M.S PROJECT REPORT

BOTTLE ASSEMBLER

Submitted in partial fulfillment for the degree of

Master of Science (MS) in Mechatronics and Robotics

By

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To the department of

Mechanical and Aerospace Engineering

(Fall 2018)

ABSTRACT

The project aims at assembling bottles in an orderly manner, free-falling from a molding machine which aids PICK AND PLACE operation performed by a universal robot. The bottle assembler (wedge plate) is a fool proof method to place bottles upright onto the conveyor without human intervention. Two linear actuators are used; one to move the wedge and the other which acts as a damper, both of which are controlled by Arduino microcontrollers. The assembler is integrated with a conveyor to display safety mechanism. Tipped over bottles on a moving conveyor are eliminated safely without disturbing incoming bottles. This is achieved by IR sensors which control a servo motor.

The system eliminates wobbling of bottles whilst being placed upright. The smooth movements of the linear actuator eliminate jerks/sudden movements. Bottles which fall while moving on the conveyor are wiped off the conveyor making way for incoming upright bottles.

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I. INTRODUCTION

The report discusses how the new design of the wedge plate differs from the conventional design. It elaborates how a synergistic combination of mechanical, electronics and software is a superior combination over just ordinary mechanical tools. Compared to the old school pneumatic pistons and dozens of air tubes, linear actuators programmed with a microcontroller enables smooth movement of the wedge, which eliminates the jerking of not just the wedge plate but also the conveyor as well.

Figure 1 Linear Actuator

The IR sensors placed exactly one above the other, detects if the bottle is placed upright or tipped over. If both read 'high' the servo does not wipe the bottle out, and if one is 'high' and the other one 'low', the servo wipes the bottle off the conveyor.

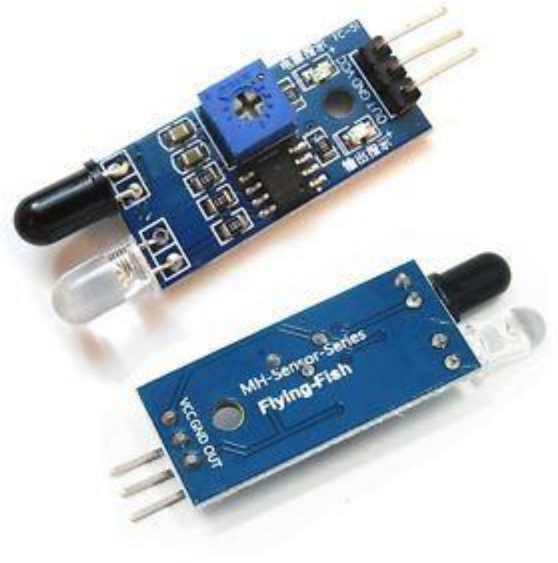


Figure 2 IR Sensor

Finally, for the system to work efficiently, a single belt conveyor of width slightly more than the bottle’s diameter would be ideal. The conveyor used for this project is driven my one motor driver, used for controlling DC motor and Arduino.

II. HARDWARE

Components:	No.
Linear Actuators	2
4-channel relay	1
IR sensors	2
Standard Servo	1
Arduino UNO	2

Table 1 Components used

1. Linear actuator:

An actuator is designed to move something: like a door, a damper, valve etc. Actuators do so many different things in so many different ways. Their applications might appear endless. An actuator is a mechanism that converts energy into motion. A **linear actuator** is an **actuator** that creates motion in a straight line. Linear actuators perform push and pull function.

The prototype uses two linear actuators: The first actuator pushes an acrylic plate, which acts as a wedge supporting dividers, from a starting position of 60 degrees to an end position of 90 degrees. The second actuator placed just below the first actuator, consisting of steel rods attached to the front end which act as dampers. Holes are present on the wedge through which the dampers actuate.

The sequence of operation is as follows:

i. The second actuator with dampers actuates forward to a length of 10mm through the holes on the wedge. At the stage, bottles are dropped and are stopped half way on the wedge.
ii. The dampers now actuate backwards allowing the bottles to fall onto the conveyor.
iii. The first actuator actuates forward to a length of 10mm pushing the wedge to 90degrees position. At this stage, the bottles are placed upright on the conveyor.
iv. The actuator now moves backward bringing the plate back to it's original position.

The specifications of the actuator is as follows:

- Stroke Length = 4 inches
- Travel speed = 12 mm/s
- Maximum current draw = 4.6 Amps
- Maximum Dynamic Load = 225 lbs (900N)
- Maximum Static Load = 600 lbs
- Diameter of Mounting hole: 0.256"(6.5mm)
- Diameter of Shaft: 0.79"(20mm)

2. 4-Channel Relay:

The 4 Channel Relay Board is a simple and convenient way to interface 4 relays for switching application. Few of it's applications include: microwaves oven, fans, DC Motor, industrial controls etc.

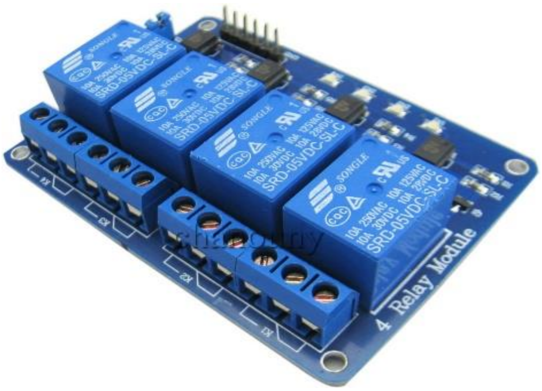


Figure 3 4 Channel Relay

Linear actuator draws current of 4.2Amps at 12V. Arduino cannot provide that amount of current(40mA). Hence we need an external power supply. Arduino provides signal to the relay to draw 4.2Amps of current at 12V from external power supply. We have used all 4 channels. The first two channels for the actuation of first actuator, and the other two channels for the damper actuator.

3. IR sensors:

These are proximity sensors, which senses presence of objects in front of it by sending and receiving IR light. For the prototype, we have used two IR sensors. The IR sensors are places 4 inches apart, one above the other, along the same line such that they can detect a standing bottle at the same time. After the bottles are placed upright on the conveyor, the conveyor starts moving. The IR sensors are placed an inch from the wedge. As the bottles move past the sensors, tiny bulbs on the sensors blink when the bottles presence is detected. If both the sensors blink, it means the bottles are upright. If only the lower sensor blinks, it means the there is a bottle that has tipped over. In response to this, the bottle is wiped off the conveyor by the servo motor.

4. Standard Servo:

Figure 4 Standard Servo

A servo motor is controlled by pulse width modulation. The position of servo is generally controlled by DC motors. Servo motors move to precise angles and positions, hence finds it's applications in variety of ways. The servo is placed on a stand at a height of 8 inches. It is placed 3 inches from the IR sensors. The servo acts as a windshield viper, which helps wipe out the tipped over bottles. A blunt blade is attached to the servo which aids in pushing the bottles away. Double A batteries have been used as an external power source to run the servo.

The operation of the servo in the prototype is as follows:

i. If both the IR sensors blink, it means that the bottles are upright and the servo does nothing.
ii. If only the lower sensor blinks, indicating a tipped over bottle, the servo rotates pushing the bottle off the conveyor. This makes way for the incoming upright bottles.

