FRC Steamworks--Gear Floor Pick Up Mechanism Design

CS450 HO–Robotics Design and Fabrication Honor

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Nov 10th, 2021

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Introduction

The FIRST program is an acronym “For Inspiration and Recognition of Science and Technology.” It is a program that “creates a global robotics community preparing young people for the future.” This gear pickup project comes from the 2017 FRC Game Steamworks. The game’s main objective is to score balls into the boilers(cylinder box) and deliver gears to the airship(elevator). The higher-scoring alliance team wins the match. This gear pickup project’s goal is to collect gears from the ground. We got inspired by team 95’s gear pickup design. So we decided to use a roller and a container to pick up and store the gears. Then, using pistons to adjust the gear position to a 90-degree angle makes it easy to place it on the airship elevator. We had one limitation and restraint in designing the proper spacing: to attach the mechanism to the drivetrain. There is another restraint with 3D printing because it can’t print the walls together. In the end, we designed the proper spacing and the 3D printed parts then attached them together.

Strategic and Functional Requirement Design Analysis--Sherry

When we started designing the gear pick-up system, we analyzed the functions we wanted it to achieve and the strategies to get there. The purpose of this process was so that we didn't have to do a bunch of extra work to create a mechanism that would be rendered useless in the end. We made a spreadsheet listing out our goals and brainstormed potential designs. Then, we went through those designs and tried to predict which one would complete the job most efficiently, and started our actual designing process from there.

The main strategic thing we wanted the mechanism to achieve was to touch a gear and "own it" and rotate the gear into a vertical position so we could deliver it onto the elevator in the future. So function-wise, the design needed an intake to pull the gear in, a storage space to store the taken gear, and a rotating mechanism.

Our original design was a claw that would clamp onto the gear and rotate with it. However, after further considerations, we decided that a claw intake requires too much precision, so we switched to having a compliant wheel-based intake system instead.

A	B	C
Strategic Requirements	Functional Requirements	Priority ranking
touch it and own it (the gear)	intake system (claw/compliant wheels/arms)	1
Keep the gear in the robot as it moves	storage system or something to clamp on	2
Rotate it so it can be delivered onto the elevator	piston/belts/pulleys	3

Figure 1. Strategic and functional requirements design analysis spreadsheet

Computer-Aided Design Process

CAD stands for the computer-aided design process. It is an efficient way to layout designs for mechanisms in 2D and 3D using a computer compared with manual drawing. The Onshape software is a free platform that allows clients to collaborate and design mechanisms in 2D and 3D. To put our imaginary design into a draft, we first used a 2D sketch function to see our assembly mechanism from a side view. (See Fig.2) We first sketch each part in the part studio as 2D models, then extrude in a specific direction to create a 3D part. We did this for the left plate, right plate, and backside plate. We used the pattern tool for the holes on the walls to first make circles with a diameter of 0.262 inches equally spaced in the 2D sketch, then extruded it. (See Fig.3, Fig.4) We inserted other existing parts from the MKCAD library to find the ½ inch thunderhex, the neo 550 motors, the 4 inch OD ½ inch compliant wheels, the ultra planetary gearbox, pneumatic cylinders, and the ball joint rod end. To connect the parts together in the assembly page, we sometimes used the grouping tool, but mostly we used fastened mate to fasten it into a single mechanism. (See Fig.5)

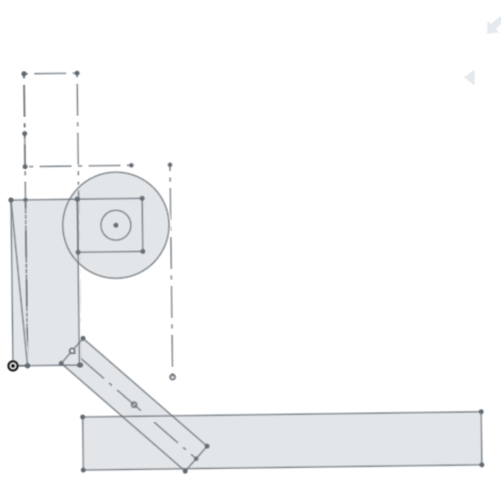

Figure 2. 2D sketch of the assembly mechanism.

