CAD Engineering Challenge
sponsored by Autodesk

v5 Motor Couplings

Team **2211A**

Caguas, Puerto Rico

Software: Fusion 360
3D Printer : Ender 3 V2

Participants:
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Introduction

#1: Define The Problem

Friction handling is crucial in robotics, especially when dealing with high-speed mechanisms, like flywheels. In order to shoot game objects at high speeds, these wheels required large gearing, which sometimes caused the motors to overheat early in the game.

To solve this problem, many teams use vex parts to create adapters that connect the shaft directly to the internal motor gear, which spins at 3,600 rpm, an excellent speed for a flywheel. This eliminates the use of cartridges and external gearing, significantly reducing friction. Even though these adapters work, they are not that efficient, and the motor's internal mechanisms are frequently damaged.

Figures 1-5: Some adapters made from vex parts

Due to this issue, we created a coupling that adapts perfectly to the inner motor gear, connecting a shaft to it without damaging any parts. Our design is more efficient than handmade adapters, capable of improving the performance of any flywheel.

Figure 6: 3d printed motor coupling

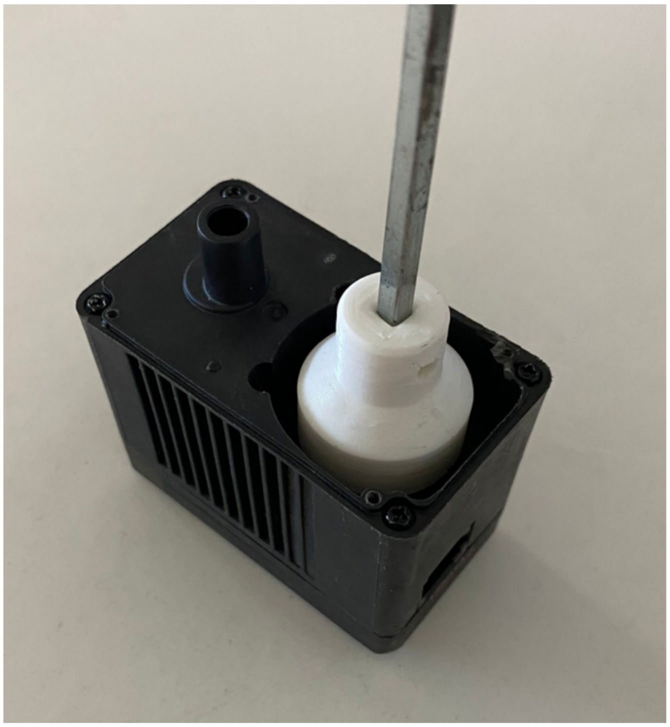

Figure 7: 3d printed coupling in the motor

Design Process

Software used: **Autodesk Fusion 360 version 2.0.15050**

Ultimaker Cura Slicer version 5.0.0

#2: Brainstorm & Develop Ideas

We made some draft sketches to illustrate the shape and size of the couplings. The space available inside the motor was analyzed using Vex parts and CAD files.

