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Optimization in the orientation recognition for pieces in the base mounting station belonging to the FMS200 through image processing

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Abstract

This research focuses on formulating an improvement proposal for the pieces' orientation recognition from the flexible manufacturing cell FMS-200, located in the Laboratory of Industrial Technology and Production Engineering of the District University *Francisco José de Caldas*, Technological faculty. The paper is aimed at seeking improvements inside the productive processes, through the measuring and selection of a faster and more efficient recognition method. This was done with a general description for the first station of the cell, and with it, a timing study, which determines the process to be improved; also, it is implemented a pieces' orientation recognition, through a Circular Hough Transform. Based on the image processing technique, thus obtaining a fast response time, so when this model is to be applied on a large scale, the operating time is reduced considerably.

Keywords: Flexible Manufacturing Cell, Timing Study, Production, Productivity, Circular Hough Transform.

INTRODUCTION

In the Industrial Production, seeking improvements is constant [1-4], therefore the implementation of several methods that help in optimizing productive chains, allows that the behavior of the procedures generates positive impacts, such as: production increase, costs reduction, quality increase, time reduction, among other advantages, which make industries more competitive. [5-9]

The flexible manufacturing system in which this investigation is based is the FMS-200; is divided by stations and is in charge to execute the assembling process for a bearing. For this case, there is used the first station, whose main function is to mount the base.

One of the sub processes executed by the first station is the orientation check, where the piece is subject to verification by a double effect cylinder, which detects if the piece is suited to continue or not with the production process.

The above, is accomplished thanks to the piece has two holes in the center of its figure, whose diameters are different; the larger diameter indicates the piece is suited, and the smallest reveals the nonconformity. The problem for this exercise is the response time on the part of the cylinder, to identify the right orientation for the piece. In view of the above, the current paper establishes an improvement proposal for the identification and immediate response of the sub process; this proposal implements a camera [10], which identifies the right position of the piece through the Circular Hough Transform, aiming to a response time reduction and helping the process to be more productive and faster.

METHODOLOGY

The process begins with the general description of the flexible manufacturing cell FMS-200 emphasizing the very first station, and each one of their sub processes, attempting to contextualize the topic with which they are going to be treated [11,12].

System Definition:

The flexible manufacturing system FMS-200 (see Fig. 1) is responsible for assembly of bearings. This system is made up of six stations, which are: base mounting, bearing insertion, axis placing, cover placing, screws insertion and robotized screwing. All the components integrated in the processes executed by the FMS-200, are commonly used in the industry, so the user can work with real elements all the time, making learning meaningful.

Figure 1: Flexible Manufacturing Systema FMS-200

As was specified from the beginning, this paper emphasizes the first station of the system, the base mounting (see Fig. 2), the process of the same is described below.

First Station Presentation

Name: Base Station Assembly.

Function: It performs the base mounting serving as a support for the turning device and its displacement.

Initially, the operation begins when the pallet is in front of the station, which is retained by a stop located in the transfer or conveyor belt. There is a confirmation indicating the validity of the pallet position and is obtained through a microswitch which provides the PLC with a signal; and for the case of a wrong position, the base will be rejected.

Figure 2: FMS-200 First Station

Extraction of a base from the feeder: This first process shows a dispenser which has the pieces stored on top of each other, which will fall by their own weight at the moment they are subtracted by the bottom of the feeder; it should be noted that this extraction is executed by a pneumatic cylinder.

Orientation Check: The extracted base in the previous process has a hole in the center, which later will be necessary for other pieces' assembly. The base must be placed on the pallet keeping the hole with larger diameter on top, since this piece can come with a wrong position. Referring to the orientation check for the piece, the station has a cylinder placed vertically, which has a rod which also has a pusher fitting the pieces' hole. It should be noted that a wrong orientation will prevent the process to be executed, and when this happens, a magnetic detector activates, and is here when the PLC control identify this piece as non-suitable and is rejected.