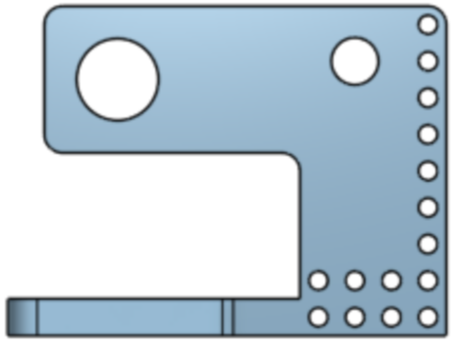

Figure 3. Extruded Side Wall.

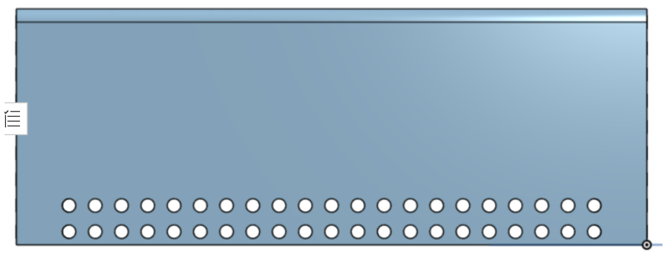

Figure 4. Extruded Back Wall.

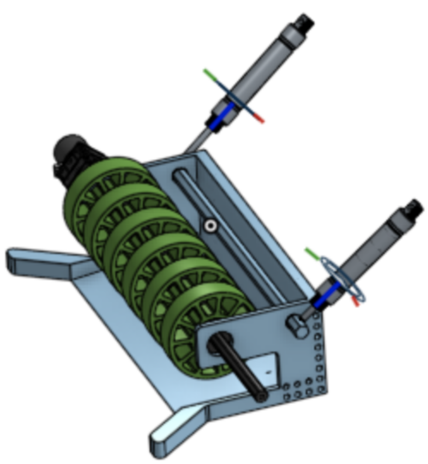

Figure 5. Final Render View.

Manufacturing/Assembly

First, we connected the walls and the bottom ramp using threaded inserts, then used bearings to attach the axle through the holes on the wall. At the same time, we put three 3-inch compliant wheels on the axle. Then, we attached the motor and ultraplanetary gearbox to the axle. We used the 3D printing machine during this process, which is a mechanism that prints out CAD designs. We used the chop saw, which is a blade that drops down vertically to cut the medal. We used the sander machine, which is rotating metal sandpaper to smoothen out the surface. We used the drill, which used attached drill bits to make holes in the plastic ramp. We ran into two problems during assembly: we didn't design motor mounts in our 3D printing design. We had to drill the holes in retroactively. Also, the original idea of riveting didn't connect the walls, so we decided to use threaded inserts.

A	B	C	D	E
Name	Amount	Total Price	Vendor	Link
Neo 450 Motor Gearbox	1	$89.95	Vex Pro	https://www.vexrobotics.com/versaplanetary.html
1/2 thunder hex	2	$9.98	Vex	https://www.vexrobotics.com/thunderhexstock.html
4" 1/2 compliant wheel	6	$54.00	AndyMark	https://www.andymark.com/products/4-in-compliant-wheel-1-2-in-hex-bore-50a-durometer
Round Body Air Cylinder Double-Acting, Universal Mount, 3/4" Bore Size, 2" Stroke	2	$68.54	McMaster	https://www.mcmaster.com/6498K634/
Ball Joint Rod end	2	$18.86	McMaster	https://www.mcmaster.com/60645K16/
1/2 thunder hex shaft bearing	4	$12.00	Vex Pro	https://www.vexrobotics.com/pro-bearings.html?q=&locale.name=English

Figure 6. Bill of materials

Figure 7. Base design (version 1)