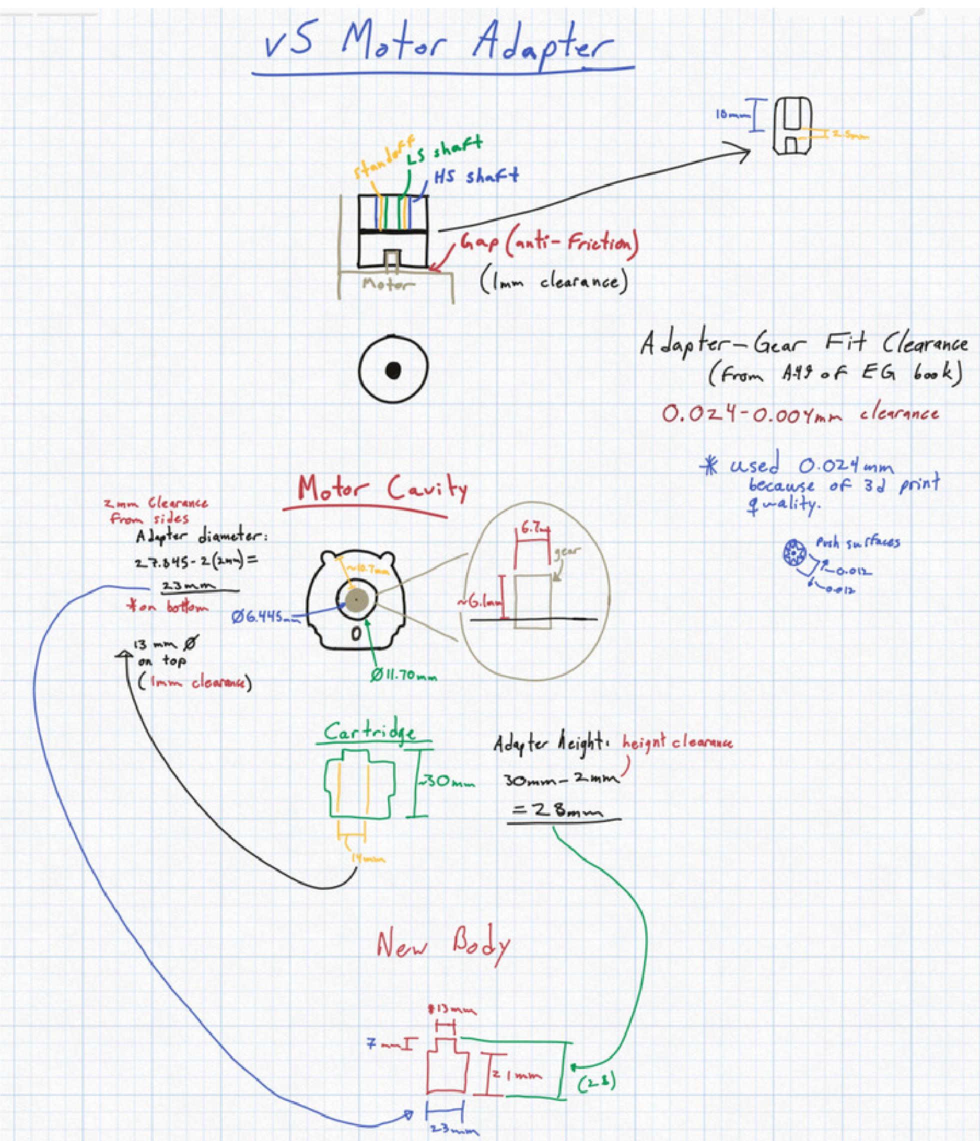

Figure 8: Draft Sketches with important dimensions and measurements

Figure 9: v5 Motor CAD file

Figure 10: Measuring motor cap with a caliper

#3: Final Design Idea

- A spacer-like form, with a wider bottom, will be used to provide a better grip when installing.
- A narrow top section will fit perfectly in the motor cap, reducing the wobbliness of the coupling.
- The shape and size of the coupling will be carefully designed to achieve maximum performance while conserving a practical and elegant design.
- Three different types of couplings will attach various types of shafts to the motor.
- A pair of set screws will hold the shaft in place.

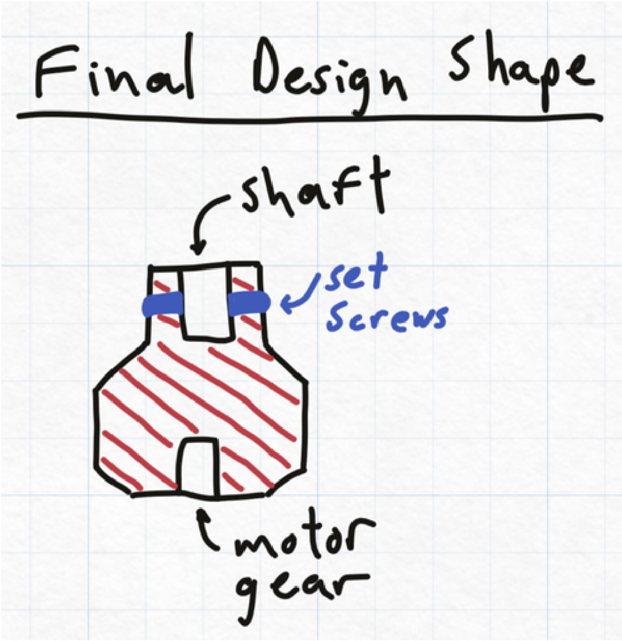

Figure 11: Coupling Shape Sketch

#4: Design & Prototype

- Utilizing the sketches and measurements made previously, we designed the coupling in Fusion 360.

- The 3d shape was modeled, using various sketches, followed by some extrusions. Sharp borders and corners were flattened using fillet and chamfer functions.

- The holes were extruded using vex part CAD files. Clearances were adjusted by printing, testing, and resizing each hole (with phase offsets and sketches) to achieve smooth, tight fits.

