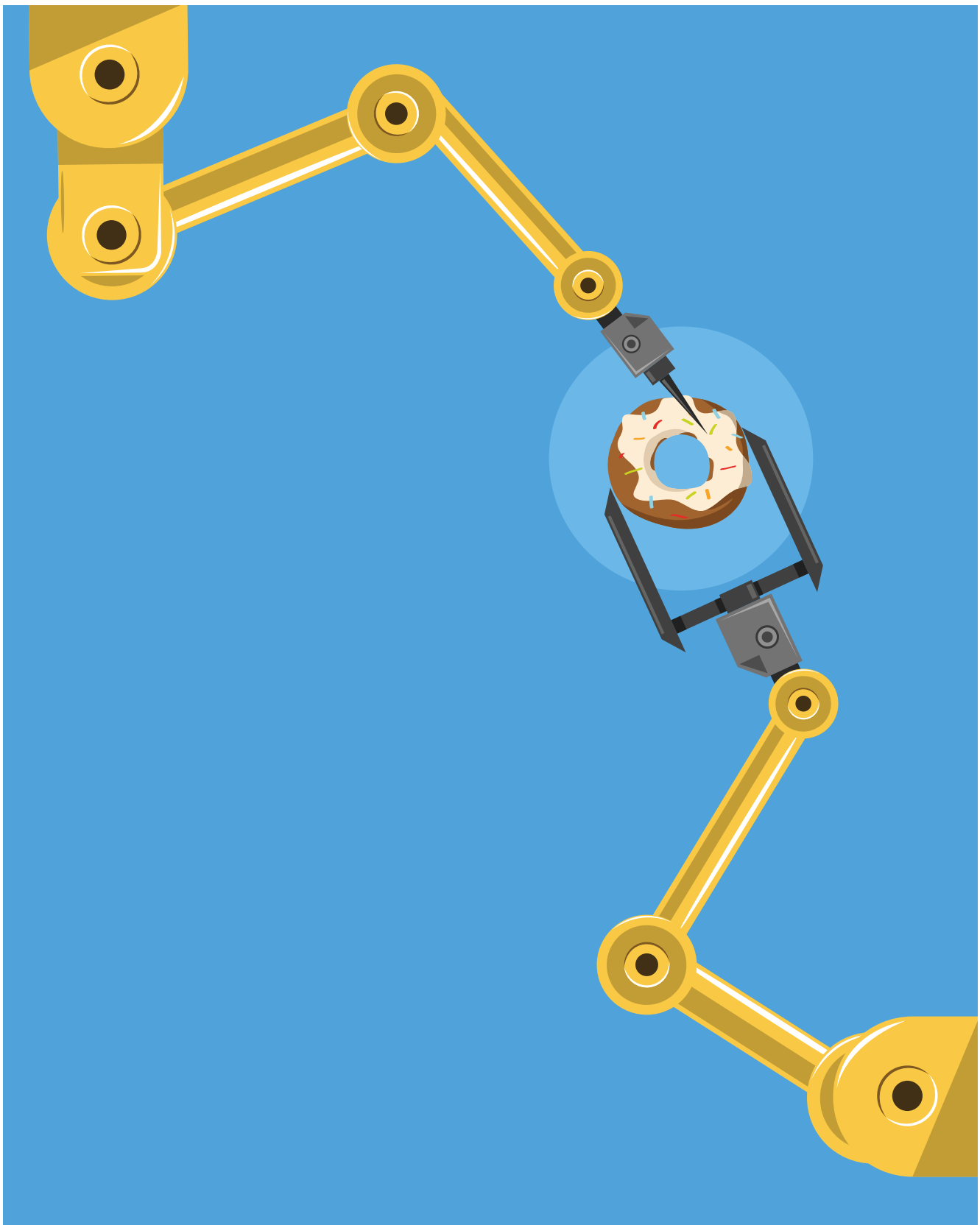

Food and Drink: Learning from Others

Contractors are borrowing techniques from the petchem, pharma and auto industries to help food and drink re-establish itself in manufacturing

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IF, by chance, you happen to be eating while reading this article you'll likely be aware of the various ingredients you're consuming. But you may not be aware of the recipe for best practice from various other industries which have been, and are being, adapted by the food and drink industry to bring you that meal.

The food and drink industry established itself as a leader in hygienic and manufacturing standards in the early 1920s (for example, in establishing the 3-A standards for the hygienic design of equipment used in the dairy industry). However, since then, other manufacturing sectors have made significant progress in design standards, such that food and drink is now playing catchup.

As end users become more discerning, expectations on food and drink manufacturers increase, and as client auditing becomes more stringent, improved design and manufacturing standards are fast becoming the norm within the industry.

Food and drink is now borrowing and embedding techniques from a range of industries, including safety from the petrochemical industry, commissioning from pharmaceuticals, and lean manufacturing from the automotive industry. These are discussed in further detail below.

