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INDUSTRIAL INTERNET OF THINGS: CASE OF USE IN A GLASSMAKER

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Abstract

While the Internet of Things concept is in full swing, in the world of industry things seem to move more cautiously. What is now known as Industrial Internet of Things -IIoT- (term coined by General Electric) moves more slowly. The connectivity to Internet in the industry has other times with respect to the world of the domestic devices.

The advanced IIoT will be industrial machines, intelligent and complex machinery that is able to report significant data of the manufacturing process, as well as its own operation, to facilitate the work of diagnosis and maintenance.

In the same way that in the office environment the photocopier can report the number of copies made, the condition of the toner and the possible faults, a packing machine of a factory can report the number of cycles executed, the time of stoppage, breakdowns, etc. and generate maintenance requests when necessary.

It will be increasingly common for manufacturers to include Internet connectivity to their machines in order to plan maintenance tasks or enable telemanagement through a Web interface.

The installation of cloud-ready instruments and sensors would allow the manufacturers and maintainers to perform remote maintenance and even telecalibration of them. Likewise, the possibility of sending measurements of sensors to applications in the cloud would allow calculations with analytics tools in near real time.

The key point for industrial devices to connect to the Internet is to ensure the security and confidentiality of the information sent.

The industrial plants are full of devices that use buses and industrial protocols-some private and others incompatible with each other-that were never intended for the Internet. They are simple protocols, normally designed to operate in master-slave mode and with polling mechanisms.

In many cases they still use serial communication buses (RS232 / RS485), and in the case of using Ethernet (or token bus, as is the case of the glassware object of our analysis) the protocols are designed to work in a local area network and not on the Internet.

In addition, industrial protocols are oriented to the transmission of simple data (measurements) and not to more sophisticated tasks such as those that would require remote maintenance.

On the other hand, while new standards emerge, we will have to live with our legacy devices and look for solutions that allow connectivity in the cloud.

In view of this analysis, we can implement from a network communication engineering to a semantic normalization of data communication, based on the information produced in a glassware.

Keywords: IoT, IIoT

Resumen

Si bien el concepto Internet of Things está en plena eclosión, en el mundo de la industria las cosas parecen moverse con más cautela. Lo que actualmente se conoce como Industrial Internet of Things -IIoT- (término acuñado por General Electric) se mueve más despacio. La conectividad a Internet en la industria tiene otros tiempos respecto al mundo de los dispositivos domésticos.

La avanzada del IIoT serán las máquinas industriales, maquinaria inteligente y compleja que es capaz de reportar datos significativos del proceso de fabricación, así como de su propio funcionamiento, para facilitar las labores de diagnóstico y mantenimiento.

De la misma manera que en el entorno ofimático la fotocopiadora puede reportar el número de copias realizadas, el estado del tóner y las posibles averías, una máquina envasadora de una fábrica puede reportar el número de ciclos ejecutados, los tiempos de paro, averías, etc. y generar peticiones de mantenimiento cuando sea necesario.

Cada vez será más habitual que los fabricantes incluyan la conectividad a Internet a sus máquinas con el objeto de planificar las labores de mantenimiento o posibilitar la telegestión mediante una interfaz Web.

La instalación de instrumentos y sensores cloud-ready permitiría a los propios fabricantes y mantenedores realizar telemantenimiento e incluso telecalibración de los mismos. Así mismo, la posibilidad de enviar las medidas de los sensores a aplicaciones en la nube permitiría realizar cálculos con herramientas de analytics en tiempo casi real.

El punto clave para que los dispositivos industriales se conecten a Internet es asegurar la seguridad y confidencialidad de la información enviada.

Las plantas industriales están repletas de dispositivos que utilizan buses y protocolos industriales - algunos privados y otros incompatibles entre sí- que nunca se pensaron para Internet. Son protocolos simples, normalmente pensados para funcionar en modo maestro-esclavo y con mecanismos de interrogación secuencial (polling).

En muchos casos utilizan aún buses de comunicación serie (RS232/RS485), y en el caso de utilizar Ethernet (o token bus, como es el caso de la cristalería objeto de nuestro análisis) los protocolos están pensados para funcionar en red de área local y no sobre Internet.

