New Paltz
STATE UNIVERSITY OF NEW YORK

Division of Engineering Programs

SENIOR DESIGN PROJECT PLAN

Fall 2018 and Spring 2019

Multi-Purpose End of Arm Tooling

Student name	Student Major	Grade Received
NAME OMITTED	ME	
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NAME OMITTED	ME	
NAME OMITTED	ME	
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Advisor's or Stakeholder's name	Affiliation
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Mike Otis	SUNY New Paltz
Aaron Phipps	MPI Inc.

ABSTRACT

The objective of this project is to design and build a robotic end of arm tooling (EOAT) for MPI Inc. The design should be able to pick up wax patterns of several different geometries and sizes without causing any deformation that would translate to the final product. It would also eliminate the need to design and manufacture new tooling for the wax patterns compatible with the EOAT, reducing manufacturing costs and time to production. The tooling itself should also be less expensive to manufacture by taking advantage of a more cost effective method, such as 3D printing. The tooling will include sensors that allow it to recognize and adapt to the injected pattern, reducing the need for human involvement in the process.

Table of Contents

Page

1. Introduction:

The project is a multipurpose gripper for the automated cell manufactured by MPI. Currently, MPI needs a different gripper for every wax pattern they make. This is a time and cost intensive process. With a multipurpose gripper, MPI can save money and time, and work more efficiently overall.

Every time a new part is missing, molten wax is extruded into a watercooled die. As soon as the wax has solidified enough, it is being lifted off the die by small jacks. This is the point at which the robot grabs the part. It then moves it over to a cutting machine that will separate the runner from the gates. The runner is the solid tube of wax that splits into the respective parts once the extrusion begins. This allows the machine to create up to four parts with one extrusion. The gate is an intentional extension on the parts that is used to connect the part to a different frame during a later step of the overall process. After removing the runner, the part can either be placed directly into a tray for transportation or it has to be set down for regripping it at a different angle.

The multipurpose gripper will improve this process by eliminating the regripping process. Furthermore, the gripper will be equipped with sensors that allow it to always grip the part with the right amount of force. Current MPI models are purely running on coordinates. Whenever a part might show slight deviations from the target, the MPI model will either not be able to hold onto it, or it will cause deformations. Either way, the part would be scrap. The sensor's in our gripper are able dynamically react to such deviations. This will improve the overall process, rendering more parts usable.

Incorporating the knowledge from seven semesters of engineering we will build a gripper that is able to perform the tasks lined out, including "smart" elements into process. The gripper will make use of sensors to grab multiple parts.

2. Project Scope Statement:

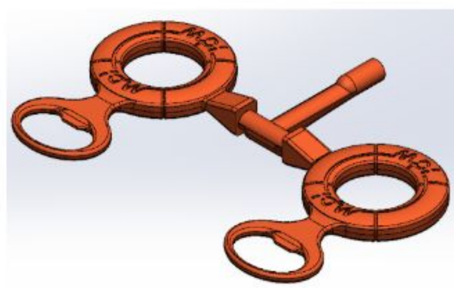
MPI desires a gripper that can pick up 2 objects having different geometries from a die. One of the required objects can be viewed in Figure 1. This object is 4 caps wax with a total width of 200mm. The other wax object is a wax bottle opener with width of which can be shown in Figure 2. The gripper itself must have some "smart" capabilities meaning that it utilizes feedback from sensors to adjust itself. Some options include:

- Photogate
- Pressure sensor
- Distance sensor

The temperature of the wax is also a constraint. Because the wax will still be warm when the gripper comes in contact with it, the wax is still relatively soft. This knowledge drives the design of the gripper to be made from a soft material where it is in contact with the wax so no deformation occurs.

Figure 1: Wax Caps Attached to Runner.

Figure 2: Wax Bottle Opener Attached to Runner.



Since the gripper must be able to work with the Machines produces by MPI, The MPI Internal standards will be followed for throughout the design of this gripper[1].
The properties of the wax used will be determined through preliminary testing.