5. Arduino UNO:

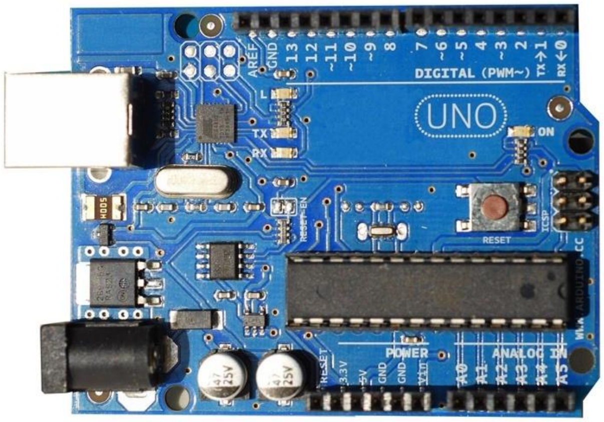


Figure 5 Arduino UNO

2 Arduino boards are used for the project, one board triggers the relay which sequentially actuates stopper actuator then wedge plate actuator

Second Arduino board is used for actuation of servo, both IR sensors are connected to this board, output of the IR sensors is taken as input for the actuation of servo.

III. EXPERIMENTAL METHODS AND TECHNIQUES

A. Before setting the prototype up, the linear actuators were programmed to our desired needs.

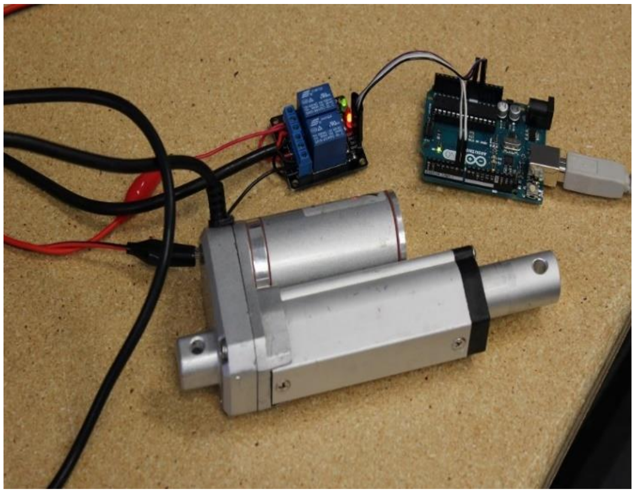


Figure 6 Testing of Linear Actuator

B. Setting up two big linear actuators for a small wedge plate with 3 slots was a difficult task. So, we came up with the idea of setting the linear actuators one above the other by building a stand for one of them. We used a small wooden block, which was glued and nailed to the wedge.

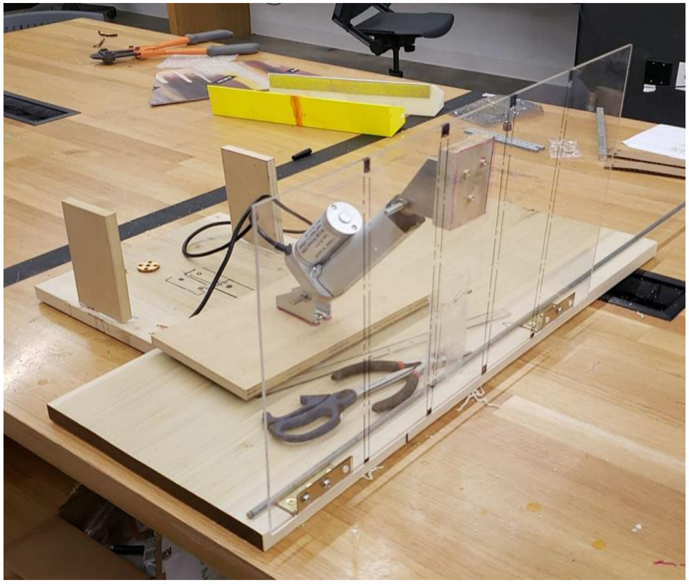


Figure 7 Placement of Linear Actuator

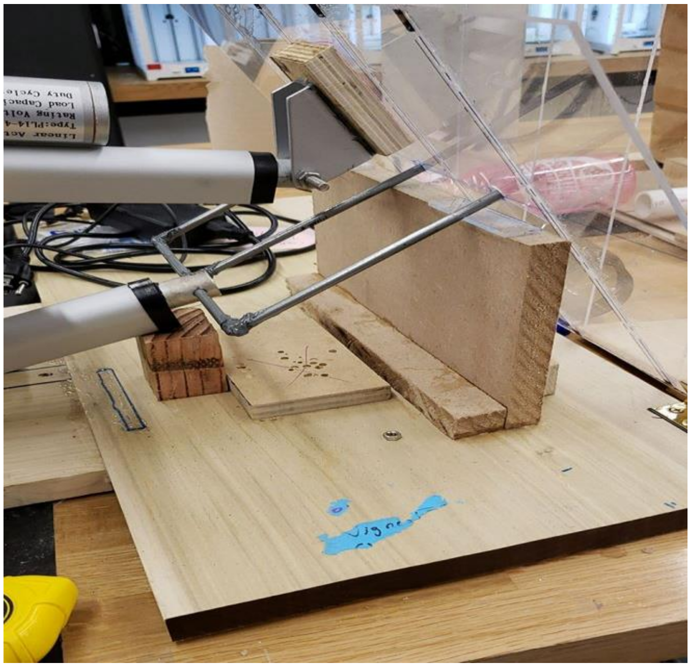


Figure 8 Wedge Plate and Stopper resting on actuator

The actuator was attached high enough such that the wedge plate's initial and final position would be 60 and 90 degrees respectively. When extended to it's maximum length, the plate would be 90 degrees and when fully retracted the plate would be at an angle of 60 degrees.

C. Unlike the previous design, the new design consists of slits on the back plate for the dividers to go through when the wedge is 90 degrees.

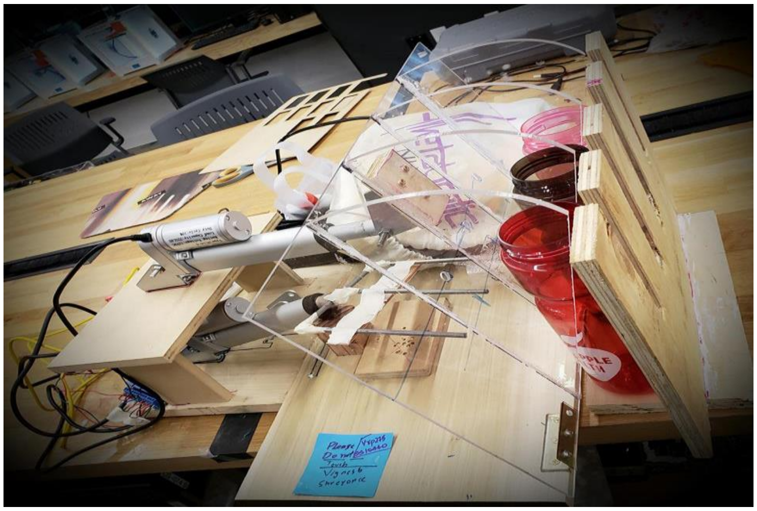


Figure 9 Placement of both actuator

This contains the bottles and prevents wobbling. The back plate is placed closed enough to the wedge such that it is equal to the length of the conveyor(8cms).