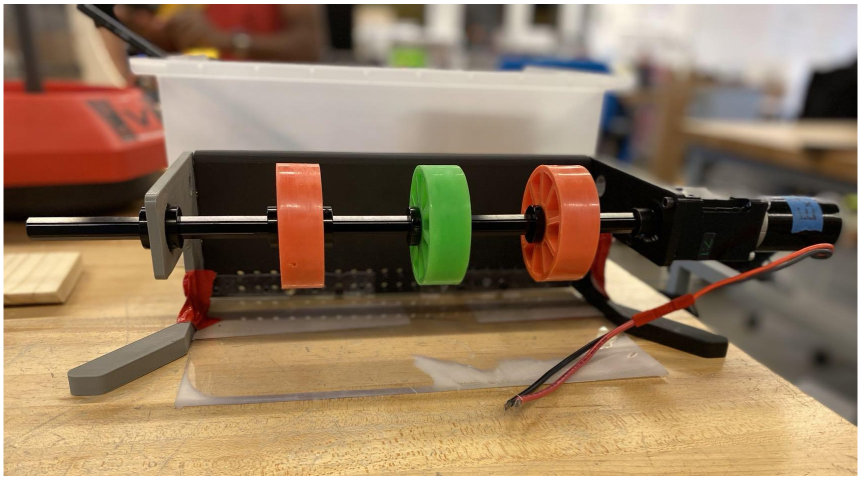

Figure 8. Final Assembly

Testing Setup/Results

For our testing setup, we did not have enough time to attach the gear intake mechanism to the robot, so we just pushed the mechanism into the gear with our hand to simulate the robot's movement.

Our first design used a piece of wood as its base, however, it was simply too thick, so we swapped it out for a sheet of polycarbonate which we bent using a heat gun and sanded the front so it formed into a blade.We also had to adjust the size of the compliant wheel from 4 inches to 3 inch because the previous one was exerting too much pressure on the gear.

Our final design picked up gears mostly without a problem, the only issue is that if the gear was rotated in a way where the compliant wheels can't contact the spires without, the pickup is unsuccessful. Also, when the base gets rotated into a vertical position, it is a little wobbly. If we were to make further adjustments to the design, we would add a few more wheels and connect the base with the two side pieces with something stronger than a piece of duct tape.

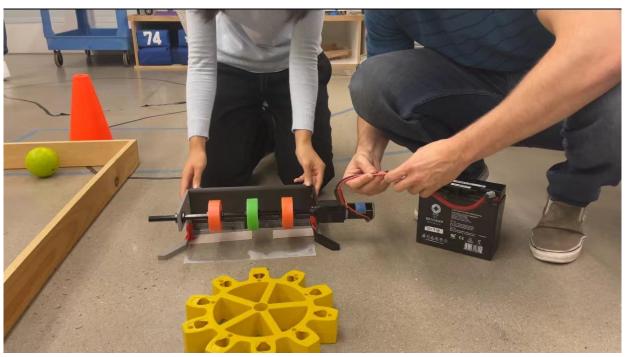

Figure 9. Testing Setup (part. 1)

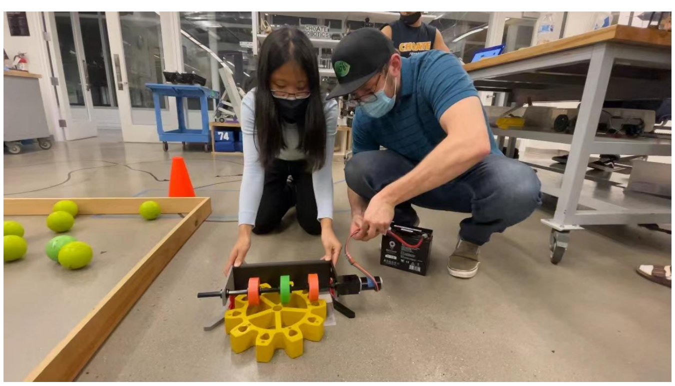

Figure 10. Testing Setup (part. 2)

Conclusion

The gear pickup project's main objective is to pick up gear from the ground. The project is rooted in the 2017 FRC project Steamwork. Steamwork is a game that robots score by putting gear on the elevator and shooting balls into the round container. We first CAD the separate parts like the walls and the ramp. Then we put it into an assembly. We updated our design and remade the assembly. Then we started our manufacturing process by 3D printing all the parts we CAD. Then, we tapped the shaft and drilled holes through the bottom ramp. Then following the CAD, we assemble it together, founding some problems like not having a motor mount. Then, we drilled through the 3D printed part to create the motor mount and attached a heat-bent polycarbonate sheet to the three sidewalls, building a base. If we had more time, we would add more wheels to the intake system and secure the base to the side walls. We learned three lessons: to create overall designs before CADing individual parts, create a bill of materials needed in the mechanism before assembly, so you don't run out of stuff mid-assembly, and separate the work with teammates based on their skillset.

Bibliography

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