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Automated Die Spray
Gibbs Diecasting

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ENGR 491 – Senior Design
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Abstract

In industry, having enough workers to run jobs can be a difficult task. My team and I at Gibbs had to come up with a solution to this problem to create more help to run the machines without having humans to rely on. Throughout this report, I will be explaining how Gibbs Diecasting plans to help solve some of those issues in certain parts of the plant. I will explain the reasoning behind it, the design of the project, and what all ways it will help our company. Using this design allowed us multiple opportunities to improve machine production and timing in the plant.

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Introduction

This project is taking place at Gibbs Diecasting in Henderson, KY. The company over the last couple of years has run into problems with being able to keep people hired to run the machines for a full 3 shifts. When we don't have people to run the machines, they must shut them down. This means there are no parts being made and the company loses money on jobs that aren't being run. My group and I were asked to come up with a solution to this problem. One of the biggest questions we get asked is "do we really need to have 2 people running each casting machine?" Over the years there have always been multiple people running a machine. After this problem worsened and machines were shut down, we came up with the idea to replace the helper side workers with robots, thus, leading to the idea to make a spray robot run on a casting machine full time. This will help save the machine's run time and allow casting operators to do less work making this job much easier.

Background

Problem Statement: This project focuses on the quality and productivity of a robotic casting work cell. The goal of the project is to install a robotic arm to increase safety for production workers, while maintaining the desired levels of productivity and quality.

Gibbs Diecasting is a company that makes cast aluminum parts and machines those parts after casting. There are multiple plants on site. The company is having issues keeping machines running due to low numbers of workers. Creating a design to replace a human is a design that will save the company money, allow better spray quality, and will help create better jobs in the plant.

Process Flow Chart

The flow chart below shows how the Diecasting process works and what takes place for the Diecasting machine to run along with the robot and what the remaining operator still does. This chart is useful to see when the robot is used and when it is sitting back at home. This also gives a simple overview of what it takes to make an aluminum part from start to finish.

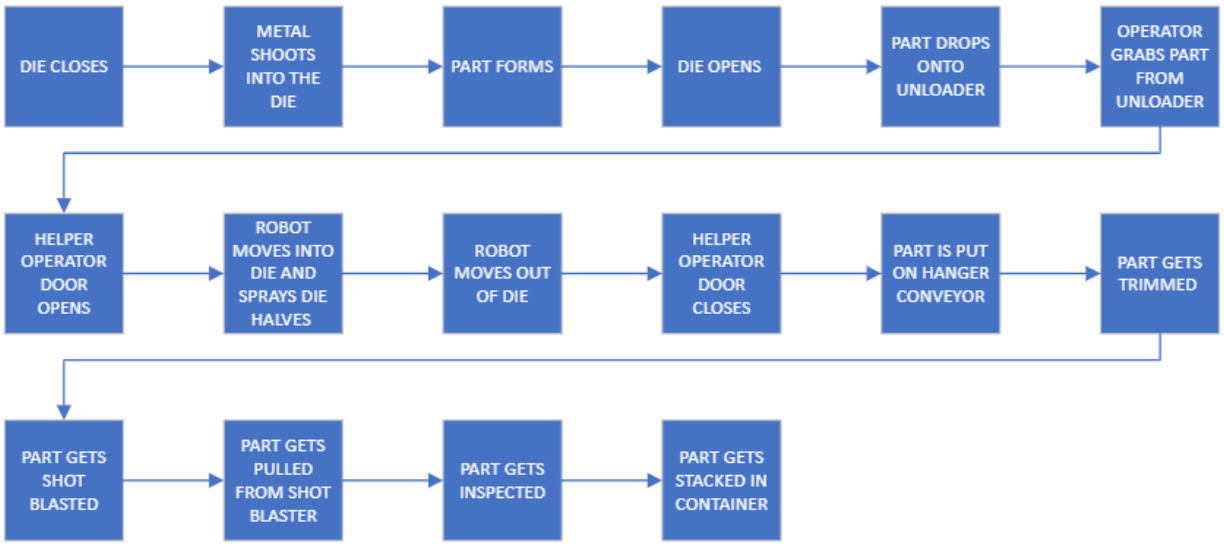

Figure 1: Process Flow Chart

System Hierarchy 1

The system hierarchy shows that Gibbs is apart of many other family companies that all fall under Koch Enterprises Inc. The diagram allows you to also see that there is more than just Diecasting under Gibbs. Using this diagram, you can see that Gibbs has trim casting and machining onsite. This project falls under the casting portion of Gibbs. In casting, our main focuses for implementing new projects is automation, safety, and maintenance. Each of these three parts work together to make sure that the plant runs smoothly, safely and efficiently.

