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Design and construction of pressure leak testers through the analysis of the filling level for the detection of defects in the nozzle of plastic containers

Diseño y construcción de probadoras de fugas de presión por medio del análisis del nivel de llenado para la detección de defectos en la boquilla de envases plásticos

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Abstrac

Plastic Container Manufacturing Process, many equipment has been developed for the detection of defects, for example: vision cameras, pressure test leak testers, colorimeters, hermeticity cameras, etc. each form is designed to detect a specific defect, it is updated as technology improves. Currently, the industry has opted for the use of microcontrollers that help automate industrial processes, one of the most used micros is Arduino due to its simplicity of programming and low cost of operation. The objective of this work is to apply an Arduino system for the monitoring of pressure leak testers in plastic containers. Finally, the paper shows the possible change of a particular system based on PLC with ladder logic language, by a simple system based on microcontrollers.

Upgrading of pressure leak testers, Plastic containers, Microcontroller programming

Resumen

En la industria manufacturera de envases plásticos se han desarrollado diversos equipos para la detección de defectos en los envases, por ejemplo: cámaras de visión, probadoras de fugas de presión, colorímetros, cámaras de hermeticidad etc., cada forma está diseñada para detectar un defecto en específico, el cual se va actualizando a medida que va mejorando la tecnología. Actualmente en la industria se ha optado por el uso de microcontroladores que ayudan a automatizar los procesos industriales, uno de los micros más utilizados es Arduino debido a su sencillez de programación y bajo costo de operación y mantenimiento. El objetivo de este trabajo es aplicar un sistema basado en Arduino para el monitoreo de probadoras de fugas de presión en envases plásticos. Finalmente, se muestra en el artículo que es posible sustituir el sistema basado en PLC con leguaje escalera, por un simple sistema basado en microcontroladores.

Actualización de probadoras de fugas de presión, Envases plásticos, Programación de microcontroladores

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Introduction

Plastic containers produced by the extrusion blow molding process usually present several defects among them: contaminated material, leaks, flanges, fins, etc. Two of the defects that critically affect the quality and functionality of the container are leaks and flanges, since a flange is the dragging of plastic that partially covers the nozzle of the container.

Most of the companies involved in the production of plastic containers have leak testers, which are equipment that detect and reject leaking containers. The newest equipment on the market has been upgraded to detect leaks and angina in a single test. However, for some companies, upgrading this equipment with the supplier often represents a large investment of time and money.

The objective of this work is to upgrade these devices using a microcontroller (Arduino) and expose the design and working principle for angina detection. With the purpose of decreasing the costs for the update of these equipments.

Figure 1 shows examples of the angina defect, the problem that represents this defect can be, from product spills in the filling lines, damage to filling equipment by clogging in the nozzles, etc.. As a consequence of the above, it is called line stoppages, either for cleaning or repair of the equipment.

Figure 1 Plastic container with angina defect
Own Elaboration

Description of the method

A major challenge for engineers is to upgrade old equipment and machines to match the level of functionality of a modern machine.

To modernize the leak tester equipment, it is necessary to renew the test head, because it houses an inductive sensor that sends the signal to the microcontroller when it detects the presence of angina by means of the mechanical activation of the poka-yoke. The head is made up of 5 pieces as shown in figure 2.

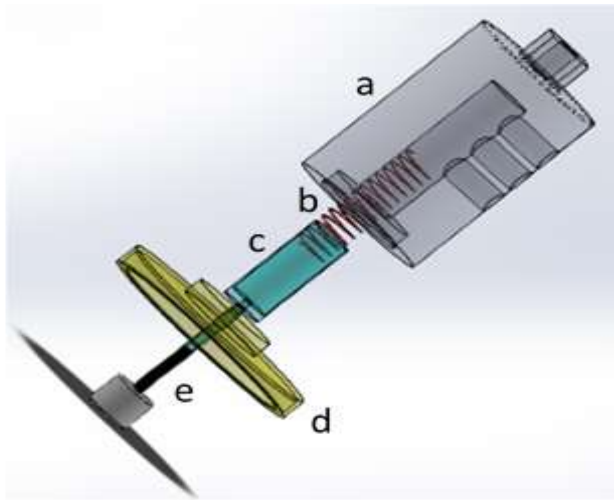

Figure 2 Components of a head [1]

Table 1 describes the functions of each of the head elements.