3. Theory:

The gripper will be handling wax object. Wax is a soft material when it is at higher temperatures. To ensure that the material is not deformed, the gripper will need to apply a specified amount of pressure to the pattern.
When the wax is extruded into the die, it is undergoing a cooling process. Heat transfer methods can be used to determine how quickly the pattern will reach a suitable state for the gripper to

handle it. The flow rate the wax flowing into the die is not a constant value and varies depending on the object being molded.

4. Project Approach:

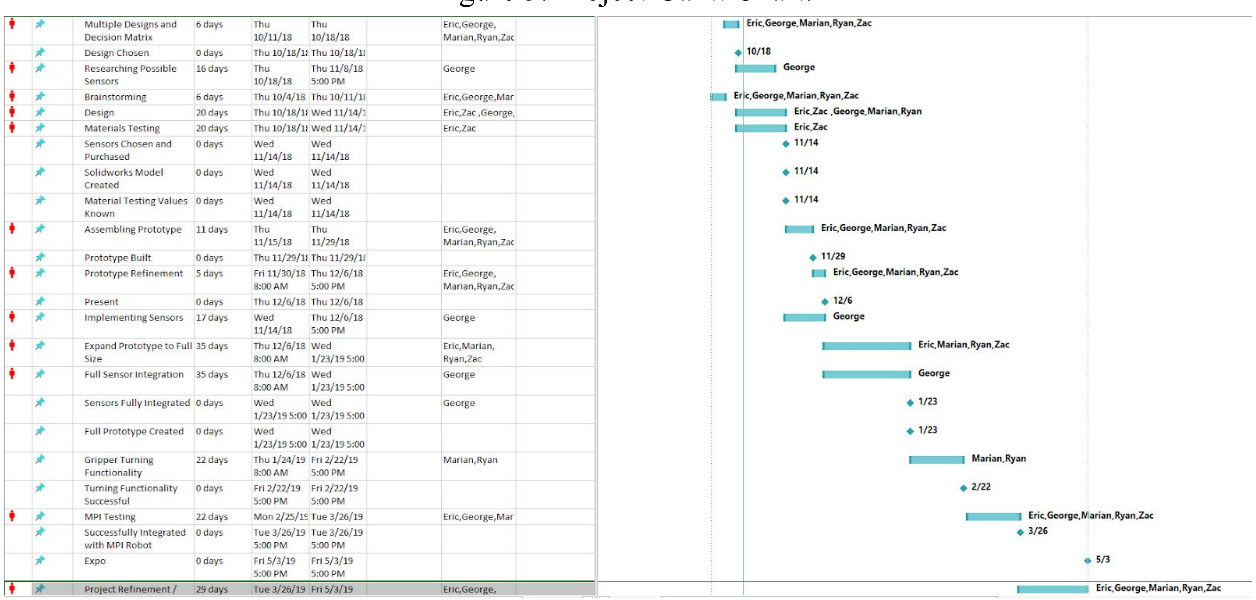
Design processes, such as a decision matrix, will be used to determine criteria for the design of the gripper. From there, a design will be chosen and further refined. Testing of the wax material will be conducted in order to determine different material properties necessary in completing the chosen design. Sensors will be chosen based on the requirements of the design.

The prototype will obtain feedback from sensors and apply the correct amount of force necessary to successfully pick up a simple wax object without deformation. This is a goal to be demonstrated at the Project Showcase. Refinements of the prototype, as well as expanding it to full size and functionality, will then be made before it is integrated with MPI's robotic arm. Once implemented in MPI's robotic arm, the gripper will demonstrate its ability to pick up both objects required by MPI.

In the second semester of the project, it was decided that constant sensor feedback was no longer needed to fulfill the requirements of the project, and may even be a hindrance to the project's success. It was decided that instead of constant sensor feedback, the tooling would incorporate suction cups that move to preprogrammed positions in a gantry system.

5. Project Schedule:

Figure 3: Project Gantt Chart.



