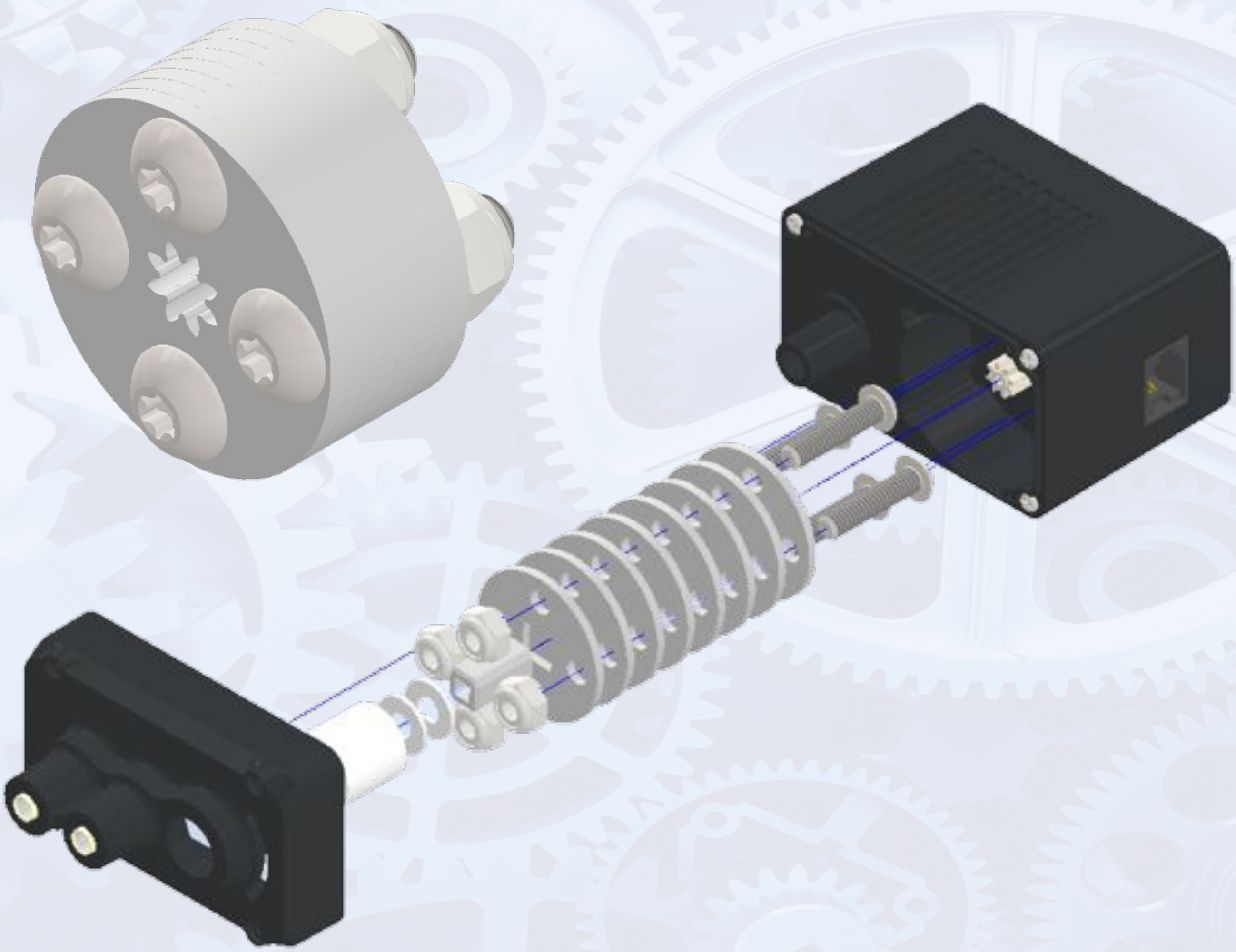
Polycarbonate 1:1 Motor Insert



Team 5956D

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Introduction

In this year's game, Spin Up, one of the main ways to obtain points is launching yellow foam disks. One of the most common designs is to utilize a flywheel. While a flywheel is the most versatile for consistently firing both long and short range, the speed of the flywheel quickly became an issue. Given the eight-motor limit, it became a challenge in figuring out the gear ratio that would best suit the flywheel without too much friction, motor overheating, or recharge time.

Upon researching, we came across a video by team 4082B, Freedom Gladiators, describing how they designed a single motor flywheel. They knew that the little white gear inside the motor rotates at 3,600 RPM and utilized this by creating a flywheel that does not have a VEX insert cartridge in the motor. This concept is perfect for a flywheel requiring the ability to spin at a very high speed. However, most teams were replacing a standard VEX motor cartridge with an unreliable setup often consisting of spacers, washers, and shaft collars all jammed into the motor to latch on to the white gear. This introduced a lot of friction into the system and caused the motor to overheat very quickly. This led to the creation of the Polycarbonate 1:1 Motor Insert.

