AN INSPECTION SOLUTION FOR PET BOTTLES

Bogdan Gurău, Dorian Dascălu, Luminița Irimescu, Traian Lucian Severin

University "Stefan cel Mare" of Suceava, Faculty of Mechanical, Mechatronics and Management
Research Center MANSiD, 13 University Street, 720229 Suceava, Romania
Corresponding author: Luminița Irimescu, E-mail luminita.irimescu@usm.ro.

Abstract: *In order to solve some problems related to checking the uniformity of the batches of PET bottles, a system for inspection has been designed and developed. The system consists of a conveyor belt of 4 m and 4 sensors: one for detecting the height of the PET bottle and 3 color sensors for inspection of the stoppers. A pusher is used to remove non-conforming bottles from the conveyor: the ones of a height other than the standard or those with stoppers of a different color than the desired one. The purpose of the inspection system is to automate the quality verification process.*

Keywords: *inspection PET bottles, quality management*

1. Introduction

The experimental stand was designed and built within a company whose main objective is the bottling of mineral water.

Due to the collaborations with numerous producers whose main objective is to provide raw materials in this segment, there have been cases in the market where due to a human error or other technical reasons the products have been mixed.

In the case of preforms, in order to avoid cases in which they can be deformed and there is the possibility to come out a little higher, a sensor was used to check their height. Also, the preforms can be deformed at the level of the stopper, so there is a possibility that the stopper is crooked on the pet bottle. To avoid this, sensors that read if the stoppers is crooked were used. Due to the crooked stoppers, microbiological contamination can occur and the product can be lost.

Because there may be different colored stoppers, three color sensors were used, each set to read a certain color. For example, one of the sensors is set to read only the red stoppers, which pass on, and the other non-compliant ones are ejected from the belt.

2. System components

The system is based on a conveyor belt with mechanical components and an electrical panel with electrical components. The components are as follows:

- Siemens three-phase electric motor (0.55kw, 230 / 400V);
- Color sensors O5G500;
- Cylindrical photoelectric sensor OGP500;
- Encoder;
- Pneumatic solenoid valves;
- Pneumatic cylinders.
- Frequency converter, max. Motor power 2.2kw;
- Power supply (240VAC input - 24VDC output;
- PLC XBC-DN20S;
- Display XP40-TTE / DC HMI
- Relay RXM 24VDC.

Conveyor Belt

The system is based on a conveyor belt, which is usually used on production lines in the food industry.

A flexible conveyor belt was used to be able to adapt to different lengths depending on how it will be used, and in this case, it will be used for the inspection of 0.5L bottles. The conveyor belt consists of a plastic conveyor chain, two support legs and a plastic drop that helps the movement of the plastic chain. The component parts were obtained from scraps from other factory lines, were reconditioned and assembled, obtaining four meters of conveyor belt., Fig. 1.

Outside the conveyor belt, guides were attached on both sides to adjust the position of the bottle relative to the sensors and to prevent the bottles from falling on it.

Siemens three-phase electric motor

The band works with an asynchronous motor, powered at 380V, which has a power of 0.55KW and a speed of 1500rpm. The "Motovario" gearbox is connected to the motor. Asynchronous motors are widely used in industry due to their low price. A disadvantage of the past in this type of engine was the inability to change the engine speed without losing torque. After the frequency converters appeared, this problem disappeared. When a bottle passes in front of the color sensor, it transmits a digital signal to the PLC depending on the set color. If a color otherthan the set stopper is detected, the position of the belt in which the non-compliant bottle is located shall be stored and the bottle shall be removed from the conveyor belt by means of the pneumatic piston.

Figure 1: *The conveyor belt*

Color sensors

The most important requirement in the food industry is the safety of the process and the quality of the products that remain constant, whether it is drinks, sweets, milk or meat processing. Even light impurities on a product can lead to great damage, whether it is the withdrawal of a complete batch of products or an expensive interruption of activity. These sensors are used for sorting, checking and recognizing objects by color.

Each sensor is set to recognize a single color, depending on the color of the stopper used in production. These sensors are powered at 24 V and controlled by the PLC, Fig. 2.

Cylindrical photoelectric sensor

Photoelectric sensors are used where accurate and non-contact detection of the exact position of objects is required. The material of the objects to be detected does not matter. If we compare the proximity sensors with the

photoelectric ones, we can see that the photoelectric ones have a much better detection area.