Multiple Designs and Decision Matrix	6 days	Thu 10/11/18	Thu 10/18/18	Eric,George, Marian,Ryan,Zac
Design Chosen	0 days	Thu 10/18/1	Thu 10/18/1	
Researching Possible Sensors	16 days	Thu 10/18/18	Thu 11/8/18 5:00 PM	George
Brainstorming	6 days	Thu 10/4/18	Thu 10/11/1	Eric,George,Mar
Design	20 days	Thu 10/18/1	Wed 11/14/1	Eric,Zac ,George,
Materials Testing	20 days	Thu 10/18/1	Wed 11/14/1	Eric,Zac
Sensors Chosen and Purchased	0 days	Wed 11/14/18	Wed 11/14/18	
Solidworks Model Created	0 days	Wed 11/14/18	Wed 11/14/18	
Material Testing Values Known	0 days	Wed 11/14/18	Wed 11/14/18	
Assembling Prototype	11 days	Thu 11/15/18	Thu 11/29/18	Eric,George, Marian,Ryan,Zac
Prototype Built	0 days	Thu 11/29/1	Thu 11/29/1	
Prototype Refinement	5 days	Fri 11/30/18 8:00 AM	Thu 12/6/18 5:00 PM	Eric,George, Marian,Ryan,Zac
Present	0 days	Thu 12/6/18	Thu 12/6/18	
Implementing Sensors	17 days	Wed 11/14/18	Thu 12/6/18 5:00 PM	George
Expand Prototype to Full Size	35 days	Thu 12/6/18 8:00 AM	Wed 1/23/19 5:00	Eric,Marian, Ryan,Zac
Full Sensor Integration	35 days	Thu 12/6/18 8:00 AM	Wed 1/23/19 5:00	George
Sensors Fully Integrated	0 days	Wed 1/23/19 5:00	Wed 1/23/19 5:00	George
Full Prototype Created	0 days	Wed 1/23/19 5:00	Wed 1/23/19 5:00	
Gripper Turning Functionality	22 days	Thu 1/24/19 8:00 AM	Fri 2/22/19 5:00 PM	Marian,Ryan
Turning Functionality Successful	0 days	Fri 2/22/19 5:00 PM	Fri 2/22/19 5:00 PM	
MPI Testing	22 days	Mon 2/25/1	Tue 3/26/19	Eric,George,Mar
Successfully Integrated with MPI Robot	0 days	Tue 3/26/19 5:00 PM	Tue 3/26/19 5:00 PM	
Expo	0 days	Fri 5/3/19 5:00 PM	Fri 5/3/19 5:00 PM	
Project Refinement /	29 days	Tue 3/26/19	Fri 5/3/19	Eric,George,

6. Risks:

The timeline of the shipment of products we need to construct the gripper with may negatively impact the progress of the project if it takes longer than expected. To avoid this, the team will communicate with the supplier to obtain frequent updates on the status of the products.

The total cost of this project is also a risk. The sensors purchased will be a majority of the expenditures for the gripper. However, to offset the cost, the gripper will most likely be made from a 3D printed material and any parts that can be 3D printed will be.

7. Conclusion:

By building a multipurpose gripper/end of arm tooling for MPI we will demonstrate our knowledge and skill of engineering in a (close to) real life environment. We will help MPI by reducing their time and cost efforts for utilizing different grippers in the future. Our product will be able to pick up two objects that vary in size and shape, namely four flowback preventer flaps as well as the bottle openers. The gripper will be able to make use of sensors to determine whether it is within reach of the parts, and ensure a proper grip without using too much force to hold the parts.

With our team's composition, we will be able to bring this product to fruition. Our four mechanical engineers are spread out across a broad spectrum in terms of expertise, and our computer engineer is confident and capable to implement all sensors into the design.

8. Bibliography/Works Cited:

[1] MPI Inc., "MPI Automated Pattern Assembly System 20-14 (APAS 20-14) Tooling Design Reference," MPI Inc., Poughkeepsie, 2018.

