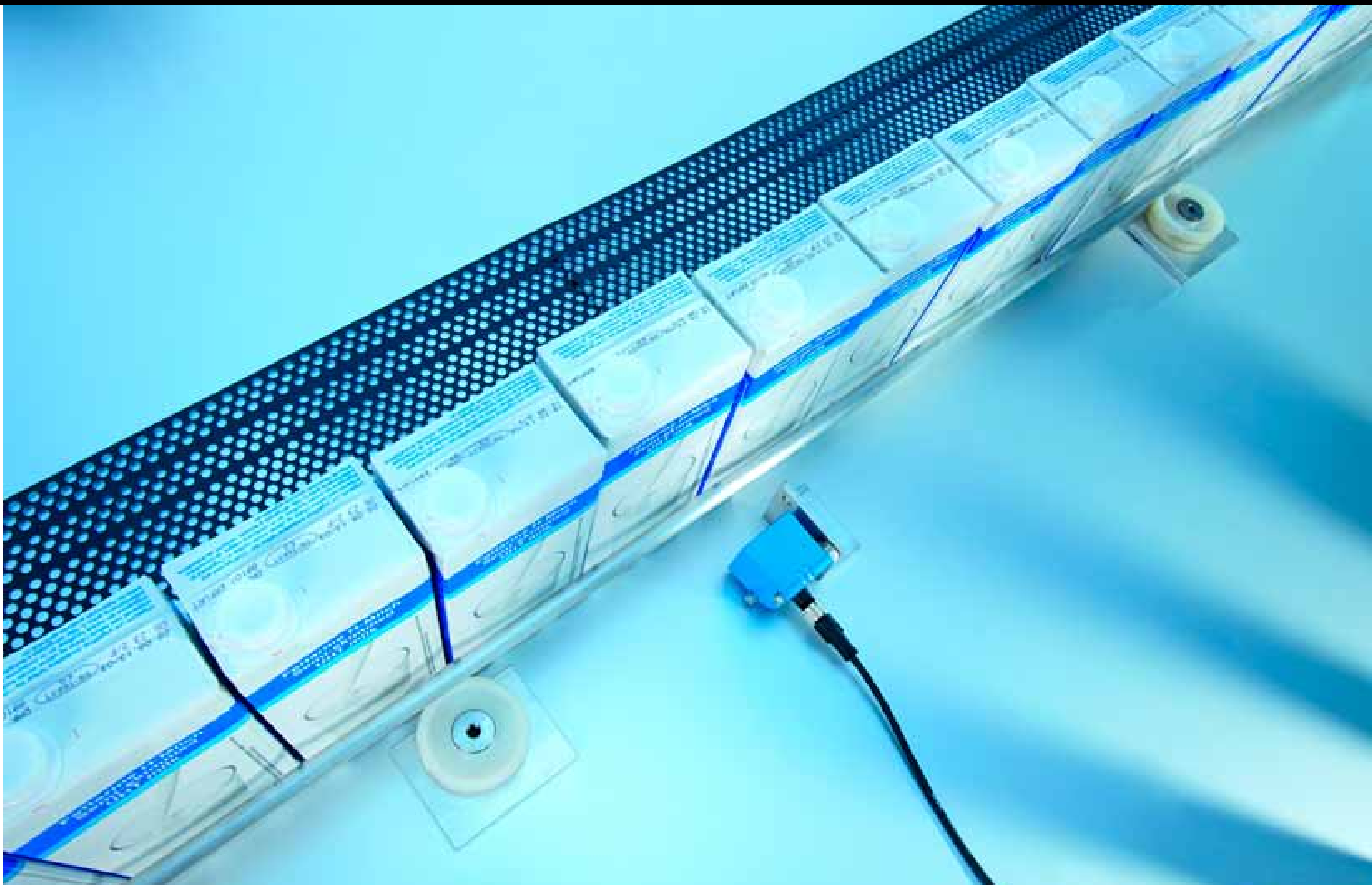
Where is production line technology headed in the food industry?



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Often attributed to the Ford Motor Co and its ability to make a Model T Ford in 93 minutes, production lines have been around for longer than people think. Even as long ago as the 12th century, the Venetian Arsenal could assemble a ship in as little as a day using a production line concept.