Además, los protocolos industriales están orientados a la transmisión de datos simples (medidas) y no a labores más sofisticadas como las que requeriría telemantenimiento.

Por otra parte, mientras surgen nuevos estándares, deberemos convivir con nuestros dispositivos legacy y buscar soluciones que permitan la conectividad en la nube.

En vista a este análisis, podremos implementar desde una ingeniería de comunicación de redes hasta una normalización semántica de la comunicación de datos, basados en la información producida en una cristalería.

Palabras clave: IoT, IIoT

1. Introduction

In modern industrial processes resource optimization has an important role because of businesses' concern regarding quality rules and specifications, which are becoming increasingly strict in industry.

In the glass bottles manufacturing industry there are many factors involved, which determine the quality of the output. One of these factors is efficiency, which indicates the percentage of prime materials that are turned into a product which satisfies the quality requirements for a particular production line.

Determining the efficiency of any industrial process is very important, as you can use it to measure the general performance of the system. With this measurement you can determine, for example, how many prime materials are being wasted, etc., therefore contributing to the search of new ways of optimizing resources and this way having a more efficient production.

When building a system which is capable of measuring the efficiency of an industrial process, we have to take into account several variables. In the case of the manufacturing of glass bottles, we

have to consider environmental factors, as well as making sure the efficiency measuring system does not interfere with the process or reduces the quality of our output.

2. Glass elaboration process

Glass is an amorphous substance manufactured mainly from silicon dioxide melted at high temperatures with phosphates or borates. It's usually transparent, translucent or opaque. Recycled glass can also be used as flux.

2.1 Stages

In general terms, modern glass containers factories operate in three stages:

2.1.1 First

Reception and storing:

In this reception and storing stage the basic processed prime material arrives in trucks. These flip in a reception hopper by means of a system of hydraulic cylinders. The lower part of the hopper is connected to a conveyer belt which drives the prime material to a bucket elevator which deposits everything in some storage silos. Recycled glass goes through a series of cleaning processes in order to remove all impurities such as plastics and metals. Once it has been cleaned, the glass is crushed in a mill and it is taken to the storage silos, dividing it based on its colour.

Weighing and mixing of prime materials:

Basic prime materials are weighed in order to obtain the right proportion required to obtain a correct mixture. The weighing machine places the elements in a conveyer belt which drives them to the mixing machine in order to homogenize the components.

2.1.2 Hot Working

The basic mixture and the recycled glass enter the furnace separately, both are melted at a temperature of 1500 °C during 24 hours. The melted material goes out of the furnace by overflow through a siphon. The air used for combustion is then preheated in some preheaters until it reaches 800°C. Then the distribution process begins. Because of gravity, glass flows through distribution channels to the containers manufacturing machines. The glass mass is cut in droplets with controlled weight, shape and temperature. Th machine has an awl which forms a small cavity in the mass of molten glass.

There are two basic methods for bottle manufacturing:

- Extrusion blow molding: Despite having been initially developed for wide mouth containers, it is achieving a high development in small mouth containers, as it gives you more control over the distribution of the glass. A premold is formed by the compression of the glass droplet against the mold and then the final form is obtained by injecting compressed air and void.
- Injection blow molding: The premold and the final form are obtained by under pressure air. There are many stages to this process, with an automatic machine of type IS (Individual Section machine) in charge of them.

The preformed droplet is then expanded using compressed air. When it expands, the droplet is forced to adopt the shape of the mold, therefore created a semi-formed bottle, also known as "parison". The semi-formed bottle is then transferred to the mold terminator which will give the bottle its final shape. When the containers exit the final blowing machine, they still have a temperature of approximately 650 °C. Once the operation is over, the mold opens so the machine can take the bottle and take it to the conveyor belt.

From the conveyor belt, containers are taken to the annealing furnace to prevent the formation of internal tensions caused by the fast cooling. This tunnel with a controlled temperature is the furnace through which the containers slowly pass, being reheated and then cooled in a predefined way.

