PACKAGING TRAINING MODULE, CAPPING AND LABELING CONTROLLED DAQ LABORATORY MECHATRONICS UTN.

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Summary-is a compact and functional liquid packaging, capping and labeling teaching module controlled DAQ (Data Acquisition Board), it has been divided into three stages or systems presents: 1) Assay Stage 2) Stage Capping 3) Stage labeling; by means of a conveyor belt the glass container will be conducted by each of the stages until the end of the process, steps also have sensors and actuators that perform specific functions. Photo electric sensors detect the passage of container and positioned in the exact site for the various actions required by the process. In step capping involves two pneumatic cylinders before it proceeds to put the caps on the container by activating an electric motor which pushes the lids onto the container. The labeling step comprises a tensioning motor and axis label, over the package the photo electric sensor gives the signal to the motor to rotate maintaining the stretched label and allowing it to adhere to the container. The module also has an HMI for monitoring, supervision and control processes using the Labview software. Besides having a control board which has manual control elements such as buttons START, STOP and emergency stop.

Terms Index — Training module, DAQ (Data Acquisition). HMI (Human Machine Interface)

I. INTRODUCTION AND BACKGROUND

Ccurrently teaching modules that simulate industrial processes help students to do internships in industrial automation, instrumentation and control enabling greater learning and creating new skills in handling the elements involved in the module. With the implementation of this training module for industrial automation practices the student learning will be much more effective as the acquired knowledge will be complemented with the practice.

He has been divided into three stages or systems: 1) Assay Stage 2) Capping Stage 3) Stage labeling; by means of a conveyor belt the glass container will be conducted by each of the stages until the end of the process, steps also have sensors and actuators that perform specific functions. Dosed stage consists mainly of a metering liquid pump having a capacity of 7 dosed fluid ounces per cycle, translated into equivalent to 0.2070147 liters, which are deposited on the glass container. Photo electric sensors detect the passage of container and positioned in the exact site for the various actions required by the process. In the capping stage involves two pneumatic cylinders A and B. The cylinder B performs the locking operation of the container to leave it in position for the cylinder to be activated and proceed to cover the container before it proceeds to put caps on the container by activating an electric motor which pushes the lids onto the container. The labeling step consists of a small engine and axle tensioning of the label, with the passage of the photo electric sensor package gives the signal to the motor to rotate maintaining the stretched label and allowing it to adhere to the container. Control of the steps mentioned above are performed with the use of the Arduino Mega and data acquisition card, which processes signals both input and output. The module also has an HMI for monitoring, supervision and control processes using the Labview software. Besides having a control board which has manual control elements such as buttons START, STOP and emergency stop.

II. CONTENT DEVELOPMENT

a. Selection of constituents

1) conveyor belt: it supports all elements involved in the training module. It should be noted that the structure must withstand loads much of the material in this case becomes liquid, rollers, tensioners, fasteners, electrical, electronic, pneumatic and electro others. The steel is the most widely used in building the structure of a conveyor belt which is rigidly connected to legs made of the same material, in addition to the various racks for holding the remainder. The profile allows placing the support for the bearings of the rollers, tensioning elements thereof. This structure is where the support is going to adapt other elements to complete the powertrain which will be responsible for transporting the containers by different module systems. For the structure of the conveyor belt has selected a rectangular structural tube NTE 2415 galvanized 2.0 mm thick.

The mechanical characteristics pipe without such:
Minimum yield stress: 270 MPa.
Minimum tensile strength: 310 MPa.
Maximum elongation: 25A.

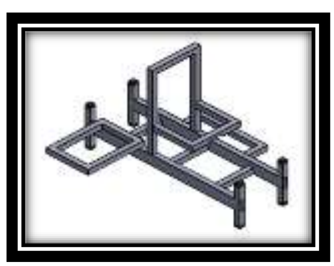

Figure 1: Structure conveyor

2) rollers: Rollers are responsible for transmitting the movement of the motor allowing the belt turn. This requires two rollers a drive transmitting motion and a tensioning roller which is the other end of the structure and serves for tensioning the belt. The tensile strength of the rollers as the material is "83 N / mm2", and has a mass of 332.88 grams:
The rollers must resist drinking water and good contact surface for better traction.

