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Real-time technology to enable business transformation and Hazard Analysis and Critical Control Points analysis

by Yves Dufort

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Abstract

The Food and Beverage Industry has historically used historian-based technology to optimize and troubleshoot production processes by looking at time-series-based process variable trends. During the same time, good manufacturing practices (GMPs) have largely relied on using paper-based standard operating procedures and manual data collection to manage quality and production activities. By adding electronic workflow management capability, GMPs, regulatory requirements, and electronic forms can replace paper-based standard operating procedures and deliver an electronic system of record that embeds all manufacturing rules, exceptions, and escalation processes.

The convergence of process historian, real-time supervisory control systems, and manufacturing operations management enables plant management to use a process-based comprehensive framework and governance system to support continuous improvement and meet regulatory requirements like Hazard Analysis and Critical Control Points (HACCP) analysis.

The net effect for companies is to allow them to standardize operating procedures across multiple sites. It also supports continuous improvement and six sigma initiatives by publishing documents, reports, dashboards, and root cause analyses of many operational issues. This electronic approach is also scalable and allows continuous improvements to monitor critical processes in addition to providing an electronic system of records for HACCP analysis. Schneider Electric is uniquely positioned to deliver high-value solutions for word-class food and beverage processers.

An opportunity for the Food and Beverage Industry

The Food and Beverage Industry is under pressure to optimize its product mix across the supply chain while protecting margins. These two objectives need to be met while maintaining product compliance and safety. Over the years, companies have put in place business transformation programs to make these cost-reduction programs both sustainable and scalable. In food processing, many processes are, by nature, cross-functional, especially when dealing with exceptions, but these processes are largely manual. Using electronic systems can help gain significant competitive advantage by combining cross-functional processes to support both HACCP analysis systems and continuous improvement systems. The following figure shows HACCP and continuous improvement activities in the context of the manufacturing operations management framework. The top section covers HACCP-related activities across all manufacturing channels. The bottom section covers continuous improvement activities.

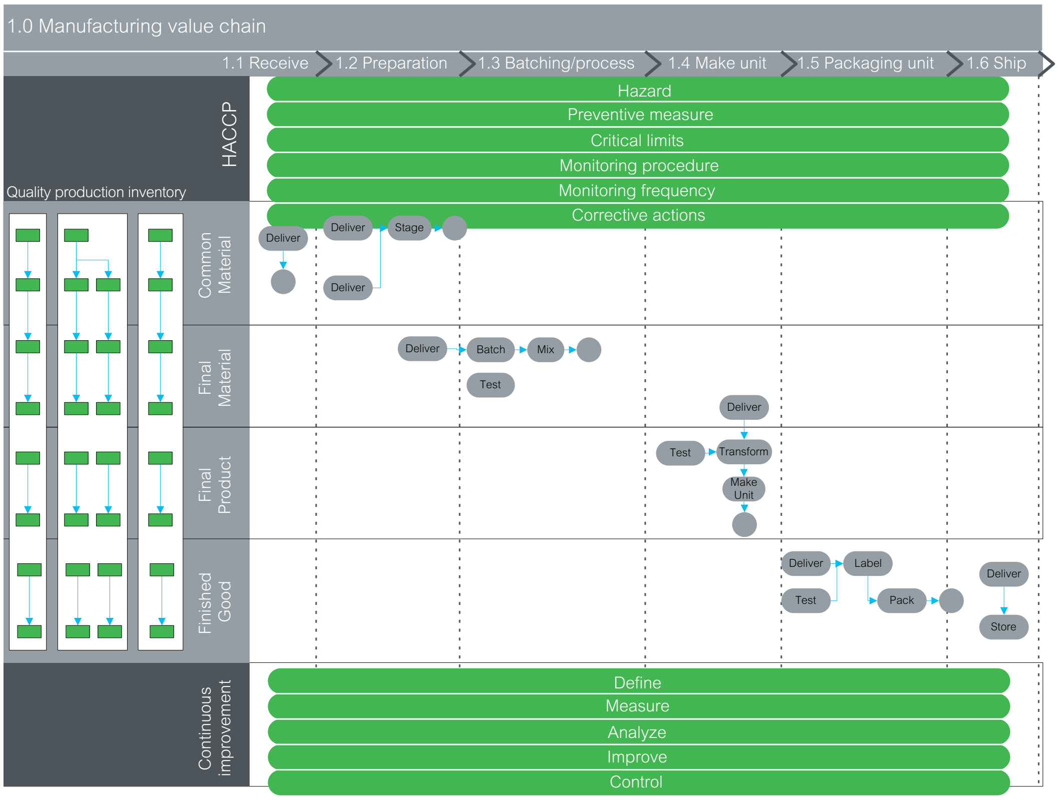

Figure 1

Value chain framework

Both systems require a process step approach to reduce waste in the context of continuous improvement and to minimize food hazard events.

