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Reconfiguration of Didactic Conveyor Belt Using Lean Manufacturing Tools

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Abstract: The present research presents the reconfiguration of a conveyor belt used for teaching practices in a higher education school, supported by lean manufacturing tools such as the Jidoka and Andon system. The conveyor belt is located in the methods engineering laboratory of the Industrial Engineering faculty, where it was aimed at seeking its automation and reconfiguration so that it can adapt to the needs of the different practices that are taught in the laboratory. It was possible to implement a Jidoka System so that by means of a sensor indicates when the pieces are out of tolerance showing a light signal, typical of an Andon system. A few bases of the band were redesigned to make them removable and achieve the modularity of the equipment depending on the practice to be performed.

Keywords: Lean Manufacturing, Jidoka, Andon, Reconfigurable Conveyor

1. Introduction

The work presented here was developed within the facilities of the Method Engineering laboratory of the Faculty of Industrial Engineering, where, in the search to optimize the laboratory resources available to perform a greater variety of practices, the objective of this project was to be able to achieve that the conveyor belt could be adapted to each practice, and that it allowed the use of lean manufacturing tools. One of the tools requested was Jidoka, which seeks that each process has self-control so in this way "make the operation stop when an abnormal condition is detected" and thus it becomes visible that there is a fault and the production line can stop and resolve the situation and return to normal production, without generating defective parts. It was also sought to implement an Andon system, which is a Japanese word that means "lamp", usually a bright sign that turns on when an abnormality is detected in the process and can be reported immediately to solve it shortly and maintain stability of the whole process. For the incorporation of the elements previously indicated to the conveyor belt, we worked with a group of students who designed some components and manufactured them by means of additive manufacturing.

2. Method

In order to achieve modularity, the need to reconfigure the conveyor belt of the Method Engineering Laboratory was raised in order to develop new practices for the students, for which first a pre-design of a new practice was made using the tools of Lean Manufacturing, Andon and Jidoka (Figure 1). A practice was proposed in which plastic pieces were transported along the band according to certain specifications, but also include parts that were outside these specifications so that by means of a sensor they were identified, a light signal was given and with electro-pneumatic elements they could divert from the main line of the band towards a line dedicated to "defective" parts, so that the main line could continue working without stopping and a "student-operator" could go and check the piece out of specifications.

In this way it was possible to identify the necessary components to achieve the reconfiguration of the band and the design of the new practice (Table 1), it was decided that the pieces that would be transported would be PVC barrels (Figure 2) and the specification to be sensed would be the height of the same, these pieces are already used in other practices within the laboratory, so the next step was to classify all the necessary components among parts that already had, what was necessary to buy and some would be designed and manufactured by additive manufacturing . Subsequently, it was proceeded to take the band measures (Figure 3) in order to carry out the design and purchase of the pieces that will allow the reconfiguration of the band. The design of the bases on which the sensor and the actuator (Figure 4) would be mounted were made, which will be removable to allow reconfiguration of the band to will allow its use in other practices; the bases will be on rails that were already on the band. A part of the bases is made of wood and the rest was designed by the group of students and elaborated by additive manufacturing in an ABS polymer, and to facilitate its assembly and disassembly according to the practice that is being carried out in the laboratory, joined to the band through a nodular iron press. Another necessary element is the so-called “triangle” that guides the pieces that move in the conveyor belt towards the sensor to identify if the part is defective or not, which will make the actuator mechanism work; The triangle is made of PVC pipes on two sides and the third side is acrylic, this piece was also mounted on the band using a nodular iron press. Finally, the design of the rail (Figures 5, 6) was carried out, a lower one whose purpose is to separate the “defective” parts that were pushed by the actuator and thus reach a different container than the approved parts, and the second rail, the upper one destined to the pieces that are within specifications, the lane is made of PVC material and will be incorporated into the lane that already is on the band, for which it was decided to leave the necessary distance to have 2 seconds of delay between the proximity sensor and the actuator and piston action. With all the pieces made, the assembly and reconfiguration of the conveyor belt was carried out so that it can be conditioned according to the practice being developed.

3. Results

To check the correct functioning of the reconfigurable conveyor belt, 3 test runs were carried out using different pressure settings, distance between parts, piston spacing to identify the most suitable to use during practice with students, so that the system identifies parts out of specification and divert them down the lane dedicated to those pieces. The height of the sensor was adjusted to pass 30 pieces (barrels) and that all parts are out of specification.