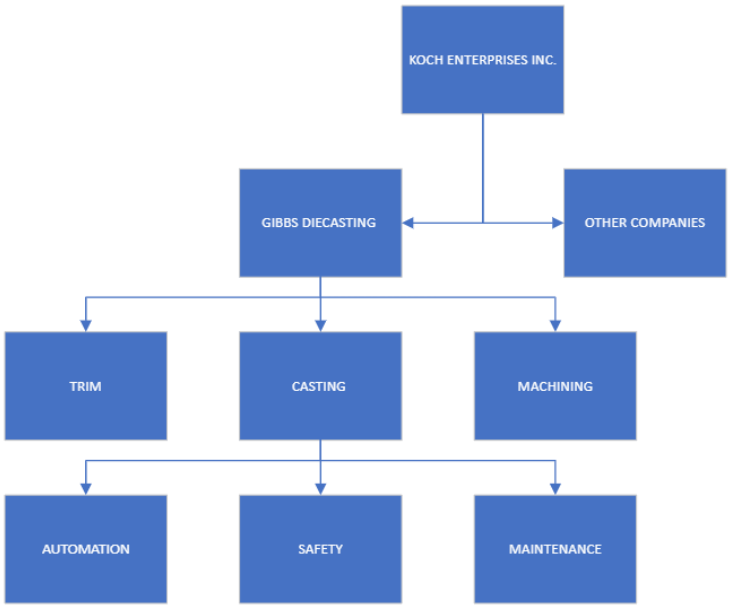

Figure 2: System Hierarchy 1

System Design

One of the biggest challenges for this design is the space we are allowed to work with to make this concept work. This design will consist of a robot, spray head, helper platform, fortress fencing, new automated casting door, and a lot of modifications to the machine to make this all work correctly. The robot will be mounted on the helper side of the machine. It will also be set up to where it can be moved out of the way for repairs as needed. The casting machine will be switched to run with the robot instead of a human worker. The project should save the company money and produce better quality parts.

System Design Concept

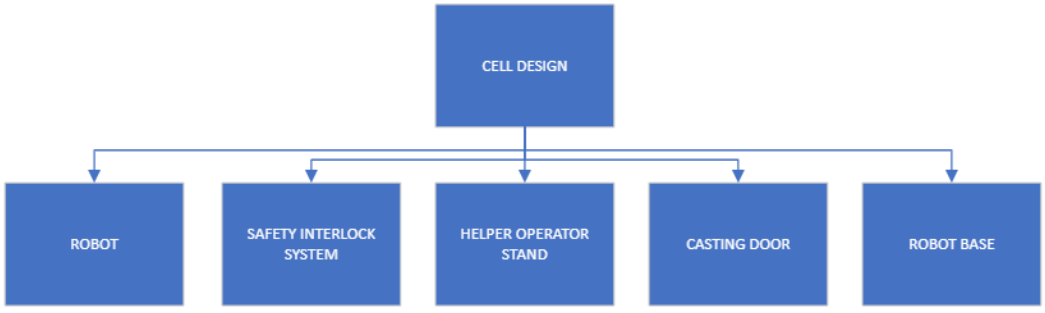

Figure 3: System Hierarchy 2

Design/user specifications and requirements

The system requirements include the design and integration of the following subsystems for operation.

- Robot
- Helper stand
- Spray head
- Fortress safety system

Figure 4 shows the current 3D CAD drawing of the machine today. It also shows the addition of the robot cell and each part that is in the cell to make it run safe and efficient. The image shows the helper side of the machine. There are two different robot positions showing the robot in the die and at a home position. Closer to the machine, the design shows a worker as if the robot was broken down and we needed to run the machine manually. This design shows each part of the machine and where the robot needs to be whether we are in auto or manual mode. Figure 5 shows the helper side of the robotic cell in more detail.

Design Concept

The below criteria include the main concepts influencing the design of this robotic cell.

- Robot will be mounted on the helper side of machine.
- Will be setup to be moved to the side if the robot breaks down.
- The casting machine will be switched to automation so it's safe.
- Project must save company money and produce better quality parts.