2.1.3 Cold Postprocessing

The bottle then undergoes a surface treatment in cold done by a lubricating liquid and with its principal objective being preventing the presence of lines in the surface of the container. The tendency towards lighter containers means more treatments have to be applied to the bottle to maintain its resistance; therefore allowing a soft flow in the lines of packing and improving the resistance to abrasion. Glass products sometimes require finishing operations such as the grinding and the polishing. This is due to the use of split matrices in the blowing operations, having to remove the marks and seams by grinding and polishing; for which we usually use iron oxide. Containers with no defects are taken by the conveyor belt to the 'cold zone' to be packed by the palletizing machine.

3. Automation and instrumentation

In order to obtain a greater quality in the production of containers, there are automatic control methods which, generally, consist of optoelectronic machines that are in charge of doing dimensional and functional controls of the bottle, as well as aspect controls, because they are critical points for the customer. Generally, in the modern line of production there are:

- A ring controlling machine (internal diameter of the neck).
- A tension simulator to remove all the abnormally fragile bottles
- A control machine which evaluates dimensional defects.
- An aspect controlling machine.

This control machines are connected by automation systems to a computer or network of computers, where the information referent to the container selection is stored and treated, with the objective of notifying the operator at real time and to guide his actions to obtain a higher quality.

3.1 Logical programmable controllers

Not so long ago, the controlling of industrial processes was done using cables, contactors and relays. The operator who was in charge was demanded high technical knowledge in order to perform them first and then maintain them. Furthermore, any variation in the process meant physically modifying most of the connections in the mounting, which required a great technical

effort and a higher economic expense. Nowadays we cannot imagine a high-level complex process being done by cabled techniques.

The computer and the logical controllers have intervened in a considerable way, so this installation is substituted for other controlled in a programmed way. The Programmable Logic Controller (PLC) was created as a solution to the control of complex automation circuits. PLC were initially introduced in the industry in 1960. The main reason was the need to eliminate the great cost replacing the complex system of relays and contactors supposed. The problem of the relays was that when the production requirements changed, the control system also changed. This was very expensive when changes were frequent.

Due to the fact relays are mechanical devices and have a limited life, a strict and planned maintenance was required. Additionally, sometimes connections had to be done between hundreds or thousands of relays, which implied an enormous design and maintenance effort. The "new controllers" had to be easily programmable by plant engineers or maintenance personal. Life time had to be long and changes to the program had to be done in a simple way; they had to work with no errors in adverse industrial environments.

According to the study of Collado Gonzalez (2012), Bedford Associates proposed something called Modular Digital Controller (MODICON) to a car manufacturer. Other companies simultaneously proposed computer based schemes, one of which is based on the PDP-8.

Communication abilities started appearing in 1973, approximately. The first system was the Modicon bus (Modbus). The PLC could now communicate with other PLCs and together they could isolate themselves from the machines they controlled. They could also send and receive variable voltage signals, entering the analog world (cf. Drury (2001)).

In the 80s an attempt at standardization of the communications with protocol MAP (Manufacturing Automation protocol) took place. There was also a time where the dimensions of the PLC were reduced and people started to use symbolic programming.

MAP provides common standards for the interconnection of computers and programmable machine tools used in the automation of factories.

At the lowest physical level, MAP uses the IEEE 802.4 protocol, also known as token bus. MAP is frequently used together with TOP, an office protocol designed by Boering Computer Services. TOP is used in the office and MAP, in the factory.

Nowadays the PLC is smaller in size that a simple relay. In the 90s a great reduction in the number of new protocols was observed, and in the modernization of the physical layers of the most popular protocols that had survived the 80s.

The last standard(IEC 1131-3) tries to unify the programming system of all the PLCs in one single international standard.

Now we have PLCs that can be programmed in block diagrams, list of instructions and structured text at the same time.

The PLC, because of its special design characteristics, has a very extensive application field. The constant evolution of hardware and software constantly expands this field to be able to satisfy the needs detected in the spectra of its real possibilities.

3.2 Sensors

In an automated industrial process, it is of vital importance that the devices which act as integrating elements of it, offer a level of security which guarantees the complete development of the execution process.

As it is known, a sensor is a type of device capable of detecting different types of materials or properties and characteristics of a material, with the goal of sending a signal based on that characteristic, as part of a process.