In test 1 the air pressure was adjusted to 5 bars with the piston at a base separation of 0 cm, and the airflow valve at 100%, with these parameters the sensor was able to detect 100% of defective parts, but only 80% of the parts were diverted correctly.

In the second test, the values were modified at 4 bar pressure, a distance between the piston and the base of 3.5 cm, and the air valve open at 50%, which kept the detection at 100% and the deflection of defective parts improved to 83%.

For the third test, values of 4 bar of pressure for the air were used, and the separation of 3.5 cm was maintained but the opening of the air valve was increased to 80% which resulted in a 90% increase in deviation and the detection was maintained at 100%.

The foregoing indicates that one of the objectives of the project is met, to achieve the reconfiguration of the conveyor to allow its modularity that manages to adapt to the needs of the laboratory practices; however, it is still necessary to make the necessary adjustments to make the deviation of the "defective" parts 100%.

4. Discussion

Although the expected results of the project were not achieved, the group of students, advised by the teachers, achieved the modularity of the conveyor, with which a wider variety of laboratory practices can be designed to favor the learning of the students of Industrial Engineering; It is still necessary to adjust the electro-pneumatic elements to ensure that all defective parts can be diverted to the appropriate rail and container. It should also be pointed out that Lean Manufacturing tools have not yet been fully implemented; with the sensor the Jidoka system was mounted, which identifies when there is a piece outside the specification and performs the action of diverting them made a special container of that pieces, but it has not yet been possible to install the light board to give the visual signal of when there is a piece with defect.

Therefore, we conclude that thanks to the modification made to the conveyor belt, students attending the Method Engineering Laboratory will be able to analyze situations very similar to those presented within a company in operation and the way in which they must react when they encounter some abnormality within the process.