Figure 2: Roll with rubber coating

3) conveyor belt: In view of the material or item to be transported is a glass container of 6.5 cm in diameter, but to give a larger contact surface and thus better traction, roll the measures taken for the tape is aligned with the edge of drum rolls. The dimensions of the conveyor belt are 11 cm wide by 1.70m long; is made of a double canvas vulcanized increasing their tensile strength, this is an easy material to achieve both bordering cost approximately $ 7.00 per meter, as well as places where you expend and the packaging conforms While the contact surface for proper transportation. The Duraflex or canvas offers a "tensile strength weft of 36 kg / cm warp and 40 kg / cm under ASTM D5035-95 (Kg / cm).

4) bearings: The bearings are selected directly by the size of the roller shaft, it is also considered the radial forces and also takes into account the force exerted by the rollers of the conveyor band use time measured in hours and the availability in the market, which are the factors to consider when selecting a bearing.

$$\text{Roller Weight} = 0.333\ [\text{kg}] * 9.8\ [\text{m / s ^ 2}]$$
$$\text{Weight roller} = 3.26\ [\text{N}]$$

The nominal value of life are taken from the illustration from SKF the value of h = 3000, which are the hours of use.

$$Ld = (h) * (rpm) * \left(60\,\frac{min}{h}\right)$$

$$Ld = (3000) * (1800) * \left(60\,\frac{min}{h}\right) = 324x10^{6}\ [rev]$$

Ball bearings for the value of k = 3.

$$C = 3.26 * \left(\frac{324x10^{6}}{10^{6}}\right)^{1/3} = 6{,}86\ [N]$$

This shows that it is a pure radial load and obtain the capacity [C] which is the same for both the conveyor rollers available band; verified in cátalos SKF groove ball bearing single row bearings to match the axes of the rollers used have the W619 / 8-2RS1 code and they may also support dynamic loads 1,9kN

5) Metering pump: VPA Series metering pumps are self-priming, positive displacement pumps air-operated meters designed for precise amounts of fluids. The repeatability accuracy of discharge is about 1/2 of 1%. The four available sizes of pumps have a capacity of delivering maximum stroke 7 fluid ounces.

The force required metering pump is obtained with the following formula:

$$F = 10 * P * \pi \left(\frac{(\text{d})^{2}}{4}\right) * n$$

The friction factor 0.8, due to the working conditions to which they will be subjected is established.

$$F = 10 * 6 * \pi \left(\frac{(6)^{2}}{4}\right) * 0.8$$

$$F = 1358\ \text{N}$$

Figure 3: Dosing pump Vpa

PUMP SPECIFICATIONS & PART NUMBERS

Nominal Stroke Capacity		Inlet & Outlet Pipe Size	Nominal Pumping Capacity**		Minimum Operating Cylinder Pressure		Maximum Operating Cylinder Pressure		Air Cylinder Consumption** (C.F.M.) at Different Air Line Pressures				Cylinder Wall Material	Series "VPA" Part Numbers	
Ounces	CM³	(NPT)	G.P.M.	CM³/Sec	psi	Bars	psi	Bars	40 psi	60 psi	80 psi	100 psi		Buna-N	FKM
7	207.0	1/2"	.55	34.7	20	1.38	100	6.90	.55	.77	.99	1.21	PVC	VPA7P-B	VPA7P-V
7	207.0	1/2"	.55	34.7	20	1.38	100	6.90	.55	.77	.99	1.21	Stainless	VPS7S-B	VPA7S-V

Figure 4: Features of the metering pump

6) Capped cylinders A and B: We require a cylinder which presses the bottle with the lid making the coat. The type of packaging has its respective cap pressure.
To see how much force is required to plug the container it

performed manually with the aid of a scale and was obtained as a result it takes 13kg to cover the container which approximately is necessary to apply a force of 130 N. The lid is located on the container waiting to be pressed by the roller a, to be the top of a highly flexible plastic material at the edges, it provides the advantage of easy covered by actuating the pneumatic cylinder and thus the container will be covered. The race is advisable to be a 50mm or higher, due to the installation conditions on the structure.