Figure 2: *Color sensors*

The sensor used to check the height of the bottles is a retro-reflective sensor model OGP500 purchased from the company IFM with a mirror view, with a visible spectrum with a red wavelength, Figure 3. This sensor has a working voltage between 10 and 35 V with a power consumption of 20 mA.

When a bottle higher than the standard height passes in front of the retro-reflective sensor, the position of the belt is stored to know the exact position of the bottle and when it reaches the ejection area, the pneumatic piston acts to remove the glass from the belt.

Figure 3: *Optic retro-reflective sensor*

Encoder (rotary transducer)

In many production processes, rotary transducers have been required to obtain correct measurement values for accurate positioning tasks. They turn rotational movements into digital signals. Rotary transducers work by optoelectronic or magnetic palpation without wear. To do this, they use a pulse recorder securely attached to the pulse disc or a mobile magnet holder.

Figure 4: *Encoder*

Pneumatic solenoid valve

The solenoid valve, Figure 5, also known as an electrically operated valve, uses electromagnetic force to operate. When an electric current pass through the solinoid coil, a magnetic field is generated which causes a ferrous metal bar to move, this being the basic process that opens the valve and works directly or indirectly in the air.

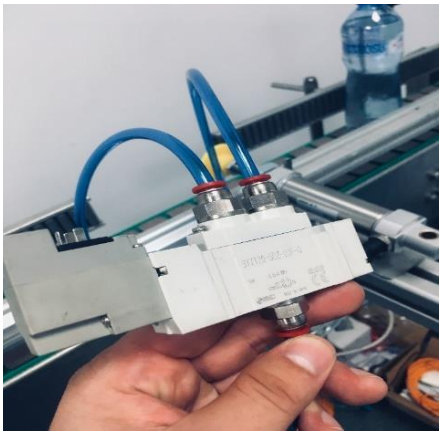

Figure 5: *Pneumatic solenoid valve*

Pneumatic cylinders

The removal of non-compliant bottles from the conveyor belt is done by a pneumatic cylinder, Figure 6, with double effect because it develops an active force in both directions of movement of the piston, being necessary to supply both chambers of the cylinder.

Figure 6: *Pneumatic cylinders*

The supply of the two chambers of the pneumatic cylinder is done by means of a solenoid valve. The solenoid valve used is a SMC 5/2 model and contains an orifice through which it is supplied with continuous air and two exhaust orifices which supply the pneumatic cylinder with air.

Power supply (240VAC input - 24VDC output)

Since there are components that are powered at 24V, we need a voltage source. The source has a single-phase input current voltage 100-200V single phase through the N-L terminals, and at the output it has a direct current voltage of 24V.

Frequency converter

A frequency converter, known as a frequency converter, is a device that receives an input power of 50 or 60 Hz and converts it to an output power of 400 Hz. Frequency converters that are solid state take alternating current (AC) and convert it to direct current (DC).

Programmable Logic Controller. PLC

The PLC is an industrial-grade digital computer designed to perform control functions, especially for industrial applications.

Human-Machine Interface HMI XP40-TTE/DC

The human-machine interface (HMI) is a component of certain devices that are capable of manipulating human-machine interactions. The interface consists of hardware and software that allow user inputs to be translated as machine signals that in turn provide users with the desired result. HMI technology has been used in various industries, such as electronics, entertainment, military, medical, etc. HMI interfaces help to integrate people into complex technological systems.

Figure 10: *Display with Human-Machine Interface*

Relay RXM 24VDC

Relays are switches that open and close electromagnetic or electronic circuits. The relays control an electrical circuit by opening and closing the contacts in another circuit.

3. Operating principle

Between the HMI and the control system, there is an RS232 and bidirectional communication.

In telecommunications, RS232, the recommended standard refers to a standard originally introduced in 1960 for the joint transmission of data.