Most food processors have invested in historian-based technology to record, visualize, optimize, and troubleshoot process variables like temperature, pressure, etc. Historian databases typically interface with control systems that are tied to both process conversion equipment and process utilities like clean-in-place, HVAC, and cooling systems. Similarly, continuous improvement teams also require process equipment information to analyze waste opportunities like yield loss reduction, energy monitoring, emission control, maintenance optimization, etc. Temperature is a perfect example of a data point that is recorded by a historian for process engineers to troubleshoot production issues. In addition, HACCP plans require temperature (and time) to be recorded to minimize product safety issues like contamination. Temperature can also be used by continuous improvement teams to understand waste streams like energy for pasteurizers.

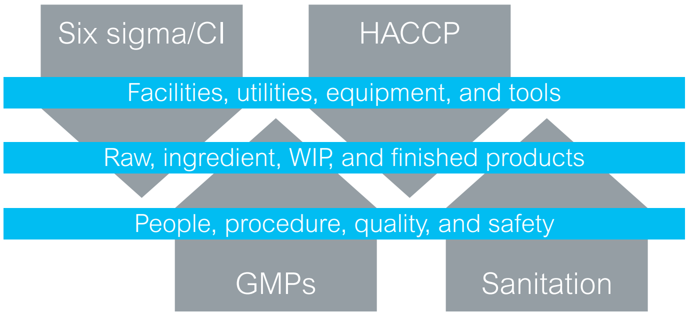

Figure 2

Continuous improvement, HACCP, GMPs, and sanitation framework

Hazard Analysis and Critical Control Points

Paper-based systems are developed by a team formed by cross-functional members, including production manager, production engineer, consultant of food hygiene and sanitation, consultant of food microbiology, and a technician from the laboratory. These teams then look at manufactured products. The products are described in terms of ingredients, processing, packaging, storage, and distribution. Each step in the process is outlined in sequence in the flow diagram from raw materials through processing, packaging, and storage.

In order to identify hazards, each product preparation process was observed for:

- Receipt of raw materials, storage, heat treatment, cooling, and packaging
- Fermentation, concentration, homogenization, additives, temperature, packaging, and storage

Each HACCP plan is constructed using the following structure:

1. Process step
2. Hazard identification
3. Preventive measure
4. Critical limits
5. Monitoring procedure
6. Monitoring frequency
7. Corrective action

Schneider Electric includes a number of products that can support HACCP plans.

The following table is an example of a HACCP plan in a typical cheese plant.

HACCP activities						
Process step	Hazard	Preventive measure	Critical limits	Monitoring procedure	Monitoring frequency	Corrective action
Receive (CPP1)	Microbiological chemical and physical contamination	Qualified supplier raw milk packaging material	No unqualified material be used	Apply supplier quality assurance	Each supply	Change supplier
Prepare/ pasteurizer (CPP2)	Survival of pathogens such as E.coli, Staphylococcus, etc.	Pasteurizer checks: • Check heat plates • Check temperature controller • Check the flow diversion	Temperature set at 72 °C for 15 sec.	• Check thermometer and time • Check if equipment is running • Supervisor managing and record keeping	• Each batch • Routinely • Each batch	• Adjust the temperature and time by setting the equipment well • Call the engineer to repair
Salting (CPP3)	Microbiological contamination	• Correct level of salt • Correct mixing during salting	Salt % = 5.0%	Records and testing	Each batch	Incorrectly salted curb must not be allowed to progress
Rennet (CPP4)	Microbiological contamination	Proper additional rate	100 ml/ 100 kg concentrate	Check the additional rate of the rennet and ph	Each batch	Applying more testing on pH
	Physical contamination	Agitate properly	Agitator set to medium	Record keeping		Operator training
Tray filling (CPP5)	Microbiological contamination	Proper temperature setting	Temperature set at 32 °C	Check thermometer	Each batch	Adjust heat to change temperature
Coagulation (CPP6)	Microbiological contamination	Proper time setting and recording	Temperature set at 40 – 45 °C is set at 30 – 60 min	Check the temperature/ time and the stirring tools	Each batch	Reject products
	Physical contamination	Taking the stirring tools out of the tank	Tools prevent coagulation	Record keeping		
Cutting (CCP7)	Microbiological contamination	Proper time and temperature setting		Check the temperature/time	Each batch	Adjust the heater to change temperature