But only now is the technology good enough that production lines that can think for themselves are becoming a reality. This development is firmly based on modern sensor and communication technologies.

The food industry is adopting many of the latest advances in sensor technology and communication systems to its production lines to improve overall efficiency and competitiveness, and cut costs.

This eBook will give you some insight into some of the advances that are already a reality.

Janette Woodhouse

Editor - *What's New in Food Technology and Manufacturing*

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Sensor technology optimises workflow

Dannielle Furness

It's rare to find a business without the desire to decrease costs and improve efficiency, but some industries are plagued by ineffective operations that are largely regarded as unavoidable. In food processing and packaging it is commonplace to experience significant downtime and idle machine running due to issues that arise when rapid cycle times are instigated. Gaps in proficiency will often be factored in to overall production targets, but what if the key to smarter, faster and more economical production was simply the introduction of enhanced, yet straightforward, technology?

Process technology and packaging automation systems perform at high speeds; more output in less time presents a distinct economic advantage for manufacturers. Flexibility is a key issue, as these lines now cater to a greater number of product variants and must be able to facilitate rapid machine format changes to deliver. Speed without accuracy can be problematic, as incorrect loading, labelling and positioning cause losses to quality, unwanted downtime and contribute to overall productivity shortfalls.

Standardisation leads to transparency

The development of the standardised IO-Link point-to-point serial communications protocol has enabled greater interoperability between the plant controller and field level devices, allowing easy implementation of a system that automatically offers increased reliability and efficiency.

IO-Link operates as a master/slave model, where a master device incorporates several ports and each slave device, one. It is an open standard, meaning that it is fieldbus neutral and it functions using standard unscreened sensor actuator cabling (SAC), reducing project planning and installation costs and delivering faster installation and commissioning times.

Through implementation of the IO-Link protocol, previously passive elements on a production line, including sensors and actuators, effectively become active process components. These devices are then able to communicate directly with existing I/O equipment and to autonomously report state and error information. Enhanced communication capability makes it is possible to transfer parameters, such as scanning distance and hysteresis, from a programmable logic controller (PLC) or industrial PC (IPC) directly to the sensor. The advantages are numerous: plant control is optimised as machine format or product changes can be implemented in milliseconds, even for difficult-to-access sensors, and remote maintenance and parameter changes can be carried out via the internet, saving time and avoiding errors.

Quality is enhanced through the continuous monitoring of process parameters and through full documentation of adjustment data. Problem-oriented system diagnostics allow operators to literally 'see what the sensor sees', leading to a reduction in downtime and maintenance costs.

Existing machines and plant can be economically retrofitted, as both IO-Link and standard modules are able to work together.

Mind the gap

It has been traditionally accepted that counting and detecting packages on a conveyor requires product separation in order to be effective. This separation is needed to accurately read packages, but the process often involves the addition of complex mechanisms in conveyor systems. It also creates a considerable problem, as leaving a gap between products leads to a higher number of collision incidences because packages are inclined to fall when moving. These collisions, in turn, create havoc on a production line by interrupting flow and decreasing end-product quality. Incorrect product grouping and inaccurate label positioning can substantially impede on accurate, free-flowing output and, while there is obvious waste associated with these problems, the flow-on effect of inefficient energy consumption due to stopping and restarting lines is often overlooked. A smooth-flowing, continuous line provides optimum power usage, keeping overhead costs to a minimum.

What's the alternative?

The absence of a viable alternative to product separation has created an attitude of acceptance, until now. Photoelectric sensor technology is currently sufficiently advanced to enable recognition of a wide range of contours, accurately detecting and differentiating between successive packaging items, on the fly. This means that products can now be accurately counted, without gaps, across a range of packaging shapes, sizes and options. The technology senses the reflective behaviour change on an object's edge contour and uses this reflectivity variation for the output of switching signals.

Rounded, round-out and prism shaped packages, common in the food and beverage industry, are detected without any additional sensor settings. Inconsistent packaging items can be distinguished from one another using IO-Link-compatible devices that are adapted and configured according to application-specific conditions.

Advanced systems are able to detect objects aligned in a push-push configuration, meaning the requirement for machine elements to execute packaging buffering and separation is eliminated. This leads to better space utilisation, less hardware requirement and shorter conveyor lines; all of which contribute to savings.