D. In place of tubes, a stand with slots were built from which the bottles slide and fall on conveyor.

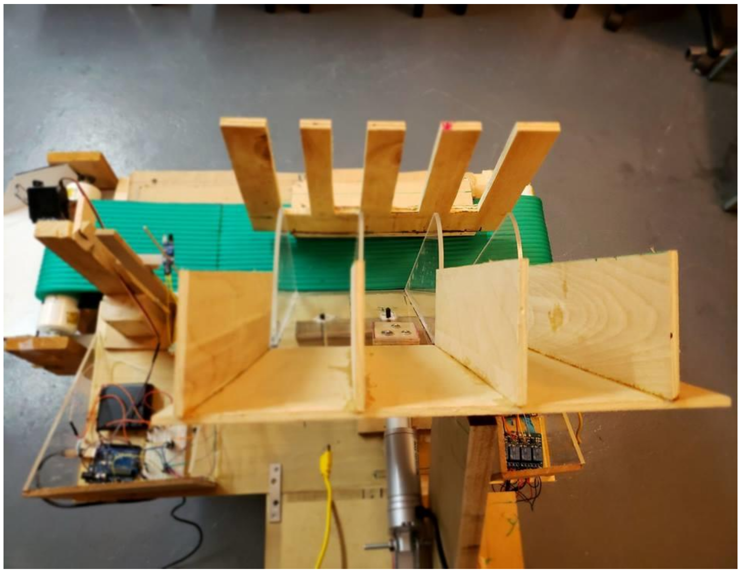


Figure 10 Setup top view

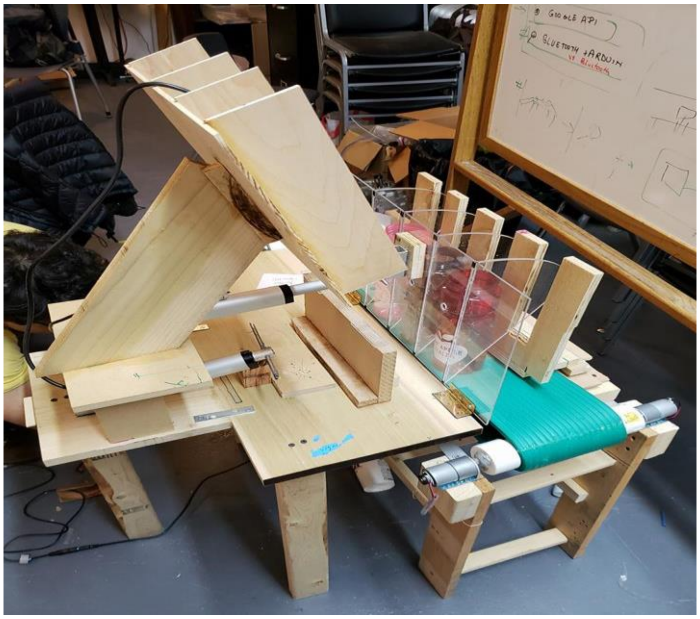


Figure 11 Setup side profile

E. Dividers were attached to the wedge plate using super glue. The wedge had to be supported at a height equal to that of the conveyor. Three wooden blocks of length 22.75 inches were used to support the wedge.

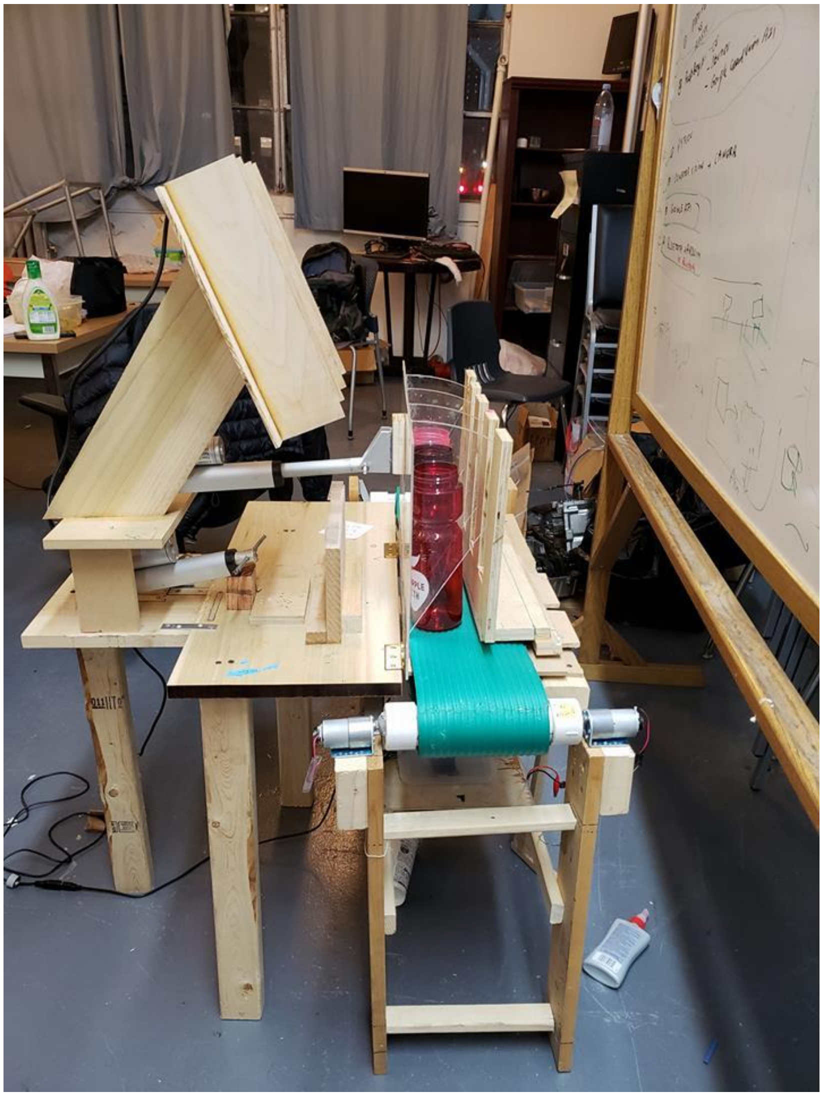


Figure 12 Setup

F. Housings were made behind the wedge plate to keep the circuit wires from being intertwined. One housing consists of the 4 channel relay and Arduino UNO controlling the linear actuators. The other housing consists of an Arduino controlling the servo.