Nom.	Name	Function
a	Printhead	It contains three holes 2 for the air inlet and outlet and 1 where the inductive sensor will be placed.
b	Spring	Allows the poka-yoke to return to its position once activated.
c	Stem	The poka-yoke of the appropriate diameter with respect to the diameter of the container for angina detection is placed in it, in addition, the spring is placed inside the stem, the case of the stem is the one that slides upwards.
d	Dish	The silicone gasket is placed on it to seal the head with the container nozzle
e	**Calibrator**	Interchangeable aluminum disc according to the internal diameter of the container nozzle.

Table 1 Elements and characteristics of the head [2]

Figure 3 in A shows the position of the stem when the head is lowered to perform the leak test, if the container has angina it will retract the internal spring making the stem rise up to the position of the sensor as seen in B thus sending the signal to the microcontroller.

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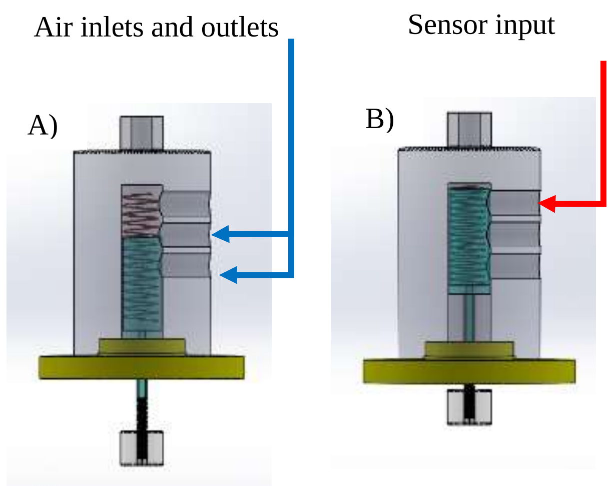

Figure 3 Head position in operation [3]

The signal sent will be processed by the microcontroller, which based on the programming code will open a relay interrupting the leak test, returning the head to its initial position causing the air to escape before the end of the leak test and consequently discarding the container for angina defect.

Circuit design

The elements in Table 2 were used to design the electrical circuit.

Component	Function
Transformer	Reduces voltage from 110V to 12V
Rectifier	Rectifies and regulates the alternating voltage of 12V
Arduino microcontroller	Receives the sensor signal to initiate the programming cycle, which will open the relay for a programmed time after the duration of the received signal.
Inductive sensor	Sends a pulse signal to the microcontroller when the poka-yoke is activated.
Relay	Interrupt tester actuator solenoid valve circuit, to raise pneumatic head actuator and interrupt leakage test

Table 2 Components of the electrical circuit [4]

Figure 4 shows the physical diagram of the proposed electrical system.

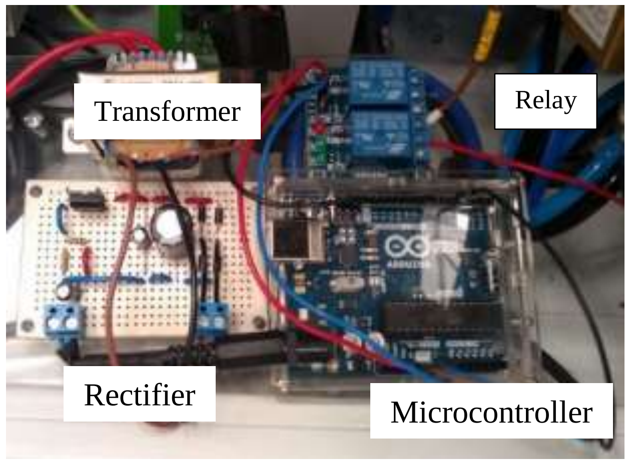

Figure 4 Circuit assembly and components [5]

Connection of the components

The Arduino microcontroller processes the signal received from the inductive sensor to start the programming cycle. The programming code consists of two beats:

First time: the time that the sensor signal must last to start with the relay opening is declared, This time is declared in ms. It helps to ensure that there are no false rejections due to rose problems with the container nozzle when the poka-yoke goes down to start the leak test.

