White Paper

REAL TIME MONITORING OF HIGH-SPEED BOTTLE AND CAN FILLING LINES MAXIMIZES PRODUCTION, INCREASES YIELD, REDUCES REWORK, AND AVOIDS PRODUCT WASTE

INTRODUCING DORCIA ENGINEERING

To keep pace with consumer demand, beverage companies rely on automated, high-speed filling lines that operate at a blur in a continuous, non-stop process flow, producing upwards of 2,500 items per minute per line. The slightest problem on these automated lines such as a missing vent tube has a major operational impact. Dorcia Engineering deploys high-frequency RFID technology to monitor these lines and quickly identify problems to maintain the highest uptime on these production critical machines; maximizing production, reducing rework, and avoiding product waste.

Grant Cook Dorcia Engineering

This white paper describes the benefit of monitoring high-speed production can and bottle filling lines in real time using Radio Frequency Identification.

Regardless of how it may be measured, the global beverage industry is enormous. Global non-alcoholic beverage sales reached the One Trillion Dollar milestone in 2019. Alcoholic beverages add another $1.5 trillion to this figure. The market is growing between 3%-4% annually, driven by an increase in worldwide disposable income.

A subset of this market is beverage containers. It's approximately valued at $250 billion dollars and understandably grows in lock step with the overall market, driven by a consumer preference for single serve containers.[1]

The volume of single use containers produced annually is staggering. The world's beer and soda consumption uses about 200 billion aluminum cans every year. Lined up end-to-end, it's enough to circle the planet every 17 hours.[2]

The U.S. beverage container market, which includes plastic, glass and aluminum cans and bottles, produced 283 billion units last year. To put that into perspective, 9,000 such containers are filled every second, each and every day. And that's just in the United States.

[1] Source: https://www.gminsights.com/industry-analysis/beverage-container-market

[2] Source: https://www.theworldcounts.com/challenges/consumption/foods-and-beverages/aluminium-cans-facts

Across the world people buy around one million plastic bottled beverages per minute without giving a second thought about the process and logistics that went into the grab and go convenience of that single serve beverage.[3]

To keep pace with consumer demand, beverage companies rely on automated, high-speed filling lines that operate at a blur in a continuous, non-stop process flow, producing upwards of 2,500 items per minute per line. These lines are critical to achieving the necessary level of production and a major bottling plant will have several lines in operation at any given time.

The slightest problem on these automated lines has a major operational impact. Though simple for a trained operator to run, troubleshooting can be difficult because when problems occur, they may not be entirely obvious.

Look at, for example, a missing vent tube. The largest commercial can or bottle filling machines operating at the highest thru- put may utilize anywhere between 96 to 165 valves which can fill cans at speeds of 1,500 – 2,500 cans/ bottles per minute. Depending on the design of the machine, each valve may contain a vent tube. Occasionally, a misalignment, or issue will occur causing the vent tube to separate from the filling valve. When this happens, the affected vent tube must be located and replaced. If the vent tube cannot be located in or around the filling machine, all containers produced during the suspected timeframe of the incident must be manually inspected or even discarded.

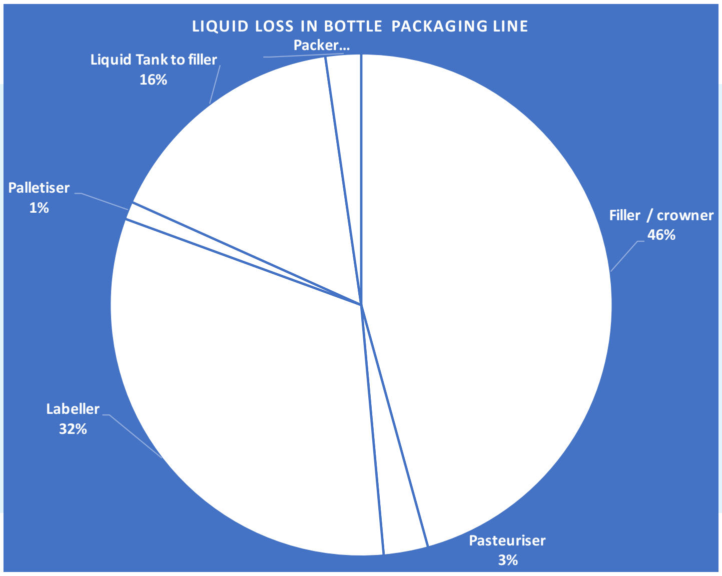
Utilizing FEIG-Electronics technology, the Dorcia Engineering Filler Vent Tube Reader individually reads and reports each vent tube, in every valve, for every revolution of the can or bottle filler. Each of the Dorcia Engineering patented traceable vent tubes contains an RFID chip. By monitoring and reporting each of the vent tubes individually, for every revolution of the filler, the Filler Vent Tube Reader can identify if a vent tube is missing or malfunctioned right away and will stop the filler. This allows the filler owner or operator the ability to quickly identify one of the leading problems related to downtime. Fewer products are affected when such an event occurs, far less finished product is spilled aand wasted, and the amount of downtime is reduced when the specific missing vent tube can be immediately identified.