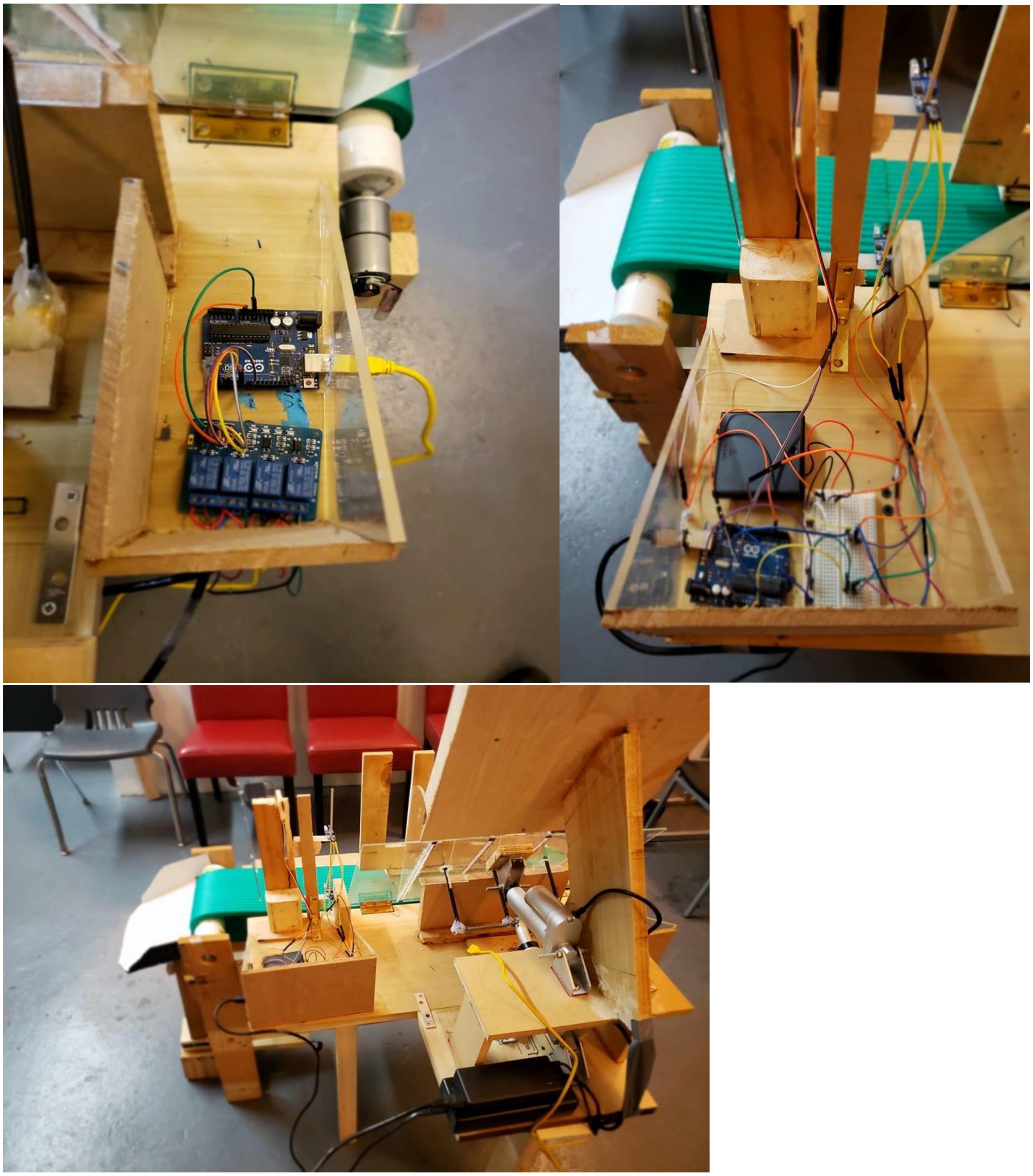


Figure 13 Arduino 1 and 2 with relay secured in housing

G. IR sensors are mounted one on top of each other such that they detect an upright bottle at the same time.

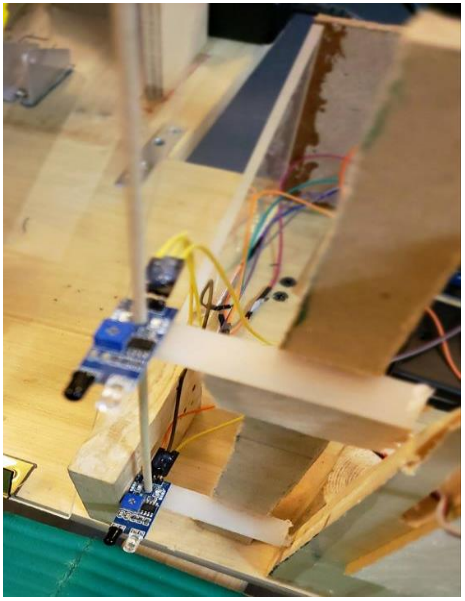


Figure 14 Placement of IR Sensor

H. A blunt blade attached to the servo is mounted on a stand designed solely to .knock tipped over bottles off the conveyor.

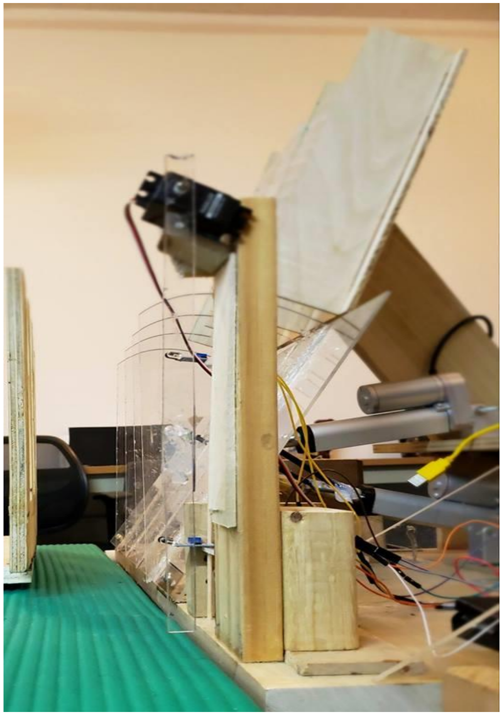
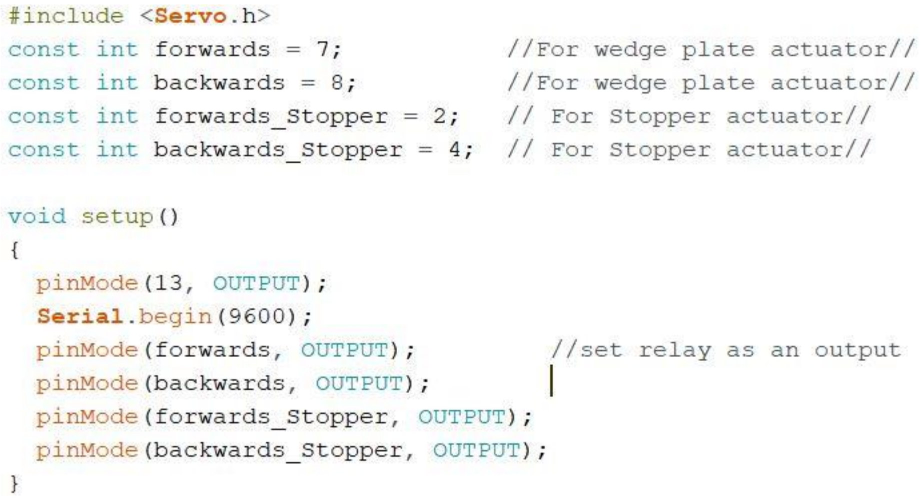


