

Design, Control, and Implementation of a Mechatronic System Used for Production Lines

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Abstract - Recently, there are much need to automate boring and repetitive jobs. Industrial automation is becoming more and more adaptable to modern technological developments. This work presents an experimental situation for controlling a DC motor used to drive a conveyor belt. This paper demonstrates the use of deep learning to facilitate task selection, placement, and object transfer using intelligent technology with advanced recognition methods. In this paper, the design, implementation, and control of the smart production line is studied. A small prototype of a real production line is built to meet the customer's demand or factory needs such as (auto assembly, packaging plants, etc...). This paper includes the required calculations, design, control system, and manufacturing process for the entire system. We will be able to (make operations on things easier, increase sorting accuracy, reduce the cause of operator injuries, increase work efficiency, increase production capacity, reduce time, workspace and labor cost, and manually and automatically control production lines.

I. Introduction

Production lines are a challenge facing the industry nowadays due to the accuracy and consistency of the recognition process. A mechatronic system with a controlled application using c++ by sensing existing parts and then transmitting data [1]. This information is processed for the handing out mechanism. Factory production lines move and sort objects automatically. Therefore, in this project, the aim is to expand one of these product lines. One here follows the steps to implement this project. The first step is to calculate the appropriate dimensions and all calculations for the control system and conveyor belt design [2]. An Inventor software package is used to design each part in the system that has a specific dimension (scaled to the actual production line) and plan the space required for the project after the calculations of the belt, pulley, and DC motor. After that, a check for the integrity of all parts has been issued after applying an appropriate load using an Inventor stress analysis software package that simulates the process prior to manufacture. A proposed design for a control system has been conducted [3] that will control the belt on and off in smart ways. A c++ with Arduino is used to implement an intelligent production line control. Arduino software controls the belt both automatically and manually (forward and backward). Automatically by using

two sensors, one is to move the belt on when the object is over the belt and the other sensor is to stop the belt off when the object reaches its destination [4]. The conveyor belt can be removed and its tension can be adjusted manually (tighten or loosen). In this paper, the process of (calculations, design, techniques used and algorithm, results, and conclusions) have been discussed.

II. CALCULATIONS

For the calculations, before design, belt specification and motor size have to be calculated accurately according to our task. Belt calculation done first because the maximum power required for the belt drive that can be transmitted must be less than the motor drive power and then from the datasheet of the DC motor one can choose the appropriate type of motor according to the reduction ratio.

A. Mathematical Equations and calculations:

These calculations done to calculate the length of the belt and the max power that needed to choose the corresponding dc motor:

For the motor power:

$$p = (t_1 - t_2) v \quad (\text{belt power that can transmit})$$

assume appropriate velocity value for the belt
 $v = 0.15 \text{ m/s}$ (max velocity)

The length of the belt is considered as follows:
we need to calculate the belt length:

for the flat open belt drive

$$L = \pi * (36/2 + 36/2) + 2 * x + 2 * (0/x)^2$$
$$= \pi * 36 + 2 * 400 = 913.04 \text{ mm}$$

Calculate the centrifugal tension

$$T_c = m \cdot v^2$$

Table 1

Material of belt	Mass density in kg / m ³
Leather	1000
Canvass	1220
Rubber	1140
Balata	1110

Single woven belt	1170
Double woven belt	1250

Table 2

Material of mass	Density in kg / m ³
Rubber	1140

$$M = 0.009 * 1 * 2 * 1140 = 2.05 \text{ kg}$$

$$T_c = m * v^2$$

$$T_c = 2.05 * 15^2 = .461 \text{ n}$$

$$T = 3 * T_c$$

$$T = 3 * .461 = 1.383 \text{ n}$$

$$T_1 = T - T_c$$

$$T_1 = T - T_c$$

$$T_1 = 1.383 - .461 = .922 \text{ N}$$

TO GET T2

$$T_1/T_2 = e^{\mu\theta}$$

Table 3

Belt Material	Wood	Compressed Paper	Leather face	Rubber face
Rubber	0.32	0.35	0.4	0.42

