NYU

Gary Plastic: Robotics Implementation

Final Review – March 20, 2018

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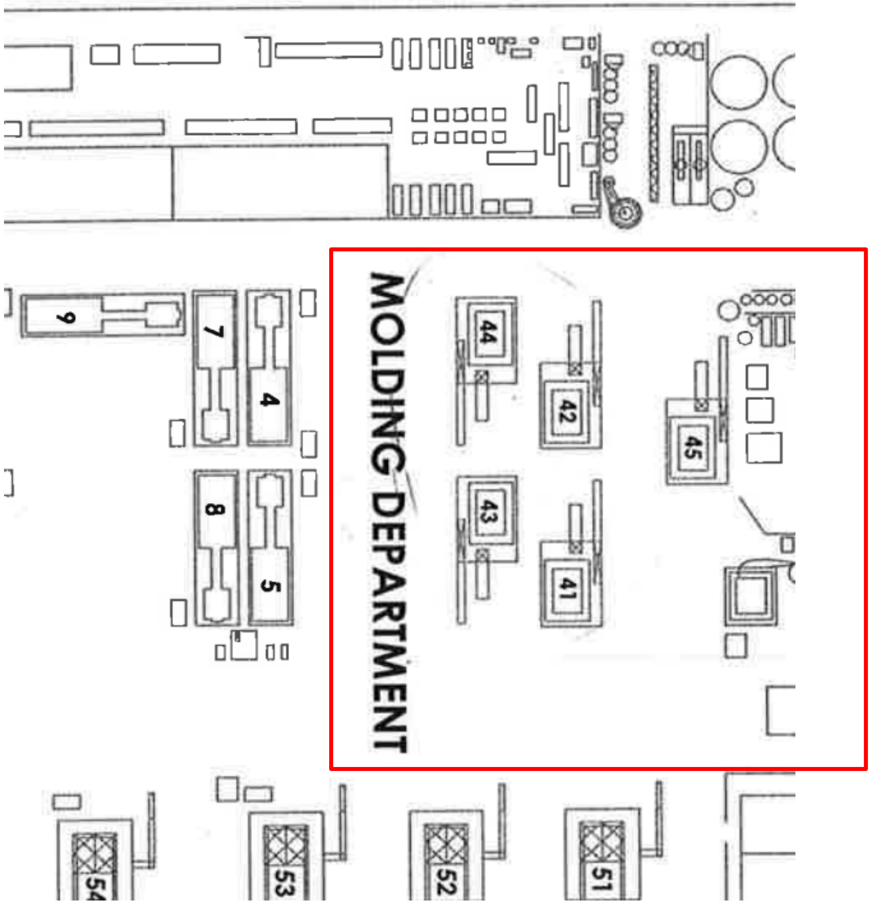
In partnership with: itac
Delivering Results to NYC Manufacturers

Objective

- To prototype/automate the pick and pack operations for bottles that are injection molded by bottle machine (#42) to allow for better utilization of floor resources (e.g. remove the need for an operator to pack the bottles in boxes post injection molding).

- Results can then be implemented with 3 more of the 9 injection molding machines, magnifying the impact.



Prototype Design Criteria

Integrated system that:

- Transfers bottles from the injection molding machine through to being packed in a box in a neat, vertical fashion (e.g. in rows).

- Keeps pace with the speed of bottle production via the injection molding machine and has the flexibility to move faster than bottle molding, as required.

- Requires no human intervention, except for the periodic transfer of packed boxes onto the pallet for transfer to WIP inventory. Must allow enough time between loading the boxes on the pallet for Floor Person to do other tasks.

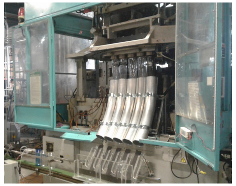
- Is flexible to adapt to all bottle types on target machines.

- Reduces idle time of human operators.

Final Results – Prototype System Description

- Fully working prototype from the injection molding machine input through packing the box, including recommendations for the box conveyor

Step 1:
Injection Molding
Machine

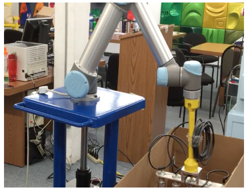


Step 2:
Tubes from Machine
to Wedge Plate

Step 3:
Wedge Plate

Step 4:
Bottle Belt
Conveyor

Step 5:
UR Robot –
Pick & Pack



Step 6:
Bottles Stacked
in Box

Step 7:
Box Conveyor

Final Results of Offline Validation Test of Prototype

- Fully working prototype run offline from the bottles being dropped in tubes (mimicking injection molding machine transfer) through packing the box, including recommendations for the box conveyor
- Setup Time: 30 minutes
- Run Time: 7 mins
- Type of Bottle: Tall Bottles
- Number of Boxes/ Bottles Packed: 1 box/ 100 bottles.
- Summary of Test: Task of packing the bottles has been accomplished.
- In the test above, one bottle tipped over in the box because the bottom surface of the box wasn’t flush to the box bottom. This led to the movement of the bottle. Going into production, the bottom surface of the box will be stable.
- The robot has been programmed to run in a continuous loop and pack multiple boxes. This feature has been tested successfully but that feature wasn't timed during our trials.

Final Results – Prototype Offline Test, System Video

https://www.dropbox.com/home/Gary Plastic NYU-ITAC Final Presentation Video?preview=IMG_0298.MOV

Key Prototype Updates since Dec 8th: Wedge Plate (WP)

Wedge Plate (WP),

- Which consists of two parts:
    - Outer wedge: Piston dampers attached to the top of outer wedge.
    - Inner wedge: Designed solely for the purpose of getting the bottles to stand upright on the conveyor.
- The dimensions of the dividers have been altered to ensure the bottles do not teeter.
- Rubber padding on inner wedge plate have been removed.
- Extra Padding has been added on the back plate.
- Five piston stoppers have been installed on the outer wedge plate to slow down the momentum of the bottle falling under the influence of gravity.
    - The bottles are dropped from the molding machine into to the tubes, they flow through the pipes and then are stopped by pistons, which will then retract and allow the bottles to land on wedge plate.
- The wedge plate then tilts forward to position the bottles vertically upright (90 Degrees) on the conveyor, with the help of hinges installed at the back of wedge plate.