The Concept

We focused on designing and prototyping a custom insert that was durable, consistent, provided no additional friction, and was VRC legal. While the idea of designing and 3D printing an insert seemed to be a simple solution, the concept contradicts rule R9g in the Game Manual. This led to the next concept of using polycarbonate. According to rule R9 of the Game Manual, teams are allowed to use polycarbonate that does not exceed a thickness of 0.070”. In order to utilize polycarbonate and still create a 3D object, we had to come up with a new idea. The concept we eventually arrived upon was stacking layers of polycarbonate on top of each other, tightening them down with VEX screws. This allowed for a sturdy, and fully VEX VRC legal custom manufactured part.

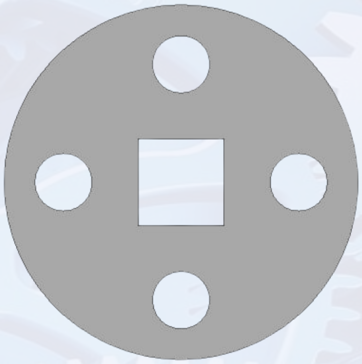
Custom Motor Insert

The Polycarbonate 1:1 Motor Insert was designed in Autodesk Inventor Professional 2022. Within Inventor, both .ipt and .iam files were created in the designing of this part. The sketch and extrude features were used to create the individual layers of polycarbonate while constraints were used to assemble the pieces together.

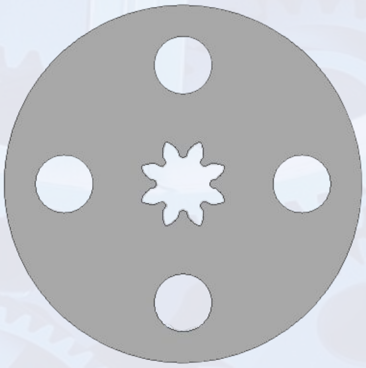
The assembly of this part includes 8 layers of polycarbonate as well as some VEX parts. Due to the part requiring both connection to the drive shaft and the white gear, two different layers of polycarbonate were designed for this insert. The outer diameter of the insert was determined to be 26 mm. This dimension is small enough to fit within the motor but still has enough area to accommodate for the other parts of the assembly, the motor’s white gear, and a drive shaft.

Custom Motor Insert

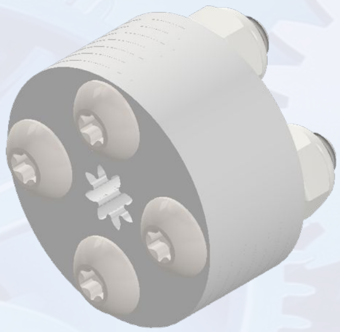
The drive shaft layer design includes circular cutouts for four VEX Star Drive #8-32 screws and a square cutout for a VEX High Strength Shaft Adapter in the center. A challenge with designing this layer was adjusting the spacing for the circular holes to be compact while allowing for the screw heads and Nylock nuts to fit without interfering with the gear or drive shaft. The center points of the circular cutouts were determined by a process of trial and error, adjusting the dimension until everything fit snugly. Once the correct spot was determined, we utilized the circular pattern sketch tool to copy the circle three more times 90° apart from each other around the outer edge of the layer.



The gear layer design has the same location of the circular cutouts for VEX screws, with the center cutout instead shaped to fit the motor gear. To ensure an accurate cut out for the gear, we had to place the sketch on top of the motor assembly with the cap removed. For tolerance reasons, the insert needed to be slightly larger than the white gear. As a result of the gear's complex geometry, utilizing the Project Geometry and Inventor Offset tools did not work. With this, we were forced to trace one of the gear's teeth by hand and use the circular pattern tool to design the star-shaped cutout for the bottom layer. The offset we ended up with was .002".



Custom Motor Insert



Once we had both polycarbonate layers designed, we were able to begin putting together our motor insert in an Inventor assembly. The total assembly includes 8 layers of polycarbonate, five Drive Shaft layers and three Gear layers. The assembly also includes a single High Strength Shaft Adapter, four 0.75” #8-32 Star Drive Screws, and four Nylock Nuts.

The Polycarbonate 1:1 Motor Insert is then placed in the motor, with the screw heads down on the gear layer side, in place of a VEX insert cartridge. Between the Polycarbonate 1:1 Motor Insert and the motor cap, we added an additional Nylon 0.5” Spacer and one to two teflon washers, depending on the motor, to keep the insert in place and prevent it from bouncing within the motor.

Conclusion

Upon finishing the design, we were able to get the layers of polycarbonate cut and constructed the insert. Through testing, we not only determined that the flywheel would be able to spin close to 3600 RPM but also discovered that it was able to run for almost six minutes straight without the motor overheating. From this project, we were able to come up with an innovative solution within the design constraints of VEX VRC as well as improve on our Autodesk Inventor skills. We very much enjoyed the challenge of working within realistic design constraints to create a product in a tight time window.