Table 1

HACCP plan example for typical cheese processing

The historian technology and real-time supervisory system can also be used to prepopulate mandatory reports like the one below. Historians can retrieve the data automatically. The data can also be averaged over time to calculate statistical value and derive process capability or detect statistical alarms to make sure the process does not drift out of control and/or specification limits.

Using the data from control systems at the predetermined frequency indicated below, along with the operator assigned to the form, can be easily done with Schneider Electric™ technology.

Table 2

Test report for fluid milk

DEPARTMENT OF HEALTH AND HUMAN SERVICES FOOD AND DRUG ADMINISTRATION		MILK PLANT EQUIPMENT TEST REPORT		
TEST NO.	TEST	TEST FREQUENCY	TESTED (X or NA)	RESULTS OF TEST (See Reverse for Working Notes)
1.	Indicating Thermometers (including air space): Temperature Accuracy	3 months		
2.	Recording Thermometers: Temperature Accuracy	3 months		
3.	Recording Thermometers: Time Accuracy	3 months		
4.	Recording Thermometers: Checked against Indicating Thermometer	3 months		Daily by operator
5.	Flow-Diversion Device (FDD): Proper Assembly and Function (HTST and HHST)			
	5.1 Leakage Past Valve Seat(s)	3 months		
	5.2 Operation of Valve Stem(s)	3 months		
	5.3 Device Assembly (micro-switch) Single Stem	3 months		
	5.4 Device Assembly (micro-switches) Dual Stem	3 months		
	5.5 Manual Diversion - Parts (A, B, and C) (HTST only)	3 months		
	5.6 Response Time	3 months		
	5.7 Time Delay Interlock (dual stem devices) (Inspect)	3 months		
	5.8 Time Delay Interlock (dual stem devices) (CIP)	3 months		
	5.9 Leak Detect Flush Time Delay (HTST only as applicable)	3 months		
6.	Leak-Protect Valves: Leakage (Vats only)	3 months		
7.	Indicating Thermometers on Pipelines: Thermometric Response (HTST only)	3 months		
8.	Recorder-Controller: Thermometric Response (HTST only)	3 months		
9.	Regenerator Pressure Controls			

Applying continuous improvement to process conversion and services

Clean-in-place (CIP) is a critical process in the Food and Beverage Industry. Not only is CIP necessary for product safety and quality, but it is also energy intensive. An optimized CIP process will ensure product quality and reduce chemical usage, rinse, and waste water. As shown below, a typical fluid milk processing operation consumes approximately two-thirds of its energy in processing and one-third in services. In both streams, 70 percent of energy flows respectively through pasteurization and CIP. This example details the energy profile.

	Process Conversion	%				Services	%
1. Receiving	0,005	7%			1. CIP	0,03	69%
2. Separation	0,005	7%			2. HVAC	0,005	11%
3. Homogenization/Pasteurization	0,0526	70%			3. Other*	0,0086	20%
4. Filling	0,01	13%					
5. Cooling	0,0021	3%					
Sub-Total (kwh/liter)	0,0747				Sub-Total (kwh/liter)	0,0436	
Total	**0,1183**				Total	0,0436	
% (Process Conversion)	63,1%				% (Services)	36,9%	
Kwh (Sub Total Process Conversion)	9 851 338				Kwh	5 749 911	
				Cubic feet			
		M3 gas	655 654	23 144 584			
		kwhr	2 914 519				
Yearly Volume (liter)	131 878 682						
Yearly Volume (gallon)	34 802 784						
energy estimate (**kWhr**)	15 601 248						
Enery Cost estimate (process conversion	985 133,76 $				Enery Cost estimate (Services	574 991,05 $	
$/kWhr	0,100 $						
Total cost estimate	**1 560 124,81 $**						

In our example, for a 34 million gallons/year fluid milk plant and a $0.10/kWhr energy cost, the average energy cost is going to be approximately $1.5 million per year.

