Manufacturing Lab Project

Automated Yoyo Assembly Manual

ENGR 480
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Introduction
This manual provides a list of instructions, diagrams, descriptions and important information for the operation and maintenance of the yoyo assembly machine.

Loading Machine
These are the necessary steps in order to load parts into the machine properly.

1. Slide bearings into track, make sure lower stop is in place before hand.
2. Place yoyo halves on conveyor.
3. Load a roll of silicon rings into place above conveyor.
4. Load screws into track.

The location of different tracks and conveyors are shown in figures below.

Starting Machine
These are the necessary steps in order to safely start the yoyo assembly machine.

1. Remove any obstructions.
2. Ensure parts are loaded.
3. Turn on power.
4. Turn red emergency stop button clockwise to turn on air flow.
5. Set PLC to run.

Clearing Machine
If machine malfunctions and jams immediately press the large red emergency button. Then verify that each part of the station has not been damaged. If a part of the machine has been damaged replace it and recalibrate machine.

Description of Operation

Indexing Turret
This is the main component of our system. It is what all the stations are centered around. It has 8 positions and rotates counter clockwise. The turret has the tendency to operate very slowly most of the time, if this occurs gently help the turret to rotate while being careful that fingers or hands do not get hurt. At each of the 8 positions there is a holder for the yoyo halves. The yoyo halves fit snugly on the holders and the holders can be rotated by gears so that different screwing operations can be performed by the stations.

Station 0 – Yoyo half pick and place system/silicon ring placement
This station feeds the yoyo assembly line. First, a conveyer belt is loaded with pre-machined yoyo halves. These yoyo halves travel under a ring applicator. The ring applicator, initiated by a sensor on the conveyer, pulls a paper roll of rings over an edge causing the rings to detach from the roll and stick to
the yoyo half. The yoyo half then travels on to be positioned under a pick and place. An optical sensor senses the yoyo half is in place and moves the yoyo half from the conveyer to a rotating turret.

Station 0 setup:

1. Match the speed of the steeper motor with the conveyer by adjusting the speed in the conveyer.
2. Adjust the horizontal linear cylinder stops to pick and place the yoyo precisely.

Figure 1. Yoyo Pick and Place Station
Figure 2. Silicon Ring Station
Station 1 – Bearing Feeder

The purpose of this station is to place a bearing onto a yoyo half. This station operates on every other turret rotation because we only want a bearing on one half of the yoyo. Once the gravity feeder at the station is loaded there are two pneumatic cylinders, one above and one on the side of the gravity feeder that control the release of a bearing as well as a sensor to see if a bearing is in place. The pneumatic cylinder that is on the side of the gravity feeder is on initially and when the sensor is triggered the cylinder that is above the gravity feeder is released and stops the bearing that is second in the line. There is also a third pneumatic cylinder that’s purpose is to make sure the bearing falls into the right position, this cylinder is released at the same time as the cylinder above the gravity feeder. The side cylinder is then released and the bearing falls down onto the yoyo half. The sensor is no longer sensing and this returns the cylinders to the original positions.

Figure 3. Bearing Feeder Station
Station 2 – Bearing Placement

The purpose of this station is to press fit the bearing on the yoyo. It operates on every other turret rotation but is the opposite rotation of station. There is a pneumatic cylinder with an aluminum block attached to the end. When the station goes the block presses down on the bearing press fitting the bearing onto the yoyo.

Figure 4. Bearing Placement Station
Station 3 – Screw Feeder/Placement

**Description:** The purpose of this station is to screw a ½ inch long, 1/8th inch diameter screw into an aluminum yo-yo half. In order to do that many sub-actions must take place. First a line of screws are placed in the gravity-feeder. This is a state that is only for loading and will not be used once the station gets going. This first state has all of the pneumatics retracted except for the gate pneumatic. In regards to how the gravity feeder works, screws are lined up end to end with their hex-bit ends facing uphill. The 2nd screw from the bottom end is pinned when the station reaches its 2nd state, holding the rest back. When this station receives its Station Go signal, the gate at the bottom of the gravity feeder opens and the 1st screw slides down into an alignment hole. The screw stops when it runs into the yo-yo half, which will have had to been in place for the Station Go signal to be sent. Then, an Allen wrench is actuated on a pneumatic to push down where the aligned screw is such that the Allen wrench enters the screw and applies pressure. The yo-yo half is mounted on a rotating mount and when a stepper motor turns on, the yo-yo half begins to spin at a slow and steady rate. The screw, if it isn’t already entered by the Allen wrench, it will now be. The spinning of the mount combined with the screw being held steady and having pressure applied on it results in the screw being driven at a steady rate into the yo-yo half. After a set amount of time for the motor and Allen wrench pneumatic, the motor deactivates (allows free spinning) and the pneumatic retracts. After a short time, the Allen wrench pneumatic is back in home position. The screw feeder then closes its gate and after a short time, opened the holding pin pneumatic and the screws increment down the gravity feeder by 1 position further. The pin pneumatic then “re-clamps” the 2nd screw. The Station Done signal and then sent to the PLC. The actions can now repeat from the 2nd state. Note that a screw is placed in every other yo-yo half.