Moving to the transfer zone: For a subsequent treatment, the base is transported to the transfer zone through a pneumatic cylinder with rectangular shape, avoiding the pushing spin. The scroll lane is plane and surrounded by guides to ensure the right transportation of the piece.

Rejecting the wrong base: With the checking process, it was determined there are no conformities with the piece's orientation, which will be rejected. For this, a simple effect cylinder is used, sending the piece to a waste ramp, so the transfer area is free and can restart the cycle using another piece.

Mounting the base on the pallet: *I*f the base orientation is correct, this will go on top of a pallet manually placed in the transfer or conveyor belt; for this, a dual axis manipulator is used where the vertical axis incorporates a platform with four suckers aiming to absorb possible non-alignments, and by this way placing the base correctly on the pallet. [4,13]

Flow Diagram:

After knowing the model for the system, it is necessary to know which flow of the process has the flexible manufacturing cell, and the intention is to modify and improve the development of one of their activities, which is the orientation check for the base (see Fig 3). This process is responsible for a mechanical actuator (double effect cylinder) and it is intended to replace it with an optical recognition, which will allow a faster response time.

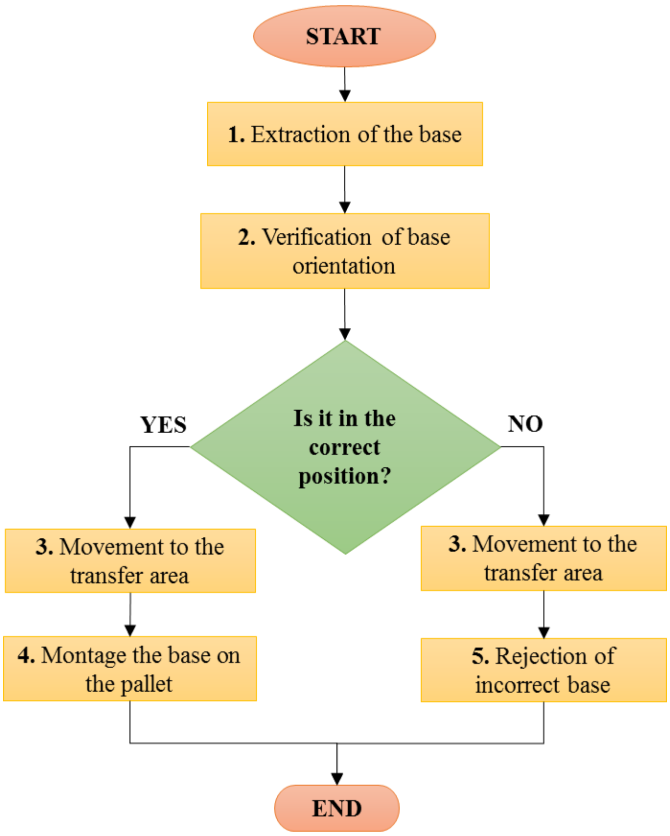


Figure 3: Process Flow Diagram

Time study:

Each one of the stations in the FMS200 has two different operation modes, which are: Manual and Auto. During Manual mode, each time a step needs to be executed, the start button must be pressed so the sequence goes with no interruption; the user who manipulates the station must give continuity by a fast button actuation, so the execution time is linked to the user. In the other hand, during the Auto mode, by starting the process, the same has no pause and the sequence goes continually.

Following, in the Table 1, a time study is shown for each one of the modes, and it considered each sub process so an average time is shown.