then $\mu = .35$

$$T_2 = .354 \text{ N}$$

$$P = 8 \text{ N.M}$$

$$\text{Power for the motor} = T * \omega = 23.4 \text{ W}$$

So the motor is safe to use as the $P_{\text{motor}} > P_{\text{max}}$

The motor is safe to use

Dc motor no. 120752

$$Dc = 12v$$

c. *Data sheet:*

As shown in fig 1 and 2 the data sheet which we use to choose the motor according to the calculated parameters and actual dimensions.

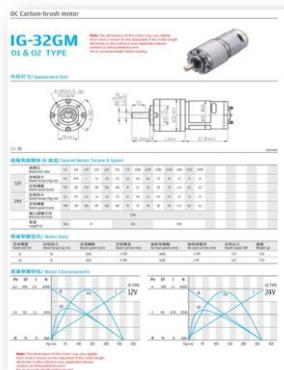


Fig. 1



Fig. 2

III. DESIGN

First, before design processes, calculations have been done to facilitate the process of the design.

A. *Belt material selection*

- We use flat belt because it is mostly used in factories and workshops where a moderate amount of power is transmitted from one pulley to another when the two pulleys are not more than 8 meters apart.

- A rubber belt has been selected because these belts may be easily made endless. These belts are found suitable for sawmills, and paper mills where they are exposed to moisture and very flexible and can transmit small weight objects.

B. *pulley fixation*

We should choose pulley fixation according to our process and we used method called split muff coupling

C. *material of parts*

We choose the Bla material and used the 3d printer to manufacture the Barts with suitable dimensions and fill up density.

D. *sensor position*

We placed the sensors according to the dimensions and the length of the belt

E. *choosing sensor type*

- We choose IR sensor since it is the most suitable sensor for distance or proximity sensing through emitting IR wave and calculating the angle of reflection.
- Infrared light is emitted from the IR LED emitter
- The reflected light will reach the PSD (U1)
- The sensor in the PSD will then determine the position/distance of the reflective object.
- Compact.
- Applicable for daytime and night time usages.
- Able to measure the distance of objects that have complex surfaces unlike ultrasonic sensors.
- High measurement range and accuracy.
- Ability to measure 3D structures.
- Fast update rate; suitable for fast-moving objects.

F. *Control system design*

We designed the control circuit by using Arduino as microcontroller and c++ as programming language.

We used Arduino as its suitable for our process and its cost less than other microcontrollers.

G. *design of the control box*

We designed the control box as shown in fig. 3 to carry all the wires and all the devices that we use to control the project (dc motor –power circuit) to minimize the space

we use to the whole project and when there is a problem in the system, we can get right into the control box.

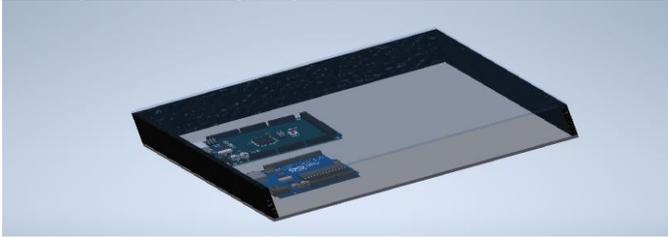


Fig. 3 The control box

H. Stress analysis:

Stress analysis ensures the integrity of the pipes and their components, the integrity of the connected equipment and the supporting structure, and that the deflections of the pipes are within limits.