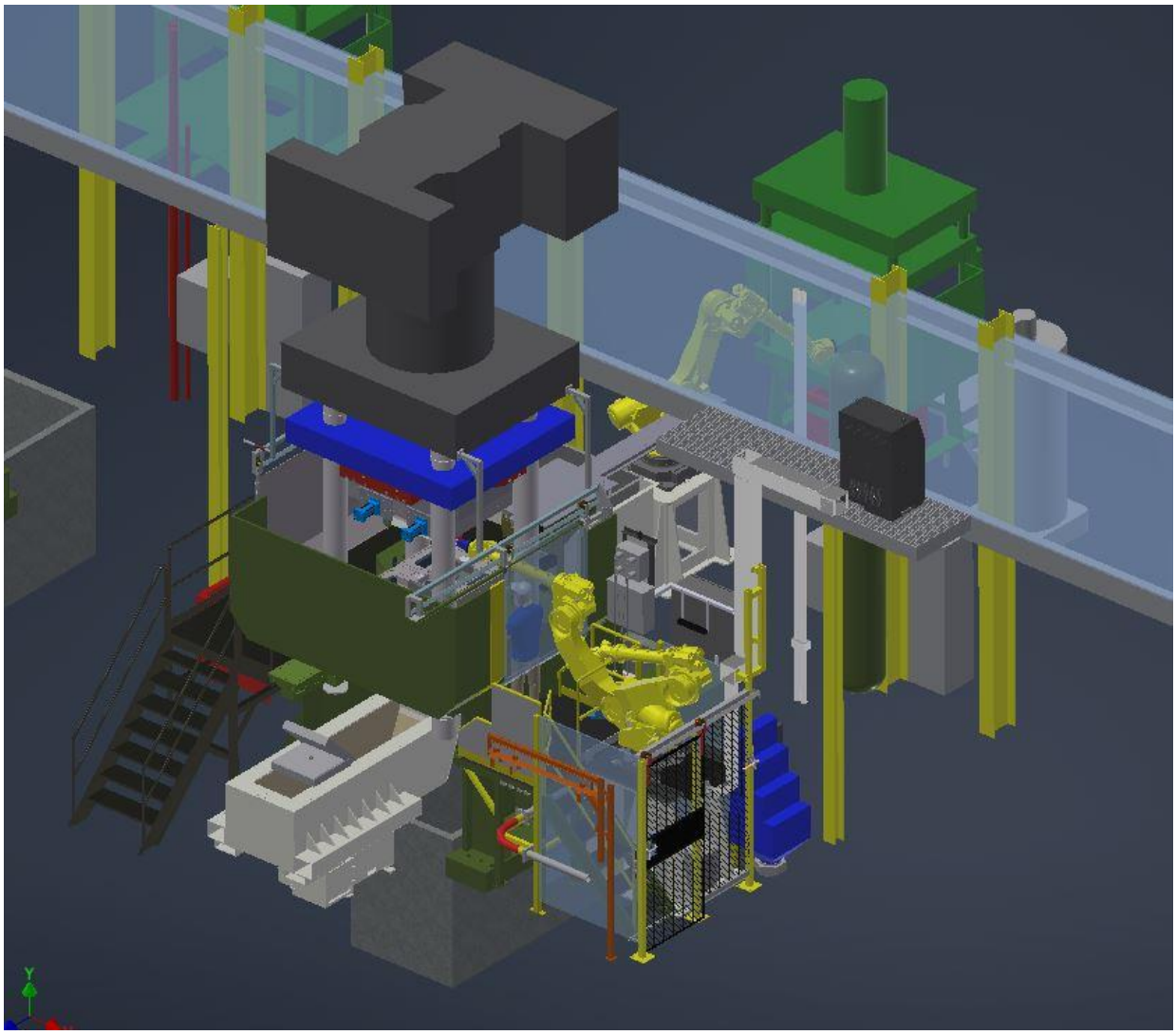

Figure 4:Cell Model

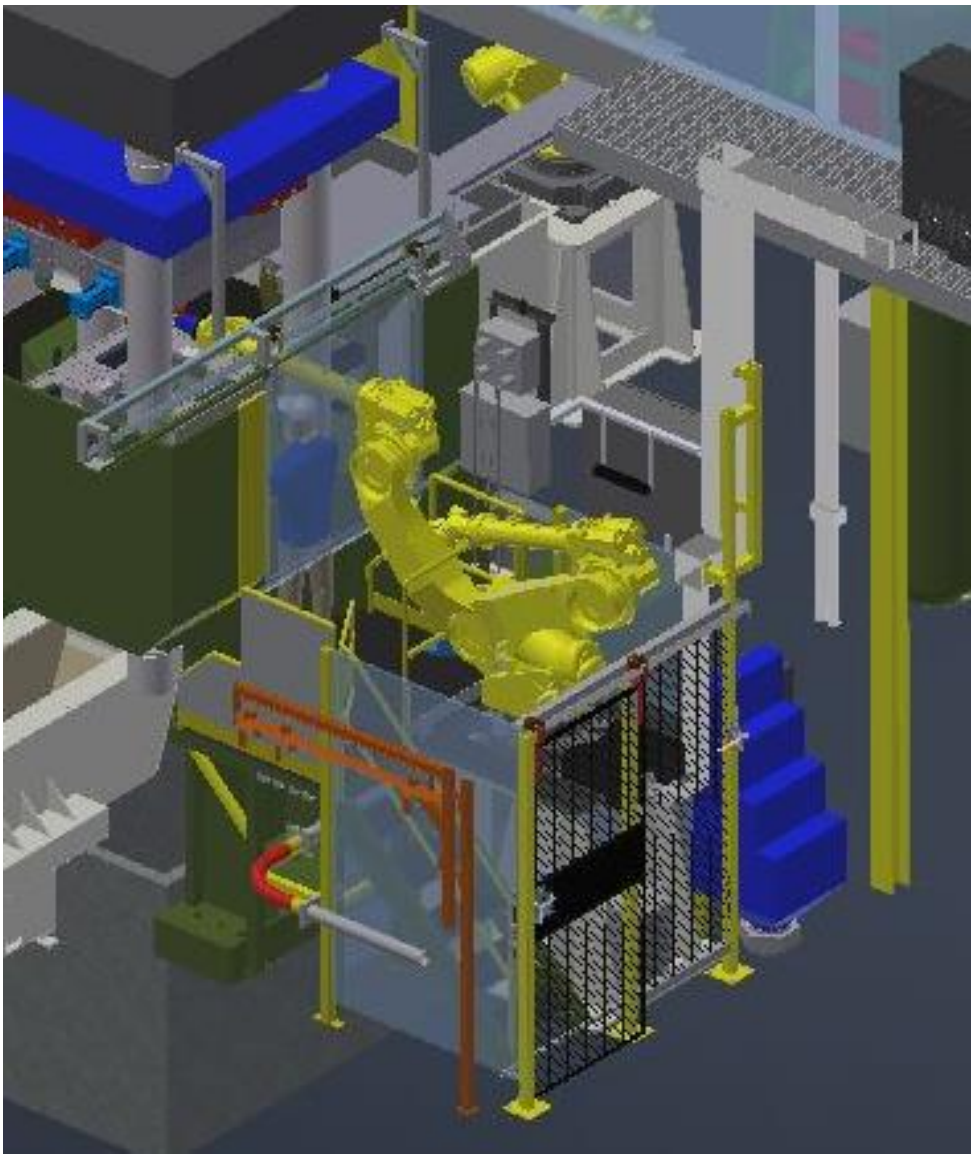

Figure 5: Helper side Cell Layout

Robot

The robot used for the project is a Fanuc R2000ib. This robot is used for multiple applications throughout the company. The spray head used was designed somewhat by Gibbs. The design was then sent out to Herco for the main design and finished product. Herco then came and helped set up the head on the robot and get it running efficiently to put it in production. Figure 6 shows CAD drawings of the spray head attachment, the spray nozzle, the spray head attached to the robot and the operation of the spray head within the work cell.

