Plant Efficiency Ideas: Bottling Benefits

New Generation of Filling Control Systems

By Bernd Schumacher

The filling control technology employed in bottling machinery has evolved over the past decade, offering higher levels of accuracy and reproducibility while achieving extremely high reliability. These improvements parallel the advancements in many other industries, where increased computer processing power and the miniaturization of components have led to distributed architectures made up of intelligent devices connected by a communication network. As we shall see, the latest generation of bottle filling controls exemplifies this trend by placing a small, intelligent device at each filling point to automatically control and monitor the filling process at that location. The resulting network topology offers significant operational and economic benefits to bottling machinery manufacturers and bottling plant operators.

First Generation: Level Switches

The earliest filling control method relied on level switches that stopped the filling process when the surface of the liquid contents reached a particular height. This method is comparable to asking a child to say "when" at the point when the desired amount of milk has been poured into a cup. With glass bottles, the surface height can be a reasonably accurate proxy for the volume of the liquid because the internal shape and dimensions remain fairly consistent and predictable from bottle to bottle.
The same cannot be said for PET (polyethylene terepthalate) bottles, which are becoming increasingly prevalent due to their low weight, less expensive transportation costs, and resistance to breakage. Unlike glass bottles, PET bottles expand to varying extents when filled with liquid. Carbonated beverages exacerbate this problem with typical pressures approaching 60 psi. Two PET bottles, filled to precisely the same level, could contain significantly different internal volumes.

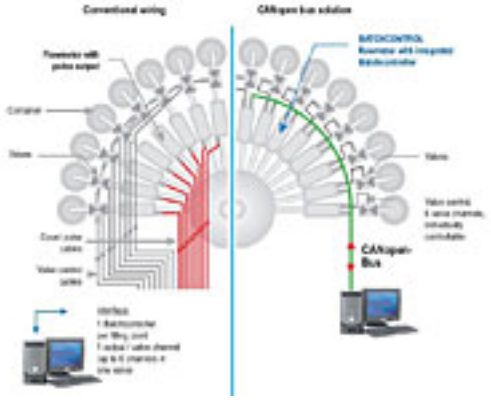
Second Generation: Electromagnetic Flowmeters

Therefore, the bottling industry needed an alternative technology to replace level switches. In the mid 1990s, the industry turned to a new generation of filling control systems that employ volumetric measurement via electromagnetic flowmeters (EMF). With precise filling, hygienic design, and outstanding CIP/SIP properties, EMF created a revolution in filling technology and filling machine design.
EMF technology has a relatively simple operating principle. An electrically conductive fluid flows through an unobstructed insulating tube and through a constant magnetic field. A voltage is induced in this fluid proportional to its mean flow velocity, and this signal voltage is picked up by electrodes. Microprocessor-based electronics converts this voltage into scaled pulses (e.g., 2 or 5 or 10 pulses per milliliter flowing through the meter's flow tube). This pulse rate is transmitted to a shared batch controller computer or PLC, which counts the pulses to calculate the

volume. When the pre-set number of pulses &#151 equivalent to the desired filling volume &#151 is reached for a particular filling station, the batch controller will switch off the valve(s) for that filling station. An algorithm can be used to compensate for overruns caused by switching delays, residual flow, and dribbling. In this way, each bottle receives exactly the correct product volume. Of course, the reproducibility of the filling process not only depends on the accuracy of the flowmeter but also on the reproducibility of the dynamic characteristics of the valves.
Electromagnetic flowmeters ensure accurate, repeatable portioning of liquids, including those containing carbon dioxide and solids, independent from any variation in viscosity or density. EMF devices contain no moving parts, thereby eliminating the costs and downtime associated with wear and maintenance. The technology is now used in filling applications for a wide variety of beverages including soft drinks, mineral water, beer, and fruit juices as well as chemical, pharmaceutical, and cosmetic liquids and pastes.