- In addition, the benefits of this design are design cycles are expensive and time-consuming.
- Analysis reduces the number of design cycles.
- Analysis reduces cost by testing your model using the computer instead of expensive field tests
- Analysis reduces time to market.
- Analysis can help you optimize your designs by quickly simulating many concepts and scenarios before making a final decision

I. Stress analysis results:

After making stress analysis to the Bal components:

Yield strength for pla =33 Map

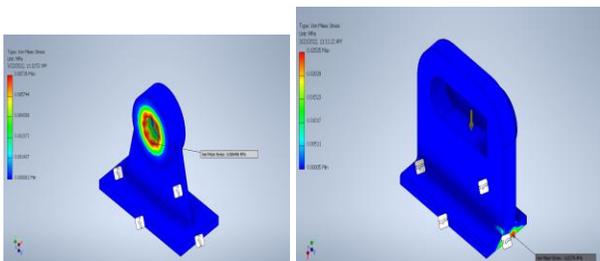


Fig. 5 Both von mises stress less than yield strength

Therefore, the parts are safe

- The problem is the stress analysis for the material is way too safe for the load exerted on it so we had to cut some of the material to get less waste of the material.

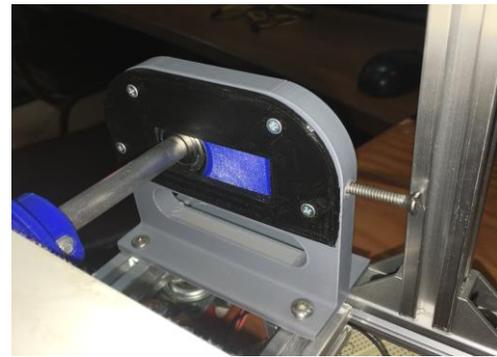


Fig. 4 The final product

J. Electrical Connection:

- The designed electrical circuit of the project is controlled with the microcontroller Arduino UNO which connected to board with sensors used.
- Motors are used for the movement of the belt “forward and backward”
- Fig. 6 will illustrate the electrical connection of sensors (limit switch, push buttons, IR sensor, led, LCD) and (DC motor) to the Arduino UNO.

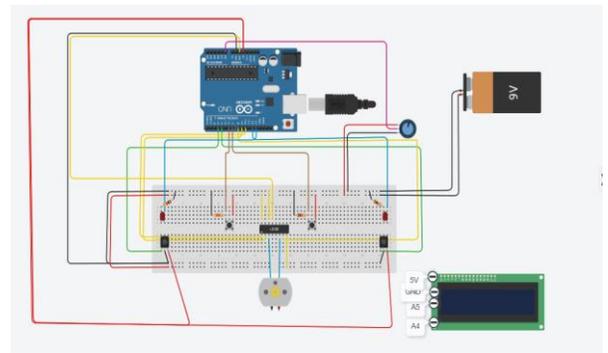


Fig. 6 The electrical diagram of the experimental

i) Microcontroller (Arduino UNO):

- Electronic board based on the microcontroller Microchip ATmega328P.
- 5V: This pin outputs has 5V from the regulator on the board. Is open source.
- . GND: Ground pins
- Is open source.

ii) **DC motor (L293D Driver):**

DC motor is used in my project for the moving belt the speed of the DC motor can be controlled by controlling the actuation signal coming from the power supply.

- change the speed and direction of the motor
- Consist of 16 pins



Fig. 7 L293D dc motor driver

iii) **Liquid Crystal Display (LCD):**

LCD used in different item to show and illustrate the user for show the word in my project used the I2C module to reduce Caples

- The LCD 16 x 2
- LCDs used in electronics equipment

iv) **I2C Module:**

- **Backlight Enable Jumper:** To control the intensity of the backlight
- **I2C Address Set:** to determine the address set for I2C
- **SDA:** is a Serial Data pin This line is used for both transmit
- **SCL:** is a Serial Clock pin, this is a timing signal supplied by the Bus Master device

v) **Infrared Distance Sensors:**

Measuring distance based on the angle of the reflected beam the reflected light sensing the emit IR sensor about calculating the angle of reflection at fig. 8:

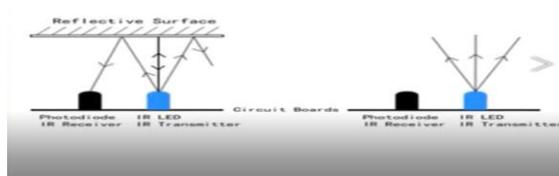


Fig. 8 IR sensor reflected

vi) **Pushbuttons:**

Pushbuttons are switches connect with two points connect with leg 5 volt and resistance and another leg with ground, when the user press the push (1) the belt moving forward, and when press to the push (2) the belt moving backward

vii) **The model:**

The electric manual circuit has two IR, 2 Pushbutton, LCD, H- bridge at fig. 9.

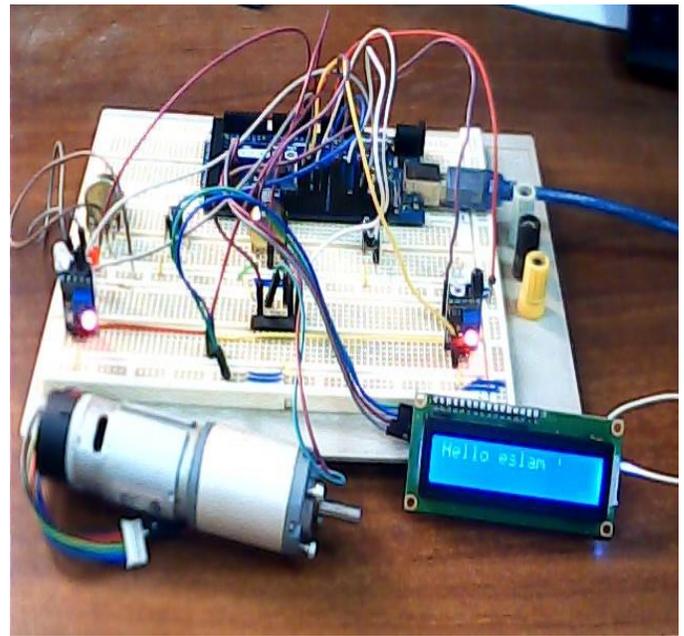


Fig.9 Electric circuit components

viii) **Code on Arduino:**

Arduino code is being created in which each sensor is defined and a certain number is assigned for each sensor. When the object reaches sensor #1, a signal is sent to the motor to start moving and drive the belt conveyor on. After the object reaches sensor #2, the sensor is triggered, and a signal is sent to LED2 so lights up and the dc motor turned off which in turns stops the belt conveyor automatically.

Another mode is the manual one. Switching the motor on and off manually. After testing our program then all connections are applied on a Perfboard as shown in fig. 10.

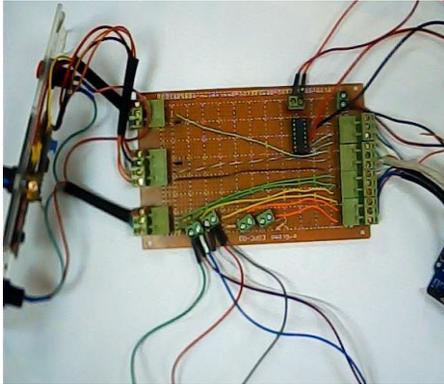


Fig. 10 Final circuit

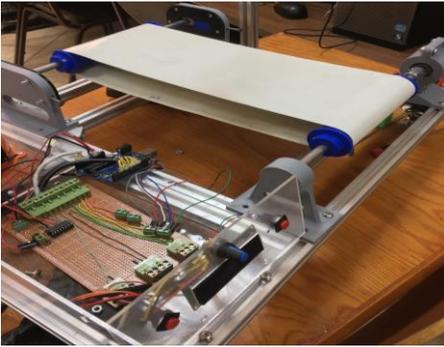


Fig. 11 Final Project

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