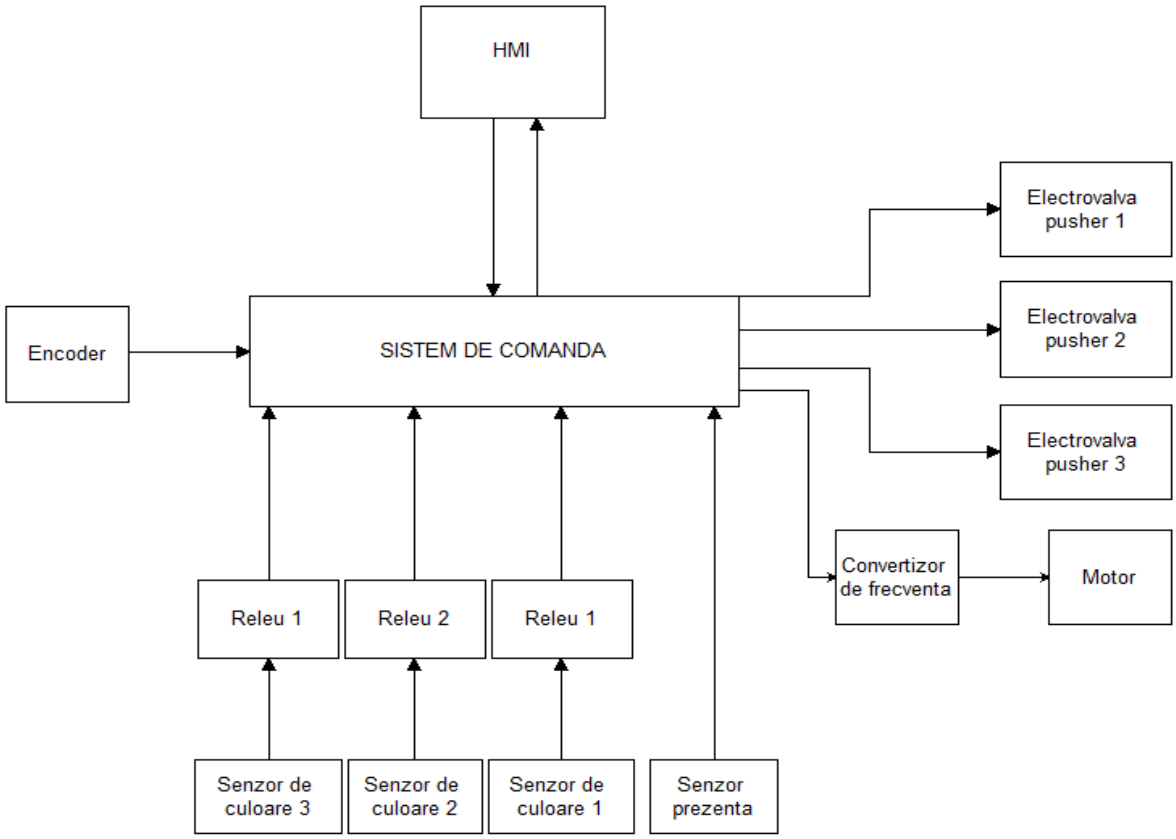

Figure 11: *Block diagram of the inspection system*

The encoder transmits a pulse communication to the control system and has a rectangular signal at the output.

Control relays are used because the color sensors automatically switch to PNP and NPN, depending on the digital load consumption, and in our case the load consumption is too low.

The retro-reflective sensor transmits a digital signal at the output, a signal that is connected to the input of the PLC and has 24V.

The connection between the control system and the frequency converter is the 10V output and the digital output communication. The digital control signal is used for the start function, and the analog signal is between 0-10V. The 0-10V range was used because the inverter is single phase.

Between the control system and the solenoid valves is a 24V output signal, the solenoid valves having pneumatic signals. When it comes to pneumatic systems, the reliability at high costs is noticeable

4. Conclusions

A solution was developed and an inspection stand of PET bottles was made to eliminate non-compliant products.

The system consists of a conveyor belt, sensors, pneumatic pistons, relays, solenoid valves, inverter, motor, PLC and an HMI. The programming of this system was made taking into account the inclusion in the bottling

process between the filling phase and the labeling phase, automating the inspection process of PET bottles.

The height of the PET bottles is checked by means of a retro-reflective sensor with the adjustable height set at the standard height of the inspected bottles.

Non-compliant PET bottles are removed from the conveyor belt using a pneumatic piston operated by the control system. The system also contains 3 color sensors for 3 different colors: red, blue and green. These are used to check the color of the caps and remove PET bottles with a different color from the stopper than the preset.

This system reduces production costs, increases labor productivity by automating the verification stage and reduces the number of non-compliant products that can accidentally reach the market.

This system can also be developed for other PET bottle verification operations, such as filling level checking or flatness of the stopper.

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