Additional: The wedge plate was shifted inward to avoid the last bottle tipping on the end of the conveyor.

Key Prototype Updates since Dec 8th: Conveyor

AFBS Bladder Stopper

- Pneumatic bladder stopper was installed on the conveyor.
- The bladder expands and halts the movement of the bottle on the conveyor momentarily, which allows the bottles ahead to be picked up by the Robot.
- The bladder stopper is located just before the pick-up spot of the robot.
- The bladder stopper is triggered by sensor count, once the sensor detects five bottles have passed by on the conveyor, the sensor sends a signal to the bladder, triggering it.
- Bladder stopper is wired to the UR robot controller and its functionality is integrated into the UR code.
- Without the bladder stopper, the bottles get too closely packed, which leads to the bottles adjacent to those being picked up, being knocked over.

Additional Points

- Additional padding has been added on the conveyor to support the bottles.

Key Prototype Updates since Dec 8th: Keyence Sensor Refinements

- The sensor is mounted on a separate stand next to the conveyor, within a distance of 20cm from the bottles.
- It is angled downwards (~10 degrees), with the sensor light aimed at the neck of the bottles on the conveyor.

- For the sensor to work effectively with clear bottles, a solid background must be used as a reflection plate. A white background should be used to maximize the sensor's effectiveness.
- The reflection plate is placed within 20cm behind the moving targets (bottles).
- The sensor is wired to the UR robot GPIO control panel.
- The sensor is triggered when the target blocks the sensor light ray. This signal is accepted as a number count in the robot code. Once the robot registers 5 counts, the robot signals the bladder stopper to activate and holds the incoming bottles in place.

Summary of Recommended Updates for Production Version:

- All the components such as the conveyor and the robot must be tightly secured at the base to avoid any shift in its position during its operation. Components should be positioned as shown in separate layout drawing.

- The tubes must also be tightly secured to ensure proper alignment with the wedge.

- A separate set of tubes should be built and used for the smaller bottles. This is because the height of the tube set for the smaller bottles will need to extend higher up, to align with the mold heads – as compared to the tall bottles.

- The wedge plate particularly, due to its high frequency, repetitive motion should be monitored to understand and predict its durability over time; more durable materials may need to be used.

- The final design of the wedge plate needs completed by Gary Plastic. This design will accommodate both short and tall bottles. See final design of wedge plate document provided separately for design dimensions and specifications of the proposed final design. Changes are primarily in the shape/ length of the wedge plate dividers.

Summary of Recommended Updates for Production Version (Continued):

- The bumper on the wedge plate will need maintained and likely updated, so that it is more durable for repeat use in production (e.g. replacing the tape that is holding the bumper onto the back of the wedge plate with a stronger adhesive.)

- The sensor must be mounted on a stand, placed next to the conveyor. The setup and placement of the sensor is mentioned on the previous slide and is critical for correct operation.

- When the sensor is restarted, switched on or the sensor/conveyor is moved in away way, the sensor has to be recalibrated. The instructions describing the recalibration is provided as a separate handover document.

- Maintenance schedules to perform preventive checks and maintenance should be developed and implemented, to ensure continued operation.

- Before the operation is started in production, the setup procedure should be followed to ensure smooth operation and to prevent issues. See the setup procedure that is provided as a separate handover document. It is an initial guideline that Gary Plastic will need to develop further.

Section B:

Financials

Design & Development Costs Incurred

Sub-System Development Cost	**Cost Category**	**Amount**
1. UR Robot	Material	$34,285
2. End Effector	Material	$ 600
3. Wedge Plate Design	Material	$ 250
4. Belt Conveyor	Conveyor	$ 1,000
5. Keyence Sensor	Sensor	$ 400
6. New Box to pack bottles	Box	$ 20
7. Metal Tubes	Material	$ 75
8. Pneumatic Pistons	Material	(all cost of subsequent material is added above)
9. Pneumatic air supply	Air supply	
10. Solenoid	Air Supply	
11. Sensor mount	Sensor	
12. ITAC-NYU Prototyping Project	Labor	$17,415 *
13. Gary Plastic Labor	Labor	$13,620 (est.)
14. Box Conveyor	Conveyor	$ 4,000
15. Bladder stopper	Material	$ 400

Total Costs To Date: $72,065 **

* A portion of the project time was spent to prototype solutions for other operational areas (e.g. pad printing).

** The total cost mentioned is excluding the Team GP labor for January.

Financial Impacts (Single Machine)

Sub-System Est. Savings per	**Cost Category**	**Amount per Machine**
1. Operator	Labor	$7,140 per month

Calculation Notes:

- Estimated cost of 16 operators/ floor guys per year is $456,944; cost of one operator per year $28,559

.

- Three operators over 3 shifts work on single machine
- So operator cost for one machine would be $7,140 per month

Payback Period

Payback Period: Period of time required to recoup (from project savings) the costs to implement a project (a.k.a. break-even point).

$$\frac{\text{Project Development Costs}}{\text{Monthly Savings}} = \text{Payback Period in Months}$$

$$\frac{\$\ 72{,}065^{*}}{\$\ 7{,}140} = \text{10 Months pay back period 1st machine;}$$

This does not account for immediately applicable impacts to 3 additional machines.

Also, does not account for resources (time/ $) spent training new operators due to turnover, as fewer operators over time will be needed, which reduces training costs and increases monthly savings over time.

* Estimated amount (not final)

Annual Savings (1 machine)

Machine 42:

After the project break-even point, Gary Plastic will save an estimated ***$7,140*** per month per machine (**$85,680** per year per machine). Per month an average of *365,318.25* bottles could be produced.

The average number of bottles produced on Machine ***42*** over the **10** month estimated payback period is **3.65 million** bottles

*For all the data, Quarter 2 sales for year 2017 were referenced.