Table 1: Features covered cylinder

TYPE	*EMC-IAS20X50S*
Fluid	Compressed air
Function	Micro double acting cylinder
Brand	SMC
Connection [thread]	M5
Maximum operating pressure	0.1-0.9 [MPa]
Operating temperature	-2 To 80 degrees Celsius
Material	Shirt: stainless steel Cylinder Heads: Die-cast aluminum
magnetic ring	standard
Diameter piston or sleeve	20 mm
Rod diameter	8 mm
Race	50 mm
Assembly	compact Hard

Given that the cylinder B capping system has the function, prevent the advancement of the container without making calculations forces being negligible, considering the use of a pneumatic cylinder of the same features mentioned above in **Table 1.**

b. Electronic design and automation

1) Circuit Tire: The tire control scheme of the metering pump and cylinders is presented as follows. Both pneumatic cylinders and metering pump are commanded by solenoid 5/2 (five-way, two positions), which are activated by their respective solenoids. The speed with which the rod moves is established through the flow controllers.

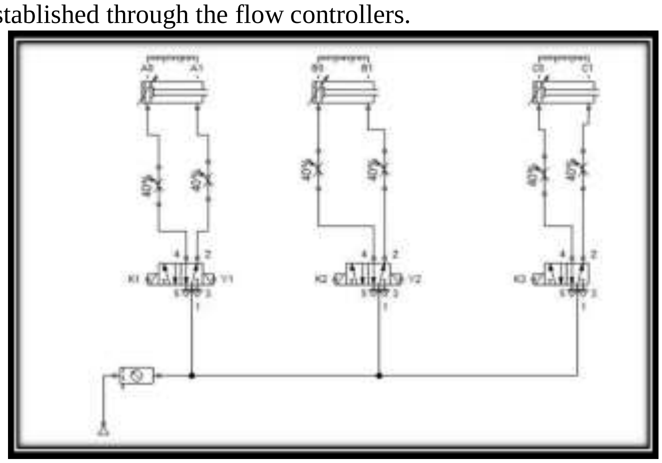

Figure 1: Pneumatic control scheme

2) Inputs and outputs System: For proper selection of the data acquisition board is necessary to know how many inputs and outputs are required which types of signals will handle and process to be performed. In addition it is essential for programming in an orderly way and make a proper connection to acquisition card data which is going to control the whole packaging system, capping and labeling.

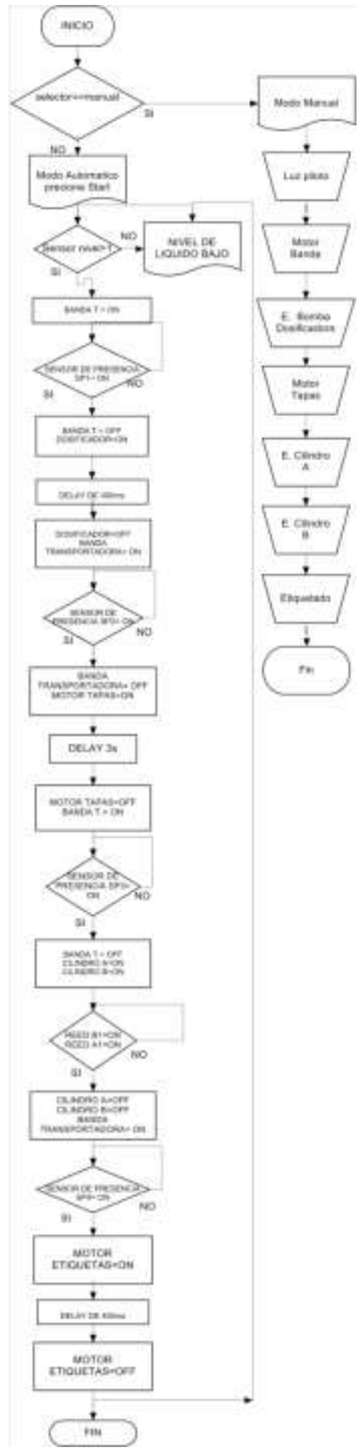

Figure 6: Flowchart

Inputs: The input signals are the presence sensors (photoelectric) as well as magnetic sensors (REED), which provide the required signals to the DAQ perform control as well as the buttons and the manual selector . All these signals are digital type.