Third Generation: Distributed Intelligence

The next major advance in filling control systems builds on the now mature EMF measurement technology by adding processing capacity at each flowmeter and introducing a more efficient digital communication network to replace the cumbersome cabling of second generation systems. The introduction in 2004 of the BatchControl electromagnetic flowmeters by Krohne Inc. of Peabody, MA, marked the beginning of this third generation of filling control systems.



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BatchControl from Krohne is a digital bus-based flowmeter that simplifies filling machine designs with on-board valve controls, integrated temperature, and a variety of diagnostic features on top of a highly precise and hygienic flow tube.

In second generation systems, the batch control function is performed by an external computer shared by multiple filling stations. Now, in the new third generation systems, the batch control function resides locally within each flowmeter so that each flowmeter can directly perform the functions of controlling and monitoring the filling process at its own filling station. With the availability of smaller and more powerful microprocessors, it is now possible to pack a batch control computer inside each EMF &#151 within a housing that is no larger than a comparable second generation device.
Third generation flowmeters not only have more onboard intelligence and functionality, but they also communicate more efficiently with the central computer. Second generation flowmeters simply send pulses to a central batch controller using 4-20 mA or 1-5 volt analog output signals proportional to fluid flow. The third

generation systems use a digital bus architecture that enables bidirectional communication of information in addition to pulses that represent filling quantity. For example, the flowmeter can communicate filling time, dribble time, maximum volume flow rate, and even product temperature. Diagnostic, maintenance, and alarm functions can be communicated over the data bus.
The intelligent devices can respond faster to changes in flow and other conditions because the flowmeter is directly connected to the valve(s). The flowmeter can typically actuate valves within 1/60 of a second. Faster response time leads to increased productivity of the entire bottling system and higher filling accuracy. In contrast, second generation systems employ a more complex, multi-step process: after the EMF processes the volumetric flow measurement, an analog signal is sent to the external batch controller computer, and then the computer performs its process, and subsequently an analog signal is sent to actuate the local valve(s).
An individual filling station typically contains up to six valves such as a main filling valve, a fine valve for slow fill start and fill end for very precise dosing, pressurizing valves, depressurizing valves, and flushing valves. The function of each can be programmed via the data bus as a factor of filling quantity, time, or flow velocity. Any valve can also be driven via this bus during the filling process, depending on the turntable position. BatchControl uses CANopen, a standard Controller Area Network open protocol for process control systems. The CANopen protocol is an ISO standard, ISO 11898, used for serial data communication. It is a mature standard with many products and supporting tools available.

Radically Streamlined Design

The advantages of third generation filling control technology are noticeable from 100 feet away because the wiring requirements are radically streamlined. A single bus connects the computer to all the flowmeters, and then short wires connect each flowmeter to the associated valve(s).

BatchControl and BatchFlux (the pulse output version) are specially designed flowmeters for filling applications.

In contrast, second generation systems have a "hub" architecture requiring a cable to run from the central process computer to every EMF and every valve. Large carousels will have hundreds of cables. In a second generation system, the central process computer usually needs to be placed on the turntable because the large number of cables makes a slip ring connection impractical.
The streamlined wiring of third generation devices reduces capital and labor costs

during system manufacturing, installation, and troubleshooting. Without all the additional cables, systems are also easier to clean and maintain. A computer can be conveniently placed in a stationary position off the turntable with a small slip ring for the data bus. Troubleshooting is easy because of bidirectional communication with each device, diagnostic tools, and alarming functions.

Third generation filling control systems utilize the type of distributed network topology that is familiar to anyone conversant in recent trends in the world of computers and telecommunications. In the past, computers systems were comprised of mainframes with analog connections to dumb terminals that were merely input/output devices, and telephone networks consisted of central office switching equipment tied by analog copper connections to minimally functioning rotary telephones. Now, digital networks, such as the Internet and mobile telephone systems, tie together increasingly sophisticated, and smaller, devices.

Bottling company manufacturers and bottling plant operators can now take advantage of these inevitable and highly beneficial technological trends in order to improve filling accuracy, increase productivity, streamline system design, and reduce maintenance costs.

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