Estimated Annual Savings (4 machines)

Machine No 41,42,43,44

Considering 4 machines Gary Plastic has the potential to save **$28,560 per month** on all four machines (**$342,720 per year**); assuming the box conveyor is implemented in a way that the Floor Person can handle transferring all WIP boxes to inventory when all four machines are operating.

In addition, training costs for new operators due to operator turnover, that is no longer required, is additional cost savings.

Section C:

Prototype and Final Production Recommendation Details

Final Summary of Work Completed (continued)

🟢 Complete
🟡 In Process
🔴 Not Yet Started

Sub-Systems/ Steps:	**Status as of** **Nov. 6th**	 **Dec. 8th**	 **Feb. 1st**	**Notes**
Step 1: **Injection Molding of Bottles**	No change required.	No change required.	No change required.	
Step 2: **Pipes from Machine to WP**				
- Concept tested (steel)	🟢	🟢	🟢	• Steel pipes are used in the final process to prevent damage to the bottles.
- Design of metal tubes for tall bottles	🟡	🟡	🟢	
- Design of metal tubes for short bottles	🔴	🔴	🟡	
Step 3: **Wedge Plate (WP)**				
- 1st concept designed.	🟢	🟢	🟢	• 2nd WP design consists of a secondary plate inserted on the first plate. The inner plate pushes the bottle to a vertical position with another set of pistons, which activate after the first plate has extended.
- Implementation of 1st wedge design.	🟡	🟢	🟢	
- Implementation of 2nd wedge design.	🔴	🟡	🟢	
- Final modifications to prototype design for tall bottles	🔴	🟡	🟢	
- Final modification to prototype design for short bottles	🔴	🟡	🟡	• Dividers have been adjusted and piston stoppers have been added.

Final Summary of Work Completed (continued)

🟢 Complete
🟡 In Process
🔴 Not Yet Started

	Status as of		
Sub-Systems/ Steps:	**Nov. 6th**	**Dec. 8th**	**Feb. 1st**
Step 4: Belt Conveyor for Bottles			
- Concept tested	🟢	🟢	🟢
- Sensor integration with conveyor	🔴	🟢	🟢
- Change of angle to allow spillage	🔴	🟡	🟢
- Interface conveyor with controller	🔴	🟢	🟢
- Mechanism to collect fallen bottles	🔴	🔴	🔴
Step 5: UR Robot			
- Pick & place programming/ concept tested	🟢	🟢	🟢
- Sensor integration with robot	🔴	🟡	🟢
- Separate programs for packing of short and tall bottles.	🔴	🟡	🟡
- Program the robot to run in a loop, to pack multiple boxes.	🔴	🔴	🟢

Notes

- A single channel belt conveyor is used. Movement is controlled by the signal received from the mold machine.
- Photoelectric sensor has been implemented to count the incoming bottles.

- Bladder end effector was successfully tested.
- Achieved the placement of 200 bottles from the conveyor to the packaging box at one go.
- To achieve packing of more than one box program code has to be modified slightly.

Final Summary of Work Completed (continued)

🟢 Complete

🟡 In Process

🔴 Not Yet Started

	Status as of			
Sub-Systems/ Steps:	**Nov. 6th**	**Dec. 8th**	**Feb. 1st**	**Notes**
Step 6: **Packing Bottles in Box**				• We are placing 5 bottles in a row. • Placement of 2 layers of 50 bottles (total 100) is complete. • The dimensions of the box for the tall bottles is 30x15x21
- Concept fully tested	🔴	🟢	🟢	
- Designing new box to pack bottles (tall bottles)	🟡	🟡	🟢	
Step 7: **Box Conveyor**				• Box conveyor similar to the one used for flyers will be appropriate, with an alteration to the angle of the conveyor.
- Concept designed	🔴	🟡	🟢	
- Concept tested	🔴	🔴	🔴	
Final Integrated System Tests				• Prototype fully tested offline. • Online test has not been conducted as the machine is not available due to production demands.
- Final offline system test	🔴	🟡	🟢	
- Final online production system test	🔴	🟡	🟡	

Prototype Summary: Tubes from Machine to Wedge Plate (WP)

Purpose: To channel the bottles falling from the injection molding machine to the wedge plate.

Design Notes:

- Steel tube design is used for long and short bottles.
- Modified steel tubes by adjusting the height of tubes, and its angle onto the wedge plate
- Steel Tubes are placed in such a way that the injection molding machine directly drops five bottle inside the tubes.
- Other end of tube opens on wedge plate.
- See provided tube designs for dimension and requirements for both short and tall bottle tube designs.

Lessons Learned:

- Proposed material used should be smooth in order to avoid scratching the bottles and to ensure the bottle's smooth transition.
- Curvature and length of tubes depends on dimensions of the injection molding machine and size of bottles.
- The transition of bottles from molding machine to the wedge plate is NOT always smooth. As a result, the wedge plate needs to be firmly attached to the floor or machine so it does not shift over time, causing misalignment with the tubes.

Prototype Summary: Tubes from Machine to Wedge Plate (WP)

Recommended Actions for Final Design Iteration for Production:

- The tubes must be placed accurately inside the molding unit, with the help of brackets at the bottom to hold it in place.
- The tubes must be aligned with the openings of the molding unit, so that the bottles being dropped land directly into the pipes.
- Ensure the molding head has enough clearance from the tubes in order to avoid the clash of molded bottles with the tubes.
- A separate set of tubes needs built by Gary Plastic to be used for the smaller bottles. This is because the height of the tube set for the smaller bottles will extend higher up to the mold heads as compared to the tall bottles. See tube designs document.
- Align the wedge plate dividers with the tubes accurately. Dimensions are attached in the documents.
- The height of the wedge plate from the end of the tubes must be enough to avoid a clash.
- See setup procedure for steps that need taken to ensure alignment.
- An alternate material for tubes may be used if scratching of bottles occurs.
- A warning system must be implemented if bottles for some reason back up in the tubes.