Table 2: Input Descriptions

INPUT	TYPE	DESCRIPTIÓN	SPECIFICATIÓN
A0	D.	BUTTON NA	START
A1	D.	BUTTON NC	STOP
A2	D.	PULSADOR NC	EMERGENCY STOP
A3	D.	SELECTOR MANUAL/AUTO	
A4	D.	DOSAGE PRESENCE SENSOR	PRESENCE = 1 NO = 0
A5	D.	PRESENCE SENSOR COVER	PRESENCE = 1 NO = 0
A8	A	LEVEL SENSOR	FULL = 3.5V EMPTY = 0V
D1	D.	PRESENCE SENSOR COVERED	PRESENCE = 1 NO = 0
D2	D.	PRESENCE SENSOR LABELLING	PRESENCE = 1 NO = 0
D3	D.	SENSOR REED A0	PRESENCE = 1 NO = 0
D4	D.	SENSOR REED A1	PRESENCE = 1 NO = 0
D5	D.	SENSOR REED B0	PRESENCE = 1 NO = 0
D6	SR4	SENSOR REED B1	PRESENCE = 1 NO = 0

Outputs: Those that gives action to pneumatic or electric actuators and are digital relay type.

Table 3: Description of outputs

OUTPUT	TYPE	DESCRIPTION
QA0	D.	DOSAGE SELENOID
QA1	D.	A CYLINDER SOLENOID
QA2	D.	B CYLINDER SOLENOID
QA3	D.	MOTOR CONVEYOR
QA4	D.	MOTOR COVER
QA5	D.	ENGINE LABELS
QA6	D.	PILOT LIGHT GREEN
QA7	D.	PILOT LIGHT RED

3) Arduino Mega: A plate consisting of a micro controller, created to facilitate the use of electronics. The Arduino Mega module has 54 inputs / outputs (of which 15 can be used as PWM outputs), 16 analog inputs as to the Arduino to function as a DAQ requires LVIFA_Base that is loaded into the microcontroller software Arduino. You must select the serial (COM) with which it will communicate the Arduino with the computer is the same, by default most of the time the system uses the COM15, then proceed to load the code to the end of the program will display a message that has been loaded successfully, as shown in the following illustration:

Figure 7: Arduino Mega

Table 4: Features Arduino Mega

Microcontroller	***Atmega2560***
Operating Voltage	**5V**
Input Voltage (recommended)	**7 – 12V**
Input voltage (Limit)	**6 – 20V**
Digital input-output pin.	**54 (15 can be used as PWM output)**
Analog input pins.	**16**
DC per pin IO	**40 mA**
DC on pin 3.3V	**50 mA**

Flash memory	**256 KB (8 KB occupied by the bootloader)**
SRAM	**8 KB**
EEPROM	**4 KB**
Clock frequency	**16 MHz**

4) HMI: The process in which the user contacts the machine is called interface. The man machine interface (HMI) must be adapted to the capabilities of the module, so this is useful and significant. The HMI in this case is done through the help of LabView software, which provides a graphical environment allowing the monitoring, supervision and control of processes in this case for the teaching module packaging, capping and labeling, giving greater functionality and maximizing the elements of the module. The HMI must have a visual environment ordered following the sequence of the process to be performed in real time.

Figure 8: HMI design

5) Electrical connection diagram: Shown as are the connections I / O card data acquisition:

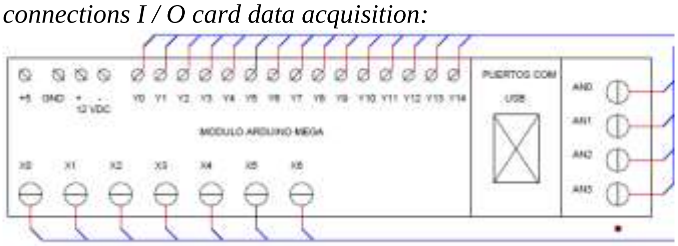

Figure 2: Electrical connection

III. IMPLEMENTATION AND COMMISSIONING

The following describes each of the steps and systems involved in explaining its operation training module and elements involved in each.