*Figure 5. Screw Feeder/Placement Station*
Station 4 – Assembly of Two Yoyo Halves
This station is responsible for screwing two yoyo halves together. One yoyo half contains the bearing and the screw and the other contains neither. The yoyo half that contains neither will be picked up using a pneumatic gripper and a stepper motor and rotated up-side-down with a pneumatic actuator. Then this station waits for the turret to rotate so that another yoyo half is in place below the gripped yoyo half. The station then lowers the one yoyo half onto the other while turning the lower yoyo half with a stepper motor so that they screw together.

Figure 6. Assembly of Yoyo Halves Station
Station 5 – Eject Station

This station ejects a complete assembly of two yoyo halves. This is accomplished by one pneumatic cylinder which lifts the edge of the yoyo off that is on the turret causing it to fall off of the turret. This station contains a sensor to tell when the cylinder is in the upward position.

![Figure 7. Eject Station](image-url)
Station 6 – Turret Position sensor
This station contains only a sensor that senses if a yoyo holder on the turret is in position. We used a break-beam sensor for this station. This signal is used to tell the turret to index.

Maintenance
The indexing turret is the component that needs the most maintenance. It needs to be checked a minimum of every month to see if all parts are working. It also needs to be cleaned and re-lubricated every month as well.

Stepper Motor Configuration
The PLC and CITRO Workbench were used to operate our stepper motors. This seemed like the best way to control the stepper motors since we had multiple motors being operated at the same station but controlling different components. Different profiles were created for the different motions the motors would need to perform but when these profiles were loaded from PLC they would not run. An improvement that could be made for our system would be to figure out why the stepper motors will not run when controlled by the PLC or possibly switch and use Linux CNC to control the stepper motors in our system.
Wiring Table

<table>
<thead>
<tr>
<th>Pneumatic Cylinder</th>
<th>PLC OUTPUT</th>
<th>PLC INPUT</th>
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<tr>
<td>Turret</td>
<td></td>
<td>Y101</td>
</tr>
<tr>
<td>Station 0</td>
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<tr>
<td>Station 0 Cylinder 1</td>
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<td>Station 0 Cylinder 3</td>
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<td></td>
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<td>Station 0 Sensor 1</td>
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<td>Station 1 Cylinder 3</td>
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<td>Station 2 Cylinder 1</td>
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<td>Station 3</td>
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<td>Station 3 Cylinder 3</td>
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<td>Station 4 Stepper motor 2</td>
<td>Module 2</td>
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<tr>
<td>Station 6 sensor 1</td>
<td>X0</td>
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Future Improvements

The major improvement that could be made would be to replace the indexing turret. The turret that has been used is very slow. We attempted to fix it by cleaning it and re-lubricating it and this seemed to work for a short amount of time but then started working poorly again. Another improvement that could be made would be to add an attachment to the third pneumatic cylinder in the bearing feeder station. We also need to improve the stepper motor control so that they work better.

PLC Ladder Logic

See attached
All stations perform operations
Stations Go

Station 1 Done
cS1DONE
Y4

Station 2 Done
cS2DONE
Y5

Staion 5 Done
Eject Done
Y10

S Turret Wait 2
Wait 2
S3
JMP

S Turret Idle
Idle state
S0
JMP

Bearing feeder
idleStn1
S10

Bearing drop
Stn1Drop
S11
JMP

SG
s Turret Wait 2
Wait 2
S3

11
_On
SP1
T3

12
Station 1 Done
cS1DONE
Y4

Station 2 Done
cS2DONE
Y5

Staion 5 Done
Eject Done
Y10

14
All stations perform operations
Stations Go

Bearing drop
Stn1Drop
S11
JMP

Page 3
On SP1

All stations perform operations
Stations Go

Station 1 Done
cS1DONE
Y4
OUT

Station #1 waits for turret to rotate twice
ST1 EO
S14
JMP

Station #1 waits for turret to rotate twice
ST1 EO
S14

All stations perform operations
Stations Go

Bearing feeder
idleStn1
S10
JMP

Station 2 idle
Station 2
S20

All stations perform operations
Stations Go

Station waits for turret to rotate again
S23
JMP
Station waits for turret to rotate again

_On SP1

All stations perform operations

Pushing bearing into place

Station 2 Done
cS2DONE

Y5 OUT

Waits for turret to rotate

S25 JMP

Push it

Station 2 Done
cS2DONE

Y5 OUT

Pushing bearing into place

Y106 OUT

S25 JMP

Push it

S21 JMP

Stations Go

Y1

Y1

All stations perform operations

Stations Go

Y1

On SP1

On SP1
On SP1

Wait state to return to idle
S22

On SP1

Station 2 Done
cS2DONE
Y5
OUT

All stations perform operations
Stations Go
Y1

The gripper flipper screwer station
station 4 idle
S40

On SP1

LD
K10
OUT
V2040
45
-On SP1

LD K10
OUT V3040

All stations perform operations
Stations Go
Y1

Moves down to yoyo
Moves Down
S41

46

48
-On SP1

LD K1
OUT V2041

process comand
B2056.7
OUT

49

cmd complete
B2022.7

SG
Moves down to yoyo
Moves Down
S41

SG
starts motion and waits for motion to start
Motor Motion
S143

SG
starts motion and waits for motion to start
Motor Motion
S143
Motor direction
Direction
B2056.4
OUT