Reliability, repeatability and accuracy of the identification system are all engineered into the system, addressing challenging technical requirements posed by this application.

> "By one estimate, companies in the food and beverage industry experience as much as 500 hours of downtime every year to the tune of thousands of dollars per hour."

A Pareto analysis conducted by the Department of Industrial Engineering at the Durban University of Technology determined that 46% of the liquid loss from a bottle filling line was attributed to the filler/crowner process.[4]

By one estimate, companies in the food and beverage industry experience as much as 500 hours of downtime every year to the tune of thousands of dollars per hour.



[3] https://www.drinklavit.com/blog/plastic-isnt-green

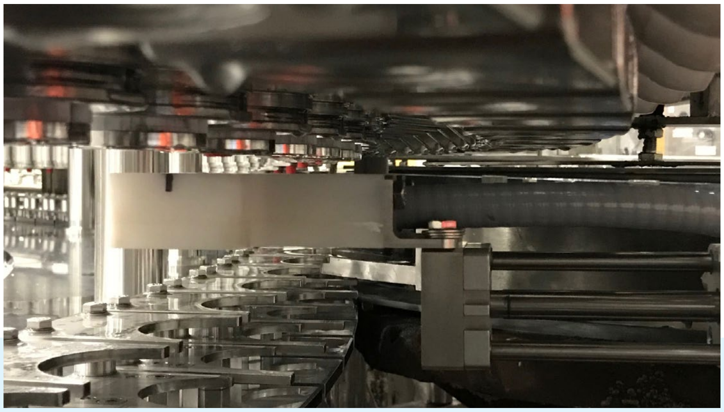
[4] https://pdfs.semanticscholar.org/41b8/30ad0602a44f3e66606442af64b9f72481e5.pdf

BASIC RFID THEORY APPLIED: MATCHING APPLICATION REQUIREMENTS TO THE TECHNOLOGY.

An RFID reader produces an electromagnetic field that radiates from an antenna. The size, shape, distance from the antenna, operating frequency and power level of the reader all define the geometric area of this field. Since the position of bottles and cans are tightly registered and well aligned in the machine, and a constant distance is maintained between products, vent tubes, and antenna, the application only requires a small antenna with a small detection area.

A passive RFID tag has no battery. Radiating energy from the antenna is the power source. When exposed to the attenna's electromagnetic field, a small capacitor in the tag becomes charged and when a sufficient voltage is produced the IC will turn on, analogous to pressing a power switch on an electronic device. As the tag leaves the antenna field, the IC turns off and transactions between the tag and reader cease. If power is momentarily lost during the execution of a command, it will fail. The reliability and accuracy of the RFID system relies on a stable antenna field.

While the tag is powered, command protocols can be wirelessly issued to read, write and configure the memory content in the tag. In this regard, the tag must remain in its' power-on state during the entire execution time of a command. Therefore, a tag is required to "dwell" within in the field a certain minimum amount of time to remain in an "on" state. The amount of dwell time can be calculated and depends on three variables.



The first variable is the linear motion of the tag. There is an inverse relationship between the conveying speed of the beverage item and the dwell time. Slower conveying speeds create a longer dwell time. Higher conveying speeds reduce the dwell time. In this application, the tagged vent tube is within the detection zone of the RFID antenna for a mere fraction of a second.

Another variable is the command execution time. The operating frequency, the air-protocol and the type of command that is issued influence the execution time. For example, some commands take more time for an RFID IC to process. Executing a write command, for instance, takes longer than a read command. In this use, the minimum required dwell time is the amount of time it takes to execute a read command that captures the unique ID number of the tagged vent tube.