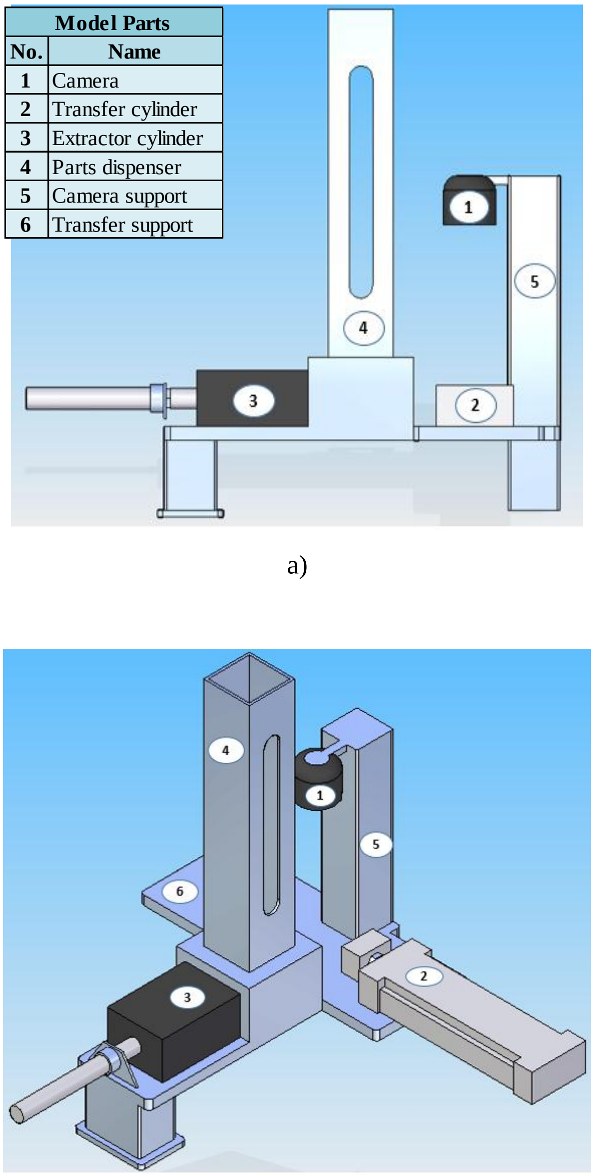
Table 1: Time Study for Manual and Auto modes

Time in seconds – First Station		
Sample	Manual	Auto modes
1	2,6	2,3
2	2,2	1,7
3	1,4	1,8
4	3,6	2,0
5	2,6	2,3
6	1,4	2,2
7	1,6	2,9
8	2,0	1,2
9	2,8	2,8
10	2,9	2,7
11	3,2	1,8
12	2,6	2,5
13	1,4	2
14	2,6	1,6
15	1,6	2,3
16	2,2	2
17	2,6	1,7
18	2,8	2,2
19	1,4	1,7
20	2,0	2,5
Total	45,5	42,2
Average	2,28	2,11

IMPLEMENTATION

With the collected data, is time to fix the implementation of an improvement to the flexible manufacturing cell [14,15], this modification tries to make a change in the orientation checking process, which currently uses a double effect cylinder to execute this task. The change focus is centered on replacing the electro-pneumatic actuator for an optic system based on image processing; the implementation of a recognition algorithm seeks to reduce the action times for this labor.

This new identification process will be implemented under the Circular Hough Transform model, which is an image segmentation tool, classified in the frontier detection technique, allowing to detect geometric shapes through the patron recognition in an image. At the same time, the transform allows the dots grouping with a corresponding model and deletes the non-matching dots. For the patron recognition, it is necessary to describe the parametric equations to be found in the image. According to the quantity of defined parameters inside each equation it is defined the search space; this space has to be discrete so the search can be performed in a finite parameters' set [16].



a)

b)

Figure 4: a) Station Side View. b) Station Isometric View.

In the Circular Hough Transform it should be a binary image obtained from the pixels conforming the frontier of the object, which means a reduced image information attempting to separate regions and identify objects of interest to be used as a reference. Usually, to the differentiation of images process, black and white colors are used. In the lineal transform for schuss recognition, the polar coordinates' equation is used; two parameters compose the equation (ρ, θ), which indicates it is bi-dimensional, as shows equation 1.

$$x \cos \theta + y \sin \theta = \rho \quad (1)$$

For the Circular Transform, as in lineal, it is necessary to define the parametric equation, which for this case is described in equation 2.