SAFETY

Given its inherent risks, it's unsurprising that the petrochemical industry has long been the leader in assessing and managing process safety. However, food and drink has had to improve process safety, particularly with the increased knowledge of potentially explosive foodstuff powders.

These improvements have been implemented using well-known process safety design activities. Applying ATEX hazard classification assessment in food and drink processes involving potentially explosive liquids or vapours and powders or dust is now not only the norm, but a minimum requirement.

Explosion prevention and mitigation systems and technology are used – for example, nitrogen blanketing of vessels, explosion venting, flame arrestors, slam-shut valves, carbon monoxide monitoring and deluge systems (water/powder) are all well-established safety techniques. They have an ever increasing prominence in food and drink, as understanding the risks associated with handling potentially-explosive foodstuffs has grown. However, there would be a greater level of investment in such systems in sectors which manufacture higher margin products (such as drinks concentrates or food supplements) than with lower-margin products (such as bulk ingredients like sugar or flour). In addition, hazard and operability (HAZOP) assessments are now widely used in the design of food and drink process systems.

HYGIENE

Although it was the food and drink industry that drove hygiene standards early on in the industrial age, it is pharmaceuticals which is now the industrial leader for hygienic design and operation. The trend over the past decade, however, has seen food and drink coming more into line with pharma in relation to hygienic design, to a greater or lesser extent, depending on the food and drink sub-sector.

Hygienic design principles that are commonly used by food and drink include improved processing room finishes for walls, floors, ceilings, doors, and fittings. This also extends to the level of air treatment within hygienic zones, with increased use of filtration, including HEPA (high-efficiency particulate arrestance), humidity and temperature control, air change rate, pressure differentials, and percentage fresh *vs* recycled mix.

Good manufacturing practices (GMP) are employed in facility design, including segregated hygienic zoning and controlling movement between zones for personnel and material. Although not to the same level of classification used in pharmaceuticals, hygienic zoning is adjusted and assessed to the level of risk associated with the product being produced. For example, the

design of an infant nutritional manufacturing facility would be much closer to pharmaceutical design than a bread factory.

LEAN MANUFACTURING

The automotive industry is synonymous with lean manufacturing – from Henry Ford's production line through to Toyota with its *Toyota Production System* (*TPS*), *Kaizen*, *Kanban*, and *5s*, and six sigma.

Using lean flow design in facility layouts is critical in the food and drink industry, when it comes to moving product, ingredients, personnel, waste, and packaging material. Often there can be a balancing act between lean design *vs* hygienic zoning design, which may require zone segregation – which from a lean perspective could be potentially inefficient. It can be a significant challenge in designing a facility to achieve the optimum combination and develop innovative solutions.

NEW FACILITY AND PROCESS DESIGNS ARE NOW INCREASINGLY INCLUDING GREATER LEVELS OF AUTOMATION WITHIN BOTH THE PRIMARY PROCESS AND PACKING AND STORAGE

Over the past decades, the food sector has, increasingly, taken on board these initiatives and adapted them to manufacturing businesses. Process optimisation is an important lean initiative considered in manufacturing facility or operation design. Designing out waste and minimising touch points is a standard for food facility design. Its industry margins are typically tight and there is always a downward pressure on headcount and waste generation, which is consistent with lean design.

In some cases lean tools and methods are used to achieve this. These methods include the *5S* methodology for work-place organisation, and *Kanban* scheduling (or *Just in Time*) for logistics and planning of ingredients and packaging in and product out – in order to minimise inventory and warehouse space requirements. Process optimisation techniques are continuously improving with the use of simulation software tools, including value stream mapping software to identify and thus remove inefficiencies from the manufacturing process and (buffer) storage calculation. These tools can also be used to provide improved percentage overall equipment effectiveness (%OEE) both within the primary process, but also at the back-end filling and packing steps. Simulation tools are often implemented within existing facilities and processes to improve operations with existing site setup.

TRANSFERRABLE: THE FOOD SECTOR HAS INCREASINGLY TAKEN ON THE LEAN MANUFACTURING INITIATIVES OF THE AUTOMOTIVE INDUSTRY

The food and drink industry historically involved manpower-heavy process operations, with little automation. New facility and process designs are now increasingly including greater levels of automation within both the primary process, and packing and storage – for example robotics, automatic guided vehicles (AGVs), and 'lights-out' automatic storage and retrieval systems (ASRS) warehouses. Many food and drink operators are also reviewing current processes and designs and implementing automated improvements to assist with process optimisation, batch recording, and control for traceability, and predictive control tools based on historical performance data. This is particularly prevalent in the dairy industry, particularly in manufacturing value-added products, where there are long continuous production runs with low product variation, allowing for maximum automation with minimal headcount. It is interesting to note that in the case of some manufacturers with a multinational presence, the approach taken to automation can vary from country to country, depending on the local labour cost.