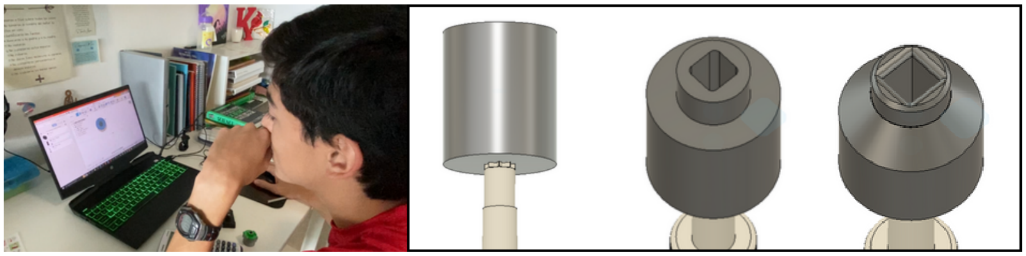

Figure 12-13: CAD design progress

- The circular pattern function was used to resize the gear hole, replicating the teeth and creating a wider, symmetrical extrusion.

- Three different coupling designs were made to attach high-strength shafts, low-strength shafts, and standoffs.

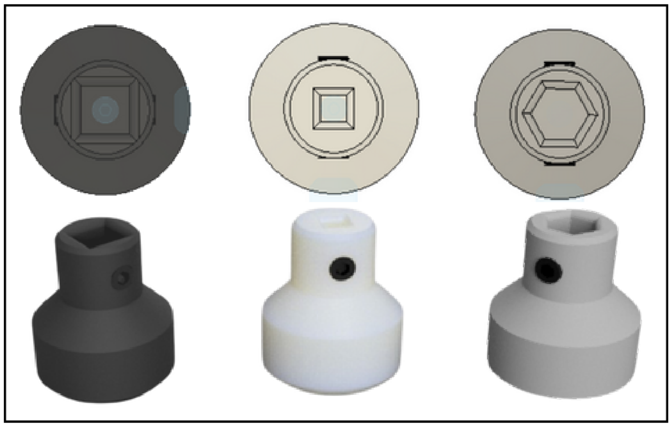

Figure 14: 3 types of couplings

- Two set screws were added to hold the shaft in place. The screws were placed on opposite sides to conserve stability. Because of the plastic material used, the thread was molded with the set screws into a circular hole.

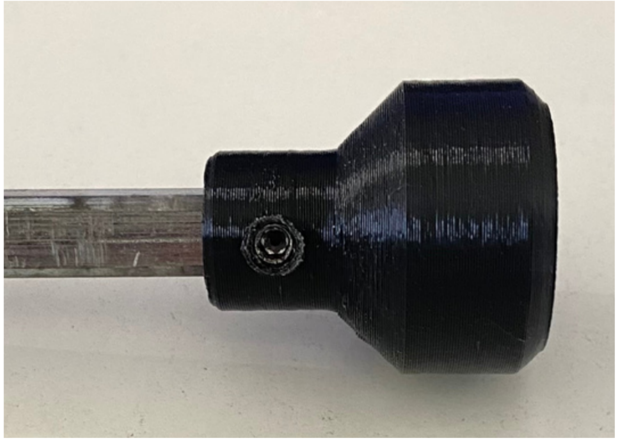

Figure 15: Coupling with set screw

- Finally, the width of the top section was carefully adjusted to achieve a tight gap, conserving stability, and avoiding any unnecessary friction.

Figure 16: Assembled v5 motor with coupling

Animation

We did some animations in Fusion 360 to test and demonstrate how the coupling fits in the motor.

In order to animate it, we assembled the components using the join function. After that, we used zoom, transform, and drive joint functions to create a short video.