In fluid milk processing plants, pasteurizers and CIP are the most energy-intensive processes. Optimized CIP equipment states are also required for HACCP records. CIP are typically skid-mount systems controlled by a dedicated control system. It's easy to interface with the control system and historize all relevant process variables. Combining continuous improvement, HACCP plan is a great example of where Schneider Electric technology can be used. The figure below shows the preoperational activities to make sure storage containers, production orders, and CIP equipment is ready to use and system of records are documented appropriately.

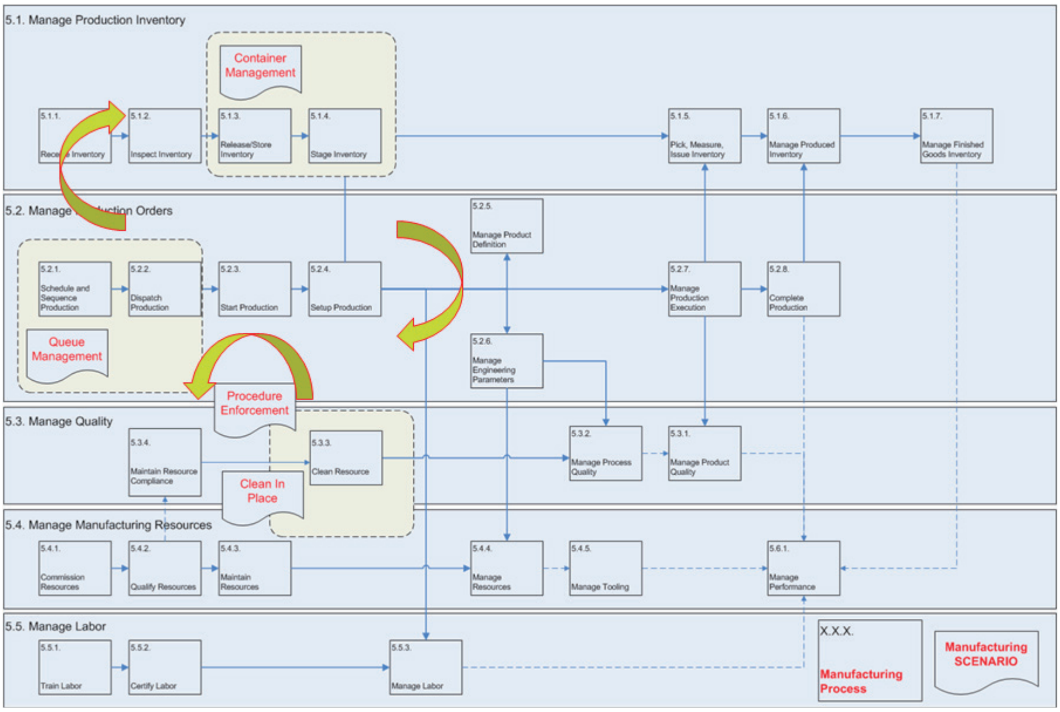

Figure 3

HACCP, CIP/feed forward flow/ preoperational sanitation

Continuous improvement program and decision support systems

Schneider Electric can help CIP teams dollarize and prioritize projects based on both benefits and risk. By using our consulting services, world-class companies can implement solutions that leverage historian databases, supervisory systems, and manufacturing operations management systems to measure key performance indicators (KPIs). The following picture shows the continuous improvement process that is used by our consulting team to drive the most promising opportunities.

Supply chain functions are now looking at optimizing the total delivery costs, which requires implementing dashboards and KPIs across the supply chain (see below).