COMMISSIONING AND QUALIFICATION

End-user expectations have risen greatly for the food and drink manufacturing sector over the past few decades, but more recently, food safety scares (such as China's 2008 melamine-contaminated baby-food scare, and Europe's 2013 horse-meat scandal) have underlined the need for robust food safety requirements, and with it an improved awareness of the need for documentation practices.

The pharmaceutical industry has long implemented best practice guidelines for documentation and commissioning exercises. These best practices include a more standardised approach in the use of documentation, systems and tools, rather than an *ad hoc* approach which was prevalent in the past for the food and drink industry.

The extent to which this is seen can vary within food and drink depending on the process complexity, the level of automation, and product risk sensitivity. For example, a long continuous dairy product line, such as a whey powder system would require a high level of attention. This compares against a more manually-intensive batch-based process, such as an artisan-baked goods line, where the equipment would be well established, more standardised, or 'off the shelf', with standalone process steps and fewer process

'handshakes', where the risk of problems is lower, so a lower level of commissioning and qualification is acceptable.

Improved documentation practices include reviewing and approving third-party design documents prior to fabrication and following these good practices through installation, mechanical completion and commissioning. A greater emphasis on installation quality is also evident in food and drink, in particular in ensuring trade-contractor documentation packs are all in place – including, for example, weld logs and certificates, and red-lined drawings. This also ensures that the comparison of the installed system walkdown as-built review *vs* the original design documents is a well-established procedure within the industry. It also extends to an improved installation quality procedure – for example, increased use of pipework passivation and testing (non-destructive) after installation and swabbing at the back-end of the commissioning process, again much more in line with the high quality seen within the pharmaceutical industry.

Qualification is the process whereby the as-built system is verified against the required design, operation and performance intent. Formal qualification is relatively new for many in food and drink, although an informal approach to this is long established. Historically, the installation qualification (IQ) stage documentation and testing was typically implemented. This has now extended to a more rigorous approach during the operational qualification (OQ) and performance and process qualification (PQ) phases. Food and drink clients also now have more involvement during these phases, with specific commissioning and validation teams assigned to be part of the process, rather than only at the point of handover from the contractor.

In addition to the specific examples outlined above, a further development is that food and drink operators are beginning to understand and see the benefits of employing external design companies to carry out fully integrated design for them. Fully integrated design now incorporates many of the improvements identified in this article but brings them together at an earlier stage in the project. It is well established that greater time allocated during the early project stages to establish the optimum facility design, the increased use of process automation, better construction standards and schedules and more stringent commissioning and qualification testing is going a long way to improving manufacturing standards and end-user satisfaction in a large, yet competitive, industry.

SUMMARY

Although examples of some of the above have been in place for some time, in some form or other in various food and drink sectors, the consistent use of these practices is now more evident.

Of course, this is not all a one-way street, and other industries have learned from techniques employed within the food and drink sector. One such practice is the use of continuous or semi-continuous processing techniques in the pharmaceutical industry, including using process analytical testing (PAT) technologies. PAT is regularly used on clean utility systems, for example, water-for-injection (WFI), where the water quality is monitored using inline analysers. As pharmaceutical manufacturing moves towards continuous processing, implementing and integrating PAT becomes a 'must-have' supporting technology. PAT has been used successfully to remove the need for final product testing by implementing endpoint detection in blending and granulation processes, content uniformity in tablet compression, film coating thickness in tablet coating, and for API processing used within reactors to determine reaction progress and endpoint (real-time analysis of the gas, liquid and solid components). Some of the techniques employed to achieve PAT are near infrared spectrometry (NIR) and mass spectrometry (MS).

VALUE-ADDED IN DAIRY: LONG CONTINUOUS PRODUCTION RUNS WITH LOW PRODUCT VARIATION ALLOW FOR MAXIMUM AUTOMATION WITH MINIMAL HEADCOUNT

FOOD AND DRINK OPERATORS ARE BEGINNING TO UNDERSTAND AND SEE THE BENEFITS IN EMPLOYING EXTERNAL DESIGN COMPANIES TO CARRY OUT FULLY INTEGRATED DESIGN FOR THEM

There remain other areas employed in the food and drink sector which as yet have been untapped and represent potential opportunities for 'crosspollination'. Centralised clean-in-place (CIP) systems are used extensively, including in liquid dairy processing, and are typically optimised in terms of automation and reuse of cleaning liquids. In addition, minimising energy and water consumption, and reducing effluent generation are important objectives in designing modern food and drink facilities. This is achieved through heat recovery/regeneration and water recovery technologies on a large scale. This makes sense where there is a large volume consumption required and environmental discharge constraints, but will become increasingly important for smaller-scale operations as resources such as water becomes more scarce and more expensive. Such opportunities exist within the advanced manufacturing technology (AMT) and consumer health sectors.

So what blend of industries will help fill the shopping trolley of the future? ■