Figure 15 Placement of Servo Mechanism

IV. SOFTWARE AND CODES

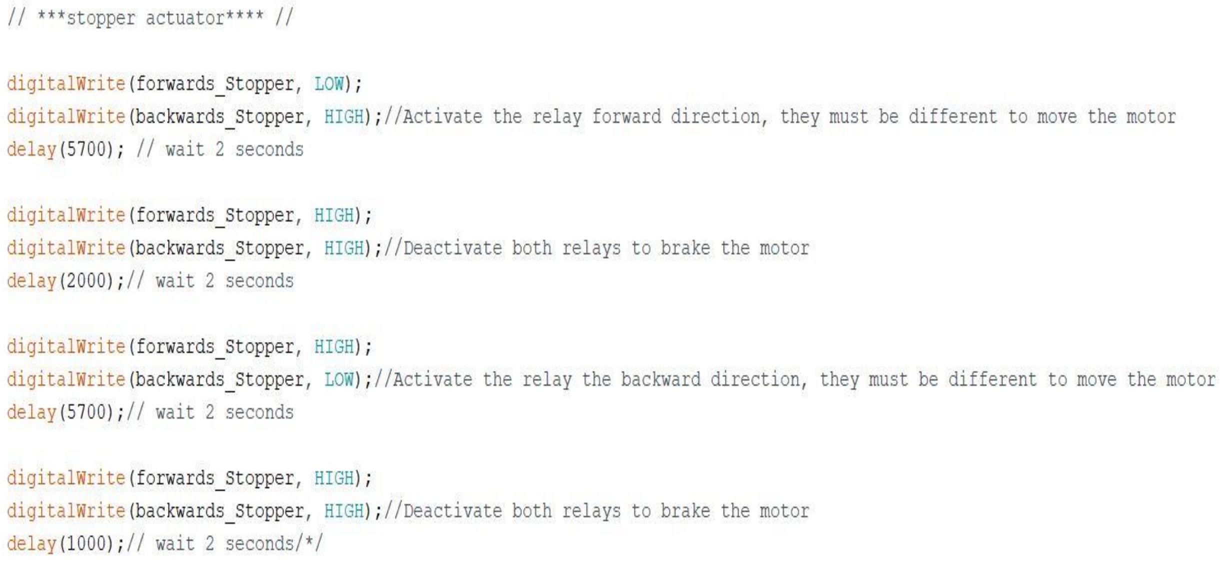
Arduino IDE is used to write the program and, it is a sequential Programming process where all the components work according to following defined sequence

1) Actuator 1 and Actuator 2 to control movement of wedge plate and stopper mechanism



```
#include <Servo.h>
const int forwards = 7;            //For wedge plate actuator//
const int backwards = 8;           //For wedge plate actuator//
const int forwards_Stopper = 2;    // For Stopper actuator//
const int backwards_Stopper = 4;   // For Stopper actuator//

void setup()
{
  pinMode(13, OUTPUT);
  Serial.begin(9600);
  pinMode(forwards, OUTPUT);          //set relay as an output
  pinMode(backwards, OUTPUT);
  pinMode(forwards_Stopper, OUTPUT);
  pinMode(backwards_Stopper, OUTPUT);
}
```

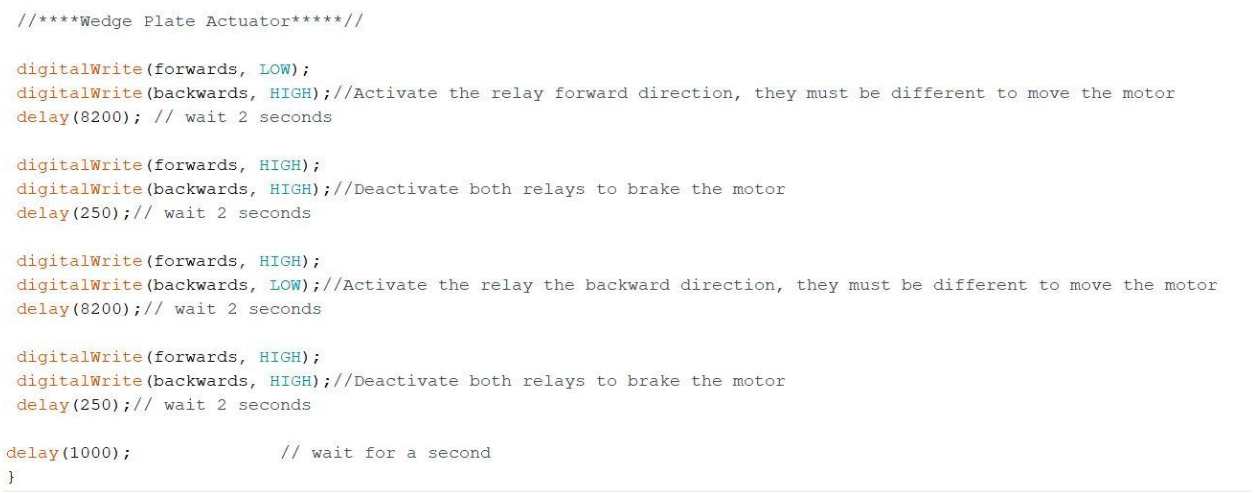
- Pins are defined for both the actuator for forward and backward movement
- Each pin provides signal to the INT pins of Relay, which triggers relay to provide actuator 4.2 Amps of current at 12 volts from external power supply for its functioning.



```
// ***stopper actuator**** //

digitalWrite(forwards_Stopper, LOW);
digitalWrite(backwards_Stopper, HIGH);//Activate the relay forward direction, they must be different to move the motor
delay(5700); // wait 2 seconds

digitalWrite(forwards_Stopper, HIGH);
digitalWrite(backwards_Stopper, HIGH);//Deactivate both relays to brake the motor
delay(2000);// wait 2 seconds

digitalWrite(forwards_Stopper, HIGH);
digitalWrite(backwards_Stopper, LOW);//Activate the relay the backward direction, they must be different to move the motor
delay(5700);// wait 2 seconds

digitalWrite(forwards_Stopper, HIGH);
digitalWrite(backwards_Stopper, HIGH);//Deactivate both relays to brake the motor
delay(1000);// wait 2 seconds/*/
```

- Speed of actuation is 12mm/second and retraction length is 100mm

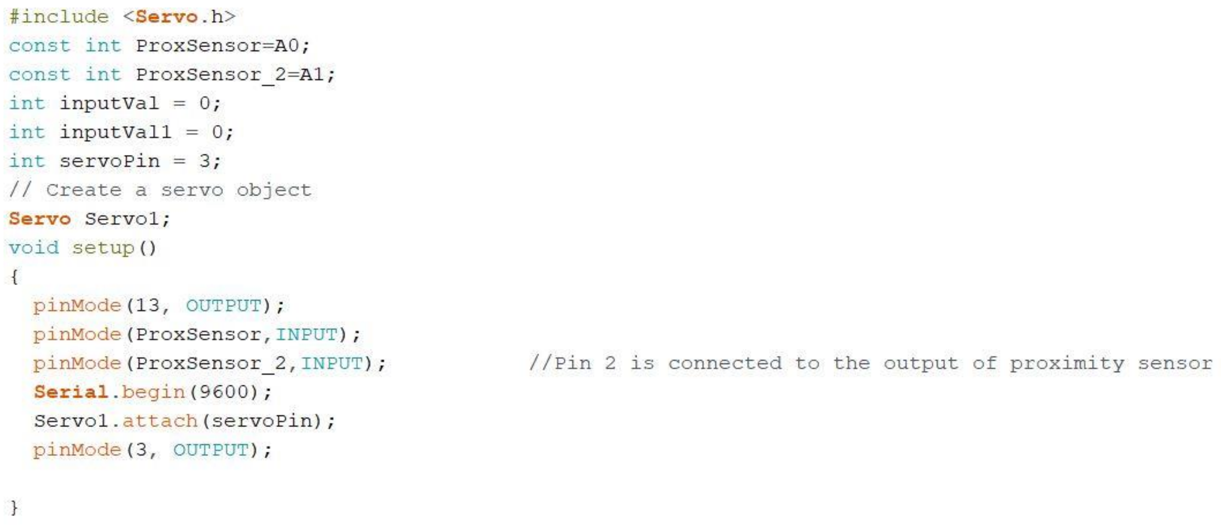
- For it to come out approximately 64 mm delay of 5700 ms is provided
- Similarly, for it to retract back delay of 5700 ms is provided



```
 //****Wedge Plate Actuator*****//

 digitalWrite(forwards, LOW);
 digitalWrite(backwards, HIGH);//Activate the relay forward direction, they must be different to move the motor
 delay(8200); // wait 2 seconds

 digitalWrite(forwards, HIGH);
 digitalWrite(backwards, HIGH);//Deactivate both relays to brake the motor
 delay(250);// wait 2 seconds

 digitalWrite(forwards, HIGH);
 digitalWrite(backwards, LOW);//Activate the relay the backward direction, they must be different to move the motor
 delay(8200);// wait 2 seconds

 digitalWrite(forwards, HIGH);
 digitalWrite(backwards, HIGH);//Deactivate both relays to brake the motor
 delay(250);// wait 2 seconds

delay(1000);              // wait for a second
}
```

