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Installation, control and automation of Carrier line

Instalación, control y automatización de línea Carrier

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Abstract

For centuries, humans have attempted to improve their living conditions, seeking to facilitate their daily tasks and in the industry, seeking to improve production processes, in order to be more competitive and generate greater wealth through their work, trying to avoid work risks and accidents, improve product quality and production times, as well as downtime. The design proposed for this work is that of a roller conveyor by gravity, controlled and monitored by PLC, sensors, dosers, and data matrix cameras, in order to have internal control of the manufacturing process of the Carrier piece. The automation of this conveyor line will reduce transport times between each work operation, eliminating unnecessary movements and increasing mobility in each work operation. This will help increase production, in addition to reducing mishandling of the piece caused by the wrong manipulation of the operator.

Automation, Control, Production line

Resumen

A través de los siglos el hombre se ha propuesto mejorar sus condiciones de vida, buscando facilitar sus labores cotidianas y en la industria buscando mejorar los procesos de producción, con el fin de ser más competitivo y generar mayor riqueza atreves de su trabajo, buscando evitar riesgos de trabajo, accidentes laborales, mejorar su calidad en el producto y tiempos de producción, así como tiempos muertos. La propuesta del diseño de este trabajo es la de una transportadora de rodillos por gravedad, controlado y monitoreado por PLC, sensores, dosificadores, cámaras data matrix, para así tener un control interno del proceso de fabricación de la pieza Carrier. La automatización de esta línea transportadora reducirá los tiempos de transporte entre cada operación de trabajo, eliminando los movimientos innecesarios y aumentando la movilidad en cada operación de trabajo, esto ayudará a aumentar la producción, además de reducir el maltrato de la pieza producido por el mal manejo del operador.

Automatización, Control, Línea de producción

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Introduction

Industrial automation

Industrial automation is the application of different technologies to control and monitor a process, machine or device that usually performs repetitive functions or tasks, causing it to operate automatically, minimizing human intervention. What is sought with industrial automation is to generate as much product as possible in the shortest possible time, in order to reduce costs and ensure quality uniformity.

There are different types of automation and, based on the needs of the process to automate, the corresponding automation will be designed. The different types of automation are mentioned below:

- Fixed automation.
- Programmable automation.
- Flexible automation.
- Integrated automation.

Material handling

The handling of materials and products can be defined as the preparation and placement of each of them to facilitate their movement within an industrial process. It includes all the operations to which the product is subjected, except the actual manufacturing work and, many times, the handling of materials and products is included as an integral part of the process.

Nowadays, there has benn a special interest in the mechanical transport of materials and products because the workforce is increasingly expensive and, at the same time, dangerous, depending on the process.

By using mechanical means to transport materials and products, safety is greater, with less risk of accidents, they do a more arduous work and at the same time they are faster and more efficient.

For industrial processes that include assembly or transfer lines of materials or products, the use of a mechanical transport system is essential. In most of them, roller belts or conveyors are used, as it is in this case.

This is due to several advantages that they present, such as the great distances they can transport products, ease of adaptation to the land or architecture of the process within the plant, their great transport capacity, the availability to transport various materials and products, and they do not alter the transported product. With time, conveyor belts have evolved their construction, design and operation according to the needs and characteristics of the production processes. There are different types of conveyor belts and they are classified based on their type of conveyor:

- Free roller conveyor

The roller conveyor is the most versatile gravity system. As the name implies, it uses metal rollers to facilitate the handling and transfer of a wide variety of products (boxes, parcels, packages, tires, pallets, barrels, etc.)

- Skate wheel conveyor

This system is used to transport light packages with a soft and irregular bottom. Ideal for off-loading trucks. The wheels are galvanized to resist corrosion.

- Flexible roller conveyor

Lightweight and portable, it is the first option for transporting materials with a regular surface and considerable weight. Used in loading and unloading trucks, packing lines, inspection and product dispatch. Unlike skate wheel conveyors, this type of equipment cannot handle products that exceed the width of the roller. These conveyors can move any product with a uniform surface such as boxes, packages, containers, etc.

- Flexible skate wheel conveyor

It is the first option for materials with an uneven base or moderate weight. These conveyors can move boxes, trays, wooden and metal bases of various sizes. Excellent alignment characteristics which prevent lateral sliding and reducing the need to use side guard.

- Ball transfer conveyor.

This omnidirectional system, allows moving the load with little force on the surface of the conveyor.

Used when manual rotation or correct positioning of a product in assembly, revision and control lines is required. Ideal for times when two production lines converge, with the condition that the item to be handled has a regular and firm base.