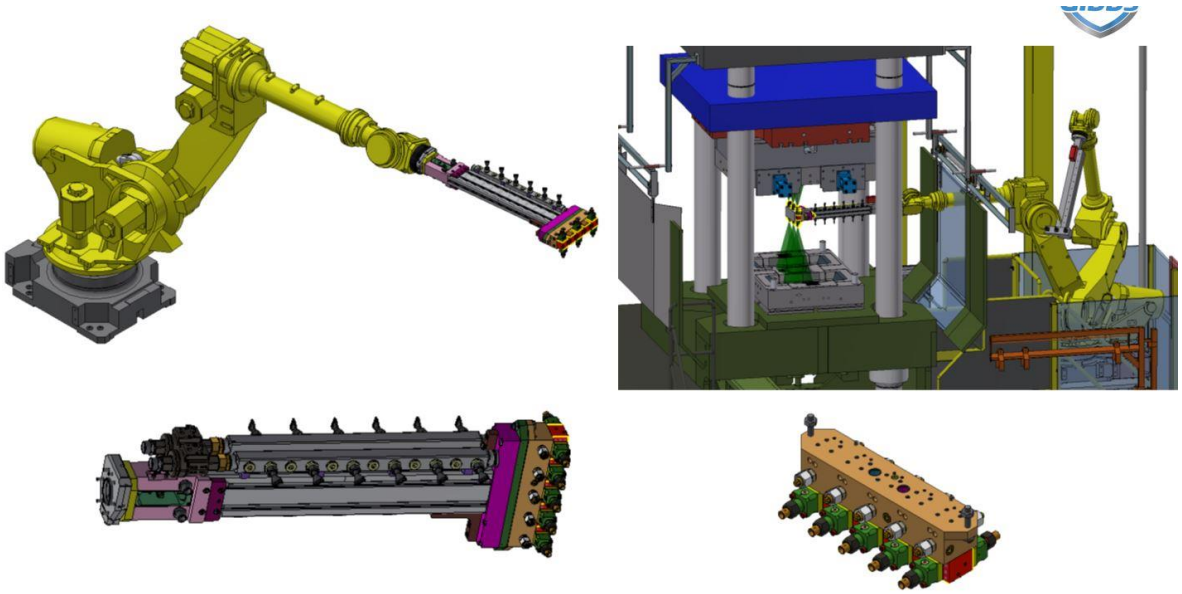

Figure 6:Robot and Spray Head

Fortress

The Fortress system is a big part of the project. It may not help the machine run but it does keep all the workers around the robot and machine safe. The yellow door in the image below keeps workers out of the cell when running. The system is tied into the machine and robot program which means the door must be locked to start up and can't be unlocked when it is running. Figure 7 shows a photograph of the Fortress system once installed in the robotic cell.

Figure 7: Entry Door/Fortress

Helper Stand

The helper stand allows the machine to be able to run in auto and manual meaning we can use the robot or if needed, a human can run the machine if the robot is broken. This platform is also a place to work on the robot and work on the machine when needed. The design was changed to give the robot as much space as possible but also allow a worker to be up there working comfortably and safely. Figure 8 shows the CAD model and parts list associated with the helper stand.

PARTS LIST

ITEM	QTY	PART NUMBER	DESCRIPTION
1	4	help platform - plate1	STEEL
2	4	help platform - tube6	STEEL
3	2	help platform - tube - 3	STEEL
4	5	help platform - floor8	STEEL
5	1	help platform - channel - 19	STEEL
6	1	help platform - channel - 20	STEEL
7	1	Helper frame front half	STEEL
8	1	help platform - tube 18	STEEL
9	1	help platform - tube 19	STEEL
10	1	Deck rev 3	STEEL
11	1	help platform - tube 20	STEEL
12	1	help platform - channel - 31	STEEL
13	1	help platform - channel - 32	STEEL
14	1	Stair Railing2	STEEL
15	1	Left handrail with kick plate	STEEL
16	1	Right handrail with kick plate	STEEL
17	4	Foot plate for helper stand	STEEL
18	1	Helper Deck Extension	STEEL
19	1	Helper Railing Plate 2	STEEL
20	10	Step tread brackets	
21	3	4 inch conduit clamp	
22	4	L Bracket	
23	1	Handrail in front of robot with kick plate	STEEL
24	1	Pipe clamp bracket	
25	1	PIPE 300 ALUM 3inch Ajax Lead assembly	
26	2	Conduit clamp mount 1	

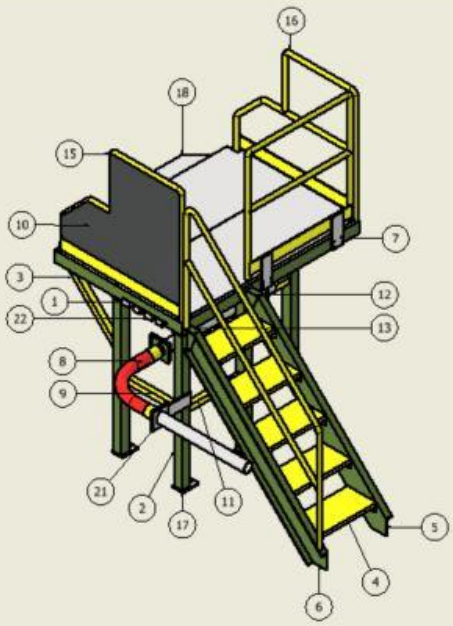

Figure 8: Helper Stand

Casting Machine

The casting machine below is a 1600-ton press. It is used to make aluminum parts using two die halves to compress the molten aluminum into multiple parts.

