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# Design and Development of Pick and Place Gantry System on Conveyor

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**Abstract -** *In industries, it is required that the processes to be very fast and efficient to save time and manpower. Handling involves the movement of materials from one place to another for the purpose of processing or storing. In industries, it is very necessary to use material handling system to move material from one place to another place continuously to minimize operation time. In this research paper the material handling equipment is developed for box manufacturing company, where there are two coloured boxes are manufactured and pick and place system help to segregate that boxes according to colour on respective conveyor. This research paper contains problem statement, objectives of the project, implementation and working of project.*

***Key Words***: **Manpower, Manufacturing, Box, Material Handling, Automation**

## 1. INTRODUCTION

Industrial automation and robotics play important role in growth of industry [20]. The main purpose of using a material handling system is to ensure that the material in the right amount is carefully delivered to the desired destination at the right time at minimum cost [3]. Material handling as such is not a production process and hence does not add to the value of the product but it costs 30-75% of the total product cost [1]. Function of material handling function includes all types of movements vertical, horizontal or combination of both include all types of material fluid, semi-fluid and discrete items and of movements required for packing and storing. The material handling function is considered as one of the most important activities of the production function as out of total time spent by the materials inside the plant area. Different methods such as fork lifting, use of bucket elevators, conveyors systems, crane, etc. has been identified for lifting or transporting bulk materials or products from one place to another in the manufacturing industries depending on the speed of handling, height of transportation, nature, quantity, size and weight of materials to be transported[2] To fulfil this need gantry type pick and place system is developed. the successful completion of this research work contains methodology that followed for development of pick and place gantry system and result after implanting pick and place gantry system on conveyor

## 2. Problem Identification

A box manufacturing company where the boxes are manufactured in two colours that are in black and white. After all the processes, these two boxes are settled on one conveyor. To segregate them according to the colour, two labours are required. One for white colour box and the other for the black colour box. For the implementation of the automation and to make the process faster, it is necessary to design and develop a material handling system which will eliminate the human efforts and make the whole process automated.

## 3. Objectives of the Project

1. To understand the current process of material handling in industry.
2. To identify the boxes according to colour by colour sensor.
3. To pick and place the identified boxes on respective conveyor.
4. To reduce number of labours for Pick and place of boxes.

## 4. Design

There are 3 main parts of this system that is pick and place, conveyor system and controlling system. Some of the parts are selected from catalogue and some of the parts are designed according to design procedure.

### 4.1 Pick and place system

#### 4.1.1 Suction Cups

The white and black coloured box having dimensions of 100 X 100mm. To pick and place that boxes two suction cups are require. Selection cups is based on theoretical holding force corresponds to that suction cups must create in order to handle work piece safety. To calculate theoretical holding force first we required calculate vertical holding force and horizontal holding force the value of that forces from the formula is 12.852N and 6.486N respectively. At the end combined two forces considered and from the manufacturing catalogue the suction cup selected for 0.617N/cup vacuum.

### 4.1.2 Pneumatic Cylinder

For pneumatic cylinder selection the diameter of cylinder is required to select. For calculation of diameter for pneumatic cylinder total weight which is required to hold that cylinder that is box weight, suction cup weight, mounting plate weight is calculated. The diameter of pneumatic cylinder is 1.41mm from calculation. According parker catalogue the model number is selected.

### 4.1.3 Actuator

To move the pneumatic cylinder horizontally actuator is required. For actuator selection parkers EL-Sizing software used. For pick and place activity belt driven actuator is used.

### 4.1.4 Motor and Gear box

Pitch of the actuator = 350

I. Pitch (P) $= \pi D$

$350 = \pi D$

Dp = 111.408mm, Rp = 55.70mm

Where, Dp: - Diameter of pulley (mm), Rp: - Radius of pulley (mm), D: - Distance Travelled (m)

II. Torque (T) = F $\times R$ =2.208 N.M

Where, F: - Force (N)

III. Speed = $\frac{D}{t}$ = 0.375 m/s

V= $\frac{\pi D N}{60\times10^3}$ = 64.285 rpm

IV. Power = $\frac{2\pi N T}{60\times10^3}$ =P = 0.014 KW

From above calculation motor is selected having output power 1.5 KW and speed 1500rpm and rated torque 4. 77N.MM. Worm and worm wheel gear box is used for speed seduction having gear ration 20:1.

### 4.1.5 FRL unit and Direction Control Valve

Working of pneumatic cylinder, suction cup required dust free air for smooth working for that purpose FRL unit is required. To move pneumatic the cylinder up and down and for working of suction cups 5/3 and 3/2direction control valves used respectively.

### 4.1.6 Vacuum generator

Vacuum generator is required to supply vacuum to suction cups. VAK is used for vacuum generator it generates pulse while placing the box on the conveyor due to which boxes placed on conveyor smoothly.