When choosing a sensor, we have to consider different factors, such as: the shape of the case, operating distance, electric data and connections, working environment, etc.

There are also some elements called transducers, which are elements that switch signals, for a better measuring of a variable in a certain phenomenon.

A transducer is a type of device which transforms one type of physical variable (for example, force, pressure, temperature, velocity, etc.) into another.

A sensor is a transducer used to measure a physical variable of interest.

Some of the sensors and transducers used more frequently are strain gauges (used to measure force and pressure), thermocouples (temperature) and velocimeters (velocity).

Any sensor or transducer needs to be correctly calibrated in order to be useful as a measuring device. Calibration is the procedure by which a relation between the measured variable and the converted output signal is established.

3.3 HMI Screens - Human-Machine Interface

With the objective of improving the operation and supervision of the different machines that currently exist, lots of ways of interaction between the man and the machine have been created, which allow the operator to have total control of the plant.

An HMI system represents the interface between the man (operator) and the process (machine); while the automaton possesses, generally, the true control over the process. You could say there is an interactive interface between the operator and the software HMI (operator panel) and a communication interface between the software and the automaton.

In its most common form, an HMI system allows you to:

- Represent processes: the process is represented on the operator's panel and changes periodically based on the state of the associated variables. If a state in the process for example, is modified, the visualization in the operator's panel will be updated.
- Handle processes: the operator can interact with the process through the graphical interface of user. For example, he can specify and modify the value of a parameter in the automaton.
- Emit Warnings: if during processes critical states of process occur, a warning is automatically emitted (for example, if a specified limit value is surpassed).
- File process values and warnings: the HMI system can file warnings and process values, this way it can document the course of the process, and later, it will also know how to access previous production data.
- Document process values and warnings: the HMI system allows the previsualization of warnings and process values in reports; this way it will be able to, for example, emit the data of production once finished the turn.
- Manage process and machine parameters: the HMI system allows storage of process and machine parameters in archives. These parameters can be transferred, for example, from the operator's panel to the automaton in one single work step, so production changes to another type of products.

4. Solution proposed

The current measuring system of the efficiency in the manufacturing of glass bottles is made up of 3 devices: the PLC, HMI screens and sensors. As explained before, the manufacturing process of a glass bottle begins by pouring the molten glass inside a mold. The production line where the design of this system is applied, the molten glass droplet comes from high recipients. Somewhere between the recipient and the mold, a sensor is placed. Its job is to send a pulse when it detects a droplet passing by. During the manufacturing process, some problems can cause the destruction or damage to containers which had already been shaped. These faults generally occur in the IS type Machine and depend on the mobile parts of the machine. At the end of the conveyor belt which carries the bottles to the next manufacturing step, a sensor indicating the number of bottles which have successfully left the molding section. The PLC receives the signals of these two sensors and does the necessary functions to determine the efficiency of the process. The data calculated by the PLC is sent to the HMI screen, where results can be visualized and also where the ranges of time when each measurement is needed are selected.

In relation to the sensors, because of the characteristics of the materials to detect, we use capacitive sensors. This devices are in areas where the process takes place, and because of that they must be built with materials which are very resistant to high temperatures whilst maintaining accuracy and precision in the measurements.

As exposed, this technology related to the PLCs is established in the industry from 1960 approximately.

4.1 OPC UA

For Rohjans et al. (2010), in most cases we should use. Gateways which allow internet connectivity (Smart Grids), for example using new standards like OPC UA, although this would require the normal use of computers.

The OPC UA(unified architecture) is a communication protocol from machine to machine for the industrial automation developed by the OPC foundation. Their distinctive characteristics are:

- Focus on communication with industrial equipment and systems for data collection and control.
- Open, freely available and with no restrictions or tariffs.
- Cross-platform – not linked to any operating system or programming language.
- Service Oriented Architecture (SOA)
- Robust security.
- Comprehensive information model, which is the basis of the necessary infrastructure for the integration of information where providers and organizations can model their complex data in a OPC UA namespace (see Rohjans et al. (2013)), take advantage of OPC UA's rich services oriented architecture.

We hope that soon, robust and low-cost embedded devices will proliferate to install the new multiplatform OPC UA servers.

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