Figure 9: 1600T Casting Press

Robot Base

The robot base design allows the robot to be mounted to the floor and disconnected from the helper platform. This means there is no feedback from the robot in the surrounding area as the robot base is very heavy and bolted to the floor. This also helps with easy removal of the robot in case of repair. Figure 10 shows the CAD drawing and parts list for the robot stand.

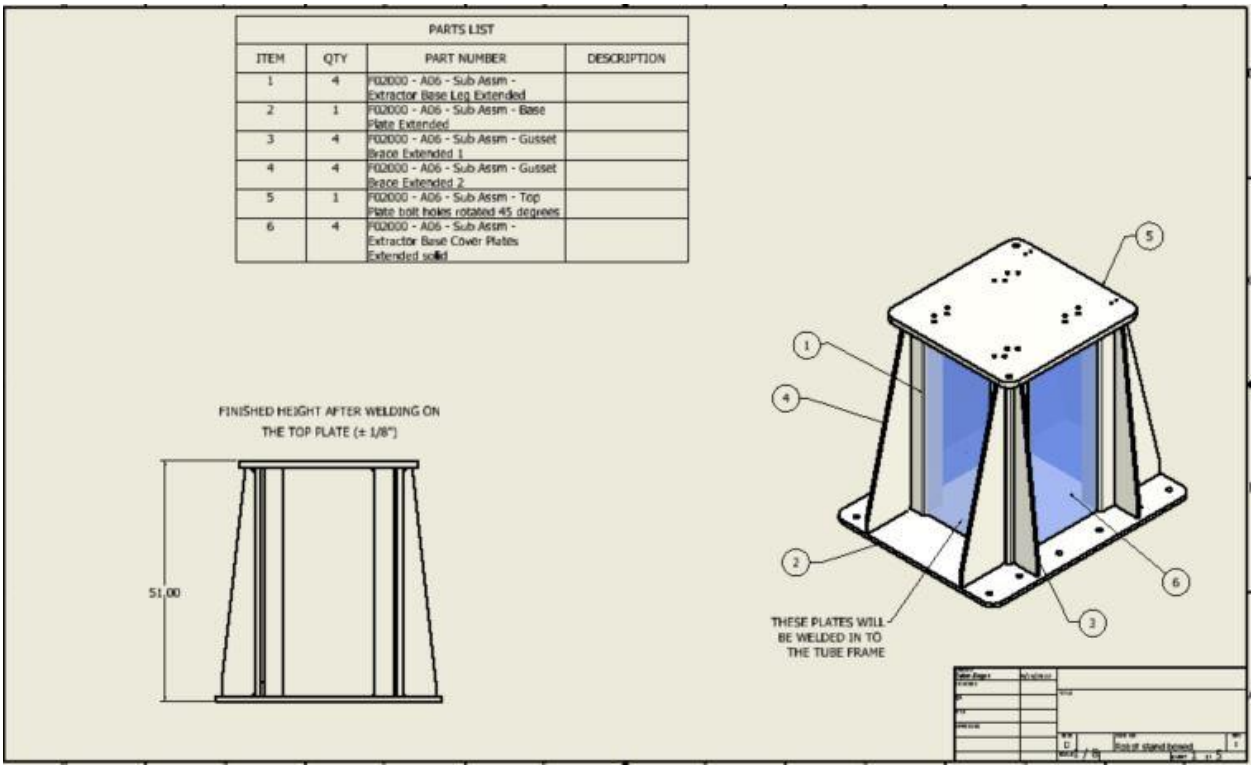

Figure 10: Robot Riser

Schedule

The below schedule documents the timeline implemented for the completion of this project.

Tech 16 cell modifications and implementation	**63 days**	11%
T16 Spray Head / Dresskit on Robot from Herco	**54 days**	5%
Send F#'s & IP addresses for all robots to Herco	1 day	100%
Send updated T14 robot backup to Herco	1 day	100%
Send 3d Die data w/ die opening for DMax to Herco	1 day	100%
Send Swat chart docs for Dmax to Herco	1 day	100%
Send cycle times for Dmax to Herco	1 day	0%
Send videos of manually sprayed Dmax die to Herco	1 day	100%
Send 3d data of Cell T16 to Herco	1 day	100%
3d concept T16 robot out die sensor bracket	3 days	0%
3d concept T16 help platform deck extension	5 days	0%
Purchase air components and Lube components ?	5 days	100%
T16 Cell Components Fabrication (Frields or Corp Maint)	**51 days**	10%
T16 Cell Modifications (while Press is DOWN)	**13.25 days**	0%
T16 Cell Modifications (while Press in Production)	**23.13 days**	0%
T16 Planned Downtime to Implement Spray	**6 days**	0%

Figure 11:T16 Schedule

Budget

The budget below shows the parts that were designed in house and sent out to be built or also built in house. Each of these items had to be custom made for this cell layout so it would fit correctly. We used a fab shop to build most of the items since there was machining and a lot of welding to be done. Below is the cost of the total cell layout and the cost of a worker. There is a 1.6 year payback period for this project per machine. This allows more machines to run and an increase in profits.

- Tech 16 Helper side automation - $216,667
- Cost per operator - $44,000/yr. + benefits
- 3 Shifts/day - $132,000/yr. for 3 operators
- Payback period: 1.6 years

Tech 16	Price
Cable Guard	$ 618.00
Robot Base	$7,942.00
Helper Platform	$5,468.00
Entry door (safety door)	$2,890.00
Casting door	$3,290.00
Air Manifold	$ -
Wireway	$ -
Robot Base Shield	In Progress

Figure 12: Budget

Results

The below list illustrates how the completed project fulfills the desired requirements, including a faster cycle time, reduced scrap, a safer work environment and a more cost-effective method of production.