Types of sensors

A sensor is basically a device that has the power to detect movement, noise, pressure, light and any other type of external element to convert it into an electrical signal. It is possible that the same equipment has different types of sensors for each operating unit. A sensor is a device which has the property of being sensitive to a magnitude of the surrounding environment, if this magnitude varies, the property also varies with some intensity, that is, it manifests the presence of said magnitude and also its measurement. There are different types of sensors and a common way to classify them is based on the digital and analog output data; they are used to develop physical interfaces, robotic systems, etc.

Some of the most commonly used sensors are:

- Photoelectric sensors.
- Inductive proximity sensors.
- Ultrasonic sensors.
- Capacitive proximity sensors.

During the development of this work, photoelectric sensors were used. These helped to detect the absence and presence of the carrier piece within the process.

Pneumatic system

For this work, the movement of the piece was carried out by means of pneumatic pistons installed inside the conveyor line. Pneumatic circuits are circuits aimed at providing the automatic drive of a device by means of a pressurized fluid (air). The pneumatic circuits use compressed air, because air is abundant, it can be stored and it is clean. The applications of the pneumatic circuits are varied, like the closing and opening of doors of trains and buses, vehicle brakes, operation of machines and tools, etc.

- Programmable logic controllers

For the selection of the Programmable Logic Controller, it is necessary to define which are the input and output signals as well as the characteristics that will be used in the operation of the conveyor. A programmable logic controller PLC is an application-specific microprocessor for industrial process control. A PLC is a control unit which includes all or part of the interfaces and/or sensors of the process, the current trend to control them is to use them in a network or as peripherals of a computer, where the computing power is combined with the ease of standard interfaces offered by the PLC.

Work development

The company made a line balance, where we identified that to increase production it was necessary to reduce transport times and relocate operations, since the transport of the piece between station and workstation was done manually. The development of this work was carried out with the traditional methodology, together with the agile methodology in the programming design part. It was necessary to implement gravity roller conveyor systems through the production line, an automation system was implemented in each of its operations, placing sensors, dosers, data-matrix cameras at midpoints of the operations, PLCs (Programmable Logic Controllers), in order to have an internal control of each step of the process, of each of its 16 operations, and thus control the path in the process. This system will greatly reduce the manufacturing time of the piece and save money during the machining, assembly and welding of the piece to be manufactured.

This work was designed based on the spaces available within the plant, using a roller conveyor and proposing different systems within it: a motion transmission system, an electro-pneumatic system and a control system governed by PLCs with sensors.

This design was made based on the characteristics and needs of the production line obtained by a physical survey in the panta, with the reliability that the production process of the carrier piece was already clearly known and with its possible modifications, if they were required in this production plant or in any other.

Methodology

Motion transmission system

For the mechanical design of the roller conveyor, the total dimensions of the Carrier line were taken into account first, based on this, all the mechanical diagrams were designed, such as the mechanical structure recquired for the conveyor, including its bases and the separation suitable between rollers. According to the given dimensions of the Carrier line, the mechanical diagrams were designed; for this step, we analyzed the movement of the piece for its correct manufacture, creating a correct installation of the conveyor line.

Figure 1 shows the diagrams that were made for the manufacture of the conveyors with their respective dimensions.

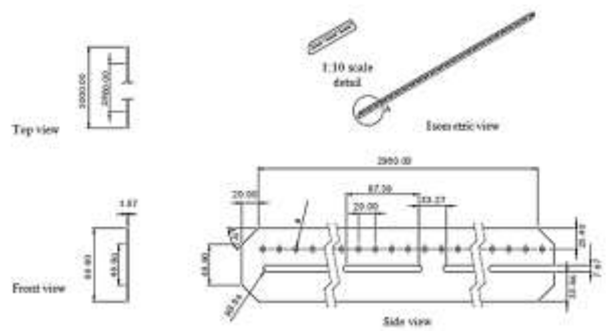

Figure 1 Mechanical diagram of the roller conveyor
Source: Prepared by the authors

Figure 2 shows part of the mechanical design of the roller conveyor, where the parts of its design are specified. The figure is complemented with table 1.