The module systems are:
-Liquid dosage.
-Covered Container.
-Labeled.

1) Stage dosage: This process begins once the presence sensor detects the passage of the container by the conveyor belt, this stops at the exact location where he is to package the liquid which in this case is water. Once the dosing pump end the dispense cycle conveyor belt started moving to the next system, the metering pump starts downloading to both receive the signal from the presence sensor, a time for liquid discharge is established then it is sent signal to the controller (DAQ) to indicate the end of the cycle and enter the liquid to the cavity to perform the next download.

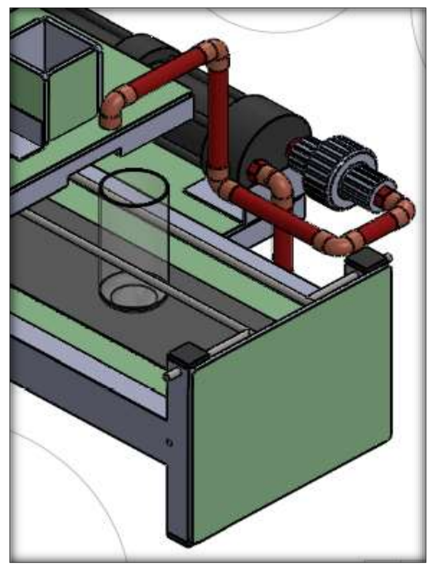

Figure 3: Liquid dispenser

2) Capping stage: As in the previous system the presence sensor is who gives the order to start with the stage covered, upon detection of the container filled with liquid and the second sensor above named conveyor belt stops where small dc motor is activated by pushing a lid to the container, after this the band should continue its march to the next point where a double-acting cylinder making stem its advance press the cover leaving the sealed container is activated. A second double-acting pneumatic cylinder is activated, its function is to position the container in the right place for a perfect covered.

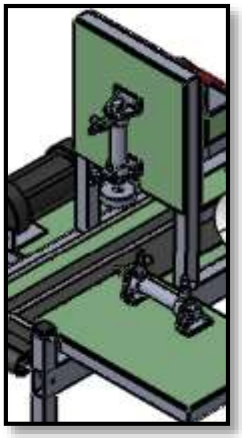

Figure 4: Capping step

3) Stage labeling: As in previous systems or stages that start at the signal of the presence sensor which detects the package this time and covered, then the motor rotates the angle at which the passage of container label is automatically affixed to thus ending this whole process comprising the training module.

Figure 5: Stage labeling

4) Conveyor belt: It is responsible for transporting the container from which is empty by the module stages, until a fluid-filled, capped and labeled container.

Figure 6: Conveyor belt

Then the entire set of training module liquid packaging, capping and labeling shown:

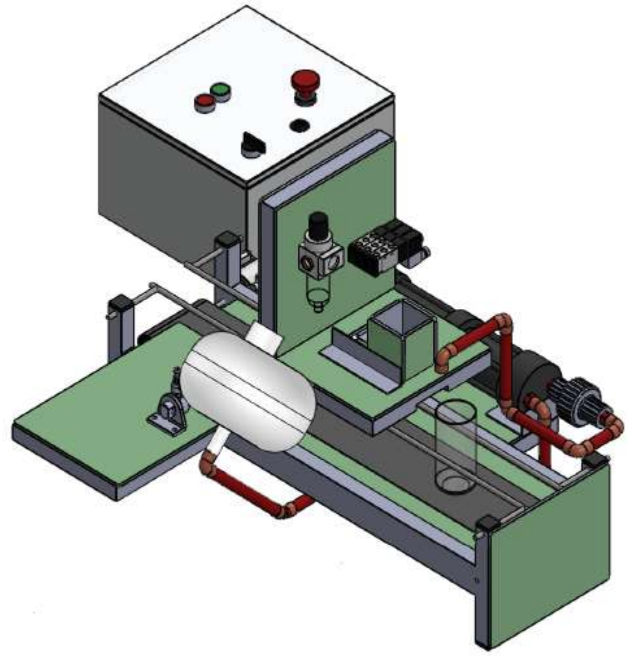

Figure 7: Full set of didactic module

IV. TESTS AND ADJUSTMENTS

It should ensure the proper functioning of the elements of the training module liquid packaging, capping and labeling, once these have been implemented, for which we proceed to testing and adjustments.

a. Functional tests of the sensors.