Machine with manual spray

- 72 sec/cycle

Machine with robot spray

- 70 sec/cycle
- Reduced scrap
- Consistent spray
- Ability to run more machines
- Easier process for operator/better ergonomics

Conclusion

This project will continue further as this year progresses. The design was implemented in the month of May and was completed in early June. The next steps are to get the machine running smoother and faster. This means making the robot design reliable, which is easier said than done in this environment and working with the older machines. I will also see if the robot will be able to last and pay for itself, making this project successful by getting rid of positions the robots can fill. This project has run smoothly and there will be 6 more machines setup with the robot by the end of 2024.

References

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"Large Size Robot - Models - Robot - Fanuc Corporation." *Fanuc,* Fanuc Corporation, www.fanuc.co.jp/en/product/robot/f_r_large.html. Accessed 4 Sep. 2023.

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Appendix

Appendix A: Schedule

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T16 Spray Head / Dresskit on Robot from Herco	**54 days**	5%
Send F#'s & IP addresses for all robots to Herco	1 day	100%
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T16 Cell Modifications (while Press in Production)	**23.13 days**	0%
T16 Planned Downtime to Implement Spray	**6 days**	0%

Figure 13:T16 Schedule

Appendix B: Bill of Materials

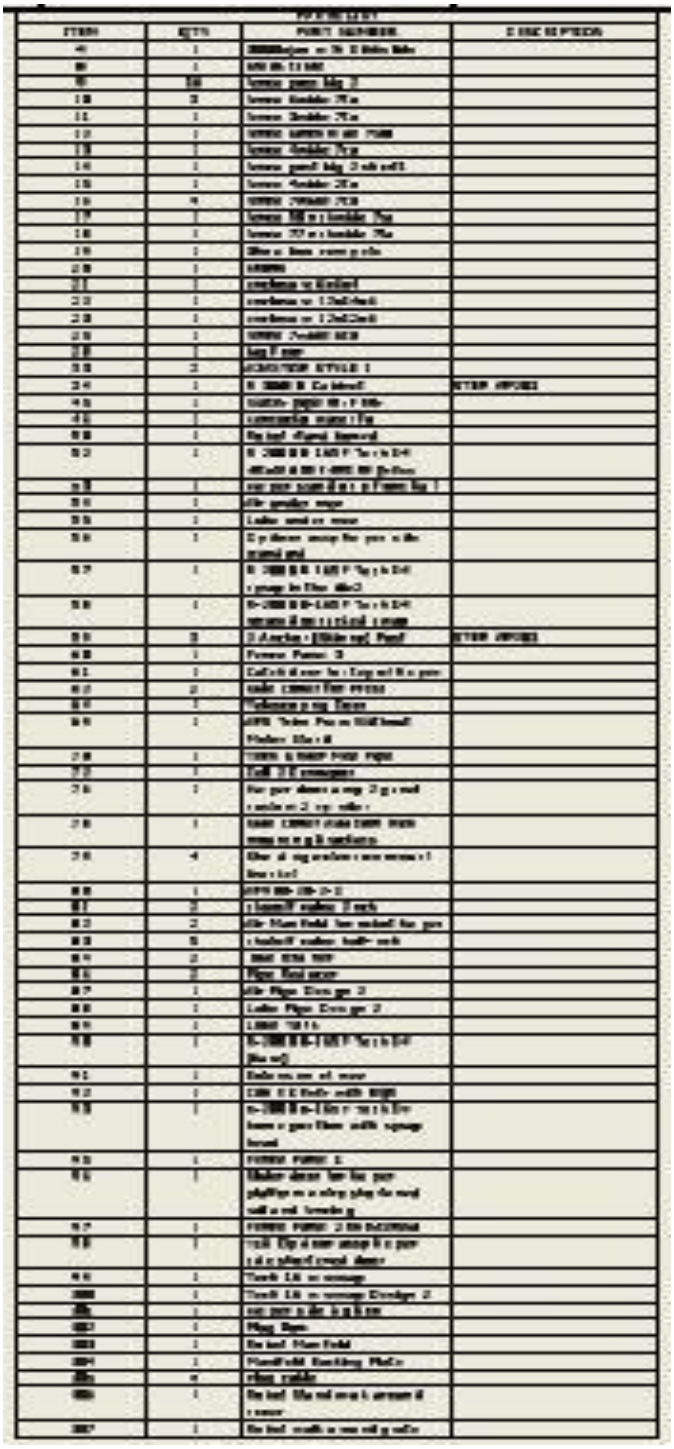

Figure 14: BOM

Appendix C: Drawings

PARTS LIST

ITEM	QTY	PART NUMBER	DESCRIPTION
1	4	help platform - plate1	STEEL
2	4	help platform - tube6	STEEL
3	2	help platform - tube - 3	STEEL
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22	4	L Bracket	
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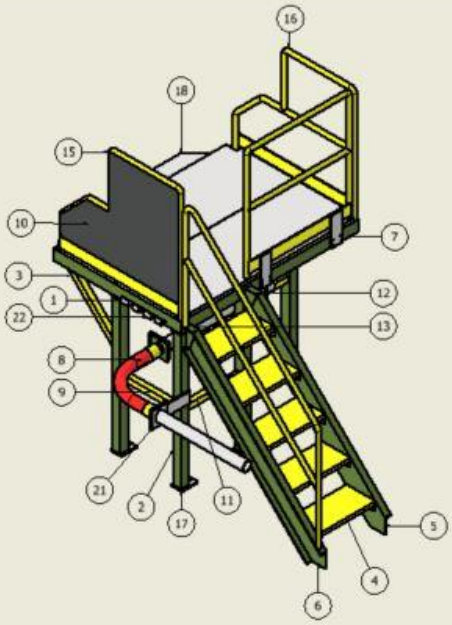
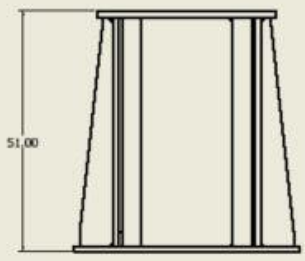
24	1	Pipe clamp bracket	
25	1	PIPE 300 ALUM 3inch Ajax Lead assembly	
26	2	Conduit clamp mount 1	

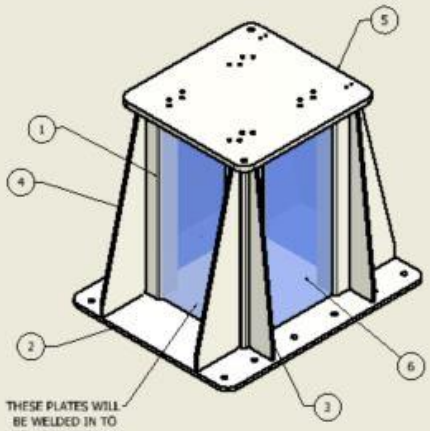


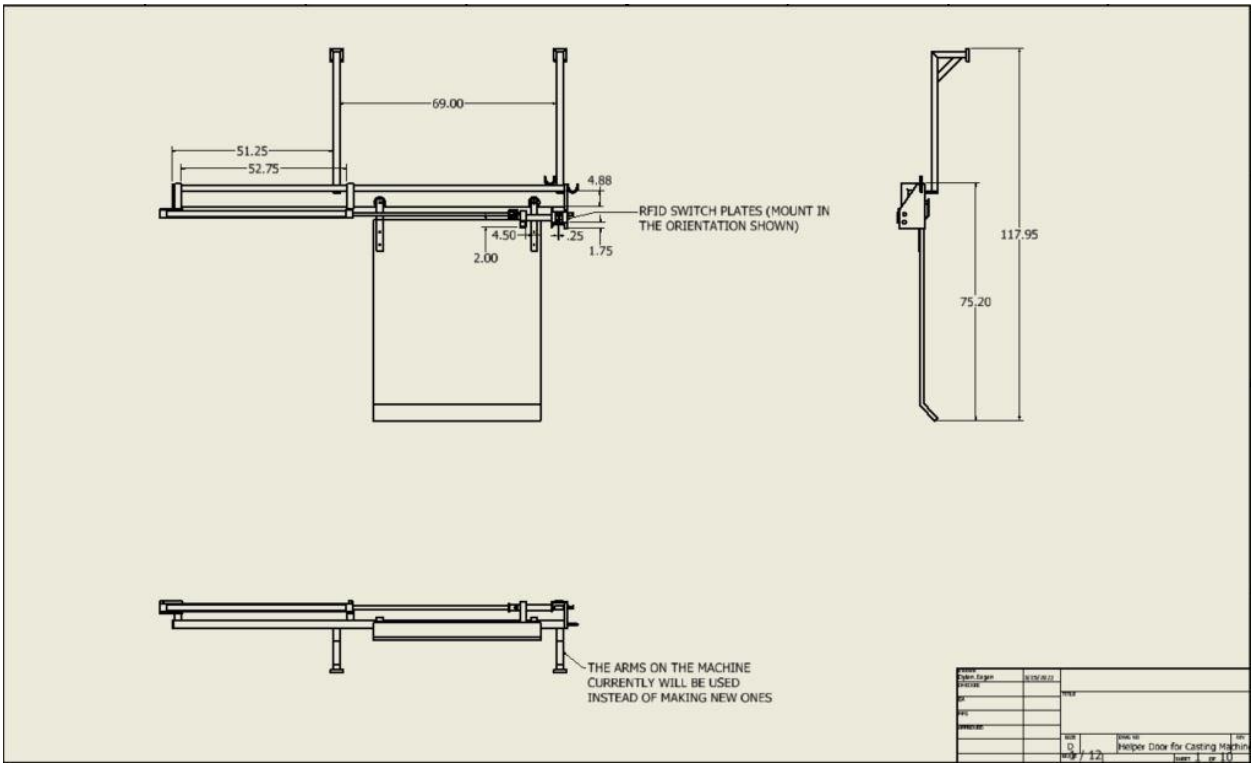
PARTS LIST

ITEM	QTY	PART NUMBER	DESCRIPTION
1	4	F02000 - A06 - Sub Assm - Extractor Base Leg Extended	
2	1	F02000 - A06 - Sub Assm - Base Plate Extended	
3	4	F02000 - A06 - Sub Assm - Gusset Brace Extended 1	
4	4	F02000 - A06 - Sub Assm - Gusset Brace Extended 2	
5	1	F02000 - A06 - Sub Assm - Top Plate bolt holes rotated 45 degrees	
6	4	F02000 - A06 - Sub Assm - Extractor Base Cover Plates Extended solid	

FINISHED HEIGHT AFTER WELDING ON THE TOP PLATE (± 1/8")