The easiest way is plug-and-play

In many instances, technology simply introduces a new set of problems; complex installation and commissioning or specialist operational training, for example. The implementation of advanced sensor technology is one case where achieving improved functionality and efficiency is actually made simpler.

The advent of IO-Link has presented opportunities to streamline previously complicated processes; utilising the inbuilt intelligence of sensor devices and eliminating complicated in-situ teach-in for machine format changes, as well as improving overall plant operation through central, continuous complete depiction of all line functions - right down to the sensor level.

The plug-and-play nature of today's photoelectric sensor devices means that no setting adjustments are required and connection is achieved using standard cabling. There are no complex operational instructions, eliminating the need for additional specialist operator training. While certain applications may call for ancillary configuration, the devices can then be used to detect multiple products and to reliably identify difficult-to-discern packaging elements including transitions on folded boxes.

Common line problems

- Issues arising from rapid machine format changes
- Inefficiency due to falling packaging and collisions
- Machine downtime
- Incorrect loading when grouping
- Inaccurate path measuring and position detection
- Incorrect labelling
- Quality loss due to crashes
- Inefficient energy use

Enhanced sensor technology provides advantages

- Streamlines hardware requirement
- Faster conveying times
- Shorter lines
- Less idle and downtime
- Increases overall capacity
- Eliminates falling packaging and collisions
- Improved energy efficiency
- Enhanced communication capability between controller and field devices
- Continuous process parameter

Complete control

The benefits of sensor technology implementation are not confined to one machine or line, as information exchange between each individual machine delivers control over the whole plant, improving overall system capacity. The advantages of this include the ability to trigger downstream processes such as code printing, labelling, barcode reading and camera control.

Inaccuracies in counting can lead to problems further down the line, where the machine controller requires a precise count to execute the secondary packaging function. Eliminating the problem earlier in the line creates a smoother transition between processes and leads to fewer errors overall.

The end of the line

In times of rapid technological advancement, it can be difficult to discern where and, perhaps more importantly, when any tangible benefit from 'improvements' will be realised in a commercial environment. It is also rare that the introduction of a new technology or approach delivers greater efficiency and cost savings without presenting additional challenges. Given these constraints, many business owners and operators simply opt for the status quo, regardless of existing inefficiencies and problems.

When an accepted method of operation is flawed to the point of causing further problems downstream, it begs for a smart solution. The development of enhanced sensor technology provides an avenue for faster, smarter and more efficient processing, without additional complex operational procedures or extraneous hardware.

Where is production line technology headed in the food industry?

With the advent of the fourth industrial revolution, exciting things are happening in the manufacturing industry.

The first industrial revolution in the 18th and 19th centuries was the mechanisation of production using water and steam power. It was followed by the second industrial revolution (over the late-19th and early-20th centuries), which introduced mass production with the help of electric power, followed by the digital revolution of the last few decades, with the use of electronics and IT to further automate production.

Now we have the fourth industrial revolution - or Industry 4.0. It started as part of a German government strategy to develop the 'smart factory', which is characterised by flexible production in which highly networked plants become self-optimising, self-configuring and self-diagnosing.

Essentially this turn of events will enable first-world manufacturers who cannot compete the with low-cost, high-volume production of developing countries to reinvigorate their manufacturing industries. Wage costs will become less of an impediment as the smart factory will require significantly fewer employees. And those required will be highly trained, tertiary qualified specialists whose contributions to company profitability will be via research and development, engineering and design.

But in the food industry most product is low cost, high volume, so how will food manufacturers benefit from Industry 4.0?

The answer will lie in the strong individualisation of products under the conditions of highly flexible (large series) production. Variability, complexity, extensive customisation plus high value add will all be features. Production operations will be more efficient and flexible with rapid innovation cycles. This will lead to improved economies of scale and faster speed to market.

Modern, integrated communication systems will enable the integration of customers and business partners in business and value-added processes. This will mean that foods and drinks that have been tailored not just for a specific vendor's shelf size but even for demographics within the vendor clientele can be made and packed automatically. If a locality has a particular interest in kosher foods, the appropriate logo can be applied specifically for that particular store while another store may prefer to have halal certification more prominently displayed.