Prototype Summary : Pneumatic Wedge Plate (WP)

Purpose: Once bottles fall through the pipes into the slots on wedge plate, the plate then moves to vertical angle of 90 degrees to place the bottles on the conveyor. The Pneumatic wedge plate consists of two pieces, is hinged at an angle, each of which is controlled by solenoid; plate has five slots to hold five bottles.

Design Notes:

- Acrylic slabs were used to build wedge plate (WP)
- Wedge plate consists of dividers which channelize the bottles onto the conveyor.
- Wedge plate pushes the bottles to a vertical position on the conveyor with pneumatic pistons hinged at the back.
- The vertically lined bottles will be picked up by the robot arm, after they moved down the conveyor.
- Piston dampers, that ensure a smooth transition of the bottles from the tubes to the wedge plate, are very important to control momentum of bottles.

Lessons Learned:

- The wedge plate is critical to the transfer of the bottles from the molding machine to the conveyor.
- Due to the piston's constraints, the plate originally did not move 90 degrees; thus bottles were not placed fully upright on the conveyor. The 2nd design of the WP was modified to include a 2nd WP inserted inside the larger original WP and a secondary pair of pistons moves the secondary plate to 90+ degrees, resolving the issue.
- WP dividers were too small for short bottles, did not extend far enough down towards the conveyor to accommodate the shorter bottles. Modified design of dividers; prototyped with cardboard modifications.

Prototype Summary: Pneumatic Wedge Plate (WP)

Recommended Actions for Final Design Iteration for Production:

- Adjust the dividers based on final measurements; final measurements are found in handover document.
- The dividers must be lined up with the exit of the tubes and the air supply to the piston stoppers must be provided securely.
- Grease the piston hinges regularly to ensure smooth movements.
- Height of the wedge plate with the steel tubes must be such that it does not collide with the tubes during its motion.
- Going into production, the padding material on the back plate must be such that it does not deteriorate rapidly.
- Wedge plate can be mounted on a bracket on the molding machine to avoid shaking of the conveyor and the conveyor must be securely mounted to the factory floor.
- A warning system must be implemented to identify if the pistons and/or wedge plate malfunction.

Prototype Summary: Single Channel Belt Conveyor

Purpose: To guide the bottles down the conveyor. A single channel narrow conveyor is ideal as it will align the bottles as they approach the pick-up point of the UR robot. It is slightly angled to allow any fallen bottles to roll of the conveyor. This is a safety feature.

Design Notes:

- Columns (side rails) used to prevent standing bottles from falling off the conveyor and the conveyor is angled to allow tipped bottles to fall.
- A bladder stopper was added on the conveyor to halt the movement of the bottles.
- Manual control of conveyor has been automated.
- The signal to move the conveyor is provided by the output of the molding machine.
- Additional padding is added on the conveyor to prevent bottles from tipping over.

Lessons Learned:

- An acrylic holder is required at the conveyor end (at the point where the bottles are picked up by the robot). This ensures that the bottles moving down the conveyor are held in place at the pick up spot, so that the bottles are picked up by the robot arm efficiently.
- The tilt of the conveyor prevents bottles which are tipped over from affecting the incoming bottles.
- The bladder stopper is placed just before the spot at which the sensor counts the target, such that when there is bottle being counted the the sensor, the bottle behind will be right before (just about to pass) the bladder stopper. This ensures accurate sensor count.

Prototype Summary: Single Channel Belt Conveyor

Recommended Actions for Final Design Iteration for Production:

- Position of the conveyor with respect to the Robot and the injection machine should be exact.
- The conveyor must be secured tightly to the ground to avoid movements/ shifting over time.
- Ensure air supply is maintained and secure.
- A warning system must be implemented if a bottle tips over and remains on the conveyor.
- Use a conveyor belt with more padding (to minimize impact), and conveyor whose speed can be increased.

Prototype Summary: UR Robot Pick & Pack

Purpose: To automate the pick and pack operation; UR robot picks up bottles from the conveyor and places them into the box.

Design Notes:

- The robot receives a signal from the sensor to pick up the bottles.
- The robot code implements multiple pallet functions, which defines bottle positions in box.
- Robot arm speed is adjustable via teach pendant.
- The sensors and pneumatic actuators used are wired into the GPIO box of the robot and its functioning is triggered by the robot code.
- End Effector: A five pneumatic bladder end effector is used to hold bottles from inside. Bladders expand and contract to pick and place bottles.

Issues/ Lessons Learned:

- Incorrect placement of the packing box may result in the UR robot outstretching causing its emergency stop to activate.
- The angled packaging box allows the bottles to not tip forward.
- Packing of the second layer of bottles does not require a cardboard separator.
- The program code will be different for small and tall bottles due to the difference in heights of the 2 sets of bottles.
- UR programming is set; waypoints will need updated once final positioning of the box in the integrated system is defined.

Prototype Summary: UR Robot Pick & Pack

Recommended Actions for Final Design Iteration for Production:

- Ensure the sensor connection is active and it is calibrated accordingly.
- The UR robot must be mounted in locked position on the floor to avoid change in its position.
- Make sure the appropriate program is running. Directions on how to turn on the UR robot and run the program are provided in separate document.
- The electrical connections to the control box of the robot must to secured properly. See separate file for directions on electrical connections.
- Before production begins, the robot arm placement spots inside the box must be re-checked.
- The program code for packing consists of 4 pallet sections, each with a start point and end point. Each pallet accounts for 5 rows. If the position of the start point and end point of the first pallet is correct, the box is located right.
- If position of box has to be shifted, the start and end positions of each pallet must be recalibrated.
- A document is attached describing the recalibration instructions.
- A warning system must be implemented if to identify if the UR unit emergency stop is triggered and/or if any other malfunction happens.

Prototype Summary: Bottles Stacked in Box

Purpose: To enable packing of 100 bottles in one box.