Second time: is the relay opening time, this time is programmed based on the duration of the test time, the opening time must be less than the test time to allow the tester to function correctly.

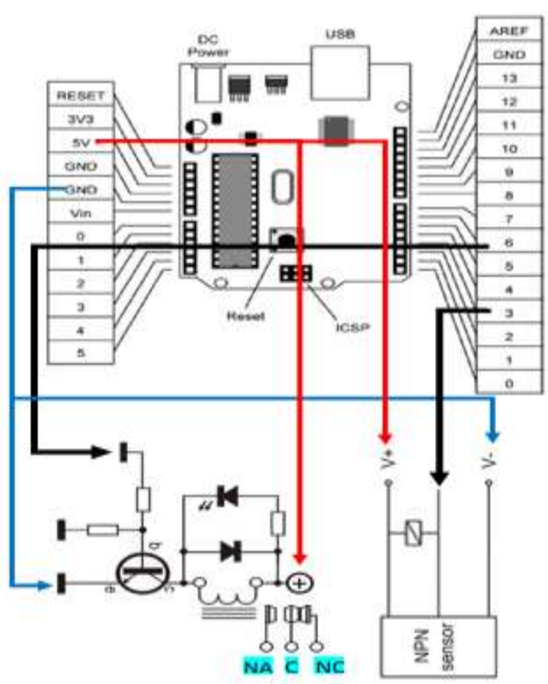

Figure 5 Structure of the proposed circuit
Own Elaboration

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Circuit implementation

To perform the installation, it is necessary to locate the solenoid valve, which activates the pneumatic piston which performs the raising and lowering of the head. The pneumatic and electrical diagram in the tester manual is used to identify the valve, or it can simply be physically traced in the equipment. Figure 7 shows how to interrupt the power supply circuit of the solenoid valve, the relay must be placed in common and normally closed.

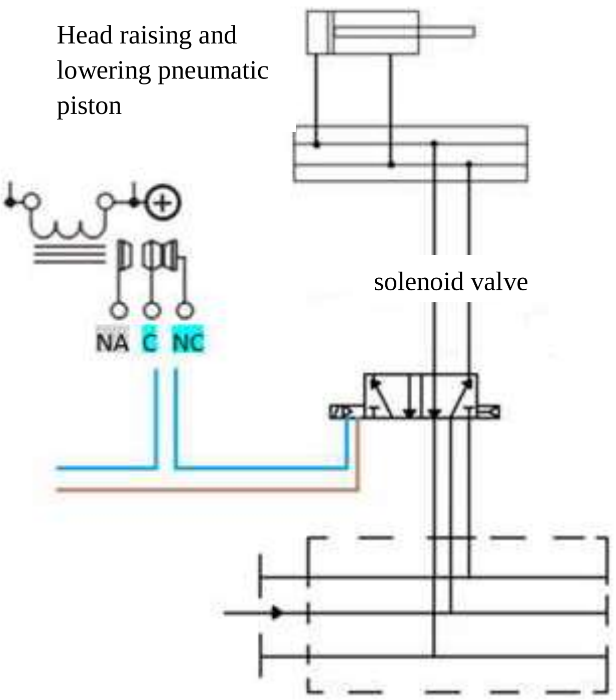

Figure 6 Connection diagram
Own Elaboration

The constructed circuit has a size of 24 x 16 cm. This allows it to be placed inside the panels of the leak testers, some models to mention are testers of the brand W. Asmler and Delta, as shown in Figure 7.