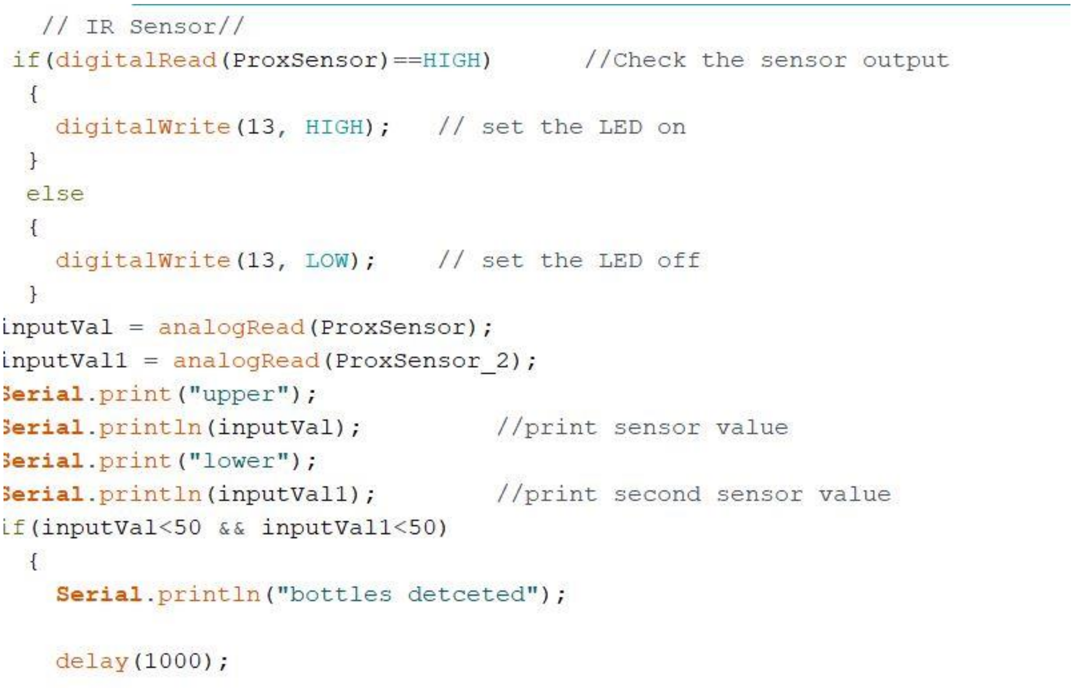
- Same principle is followed by second actuator it is made to come out full 100 mm of its length so delay of 8200 ms is provided.

2) IR and Servo actuation Code for safety mechanism



```
#include <Servo.h>
const int ProxSensor=A0;
const int ProxSensor_2=A1;
int inputVal = 0;
int inputVal1 = 0;
int servoPin = 3;
// Create a servo object
Servo Servo1;
void setup()
{
  pinMode(13, OUTPUT);
  pinMode(ProxSensor,INPUT);
  pinMode(ProxSensor_2,INPUT);           //Pin 2 is connected to the output of proximity sensor
  Serial.begin(9600);
  Servo1.attach(servoPin);
  pinMode(3, OUTPUT);

}
```

- Servo Library is included
- Two Variables are defined to store IR sensors value
- Servo Pin is defined as PIN 3
- Upper and lower IR sensor value are defined as Analog pin AO and A1



```
   // IR Sensor//
 if(digitalRead(ProxSensor)==HIGH)      //Check the sensor output
  {
    digitalWrite(13, HIGH);   // set the LED on
  }
  else
  {
    digitalWrite(13, LOW);    // set the LED off
  }
inputVal = analogRead(ProxSensor);
inputVal1 = analogRead(ProxSensor_2);
Serial.print("upper");
Serial.println(inputVal);         //print sensor value
Serial.print("lower");
Serial.println(inputVal1);        //print second sensor value
if(inputVal<50 && inputVal1<50)
  {
    Serial.println("bottles detceted");

    delay(1000);
```

- Status of IR sensor is checked by setting Led High and Low
- Values from IR sensor are stored in variable inputval and inputval1
- If Value of both sensors are below 50 then both upper and lower sensor give high and bottles are detected is printed on terminal

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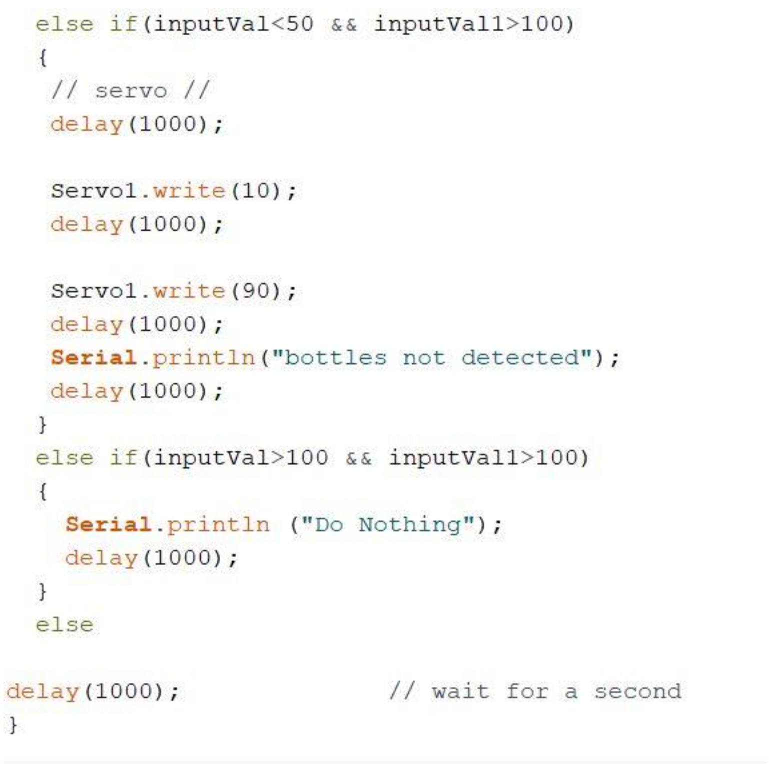


```
  else if(inputVal<50 && inputVal1>100)
  {
   // servo //
   delay(1000);

   Servo1.write(10);
   delay(1000);

   Servo1.write(90);
   delay(1000);
   Serial.println("bottles not detected");
   delay(1000);
  }
  else if(inputVal>100 && inputVal1>100)
  {
    Serial.println ("Do Nothing");
    delay(1000);
  }
  else

delay(1000);              // wait for a second
}
```