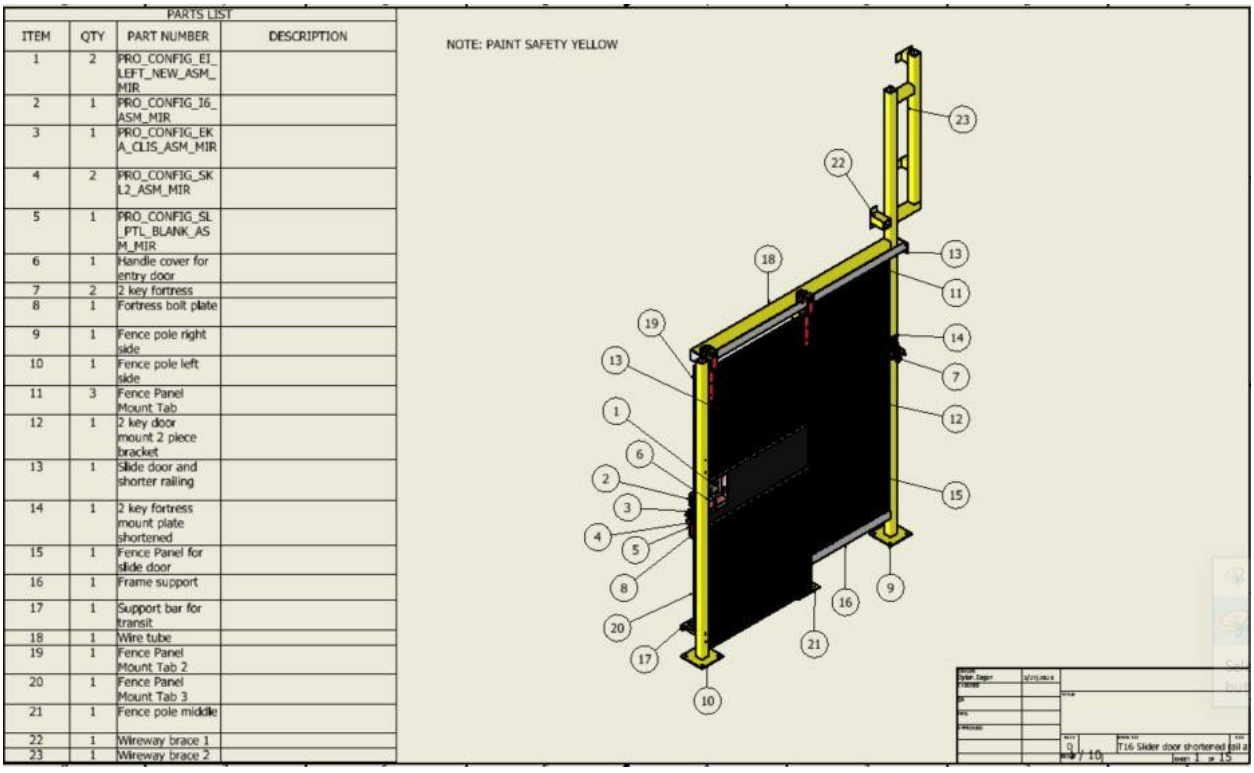






PARTS LIST

ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	PRO_CONFIG_EI_LEFT_NEW_ASM_MIR	
2	1	PRO_CONFIG_16_ASM_MIR	
3	1	PRO_CONFIG_EKA_CLIS_ASM_MIR	
4	2	PRO_CONFIG_SKL2_ASM_MIR	
5	1	PRO_CONFIG_SL_PTL_BLANK_ASM_MIR	
6	1	Handle cover for entry door	
7	2	2 key fortress	
8	1	Fortress bolt plate	
9	1	Fence pole right side	
10	1	Fence pole left side	
11	3	Fence Panel Mount Tab	
12	1	2 key door mount 2 piece bracket	
13	1	Slide door and shorter railing	
14	1	2 key fortress mount plate shortened	
15	1	Fence Panel for slide door	
16	1	Frame support	
17	1	Support bar for transit	
18	1	Wire tube	
19	1	Fence Panel Mount Tab 2	
20	1	Fence Panel Mount Tab 3	
21	1	Fence pole middle	
22	1	Wireway brace 1	
23	1	Wireway brace 2	



Appendix D: Budget

- **CT23xxxB TECH 16 HELPER SIDE AUTOMATION - $216,667k**

Figure 15: Budget

Cell #	Status	Arrival Date	Price	Notes
T16				
Cable Guard	On site	5/12/2023	$618	Done
Robot stand	On site	5/12/2023	$7,942	Done
Helper Platform	On site	5/12/2023	$5,468	Done
Entry Door (Fortress)	On site	5/12/2023	$2,890	Done
Casting door	On site	5/12/2023	$3,290	Done
Manifold	On site			Justin and his group will build "done"
Wire way	On site			Billy will install (matr'l on site) "done"
Robot Stand Shield	Design			Needs Designed
Robot switch bracket	On site	6/12/2023		Done

Appendix E: Design Considerations and Standards

- Environmental
- Safety
- Economic
- Societal/Cultural
- Global
- Ethical
- What criteria are most impactful during your design?
- Quality
- Cost

Design Requirements

- Function Capability – spray die consistently
- Interoperability – work along an old casting machine
- Sustainability – work around the clock
- Maintainability – regularly maintain the robot
- Affordability – cost of the robot compared to a human

Appendix F: FMEA

Process Function	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Potential Cause(s)/ Mechanism(s) of Failure	Occur	Current Process Controls	Detec	RPN
Robot Spray	Spray Head Leak	Downtime	5	Failed seals	2	Spare Seals	5	50
Robot	Crash	Broken Parts	5	Broken Spray Head	3	Spare Parts	2	30

Figure 16:FMEA