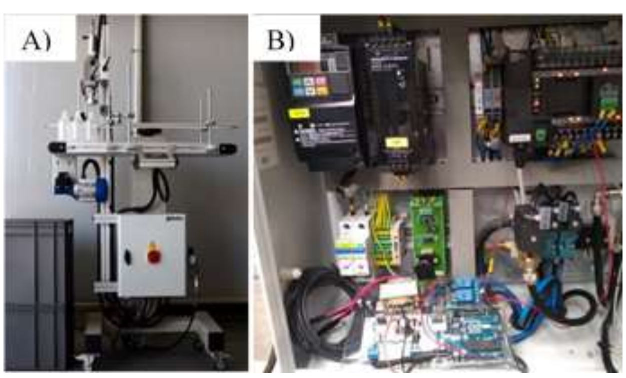

Figure 7 A: UDK050 Delta tester. B: Circuit assembly inside the leak tester panel, DELTA [6].

Results

As already mentioned, leak testers start their test or measurement cycle, starting from the signal of the reflective sensor that detects the presence of the container [7-8]. The test cycle consists of a filling time (T1), during which the tester injects air until reaching a programmed test pressure (P1).

Once this test pressure is reached, there is a stabilization time (T2) in which the air inside the container is stabilized so that the pressure sensor obtains a reference reading which can be equal to the test pressure.

After that comes a test time (T3), during this time the tester will measure the pressure reading inside the container, when the container does not leak the reading measured initially will be maintained with little variation and if the container leaks, the pressure reading will decrease considerably and will be less than the programmed test pressure, based on a previously programmed pressure limit (P2) the tester will reject the leaking container.

If the container has an angina defect, the head will be retracted and will send a signal to the inductive sir, the signal duration time is previously programmed (TS).

When the signal duration time is reached, it immediately triggers the opening of the relay, based on a programmed opening time (TR).

When the relay signal opens, it returns the piston to its initial position causing all the air inside to escape and the container to be rachando by angina, however, it closes again before the end of the programmed test time in order to start the next cycle, since, if it remains open after the test time ends, it will reject all the containers before lowering the piston.

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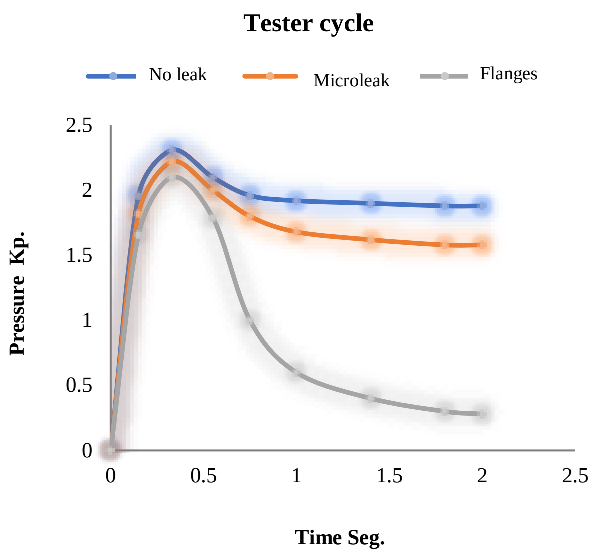

Graph 1 Behavior of the pressure system in the tester and poka-yoke
Own Elaboration

T1: Filling time
T2: Pressure stabilization time
T3: Measurement time
TS: Time of sensor signal duration for relay activation
TR: Relay opening duration time
P1: Test pressure
P2: Pressure limit or minimum allowable pressure after stabilization

Figure 1 shows three examples of pressure behavior based on the following three possible cases:

1. It is the pressure behavior of a container without leakage.

2. It is the pressure behavior of a container with micro leakage. If the leak is larger, the pressure drop will be more noticeable.

3. It is the depression behavior of a container with angina due to the fact that in that time the test is suspended and the air escapes during the measurement time.

Conclusions

The implementation of this update was carried out in different leak tester equipment, also in different products, so it was possible to conclude with the following:

– It was observed that for the correct operation of the Poka-yoke it is necessary to control the factors that influence with the centering of the head with respect to the container nozzle, these factors are; proper centering of the lateral guides, conveyor belt speed and head down speed.