Design Notes:

- The robotic arm packs the bottles row by row into defined positions inside the box.
- Dimensions of the box for tall bottles is 30 x 15 x 16. [NOT FINAL]
- Box is placed at certain height and elevation from one end. The elevated box. from one end, helped to stack the bottles perfectly
- The box will accommodate 2 layers on 50 each, one on top of the other – no divider needed..

Issues/ Lessons Learned:

- Placement of the box is critical.
- The bottom surface of the box must be flush, taped down, to avoid tipping of the bottles.

Prototype Summary: Bottles Stacked in Box

Recommended Actions for Final Design Iteration for Production:

- The position of the UR with respect to the box conveyor must remain fixed, so there is not need of reprogramming the UR.
- The stand on which the box is placed should be securely fixed in position as well.
- Tape the bottom flaps of the box to ensure bottles do not tip over after being placed in the box.
- The approach and exit motion of the robot will vary for small bottles and tall bottles because of the difference in height.
- The waypoints in the program code will need to be altered to accommodate the tall and small bottles.

Prototype Summary : Box Conveyor Design

Purpose: A continuous feed of packaging boxes so that the packing of bottles operation is not delayed for a long duration. This will ensure that an operator doesn't have to come in every 6-7 minutes to replace the box and move the filled box to the WIP pallet.

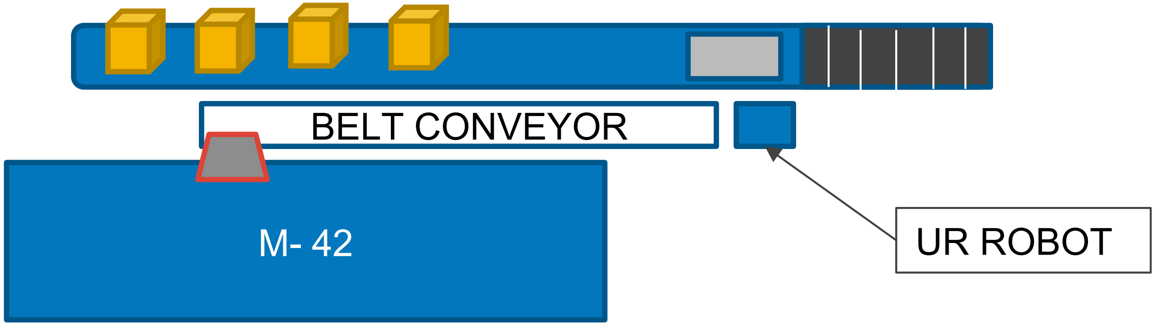
Proposed Design :

- The design of the box conveyor will be similar to the one used for the flyer operation.
- A 12 feet long conveyor system can accommodate 4 boxes. In order to accommodate 8 boxes on the conveyor, a long straight conveyor can be used.
- An alternative to a straight conveyor can be a curved conveyor, which will save space on the factory floor.
- Sensors detect the box and clamp it in place in the defined position so that the bottles can be placed in the box by the robotic arm.
- Once the box is packed, it flows down rollers onto a pickup area.
- Once the robot packs a 100 bottles, it signals the box conveyor to get the next box in place. And the operation continues.
- UR robot movement needs validated to ensure full range of motion required in proposed layout is possible.

Prototype Summary: Box Conveyor Design

Recommended Actions for Final Design Iteration for Production:

- The box conveyor will hold 4 cardboard boxes sequentially.
- Additional sensors will be required to signal the box conveyor to move along after one box is packed with 100 bottles.
- The box being packed by the UR robot must be clamped in place to keep its position fixed.
- The packed boxes will move along rollers onto a holding area. Once all the boxes are packed, an operator will move the packed boxes on a pallet and load new boxes onto the box conveyor.
- Note: if Gary Plastic decides to use the below layout for the box conveyor then the waypoints in the UR code will need updated to make the code production ready, once the final position of the box conveyor is integrated and system is run online . Gary Plastic may want to explore other layouts that provide more accessibility to the belt conveyor and other components.



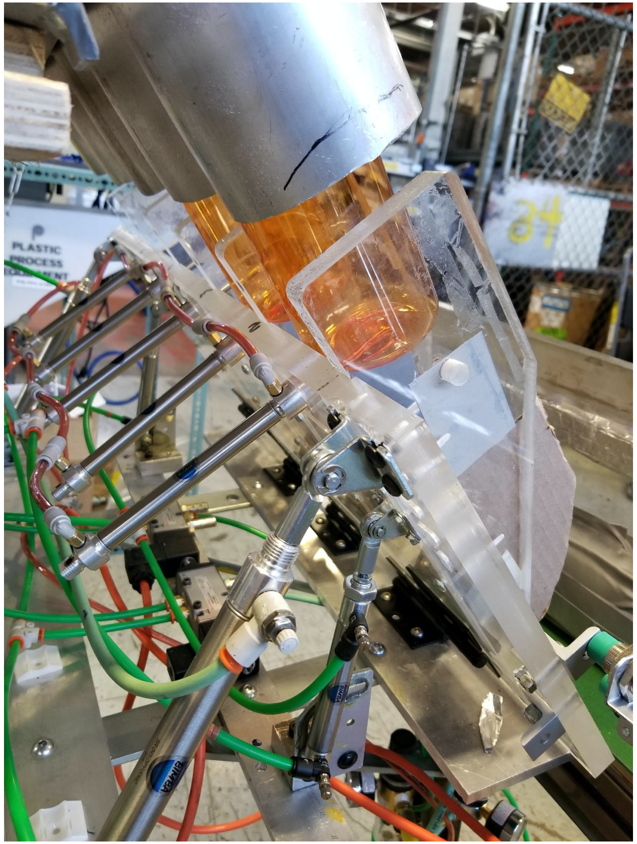
THANK YOU !