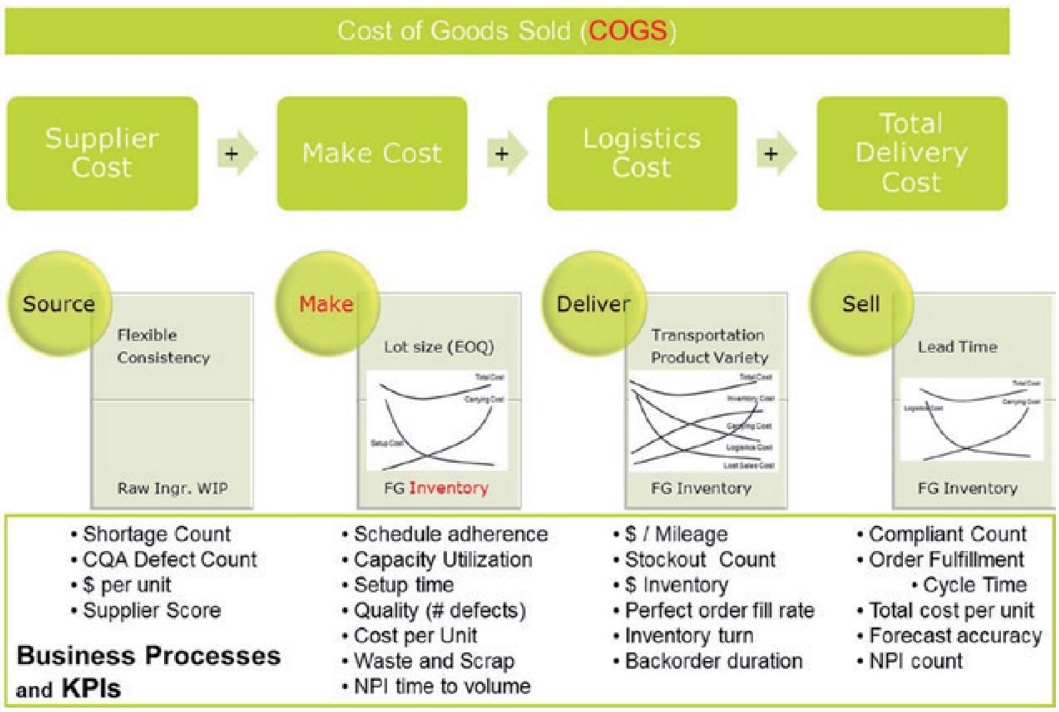

Figure 4

Key performance indicators

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Conclusion

Schneider Electric solutions and services have unique capabilities to help companies leverage technology to support continuous improvement and HACCP plans. This can be done by first leveraging existing process historians. The convergence of technology to support these cross-functional processes provide food, beverage, and consumer packaged goods companies with a competitive advantage to manage costs, improve processes, and comply with regulatory requirements.

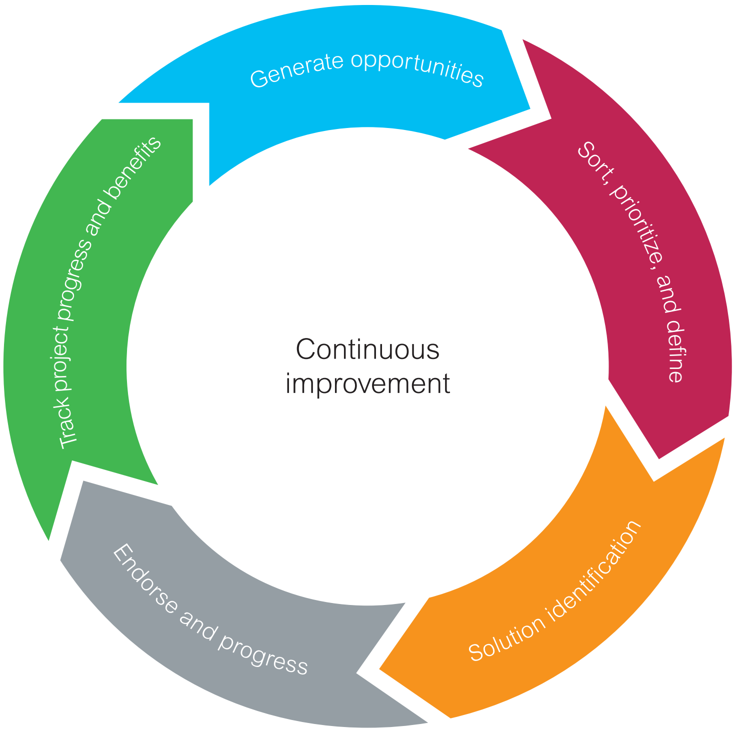

Figure 5
Continuous improvement process

About the author

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