The 'intelligence' of the smart factory will be made possible by the use of networking technology, sensors and transmitters that will be embedded in nearly everything, and business-to-business communication will be endemic. All of these innovations will enable products and machines to communicate with one another and exchange commands. The factories of the future will optimise and control their manufacturing processes largely by themselves.

Production facilities will be able to coordinate their work steps and exchange information with one another, and there will be no need for technicians to set foot in the production halls for servicing, with machinery inspections carried out remotely instead.

Today, entire production and logistics processes have to react dynamically. In the future, the reality in manufacturing will be that products along the production line will know where they are, which steps they have already completed and what they still need to become a finished product for a specific client. For this to be possible, facilities will use a data network to communicate with one another, and even the products themselves will have to 'log in'. Human beings will use this network connection to control and monitor production too - to keep an eye on plant operation even if they don't happen to be in the production hall.

Currently, most processes are controlled centrally. Future requirements will call for production systems that are steered by cyber-physical systems (CPSs). These operate using intelligent sensors to perceive their environment and actuators with which they can influence this environment. CPSs can be integrated in products, machines and plants, which can adapt to changing tasks and operating conditions by means of self-optimisation and self-configuration.

These systems have the potential to significantly increase productivity in manufacturing and in the supply chain. The result will be more autonomy and smart production processes that can control and regulate themselves. The advantages include manufacturing process optimisation that goes beyond 'lean manufacturing', along with the avoidance of damage and accidents due to the timely detection of problems and risks.

This is already a familiar concept in IT with self-healing systems, in which any errors that arise are detected and resolved by the system itself. The Industry 4.0 initiative is designed to carry this concept over to things like production processes on the meta level and to products themselves.

However, there is a long way to go before we achieve Industry 4.0 - experts are predicting 10 to 20 years. There are still difficulties in mastering security and managing the volume of communications and data.

Security is a top priority - the embedded software will have to be completely reliable and the entire system safe from hacking.

Making more products with the same resources

Technology can play a significant role in equipping manufacturers and their workforce with the modern production systems that will enable them to create flexible, complex and responsive solutions that enhance their international competitiveness. Developments in information technology mean companies can change from their 'make to sell' system to 'sense and respond'.

To do this company's need an efficient and reliable way to 'sense'. Luckily the combination of declining prices for sensors, cameras and control systems and their increased reliability means that manufacturers can now economically justify mobile technology in many applications.

CPSs are becoming increasingly important in this context; that is to say, the networking of embedded ICT systems both with one another and with the internet. Along with increased automation, the development of intelligent monitoring and autonomous decision-making processes is particularly important in order to be able steer and optimise both companies and entire value-adding networks in almost real time.

All of these sensors, checking temperature, pressure, power, energy use etc, create huge amounts of data. If you're scanning to the nearest second, it's easy to rack up several terabytes of information in under a week; but just collecting data is not enough. You must have suitable methods to evaluate the information. It is currently estimated that operators are only using about 7% of this data for maintenance or protection from breakdowns.

A wide range of sensor types can be used to develop measuring systems that are adapted specifically to the respective process or production machine. To achieve high signal quality with the utmost sensitivity, it is generally necessary to place the sensors as close as possible to the process area. This can be achieved through specific integration of miniaturised sensors into the relevant mechanical components.

By applying sensors close to the process area in combination with adapted monitoring and measuring systems, the manufacturing quality and the stability of the manufacturing process can be increased significantly.

To obtain meaningful results, data has to be recorded and evaluated in a suitable way. When high manufacturing speeds are involved, recording data with high signal quality is a challenging task. This necessitates powerful hardware in combination with intelligent analysis algorithms for data acquisition.

We're still a long way away from the vision of Industry 4.0, in which smart machines automatically report of their own accord when they need maintenance or spare parts.

Some of the challenges to be addressed include:

- Interoperability - Standards for the secure communication within the factory are required to ensure consistent data exchange between machines and IT systems. The manufacturing sector will need methods, tools and software components to synchronise products, production plants and processes and the supporting IT systems, namely PLM, digital factory and MES.
- Data mining - The volumes of data resulting from shopfloor-related IT systems and the operation of plants, both of which are supplied by sensor data, open up potentials for cost efficiency and improvement. However, most of these gems are still hidden within the data and are waiting to be discovered.
- Use-centric - To prevent individual users from being overwhelmed by all the information provided by the individual systems of a factory, the information must be made available as role-specific information and must be distributed accordingly.
- Security - Data must be protected against attacks by interception and modification.
- Plant-wide condition monitoring - Many companies use technology of this sort already but usually they only monitor individual components and not the entire facility. This is especially true for continuous manufacturing processes, where creeping change can suddenly cause a breakdown unless operators have their eye on all the variables. One example could be a pipeline blockage as a result of a gradual build-up of liquid or viscous material deposits on the pipe's inner walls.