## 4.2 Conveyor System

Design of conveyor system consists of design of shaft, selection of belt material, motor and gear box design.

### 4.2.1 Shaft Design

There are two shafts required one is for belt moving and another is motor mounting shaft. These two are standard shaft according to shaft design procedure these two shafts are checked for stress capability checking. For shaft design maximum shear stress theory is used.

### 4.2.2 Motor and gear box selection

Given: -

Velocity of conveyor: - 7m/min

I.Speed of conveyor (N)

V= $\frac{\pi D N}{60\times10^3}$

$N = \frac{0.11\times60\times10^3}{\pi\times46} = 47.7 \approx 48\ rpm$

II. Factor of safety weight

Belt weight = 1.5 kg

Drive roller weight ($W_D$) = $\frac{\pi}{4}\times(D_o{}^2 - D_i{}^2)\times L\times\rho$

($W_D$)= $\frac{\pi}{4}\times(0.046^2 - 0.042^2)\times 0.180\times 2700$

= 0.134kg

Total weight (W) = Box weight + Roller weight + belt weight = 2.068 Kg

Total weight = $2.068 \times 0.33 = 0.682\ Kg$

Factor of safety weight = $0.682 \times 2 = 1.368\ kg$

I.Torque (T)=FxR = 1.368 X 9.81 X 23 =308.66N.mm

II. Power (P)= 0.00154 Kw

P = 0.00154 X 1.341 = 0.002hp

According to standard catalogue motor of 960 rpm with gear ratio 20 and 0.18-kW motor is selected.

### 4.2.3 Belt selection

PVC material belt is selected from Chiorino's conveyor belt manufacturing catalogue. For selection the weight of box is considered.

## 4.3 Control System

Control system consist reed sensor, colour sensor, relays, global PAC, EtherCAT module, servo drive AC, VFD. Colour sensor is main part of the project it is used to colour detection of object. reed sensors used to know the movement of pneumatic cylinder EtherCAT is the Ethernet based system used to transfer the data from software to system. Parker automation controller (PAC) is combination of advanced logic, multi- axis motion, signal handling, and web-published visualization into one performance driven solution, thus eliminating the need for necessary hardware and communication links, and increasing developer efficiency. The all programming for this application is done in Parker Automation Manger (PAM). The language used for programming is continuous functional chart.

## 5. Implementation

In this paper we implement a system which is used for pick and place of object on conveyor. In this system company uses, belt driven actuator, pneumatic cylinder, suction cups, vacuum gernator, direction control valve, conveyor system, colour sensor, global PAC, EtherCAT module and HMI for easy operating. There are two colour boxes one is in black colour and another one is in white colour. In this mechanism 3 conveyors arranged parallel to each other in which 1 is input conveyor and other 2 are output conveyor. Pneumatic cylinder assembled with vacuum cup and whole assembly screwed to belt driven electronic actuator. Belt actuator moves the pneumatic cylinder assembly horizontally. Vacuum cups used to pick the box and according to detected colour of box it places the box on assigned conveyor. Compressed air is supplied to pneumatic cylinder for up and down position as well as to vacuum generator to generate vacuum and provide to suction cups to for picking and placing action of box. If white colour box detected by colour sensor it sends the signal to pneumatic cylinder pneumatic cylinder goes vertically downward, due to downward movement of cylinder vacuum cups create vacuum in between cup and upper surface of the box and vacuum cup picks the box. As mentioned in the program the picked box placed on the conveyor. After placing the box, it goes back to original position. Same procedure is followed for black coloured box but pneumatic cylinder placed that box opposite to white coloured box conveyor. Benefits of this mechanism are that it consumes less floor area. Mechanism cannot damage the boxes. Following Fig. 1 shows the development of pick and place system on conveyor.

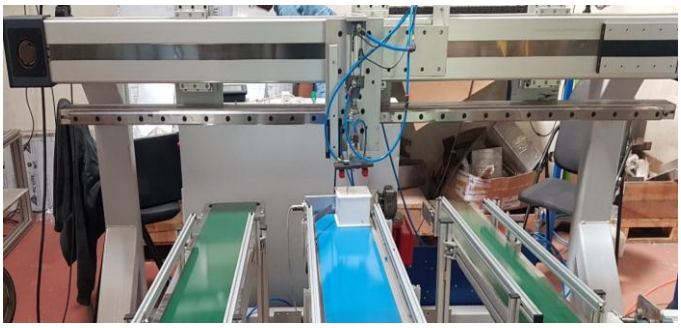

**Fig -1**: Development of Pick and Place Gantry System on Conveyor

## 6. Working of Project

1. To start the pick and place gantry system and conveyor first switch on the compressor and MCB's from control panel.
2. Switch on the global PAC.
3. First by using HMI screen take the pneumatic cylinder at home position make sure that all auto code gets on.
4. Now boxes from middle conveyor come one by one.
5. Colour sensor sends the signal according to colour detection to control panel.
6. In programme when condition gets true pneumatic cylinder goes downward and vacuum gets on for picking action of box.
7. There are two different conditions one is for white box and another one is for black box. For white box START and for black box ISEL 1 AND START are the conditions. According to colour boxes the conditions will be activated and pneumatic cylinder moved in defined direction.
8. After pick up of box it is required to place the box on respective conveyors therefor according to flow chart the series of operation done and for placing of box ISEL 0 AND START this command is activated due to which box is placed and pneumatic cylinder return back to home position for next cycle.