Enable Out
B2056.0
OUT

Output active
B2022.4

T5
K40

wait for motion to stop
S151
JMP

wait for motion to stop
S151

Output active
B2022.4

Grips the YOYO
Grab That YOYO
S42
JMP

Grips the YOYO
Grab That YOYO
S42

Grips the YOYO
Grip that thing
Y110
OUT
Grips the YOYO
Grip that thing
Y110

Moves up while gripping
Move up
S43
JMP

SG
Moves up while gripping
Move up
S43

_On
SP1

Grips the YOYO
Grip that thing
Y110
OUT

LD
K2

OUT
V2041

process comand
B2056.7
OUT

cmd complete
B2022.7

Starts motion and waits for motion to start
S144
JMP

SG
Starts motion and waits for motion to start
S144

_On
SP1

Grips the YOYO
Grip that thing
Y110
OUT
On SP1

Enable Out B2056.0

Output active B2022.4

TMR T6
K30

wait for motion to stop S150 JMP

wait for motion to stop S150

Output active B2022.4

SG wait for motion to stop S150

Flipping the YOYO Flipping Off S44 JMP

Flipping the YOYO Flipping Off S44

On SP1

Grips the YOYO Grip that thing Y110 OUT

YOYO gets flipped upside down Y107 OUT

YOYO upside down

On SP1

Page 11
YOYO gets flipped upside down
YOYO upside down

wants for turret to rotate
Wait 1 station 4
S45
JMP

SG
waits for turret to rotate
Wait 1 station 4
S45

_Grips the YOYO
Grip that thing
Y110
OUT

_On
SP1

YOYO gets flipped upside down
YOYO upside down

Y107
OUT

_On
SP1

Station 4 done
Station 4 done
Y7
OUT

Station 4 done
Station 4 done

Y7

Waits for turret to rotate
Wait 2 Station 4
S46
JMP

SG
Waits for turret to rotate
Wait 2 Station 4
S46
Station 4 done
Station 4 done
Y7 OUT

Grips the YOYO
Grip that thing
Y110 OUT

YOYO gets flipped upside down
YOYO upside down
Y107 OUT

All stations perform operations
Stations Go
Y1

Lowers with YOYO gripped
Get Low
S47 JMP

YOYO gets flipped upside down
YOYO upside down
Y107 OUT

Grips the YOYO
Grip that thing
Y110 OUT
On SP1

LD K3

OUT V2041

process command
B2056.7
OUT

Start motion and wait for motion to start

S145

JMP

Grips the YOYO
Grip that thing

Y110

OUT

YOYO gets flipped upside down
YOYO upside down

Y107

OUT

Motor direction
Direction
B2056.4
OUT

Enable Out
B2056.0
OUT
6/11/2014

Output active B2022.4

Wait for motion to stop
S152

JMP

Wait for motion to stop
S152

Screws the two YoYO halves together
Screw you yoyo
S140

JMP

Screws the two YoYO halves together
Screw you yoyo
S140

On SP1

Grips the YOYO
Grip that thing
Y110
OUT

On SP1

Y107
OUT

LD K4

OUT V2041

process comand
B2056.7
OUT
On SP1

LD K1

OUT V3042

B3056.7 OUT

cmd complete

Robot arm moves up

Moving on up

S141

JMP

SG

Start motion and wait for motion to start

S146

On SP1

Grips the YOYO

Grip that thing

Y110 OUT

Y107 OUT

On SP1

YOYO gets flipped upside down

YOYO upside down

On SP1

Motor direction

Direction

B2056.4 OUT

On SP1

Enable Out

B2056.0 OUT
All stations perform operations
Stations Go

Activate pick and place
yoyo present

Picks up yoyo and
places on turret
pick n’ place
S170

SG
Picks up yoyo and
places on turret
pick n’ place
S170

SG
Eject station idle
Eject Station
S50

All stations perform
operations
Stations Go

Wait for turret to rotate
S51

SG
Wait for turret to rotate
S51

On
SP1

On
SP1

On
SP1

Y1

X1

S170

Y113

Y116

Y112

C, Screwer
OUT

OUT

OUT
On SP1

Stations Go

All stations perform operations

Wait 2

SG

Wait 2
S52

On SP1

Stations Go

All stations perform operations

Eject yoyo

SG

Eject yoyo
S53

On SP1

Return to idle state

Eject X2

Y111 OUT

Y10 OUT

S52 JMP

S53 JMP

S54 JMP
This is the initialization state and is used for loading the gravity feeder. The three outputs are to put the 3 pneumatic cylinders in position. The vertical one is to be retracted, the bottom one (gate) extended and middle one (pin) retracted. After a short time, they are in position and C63 is the Station 6 Ready signal.