9. Appendix

I. Project Stakeholders and Communication Plan

Below is a table listing team members and their respective roles and responsibilities. The table shows primary roles and responsibilities and group members will most likely partake in other areas than stated below.

Table 1: Team Members and Responsibilities.

Team Member	Roles / Responsibilities
Zac Covert	CAD / Materials Testing / Sensors
George Dagis	Programming / Sensors
Marian Elflein	Documentation / Kinematic Analysis
Eric Milczewski	Materials Testing / CAD / Programming
Ryan Foertsch	Kinematic Analysis / Documentation

Below is a table which lists meeting times. Days, times, attendees and description of what goes on at the meeting are included. In the table below, "team" is defined as all 5 members of the group. The stakeholder is MPI.

Table 2: Overview of Meetings.

Day	Time	Attendees	Description
Mondays	11:00 - 2:00, 5:00 - 7:50	Team	Class, team works on project and future plans when lecture finishes
Thursdays	11:00 - 2:00	Team	Team meeting to catch up and work on project
Thursdays	11:30-12:00	Team, advisor, stakeholder	Conference call with Aaron Phipps

The group will visit the facility as needed.

II. LESSONS LEARNED:

One of the key lessons learned is to include as many important criteria in a decision matrix as possible. With the decision matrix displayed to the customer, it was pointed out that the more criteria, the better. This helps shaping the constraints.

III. DESIGN SPECIFICATIONS AND CONSTRAINTS THAT ARE DRIVING THIS PROJECT

This table shows the design constraints that will drive this project:

- The gripper must be able to grab the wax pattern without causing deformation to it.
- The gripper must be adjustable to be able to pick up objects in patterns of two or four from the smallest size being two objects that are separated by 50 mm, and the largest being four objects that are each separated by 200mm.

IV. ENGINEERING STANDARDS THAT WILL BE USED IN THIS PROJECT

This table shows the engineering standards planned for use in this project:

Table 9.2: Engineering standards used in this project.

Engineering Standard	**Where it was used**

V. DIFFERENT DISCIPLINES PLANNED FOR USED IN THIS PROJECT

The first column of Tables 9.4 and 9.5 show that different disciplines that will be used in this project. More specifically, the second column shows the course(s) within the disciplines whose learning outcomes are planned for use in the project.

Table 9.4: Computer Engineering (CE) Disciplines and Courses within Discipline in the CE program

Discipline	Course in the discipline	Check if Used
Software	EGC251 C/C++ Programming	X
	CPS210 Computer Science I	X
	CPS310 Computer Science II (Data Structures)	X
	CPS353 Software Engineering	
Computer Systems	EGC331 Microprocessors + EGC332 Microprocessors Lab	X
	EGC433 Embedded Systems	X
	EGC442 Computer Architecture	
	EGC451 Real-Time Systems	
Digital Systems	EGC220 Digital Logic Fundamentals + EGC221 Digital Logic Lab	X
	EGC320 Digital System Design	
	EGC441 System On Chip	X
	EGC445 VLSI Design + EGC446 VLSI Lab	
	EGC447 Functional Verification	

Table 9.5: Mechanical Engineering (ME) Discipline and Courses within Discipline in the ME program

Discipline	Course in the discipline	Check if Used
Computers	EGE331 Computer Simulations	X
	EGM302 Finite Element Analysis	X
	EGM393 Advanced Computer Aided Design	X
Mechanics & Machines	EGM211 Statics	
	EGM212 Dynamics	X
	EGM311 Kinematics of Machines	X
	EGM312 System Dynamics	X
	EGM393 Advanced Computer Aided Design	X
Thermodynamics / Dynamics	EGM331 Thermodynamics	
	EGM332 Fluid Mechanics + EGM333 Fluid Mechanics Lab	X
	EGM334 Heat Transfer	X
	EGM335 Thermo Systems Design	
Materials	EGM221 Engineering Materials	X
	EGM322 Mechanics of Materials + EGM323 Materials Lab	X
	EGM393 Composite Materials	
	EGM393 Design of Machine Elements	