Implications in the food industry

Food and beverages have to comply with strict requirements when it comes to safety, quality, shelf life and compliance. Industry 4.0 can impact the food industry by allowing it to become more flexible without affecting any of these parameters.

Production flexibility can be seen in product batches. By focusing on small batches, companies will be able to react better to customer demands and drive their production towards a make-to-order system. But smaller batches lead to more changeovers in production - this is where Industry 4.0 will deliver significant enhancements.

No chance for industrial pirates

Though it looks like something straight out of a science fiction film, it will soon become a reality in the production halls of the future: products along the production lines will know where they are, which steps they have already completed and what they still need to become a finished product.

Facilities will use a data network to communicate with one another. For these functions secure access that keeps industrial pirates and saboteurs out is indispensable. Image: © Fraunhofer IPA

Production facilities will coordinate their work steps and exchange information with one another. There will be no need for technicians to set foot in the production halls for servicing, with machinery inspections carried out remotely instead. In a word: products and plants will be intelligent. This is also referred to as 'Industry 4.0' - meaning industry of the fourth generation, following mechanisation, electrification and digitisation.

There's one sticking point, though. Facilities will use a data network to communicate with one another, and even the products themselves will have to 'log in'. Human beings will use this network connection to control and monitor production, too - to keep an eye on plant operation even if they don't happen to be in the production hall. On top of this, there will be remote maintenance and remote software updates. For all these functions, one thing is indispensable: secure access that keeps industrial pirates and saboteurs out. Certainly, businesses can use a normal internet connection for this form of data traffic, securing it through a 'virtual private network', or VPN for short.

"But there's something many people don't know: there are VPNs and there are VPNs - and not every VPN is secure," explains Bartol Filipovic, division director at the Fraunhofer Institute for Applied and Integrated Security (AISEC) in Garching, Germany.

That is why researchers have come up with a router that offers secure VPN access. Authorisation and firewall functionalities provide additional access protection. The necessary security protocols can also be integrated directly in the industrial customer's plants and machinery.

"The system is a software kit. We've already developed the basic components, and we can tailor them to fit the customer's specific requirements," Filipovic points out.

The process takes around four weeks to complete. The researchers integrate simple systems at the same time, such as sensors in the pharmaceuticals industry that report filling levels or mixing ratios - these, too, should not forward their information to unauthorised parties.

Physical protection: film sounds an alarm

On the one hand, the system protects companies from spies trying to hack their way into the network from off-site locations. On the other hand, it also outwits data thieves trying to coax secrets out of routers and circuit boards on location. A special film affixed to security-relevant casings immediately reports any attempts to unscrew the protective covering to access security-relevant data.

Developed at AISEC, the film is affixed to the router casing, or directly onto the circuit boards - the boards containing key control elements such as microcontrollers, chips, diodes and other security-critical processing units - and sealed shut at multiple points. If the router is switched off, all of the software it contains is stored in encrypted form. If it is in operation, though, it needs the decrypted program code. Each decryption key is a function of the properties of the protective film. And if these properties are changed - by tearing open or drilling into the film to reach the circuit boards, for instance - the film detects the attack in a few milliseconds and responds immediately: it deletes all of its unencrypted, security-relevant data.

Unauthorised intruders cannot get to the software. Data deletion is no problem for the business, however: all a company has to do is reinstall the software and affix a new protective film.

"Combining software and film gives us an ideal security level," Filipovic says, "and the events of 2013 very clearly taught us just how important that can be."

Secure communication software and hardware are fundamental to the evolution of production towards digitisation and Industry 4.0; and protection against espionage, sabotage and product piracy is crucial to innovation and a strong competitive position.

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Toll free: 1800 334 802 **Email:** sales@sick.com.au
Website: www.sick.com.au

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