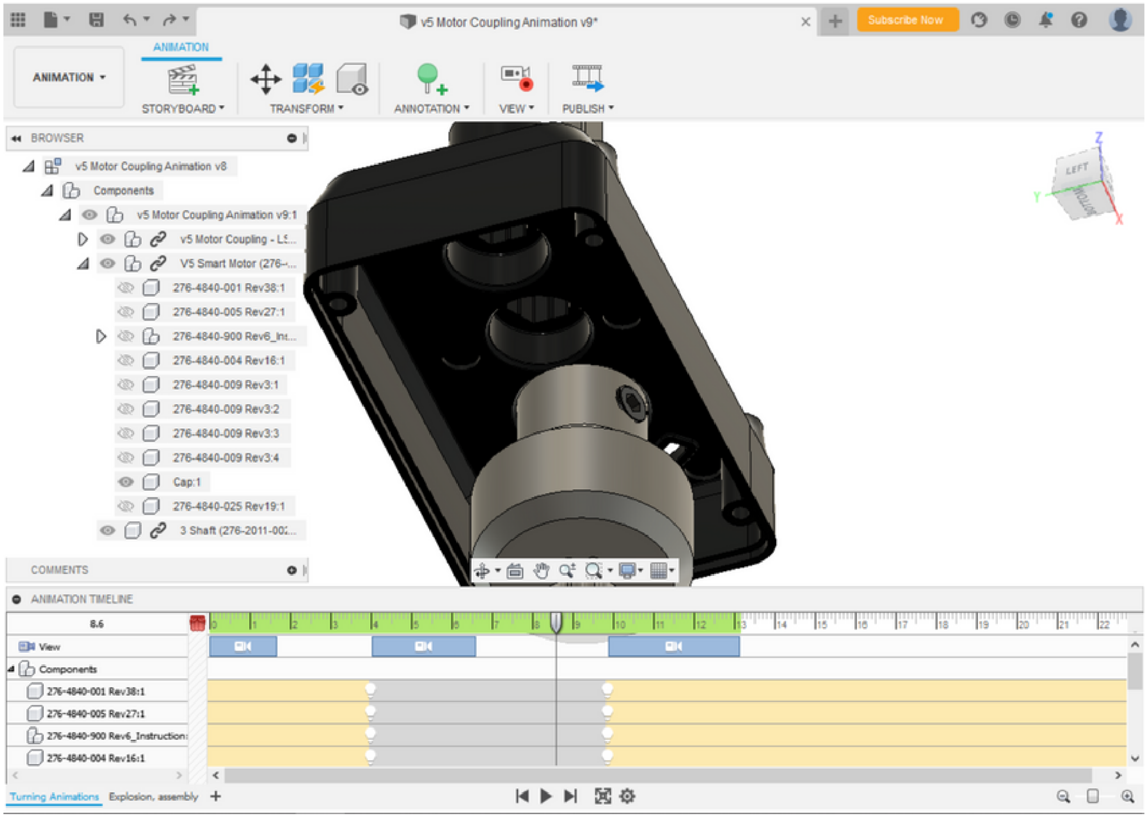

Figure 17: Fusion 360 Animation Panel

Features Used

Fusion 360 - Features used for V5 Motor Couplings design

SKETCHES	SOLIDS	ASSEMBLY	ANIMATION
Line	Extrude	New Component	Appearance
2-point rectangle	Press Pull	Capture Position	Storyboard
Center rectangle	Fillet	Move/Copy	Drive Joints
Center diameter circle	Chamfer	Join	Zoom Window
3-point circle	Offset face	Drive Joints	Auto-explode
3-tangent circle	Move/Copy		Transform Components
3-point arc			
Center point arc			
Circumscribed polygon			
Inscribed polygon			
Circular Patterns			

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Design Specs.