- If upper IR gives value below 50 and lower gives above 100 then upper is low and lower is high which actuates the servo and pushes fallen bottle out of conveyor.
- If both upper and lower sensors give value 100 then both are low and it prints do nothing on terminal

2 IR Sensors are placed on a Vertical stand on a straight line

- If both the sensors give high signal, then bottle is passing vertically on the conveyor and it prints bottle is detected on terminal

Upper IR Sensor	Lower IR Sensor	Result	Remark
High	High	Bottle detected	Bottle is Vertical as desired

Table 2 IR Sensor case 1

- If Upper Sensor gives low and lower sensor gives high, then bottle has fallen on conveyor which will actuate servo mechanism to push bottle out of conveyor and it prints bottle not detected.

Upper IR Sensor	Lower IR Sensor	Result	Remark
Low	High	Bottle not detected	Bottle is pushed out from conveyor

Table 3 IR Sensor case 2

- If both upper and lower sensor give low signal, then it prints do nothing because bottle is not detected by either of the sensors.

Upper IR Sensor	Lower IR Sensor	Result	Remark
Low	Low	Do nothing	No bottle is passing

Table 4 IR Sensor case 3

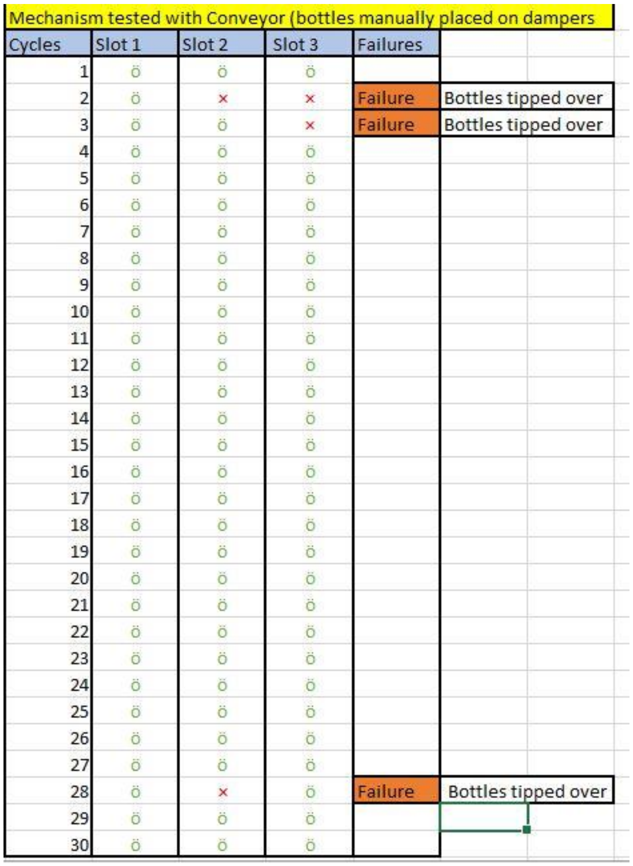
V. Evaluation

The wedge plate was tested under three conditions, two of which involves placing bottles directly over the dampers when fully actuated forward. The third condition where the bottles were dropped from a height from the stand built in place of tubes. Each condition was tested with 30 trials.

The conditions are as follows:

- With conveyor
- Without conveyor
- With and without conveyor dropped from height

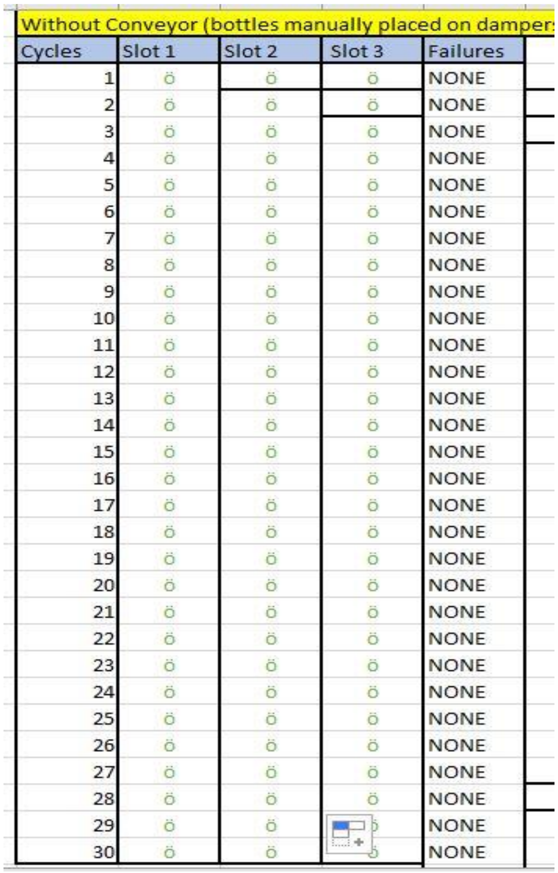
Tested for 30 cycles without Conveyor



Mechanism tested with Conveyor (bottles manually placed on dampers

Cycles	Slot 1	Slot 2	Slot 3	Failures	
1	ö	ö	ö		
2	ö	×	×	Failure	Bottles tipped over
3	ö	ö	×	Failure	Bottles tipped over
4	ö	ö	ö		
5	ö	ö	ö		
6	ö	ö	ö		
7	ö	ö	ö		
8	ö	ö	ö		
9	ö	ö	ö		
10	ö	ö	ö		
11	ö	ö	ö		
12	ö	ö	ö		
13	ö	ö	ö		
14	ö	ö	ö		
15	ö	ö	ö		
16	ö	ö	ö		
17	ö	ö	ö		
18	ö	ö	ö		
19	ö	ö	ö		
20	ö	ö	ö		
21	ö	ö	ö		
22	ö	ö	ö		
23	ö	ö	ö		
24	ö	ö	ö		
25	ö	ö	ö		
26	ö	ö	ö		
27	ö	ö	ö		
28	ö	×	ö	Failure	Bottles tipped over
29	ö	ö	ö		
30	ö	ö	ö		