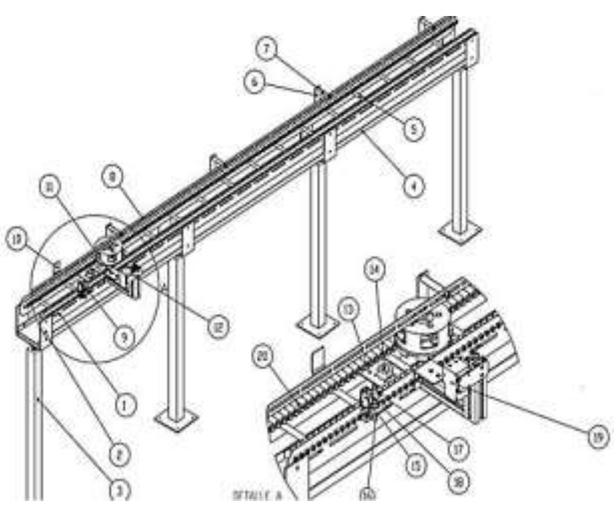

Figure 2 Scale diagram of mechanical components
Source: Prepared by the authors

No. of element	No. of piece
1	Laterals
2	Lateral supports
3	Support - legs
4	Burr
5	Lateral separator
6	Guide shaft support
7	Guide shaft
8	Guide
9	LR-2B100N sensor base
10	R-5 Reflector Base
11	Aluminum outline base
12	SR-1000 Base
13	RSQB32-20D stop base
14	RSQB32-20D
15	LR-ZB100N_ZB100P
16	OP-87404_Bracket
17	OP-87405_Bracket
18	OP-87406_870407_Bolt
19	SR-1000
20	Roller

Table 1 Conveyor mechanical design components
Source: Prepared by the authors

Electro-pneumatic system

For the installation of the pneumatic pistons, the conveyors were designed with base slots for the installation, which is where the pistons are mounted on the lateral bases of the conveyor; the slot was placed so that it could be adjusted in some future or with some modification. Figure 3 shows the mechanical design of the base for the assembly of the pistons.

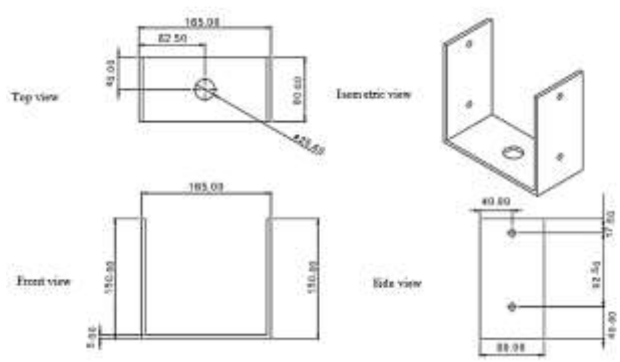

Figure 3 Base for pneumatic pistons
Source: Prepared by the authors

Figure 4 shows the pneumatic piston assembly diagram used in the conveyor belt.

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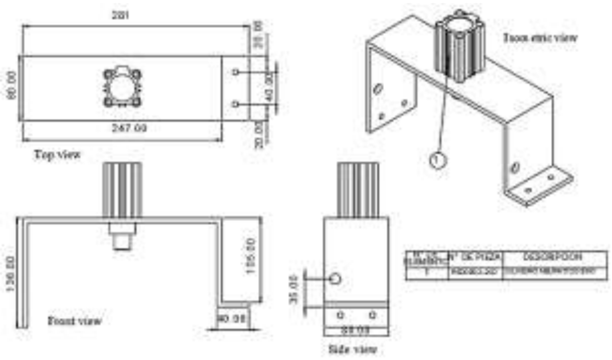

Figure 4 Assembly diagram of pneumatic pistons
Source: Prepared by the authors

Figure 5 shows the design for the lifting pistons that are required in some of the process stations.

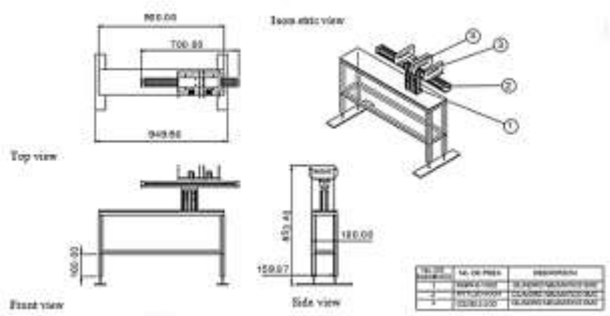

Figure 5 Mechanical diagram of lifting pistons
Source: Prepared by the authors

Control system

The programming is ladder type; Figure 10 shows part of the program used within the automation of the Carrier line conveyor belt.

The main function of this automation is to have an internal control of each operation. Since within each of the operations Data-matrix sensors and detection cameras will be placed in each piece, this system is implemented at the entrance and exit of the operation, in order to detect in time the exact movements of the pieces; in case of having lost pieces, the company will be able to detect them in time from a computer, where it will receive all the exact information of each piece. In order to implement this, a database was created where this information will be collected; in the control cabinets the PLCs are mounted.

