been getting smaller, faster, smarter, and less costly over the last ten years. This means that they can be applied to more sophisticated control problems, and can do complex mathematics, log data, handle alarm management algorithms, and all the while producing sophisticated graphics in real-time. Here, for example is an Advantech IPPC-8151S, an all stainless steel housing containing a complete information enabled automation computing platform.

Modern HMI panels used in the food and beverages industries are designed for use in the sanitary and sterile environment. They support a variety of setup styles, including panel mounting in a larger control cabinet, VESA mounting, conventional desk stand mounting and on mounting arms for wall or ceiling mounting.

These designs are IP66, waterproof and dustproof, so they can survive anywhere in the food or beverage process facility. IP66 HMIs can easily survive hose sprays and wash downs, even with corrosive or caustic chemicals. The touch screen itself is durable in both an acid and alkaline environment, and is designed to withstand detergents and commercial cleaners. A standard

feature in a modern HMI that is purpose-built for the food or beverage industries is a “touch clean mode” where the touchscreen is capable of being disabled during the cleaning process with a special gesture. This avoids accidental touches while cleaning…a significant safety feature.

Another important design feature of a purpose-built food and beverage HMI or control system is the use of proper sanitary design in the enclosure, pursuant to U. S. FDA Hygienic Design requirements. The enclosure itself is 316L stainless steel, which is not only anti-oxidation and corrosion-resistant, but anti-bacterial and provides a solid enclosure that withstands high vibration and high moisture environments. Any purpose-built HMI for the food and beverage industries (or by extension, the pharmaceutical or biopharmaceutical industries) needs to conform to US FDA requirements as shown in 21CFR177 with respect to the material of gaskets and seals.

Common I/O and Controls: PACs and Embedded PCs

The IPPC, TPC and UNO devices from Advantech are examples of combined HMI/PAC devices that can be used to both display and control processes. In many applications, the HMI is primarily used to display information from the PAC and the other embedded PC controllers on the factory floor.

In the early 2000s, Craig Resnick of ARC Advisory Group gave a name to industrial computers re-packaged in a design that was very similar in form factor to the conventional PLC. He called them Programmable Automation Controllers, or PACs. Resnick’s PAC combined the features of a PC-based industrial computer with the control capabilities of a typical PLC. He noted that a PAC should combine the reliability of a PLC with the computing power and commercial, off-the-shelf (COTS) operating system and software capabilities of the PC.

Here is an example of a modern PAC, the Advantech APAX. It is an excellent illustration of all the advantages of a modern PAC system. It integrates control, information processing and networking in a single platform.

Moreover, by leveraging the dual-core multiprocessor architecture of the modern PC into automation technology, the system architecture provides dual controllers for different tasks, the same I/O with different controllers, and flexible I/O expansion with changeable controllers, reducing installation time and expense and integration complexity.

The modern PAC is a unitized platform that supports all of the control requirements in an entire food and beverage processing facility. PACs are capable of operating as a complete, complex computing node in a distributed network, and as such, have succeeded in blurring the line between programmable control devices and such formerly higher functioning devices such as DCS field controllers and SCADA Remote Terminal Units (RTUs).

A typical PAC now provides:

- Multi-domain functionality, including logic, continuous and motion control on a single platform
- Open, modular architectures with de-facto standards for network interfaces or protocols
- Single multi-discipline development platform that incorporates common tagging and a single database
- Software tools that allow the design by process flow across several machines or process units

Process Control

The purpose-built PAC for food and beverage industries needs to support not only digital and discrete I/O, but also analog I/O for flow, level, temperature, pressure, and has to have voltage (0-5 VDC), current (4-20 mADC) and low frequency (pulse) analog inputs. These inputs would be essentially useless unless the PAC also has a built-in PID control algorithm that is of a sophisticated nature. As an example, the APAX 5570 shown here is equipped with a very sophisticated auto-tuning loop tuning capability. PACs must have strong computational power for these features.

Batching

Early PLCs were designed for discrete inputs primarily. The development of multiple types of I/O and the Sequential Function Chart language of the IEC61131-3 standard, and especially the development of ISA88 (the batch process standard) made it possible to turn a PAC into a complete batching controller, running recipes, step charts and sequential functions entirely in the field. And since PACs are easily networked using standard industrial Ethernet, it made it possible to extend the advantages of distributed control to a wide variety of continuous, batch, and discrete processes using the same computing platform.

Motion Control

The same PAC that can be a continuous process controller or a batch controller can also be used as a fast motion controller. These controllers are often used in packaging lines in the food or beverage plant. Complex labeling and packaging applications can be controlled by the same computing platform that controls, for example, the brewery's kettles, and can be programmed using the same programming tools and engineering libraries. This alone is a huge cost and training saving, not counting the reduction in inventory and parts made possible by using a common computing platform like the APAX.

Video Inspection

The same high speed that makes fast motion control possible also makes the PAC ideal for vision systems and video inspection.

Common Networking and Communications: Industrial Ethernet

Because PACs are special purpose versions of PCs, they share the on-board capabilities of networking over standard networks such as Ethernet with their desk-mounted cousins. Most PACs have integrated capabilities for the standard network interface protocols such as TCP/IP, SMTP, and OPC. PACs can integrate multiple legacy industrial field networks, such as Modbus, RS232/422, RS485, CANbus, DeviceNet, Profibus, Foundation fieldbus and others, over standard Ethernet networks, either wired or wireless.

The Food and Beverage Plant of the Future

The future of control in the food, beverages and pharmaceuticals industries will require linking the powerful HMI with modular I/O, robust computing platforms like PACs and embedded PCs with a

complete industrial Ethernet product offering including managed switches, Power over Ethernet, and a common set of engineering tools.

Producing all these tools on a common computing platform means that the end user can select a single vendor for every one of these applications, throughout the plant. This can provide economies in purchasing, inventory, parts, safety, training and operations and maintenance for the plant.

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