Tested for 30 Cycles with conveyor

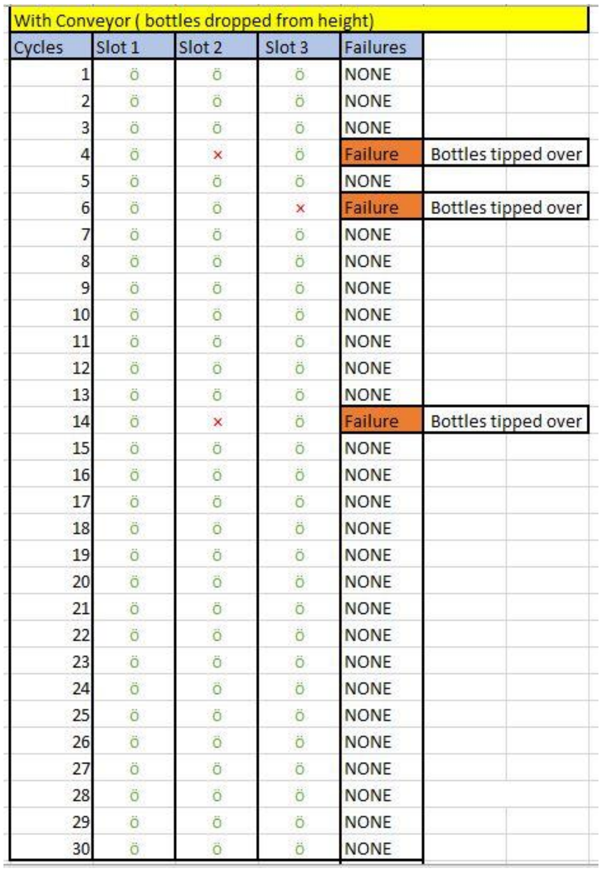


Without Conveyor (bottles manually placed on damper

Cycles	Slot 1	Slot 2	Slot 3	Failures
1	ö	ö	ö	NONE
2	ö	ö	ö	NONE
3	ö	ö	ö	NONE
4	ö	ö	ö	NONE
5	ö	ö	ö	NONE
6	ö	ö	ö	NONE
7	ö	ö	ö	NONE
8	ö	ö	ö	NONE
9	ö	ö	ö	NONE
10	ö	ö	ö	NONE
11	ö	ö	ö	NONE
12	ö	ö	ö	NONE
13	ö	ö	ö	NONE
14	ö	ö	ö	NONE
15	ö	ö	ö	NONE
16	ö	ö	ö	NONE
17	ö	ö	ö	NONE
18	ö	ö	ö	NONE
19	ö	ö	ö	NONE
20	ö	ö	ö	NONE
21	ö	ö	ö	NONE
22	ö	ö	ö	NONE
23	ö	ö	ö	NONE
24	ö	ö	ö	NONE
25	ö	ö	ö	NONE
26	ö	ö	ö	NONE
27	ö	ö	ö	NONE
28	ö	ö	ö	NONE
29	ö	ö	ö	NONE
30	ö	ö	ö	NONE

Table 5 & 6 Evaluation (i)

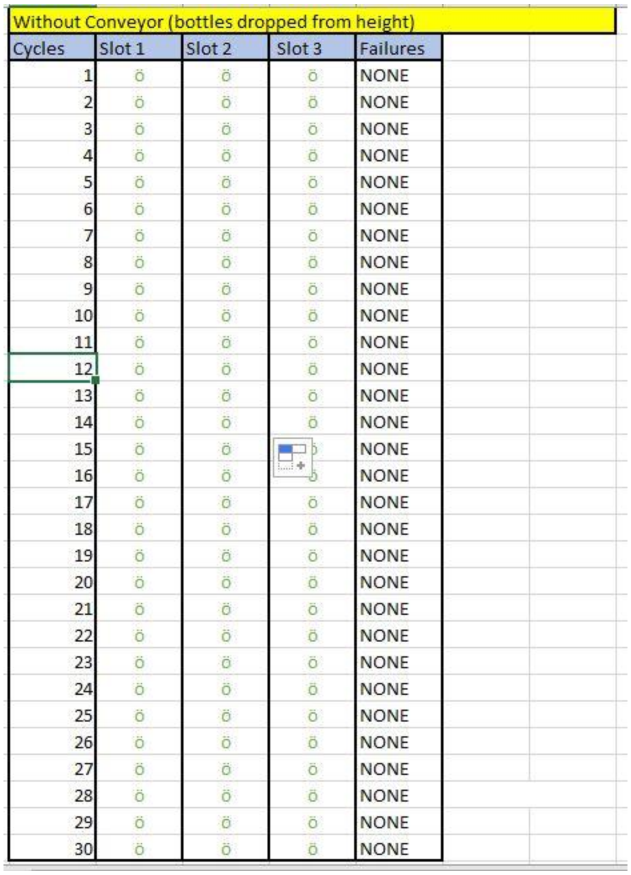
With Conveyor Tested Dropped from height



With Conveyor (bottles dropped from height)

Cycles	Slot 1	Slot 2	Slot 3	Failures	
1	ö	ö	ö	NONE	
2	ö	ö	ö	NONE	
3	ö	ö	ö	NONE	
4	ö	×	ö	Failure	Bottles tipped over
5	ö	ö	ö	NONE	
6	ö	ö	×	Failure	Bottles tipped over
7	ö	ö	ö	NONE	
8	ö	ö	ö	NONE	
9	ö	ö	ö	NONE	
10	ö	ö	ö	NONE	
11	ö	ö	ö	NONE	
12	ö	ö	ö	NONE	
13	ö	ö	ö	NONE	
14	ö	×	ö	Failure	Bottles tipped over
15	ö	ö	ö	NONE	
16	ö	ö	ö	NONE	
17	ö	ö	ö	NONE	
18	ö	ö	ö	NONE	
19	ö	ö	ö	NONE	
20	ö	ö	ö	NONE	
21	ö	ö	ö	NONE	
22	ö	ö	ö	NONE	
23	ö	ö	ö	NONE	
24	ö	ö	ö	NONE	
25	ö	ö	ö	NONE	
26	ö	ö	ö	NONE	
27	ö	ö	ö	NONE	
28	ö	ö	ö	NONE	
29	ö	ö	ö	NONE	
30	ö	ö	ö	NONE	

Without Conveyor Dropped from height



Without Conveyor (bottles dropped from height)

Cycles	Slot 1	Slot 2	Slot 3	Failures
1	ö	ö	ö	NONE
2	ö	ö	ö	NONE
3	ö	ö	ö	NONE
4	ö	ö	ö	NONE
5	ö	ö	ö	NONE
6	ö	ö	ö	NONE
7	ö	ö	ö	NONE
8	ö	ö	ö	NONE
9	ö	ö	ö	NONE
10	ö	ö	ö	NONE
11	ö	ö	ö	NONE
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23	ö	ö	ö	NONE
24	ö	ö	ö	NONE
25	ö	ö	ö	NONE
26	ö	ö	ö	NONE
27	ö	ö	ö	NONE
28	ö	ö	ö	NONE
29	ö	ö	ö	NONE
30	ö	ö	ö	NONE

Table 6 & 7 Evaluation (ii)

VI. Conclusion

The prototype was tested multiple times under various conditions. A high quality single belt industrial conveyor was not affordable, hence the wedge was tested under different conditions. Despite the conveyor being flimsy and delicate, satisfactory results were achieved. But under ideal conditions where we have a sturdy single belt conveyor, the wedge plate performs exceptionally well. This is done by moving the back plate close enough to the wedge such that the distance between the two is 8cms. The completion of this project signifies the birth of a system that has never been used before, and we are confident that this will set benchmark in the world of manufacturing.

Acknowledgment

We would first like to gratefully acknowledge Dr. Vikram Kapila, Head of department of Mechanical and Aerospace Engineering, NYU Tandon School of Engineering, for giving us the privilege to work under him. It is only under his able guidance and active support that we were able to bring the project to a highly satisfactory conclusion. We would also like to acknowledge Dr. Mizanoor Rahman of the Department of Mechanical and Aerospace Engineering, NYU Tandon School of Engineering, whose ideas and direction helped us complete the project on time.