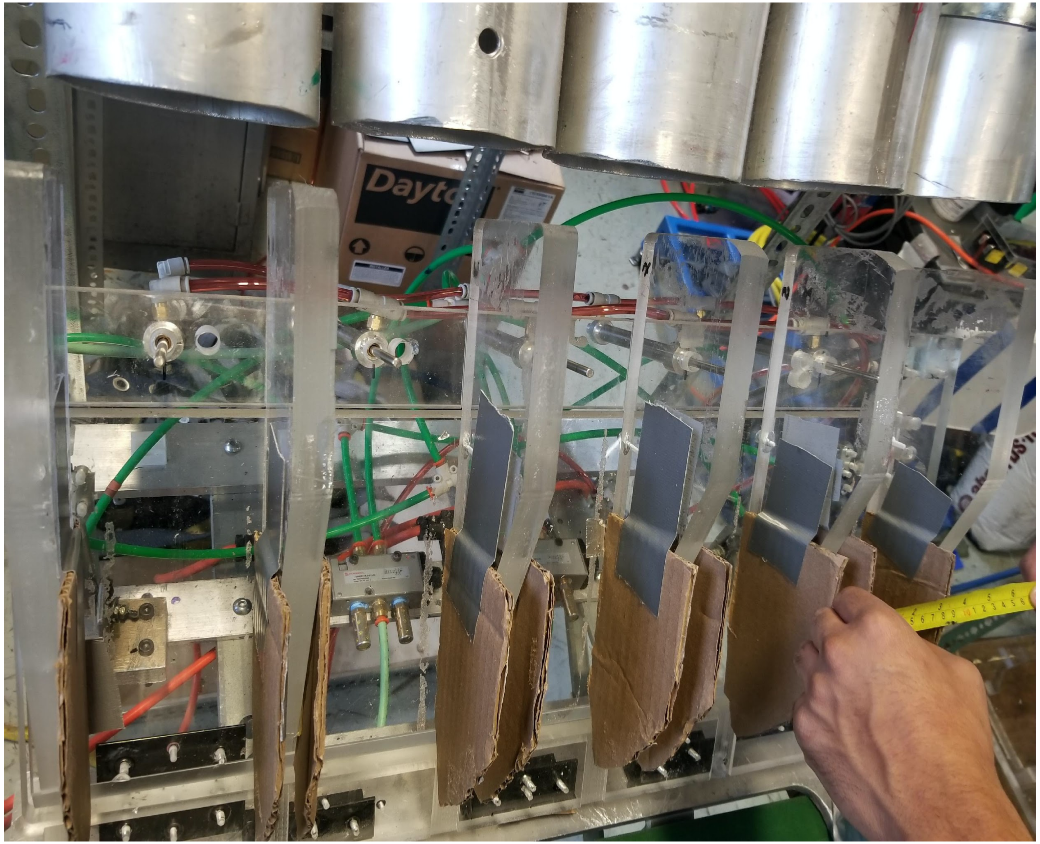
APPENDIX / EXTRA SLIDES

Photos of Components – Tubes

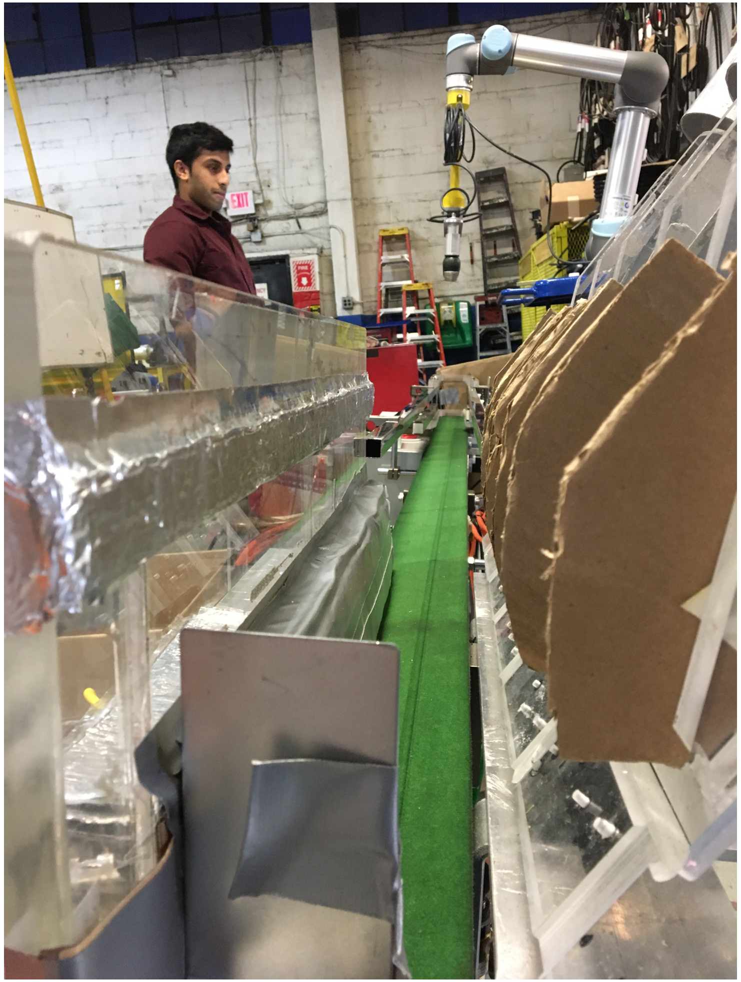
Photos of Components – Tube and Wedge Plate Alignment