Technical drawings - Fusion 360

All dimensions are in millimeters

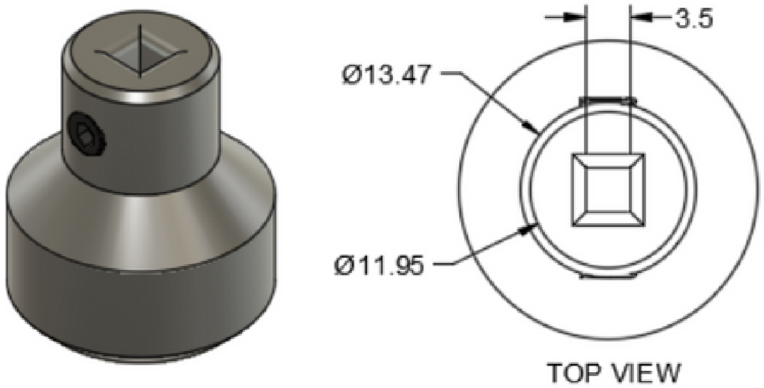


Figure 18: LS shaft coupling

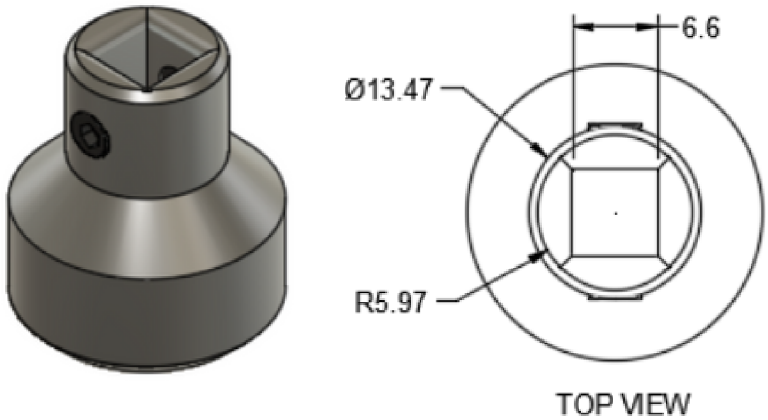


Figure 19: HS shaft coupling

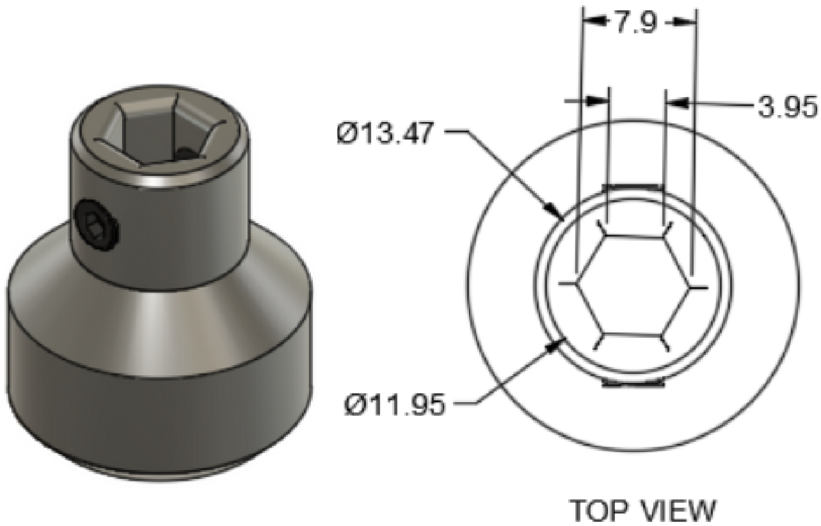


Figure 20: Standoff coupling

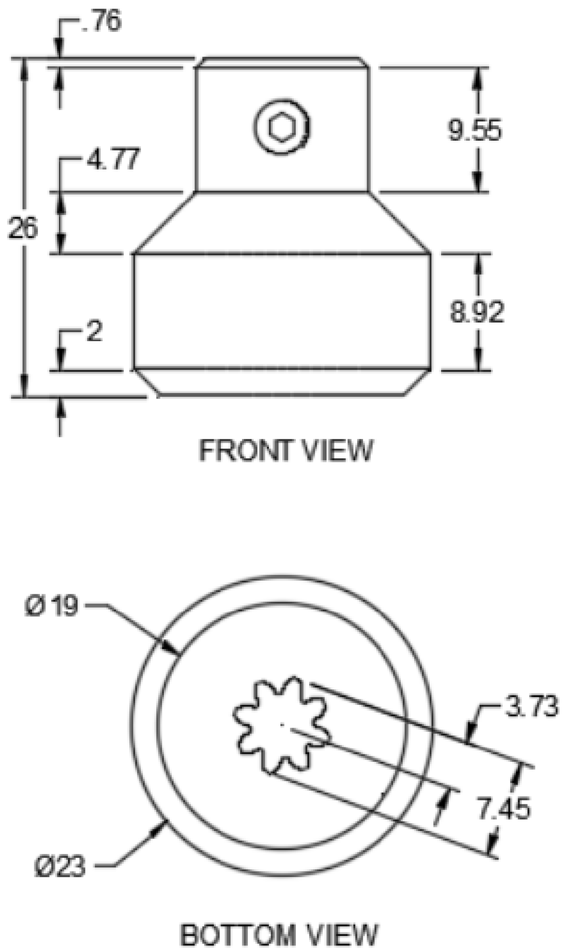


Figure 21: Coupling body dimensions

3d Printing

#4: Prototype

During the development of our design, we used 3d printing as a fast prototyping method to test our parts. As we tested them, we adjusted the design until the clearances and dimensions were just right.

Figure 22: Prototype print tests

Furthermore, we used the 3d printed prototypes to test the functionality of the design, once it was done.

The couplings were 3d printed on an **Ender 3 v2** 3d printer, using **PLA** filament, at 0.16mm layer resolution. The CAD files were sliced using Ultimaker Cura. Different colors were used to distinguish coupling types.