The final variable in the equation is the operating frequency of the RFID system. Higher frequency provides greater bandwidth and can execute commands much faster than lower frequencies. High frequency (HF) RFID operates at 13.56MHz. It is capable of reading anywhere from 30-800 tags per second depending on the air protocol and implementation by the silicon manufacturer. In theory, the ISO 18000-3 Mode 3 protocol, which is the fastest HF protocol, can read up to 800 tags per second. RAIN (UHF) RFID operates at 915MHz and can detect up to 1200 tags per second. In real world applications these numbers are substantially de-rated. Yet, either technology is capable of handling even the fastest beverage lines.

Dorcia Engineering chose to utilize HF RFID for a number of technical reasons. First, an HF antenna produces a well-defined, controlled, and limited detection area in comparison to UHF RFID. A UHF antenna can be prone to picking up extraneous tags that are outside of the intended detection area, often produced by the RFID signals reflecting off metal surfaces. Metal is everywhere on a bottling conveying line.

A more significant issue with UHF is signal absorption in liquids. UHF RFID operates near the microwave band. Liquids absorb ultra-high radio frequency signals in the same manner that liquids in foods absorb them in a microwave oven. While steps can be taken to address the problems associated with absorption and reflection, those issues are not present with high frequency. For the beverage industry, HF is decidedly the better-suited technology.

In addition to the addressing the technical requirements relating to RFID technology, Dorcia Engineering configured the FEIG reader in its automatic operating mode whereby the reader itself issues protocol commands to the tags. This mode of operation eliminates a substantial amount of communication traffic that normally takes place between a reader and the control system.

Commonly, an RFID reader is controlled by a host application that issues individual commands to a reader to interrogate for tag data. While this method of control is effective in many applications, it introduces an undesirable latency in high-speed, real time systems. Latency is the time it takes to transmit, receive, and process individual command transactions.

FEIG's buffered read mode offloads the task of tag interrogation from the host by performing it internally within the reader. Acting as a state machine, the FEIG LR2500 reader issues tag interrogation commands at the speed of its internal firmware. Tag responses are collected and placed into a stacked buffer of the reader's memory. Dorcia's host application then queries the reader and manages the stack with only three simple commands: Initialize Buffer, Read Buffer, and Clear Buffer.

The Dorcia Engineering Filler Vent Tube Reader (FVTR) is mechanically mounted between the can or bottle in-feed and the discharge of the filler. The Filler Vent Tube Reader automatically extends an antenna underneath the filler valve, which reads each of the RFID enabled

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traceable vent tubes. Each valve has a traceable vent tube mounted in it. The Filler Vent Tube Reader learns the unique identification and location of each traceable valve and can then alert and detect if one of the vent tubes is missing or damaged.

The Filler Vent Tube Reader can be mounted on a standard can or bottle filler during its regularly scheduled maintenance in a matter of a few hours. The old non-Traceable Vent Tubes are removed and the patented Dorcia Engineering Traceable Vent Tubes are installed in each valve.

The process of checking vent tubes is traditionally done manually and requires the filler operator to stop the production line every 30 minutes or every hour to perform manual vent tube checks. By implementing the Filler Vent Tube Reader with Traceable RFID enabled vent tubes, filler operators can perform automatic vent tubes check every revolution of the filler and report the position of each vent tube on a computer for the Quality Team to record and print.

A vent tube loss at a large-scale bottling or canning company can result in large product holds, product waste, and substantial down time. **As a result, most of the large-scale bottling or canning companies have implemented a process of checking for vent tubes manually and require the filler operator to stop the production line every (30) minutes or every hour to perform a manual visual vent tube check.**

By implementing the Dorcia Engineering Filler Vent Tube Reader coupled with the FEIG Electronics technology large-scale bottling or canning companies can perform an automated vent tube check every revolution of the filler and will be alerted as soon as a vent tube malfunction occurs. This innovative solution will allow RFID to be used as a control parameter in this high-speed process, yielding more uptime, decreasing consumer risk, and reducing product waste for large-scale bottling or canning companies.

Typically, the return on investment when implementing the Dorcia Engineering Filler Vent Tube Reader is acheived within the first or second occurrence of a missing vent tube.

We at Dorcia would love to help better understand how we may be of service to you and your customers. Thank you for taking the time to read this article. We look forward to the opportunity to work with you!

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FEIG ELECTRONIC is a privately held manufacturing company with more than 50 years of experience and is diversified across many markets and applications including authentication, payment, ticketing and access to accurately and securely identify people, vehicles and assets. FEIG is a global supplier of RFID readers and antennas for all standard operating frequencies: LF (125kHz), HF (13.56MHz) and UHF (860-960 MHz).

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