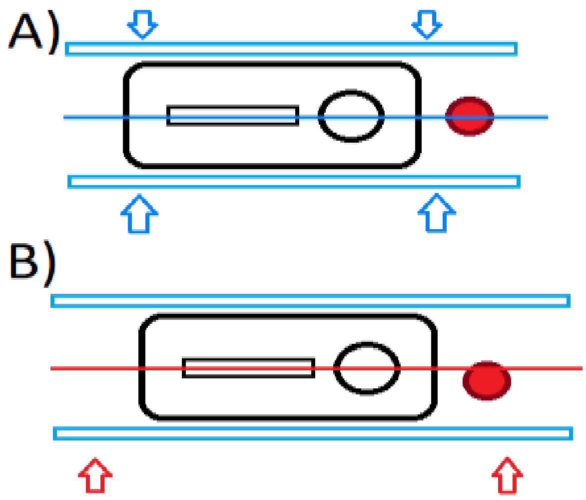

Figure 8 Centering of head guides
Own Elaboration

– A higher efficiency of angina detection was shown in machines with a high production cycle of only 5 pcs per minute, which allowed a test time of 12 sec. for each package.

This allowed to reduce the speed of the conveyor belt, to avoid that, when braking, the container would move by inertia causing it to move off-center with the head, and also to reduce the downward speed of the head piston, thus providing a smooth entry of the head with respect to the nozzle of the container.

The machines with this cycle were those that produced carafes, the carafes had a diameter greater than 45 mm, which allowed a considerable improvement in the centering of the head and completely mitigating false rejections due to a bad centering.

On the other hand, an unconventional operation was observed in machines with a production of 26.6 cans per minute. Mostly on machines that produced one liter containers. Allowing a test time of only 2.3 sec. per container.

Adding the problem that the diameter of the one-liter container was smaller (28 to 38 mm), the production speed and the smaller diameter of the container made it difficult to center the poka-yoke with respect to the nozzle, generating false rejects.

Recommendations

For the upgrade of testers that are on machines with very fast cycles, it will be necessary to implement a mechanical stopper, thus eliminating the movement of the container by inertia when braking the belt between each test, as shown in Figure 9.

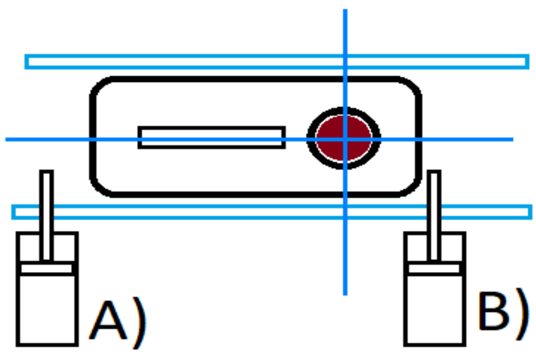

Figure 9 Improved mechanical stop. A) retains the rear container. B) Brakes the container to start test
Own Elaboration

It is also necessary to change the design of the calibrator, giving it a longer chamfer to help center the container as the head moves down towards the container nozzle, as shown in Figure 10.

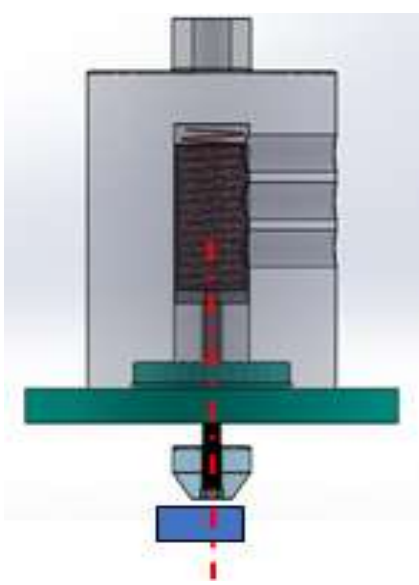

Figure 10 Poka-yoke with a larger chamfer to improve container centering
Own Elaboration

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