Photos of Components – Wedge Plate – Primary/ Secondary Movable Plates

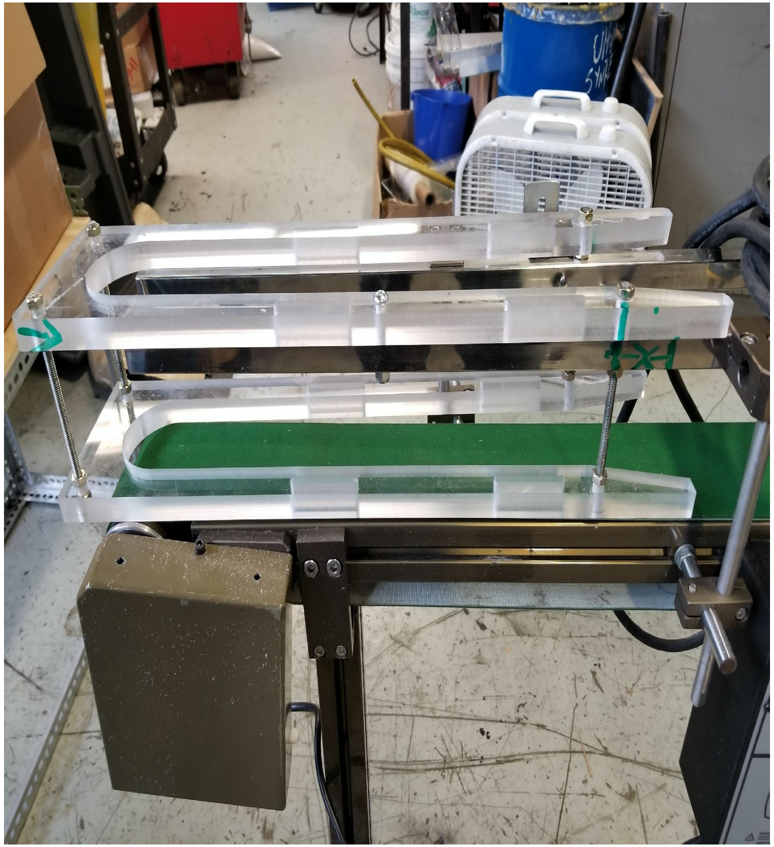


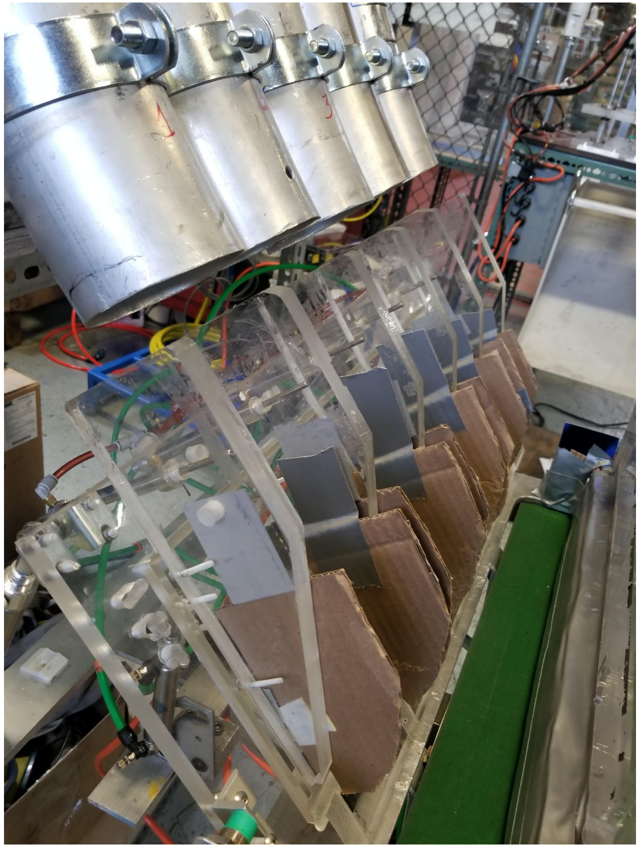


Photos of Components – Wedge Plate – Stationary Back Plate

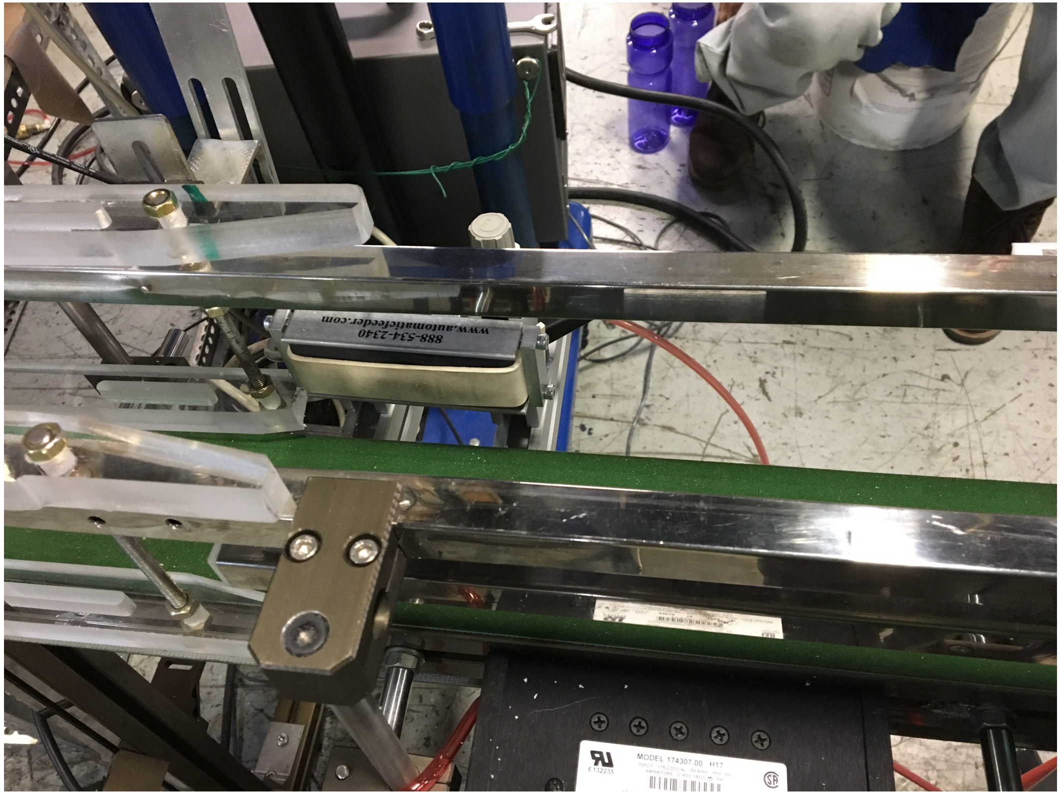


Photos of Components – Wedge Plate – Belt Conveyor

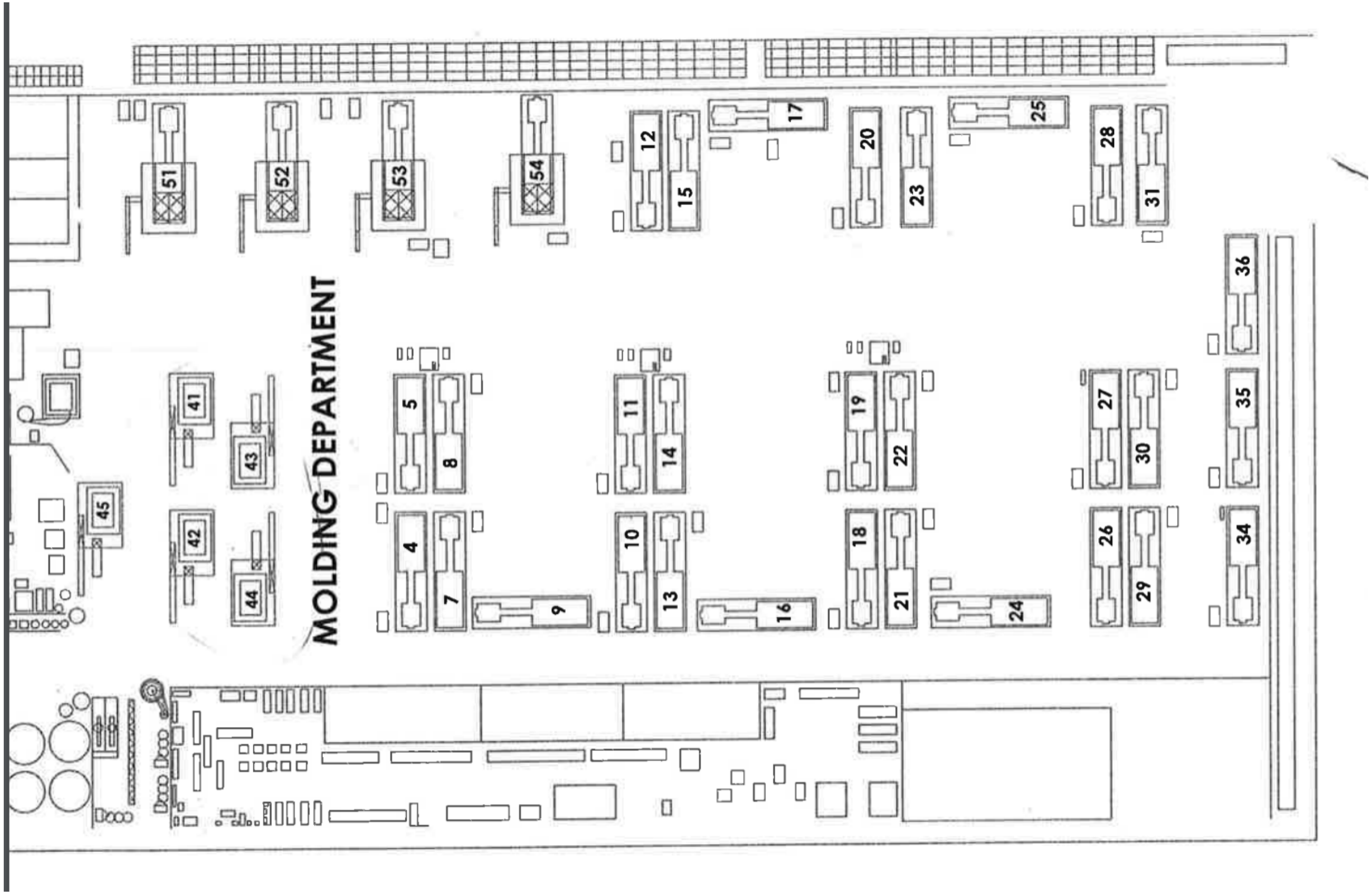




Photos of Components –Belt Conveyor – Sensor and Bladder Stopper



Floor layout



Universal Robot arm [UR-5]

- 6 DOF robotic arm
- It is a collaborative robot.
- Has a controller with programming interface.
- Has a GPIO board to interface sensors.
- Ability to interface safety devices.
- Max payload of 5kgs.

Labor Structure of Molding machine 41,42,43 and 44

Sr. No.	Department	Job Description	Total Count	No. of Shifts
1	Operator	Packs the bottle	12 (4 operator/Shift)	3 Shifts
2	Floor guy	Material handling, getting raw material, Shipping packed bottles to inventory	3 (1 fLoor guy/shift)	3 Shifts
3	Molding Supervisor	Supervises one or more Mold machines	4 (1st Shift - 2 2nd Shift - 1 3rd Shift - 1)	3 Shifts
4	Molding Manager	Oversees whole Mold operation	0.6	1st Shift
5	Molding Quality Control	Quality Control Check	4 (1st Shift - 2 2nd Shift - 1 3rd Shift - 1)	3 Shifts
6	Tool room technician	Maintenance of mould and machine	1	1st Shift

Operational Summary:

Time it takes injection molding machine 41 to produce 100 bottles: 6 mins 40 secs

Time it takes UR robot to pick and pack 100 bottles (Test mode): 6 mins 20 secs

So what does this mean?

- The time required to pick and pack the bottles can be reduced by speeding up the robot 2x times. This increases the time duration of response, to correct the error.
  - If an error occurs, then a siren, integrated with a sensor would go off.
- Also, we have not yet met the project Objective as an operator would still be required every ~7 minutes to move the full box.
  - Objective would be met if a conveyor system for the boxes is brought to use, where a conveyor would move boxes out of the way once full and replacing with an empty box.
  - Ideally, the conveyor system should be able to hold at least 8 full boxes so that an operator would be required every ~56 minutes to load half a pallet (8 boxes).