To carry out the automation process between each operation, Allen Bradley Micrologix 1200 PLCs were installed. These PLCs were selected to take full advantage of the proposed programming and implementation.

For the installation and commissioning of the PLCs, physical arrangements were designed within the assigned available work area that was assigned, using the SolidWorks program; with the help of the program and taking into account the space allocated for each cabinet, we carried out the measurements of the spaces to design the physical arrangement at scale. Figure 7 shows the general connection diagram of the source.

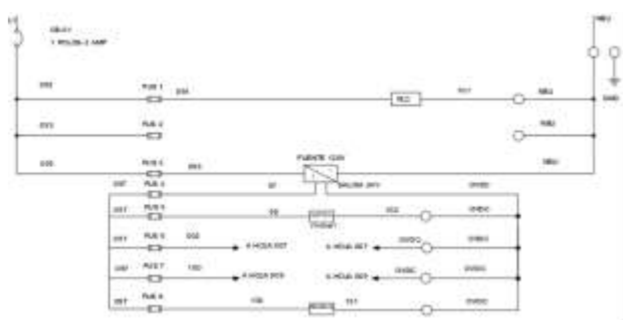

Figure 6 General connection diagram design
Source: Prepared by the authors

Results

The results of each part of the development of this work are shown below.

Motion transmission system

One of the main objectives of this work was to optimize through a conveyor belt the travel times of the manufacturing process of the Carrier line; in figure 8 we can see part of the installed conveyor belt.

Figure 7 Conveyor Belt Installation
Source: Prepared by the authors

Electro-pneumatic system

The electro-pneumatic system designed for the different fixed and rotating cylinders can be seen in Figure 8 and 9, showing the results obtained.

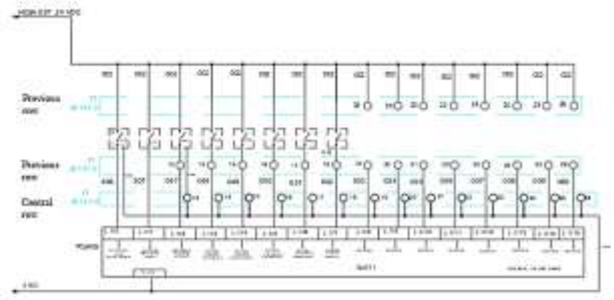

Figure 8 Connection diagram of the rotating piston, chamber, presence sensor
Source: Prepared by the authors

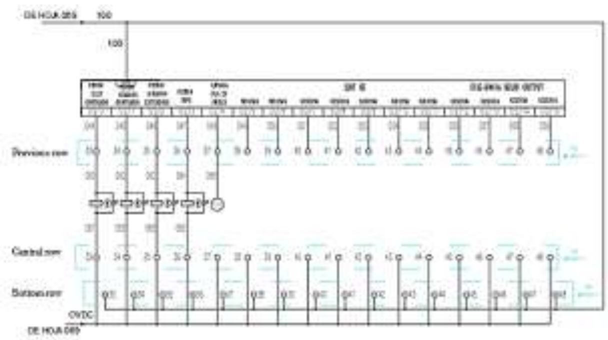

Figure 9 Electric diagram of stop piston, extended spinner, contracted spinner
Source: Prepared by the authors

Control system

We used ladder programming for the development of the program applied in this work; part of the program is shown in Figure 10.

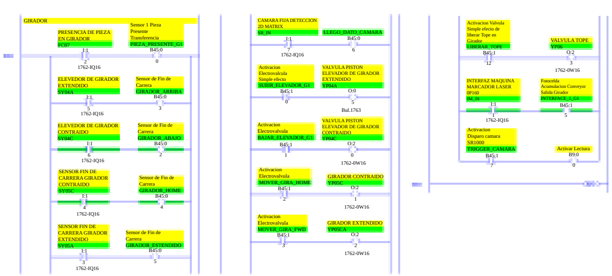

Figure 10 Ladder program, Carrier line conveyor
Source: Prepared by the authors

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Conclusions

The results obtained were those desired during the work proposal and the design of automation and operation of the conveyor belt.

The system provides information on the location of the piece, showing in which station it is located for its machining, as well as the progress within the manufacturing process; thus, offering better time control and machining of the piece.

An area of opportunity of the system is the creation of automation subsystems where the process can be handled in a modular way, for any events of failure in any of the 16 workstations through which the piece is transported.

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