To perform this test, continuity is checked by using a multimeter, in the sensors involved in the module, if any continuity means that the sensor signal is sent without any problem to the data acquisition board. In the case of magnetic switches that are located REED as limit switches at the ends of pneumatic actuators, which when activated will verify whether the sensors are activated or not. In the case of photoelectric sensors it is much easier to check because this has an LED that indicates whether the presence in this case the container is detected, but for the safety of its functioning can be tested continuity.

Table 1: Sensor Test.

Sensor	**Condition**	**Continuity**	**Setting**	**Continuity**
REED A.0	Cil. A retiring	yes	None	yes
REED A.1	Cil. A advanced	yes	None	yes
REED B.0	Cil.B retiring	yes	None	yes
REED B.1	Cil. B advanced	yes	None	yes

S. P. 1	Dosificado	yes	None	yes
S.P.2	Tapas	yes	None	yes
S.P.3	Tapado	yes	None	yes
S.P.4	Etiquetado	yes	None	yes

b. Testing operation of pneumatic actuators.

The forward and reverse speed of pneumatic actuators is established through these flow regulators regulating the speed of progress either as a return. The metering pump requires a moderate flow to proceed to packaging liquid and rapid return for loading liquid. A cylinder for the required progress of normal since this cylinder serves to prevent the advance of the package, similarly to kickback. The cylinder B demand for lower-middle, to the process capping speed given that the container is made of glass and if speed is excessively fast can damage the container.

The process to be followed for calibration is as follows: The controller turn all the way to its position which is 100%, then to the other position that is closed is 0% of the flow of air, he is counting the laps run regulator and thus regulate the speed as appropriate for each share either forward or reverse.

Table 2: Speed control actuators

Actuator	Speed %		Turns screw	Forward / reverse
	Advance	recoil	Number of turns	
Dispenser	35 %	80 %	6	Yes
			2	
A	50 %	50 %	2,4	
			2,4	Yes
B	45 %	45 %	3	
			3	Yes

V. CONCLUSIONS

- Mediante el uso del módulo didáctico de envasado tapado y etiquetado de líquidos controlado por DAQ, se complementara los conocimientos y fundamentos teóricos vistos en el aula, para un aprendizaje más didáctico.
- Se ha realizado una comparación, selección y dimensionamiento de los elementos principales del módulo didáctico como son actuadores neumáticos, motores, dispositivo de control, estructura y demás elementos complementarios para un funcionamiento correcto del módulo y pueda ser usado como una herramienta didáctica para los estudiantes de la carrera en ingeniería mecatrónica de la UTN.
- Se ha realizado el control de un proceso industrial en este caso específico de una envasadora de líquidos, tapado y etiquetado usando recursos tanto en software y hardware para tener un interfaz hombre máquina y poder controlar o monitorear los principales parámetros del modulo didáctico.
  Se desarrollo 5 prácticas para el uso del modulo didáctico, las cuales permiten al estudiante comprender de una mejor manera y con mucha más versatilidad a la adaptación, ya que el módulo se encuentra abierto a modificaciones tanto en su programación, como en dispositivos.

VI . RECOMMENDATIONS

- Para garantizar el aprendizaje y una correcta utilización del módulo, se sugiere regirse a la guía de prácticas que se presenta.
- Revisar y cumplir con el manual de mantenimiento del módulo didáctico, para asegurar que las conexiones y los elementos se encuentren debidamente montados.
- Como paso previo a la iniciación para el control automático del módulo, se debe garantizar que la cavidad de la bomba dosificadora este llena y libre de aire, para garantizar la repetitividad de dosificado, en lo que se refiere a volumen de líquido.
- En el caso de que el uso del módulo se lo realice de forma paulatina o periódica es recomendable la adaptación de un lubricador neumático.
- Este módulo es funcional y versátil de manera que se podría incrementar varias etapas, como la de control de calidad mediante visión artificial. Para un completo aprendizaje y dominio de destrezas por parte del usuario.

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