$$(x - a)^2 + (y - b)^2 = R^2 \quad (2)$$

Where (a, b) is the center of the circle and R is the radius, so it indicates it has three dimensions. To know which of the dots or pixels from a binary image are inside a circle of radius R, a variation of the position of the circle's center (a, b) is realized for each of the pixels or dots, obtaining a variety for R values. [17]

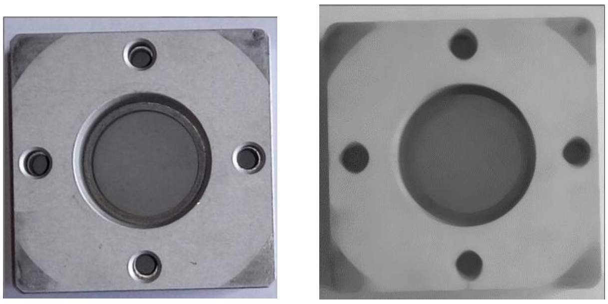
By implementing this algorithm inside the flexible manufacturing cell, it can be determinate which process give the fastest and more effective response regarding the piece orientation; Fig. 4 details the camera implemented and the location in the first station of the FMS-200.

RESULTS

To determinate the behavior of the productive process for the simulation of the flexible manufacturing cell, it should be noted the time study for itself, shown in Table 1, Time Study for Manual and Auto modes, where it can be seen that the response time regarding the piece's orientation check are too elevated considering this cell can be used for large scaling production processes, which would create a bottleneck in the system; the average time for this process is 2,2 seconds according to the results obtained during the study.

The implementation of the Circular Hough Transform as a basis for an appropriate image processing for conformity detection in the piece, was realized after the capture and processing of a wireless IP Camera, brand Bosch NBC- 265-W series, 720p HD with IEEE 802.11 b/g standards, which H.264 compression technology. The processing step, is installed in a PHYTON based development interface, running on a Windows 7, 32-bits operating system. Using an Intel Core I5-4200U CPU 2.3 GHz processor and 6 Gb RAM.

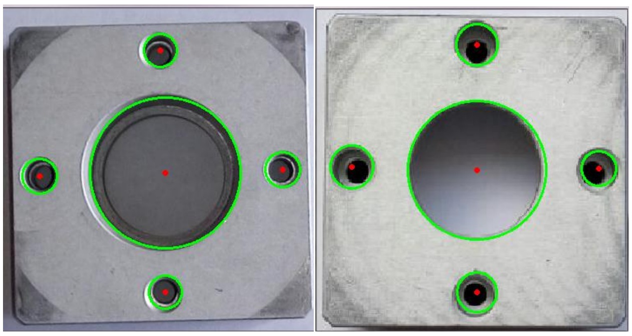
The implemented algorithm for validation, first captures the piece image, then converts it to gray scale, followed by a digital filtered (see Fig. 5), this aiming to adapt the direct input to the Circle Hough Transform function, responsible for evaluating the diameter of all the circumferences disposed in the pieces for selection (see Fig. 6).



a) b)

Figure 5: a) Original Piece Image b) BW filtered image.

As it can be seen in Fig. 6, the algorithm processes the image analyzing and looking for possible circles of the piece. The app will give the total amount of founded circles with their center coordinates (xc,yc) and the radius of all of the founded elements in the photo. By processing the array of this information, it can be quickly identified the differentiator factor of the respective work pieces, since just by validating the data from the central circle (the one with the largest diameter), the orientation for the work piece can be identified; the execution of this algorithm takes barely an average time of 35 milliseconds, equivalent to the 1.59% of the time it takes by a mechanical method



a) b)

Figure 6: a) Straight Piece Detection. b) Backwards Piece Detection.

CONCLUSIONS

This change of technology used during this project, allowed to identify an effective work method according to the response time of the flexible manufacturing cell, with the optical verification prototype it is generated an improvement in the process seeking to extend the action field and to create new improvements on the current system, since the change of technology according to the pieces' mechanical detection reduces drastically the action times, allowing this way an increase for production, and therefore a reduction for the general process' time.

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