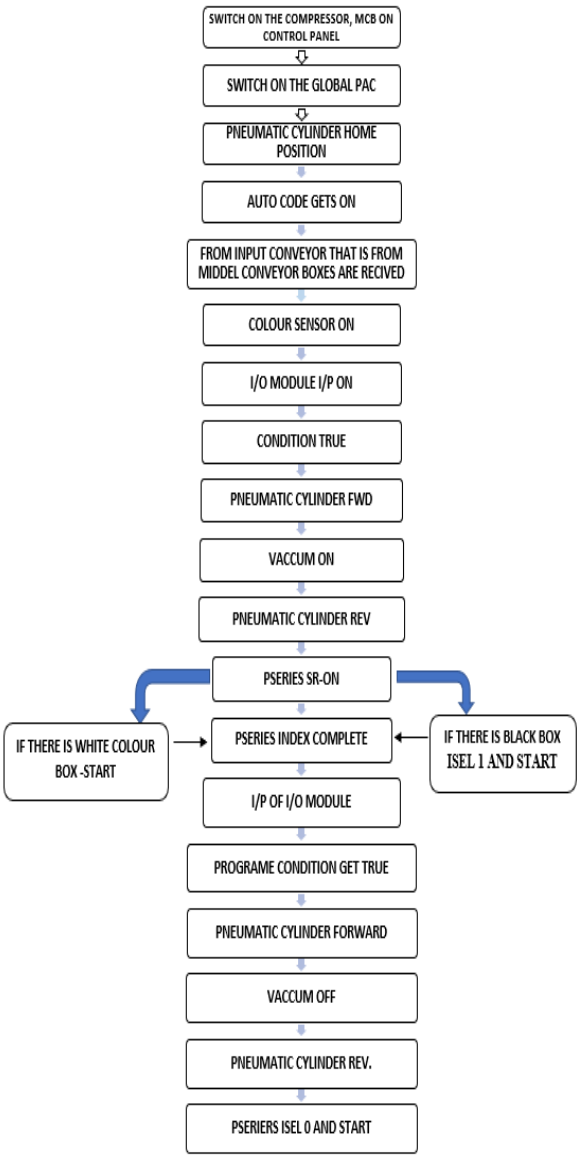


**Fig -2**: Flowchart of Working

## 7. Result

By implementing this project to the company result can be dived into three parts which are as follows.

### 7.1. Labour cost

In industry with the help of traditional method total 3 labor per shift are required but instead of manual method this developed project eliminate that 6 labors from two shifts. Industry save their labor cost annually more than 4 lakh and return of investment is 1 year 17 days for this project.

### 7.2 Human Effort

Box manufacturing company work in 2 shifts. In traditional pick and place process, three labors per shift are required, 1 labor for white box to pick that box from conveyor and place into trolley, another one is for black box and one labor is required to drive that trolley when it is loaded up to dispatch department. With the help of this project there no labor required to pick and place the box and transfer to dispatch department. Full process is automatic.

### 7.3 Productivity Improvement

From traditional method of pick and place system following data are given

1. In 1-hour, white colored boxes transfer to dispatch department: - 32-33
2. In 1-hour, white colored boxes transfer to dispatch department: - 31-32
3. Average time required to transfer the boxes in to trolley: - 53 sec/box
4. Number of shifts is – 2
5. Total boxes production in 1 day: - 900-1000 approx.

With help of automatic pick and place gantry system time required to transfer each box to the dispatch department is 45 sec. in comparison with traditional method pick and place system required less time. Therefor in one shift 320 black and 320 white boxes that is total 640 boxes are transferred. In two shift 1280 boxes are transferred.

With manual effort the box transfer in two shifts is 800 - 900. With the help of pick and place gantry system the boxes transfer in two shifts is 1280. There is increased in productivity by 42%. Bellow graph shows the productivity improvement.

## 8. Conclusion

Nowadays most of the manufacturing industry moving towards automation for reduce human effort, make the process automated, and reduce material handling time and cost. Therefore, this project has been effectively developed to handle required task. It can be identified colour of boxes and grab it and place it on required conveyor. By development of pick and place gantry system on conveyor reduces organisational worker effort and time for material handling as well as number of labours reduced by development of this system. It has future scopes like this system used for any product which have flat smooth surface.

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