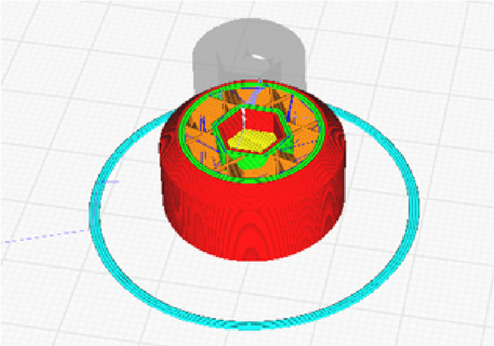


Figure 23: Slicer software

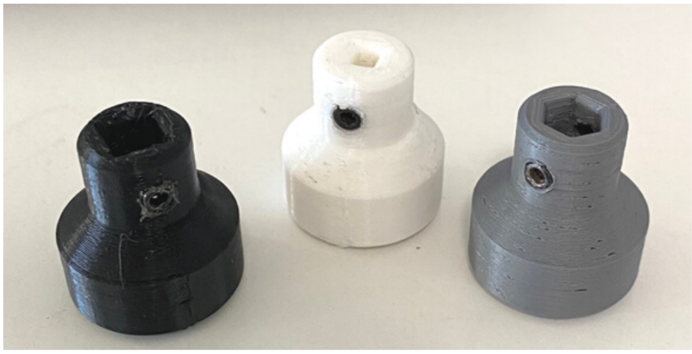
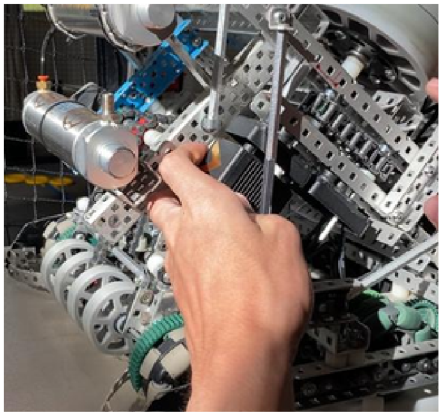


Figure 24: Final Prototype Prints

Testing

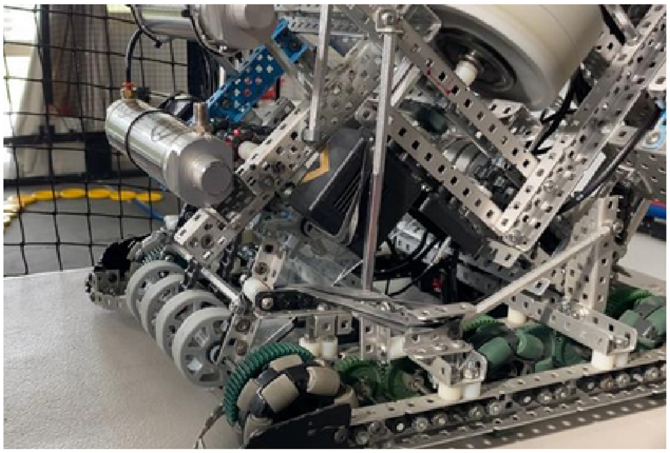
#5: Test Functionality

We tested the three coupling prototypes in a v5 motor, and they worked perfectly. Then, we implemented our new part design onto our Spin Up robot.



Figures 25-26: Installation of a LS shaft coupling

Although it is only a PLA prototype, our piece worked much better than the handmade adapter we had. The simplicity of the design made the installation process pretty easy, and the efficiency and stability of the flywheel was improved. In the future, our couplings could be fabricated out of better materials, such as nylon.



Figures 27-28: Flywheel motor with coupling.

Conclusion

#6: Evaluate

These motor couplings are a really efficient and reliable substitute for handmade adapters. Using them eliminates the need for heavy cartridges and big transmissions. It significantly increases the efficiency of flywheels, achieving a fast, stable, lightweight, and compact mechanism.

While completing this challenge, we learned how to use more complex functions (patterns, offsets, etc...) in Fusion 360 to design, improve, prototype, and animate a custom-made part. We also applied clearance and spacing techniques. In addition, we worked with technical drawings and slicing programs. Overall, we enjoyed working with CAD and 3d printing software. This project helped us elevate our design, documentation, and drawing proficiency. These skills will help us improve the quality of our designs in future robotics competitions. Furthermore, they will be essential in our our future career paths, since they are necessary for various areas of technology and engineering. By using this powerful software, we will be able to design anything, make prototypes, and document our process in the best way possible.

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