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5. Tables and Figures

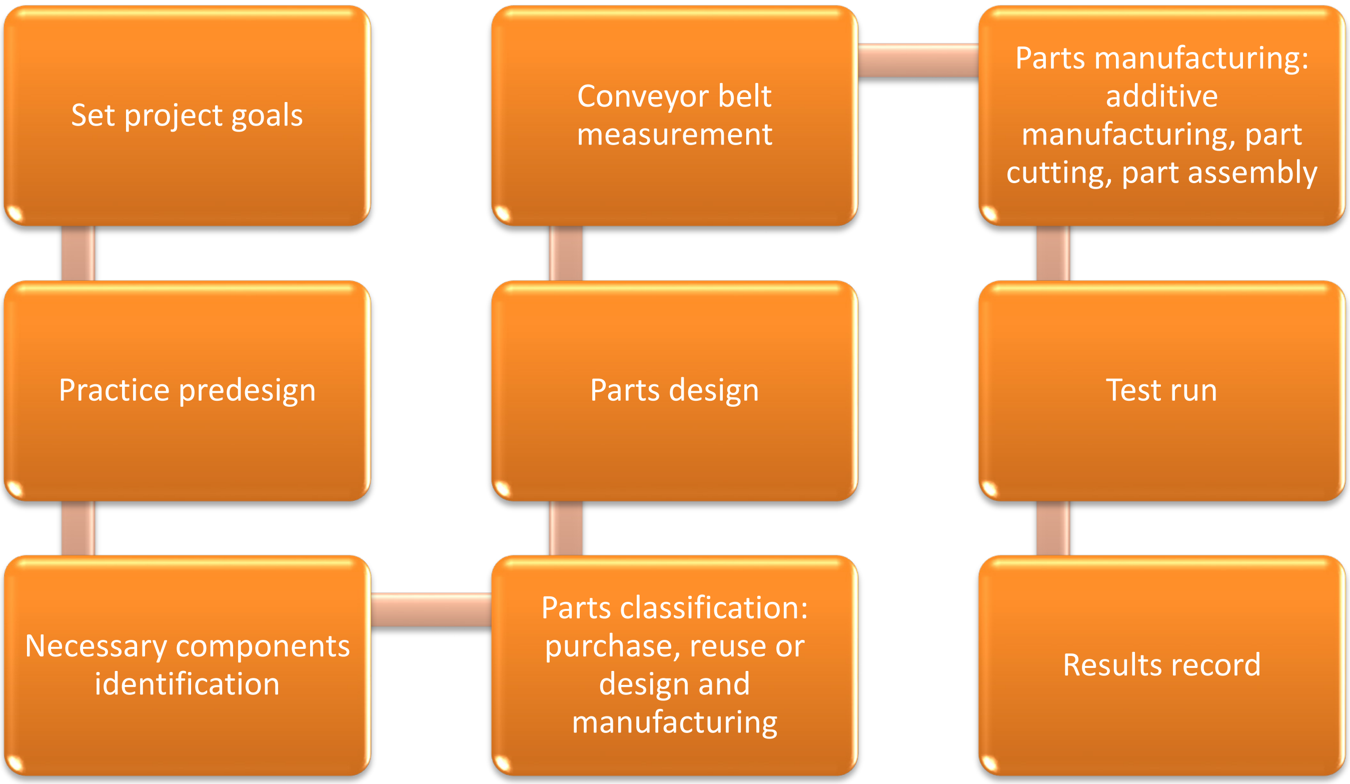

Figure 1. Reconfiguration methodology. Bacre-Guzmán (2019)

Figure 2. Plastic barrel

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Table 1. Andon prototype material

Part
7/8" PVC tube
Nodular iron press
7/8" pvc elbow
Plug
PVC glue
7/8" T junction
Wood
Acrylic
Epoxy clay
Nuts and bolts
Cianoacrilato (super glue)
Steel strips
Soldering tin
Resistol 850 glue
Resistol 5000 glue

Table 2. Electric equipment

Material
Proximity sensor
Double acting piston
24 V regulator
PLC FESTO CECC-LK
Compressor
Humidity filter
Banana jack cables
Hose
Pressure regulator
Compressed air distributor

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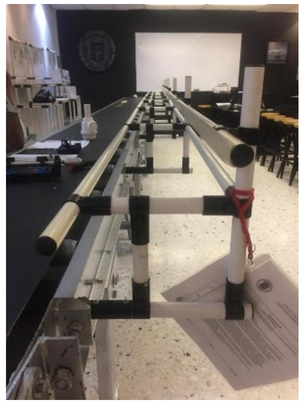

Figure 3. Belt conveyor

Figure 4. Actuator base

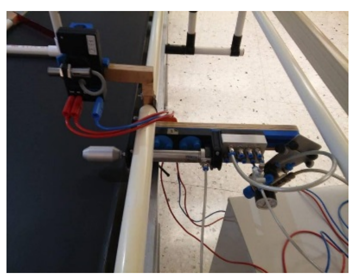

Figure 5. Detachable rail.

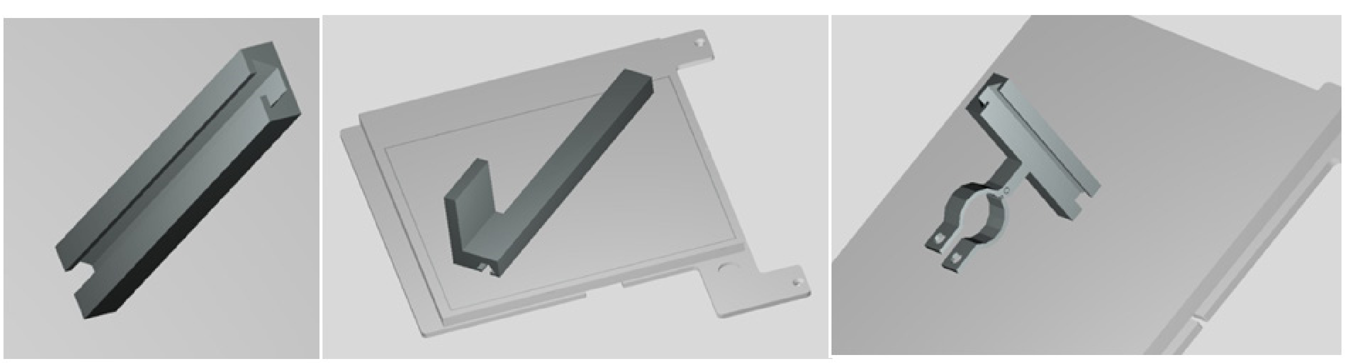

Figure 6. Rail, base and support

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