“Make It Real” CAD Engineering Online Challenge 2021

Entry

VEX Smart Motor Quickswap System

4253B

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Problem

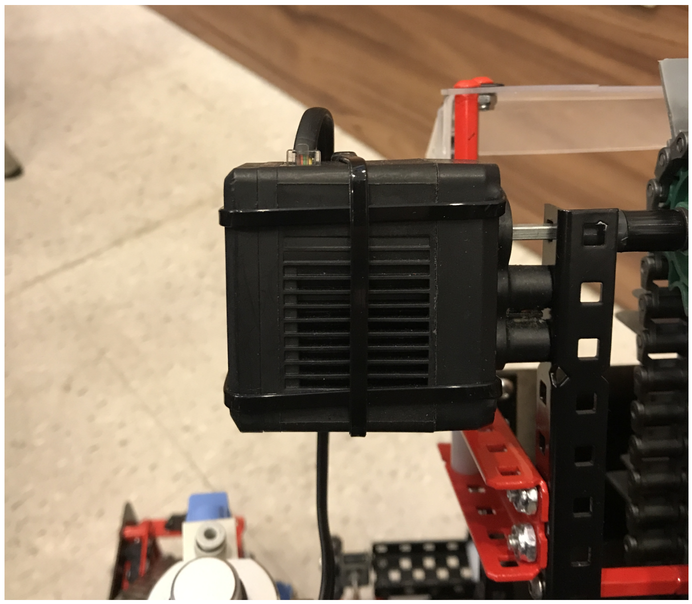
When competing, V5 motors are used to power the many mechanisms on a team’s robot. After matches, we noticed our motor module overheating, decreasing the motor's efficiency.

Motor overheating is caused by a poorly optimized gear ratio. Small motors like the V5 motor need to run at full speed for an optimal current draw, which produces little torque. To solve this, teams use gearboxes to lower the output rpm and increase torque. The motor overheats when the output torque of the gearbox does not satisfy the torque needed to operate a mechanism. This causes the motor to draw extra current, generating heat. V5 motors are also fully encapsulated in a shell, preventing airflow from ventilating the motor.

To combat the issue of overheating, teams have tried many different solutions, such as using fans and compressed air between matches to cool motors down. However, plastic is a good insulator and traps heat, limiting the efficiency. Others utilized extra motors to periodically swap fresh ones in. This process of swapping is very tedious: the motor’s screws are close to the output shaft, making it impossible to swap motors without removing the output system. The estimated time for a single swap is at least 15 minutes, with areas such as the drive taking considerably longer.

To cut down on time, teams use the traditional version of quickswap. By removing the screw beforehand and using zip ties to hold the motor intact, the team eliminates the tedious process of removing the motor screws. Three long zip ties are used to properly secure the motor, which saves a significant amount of time and is currently the best competition-legal solution.

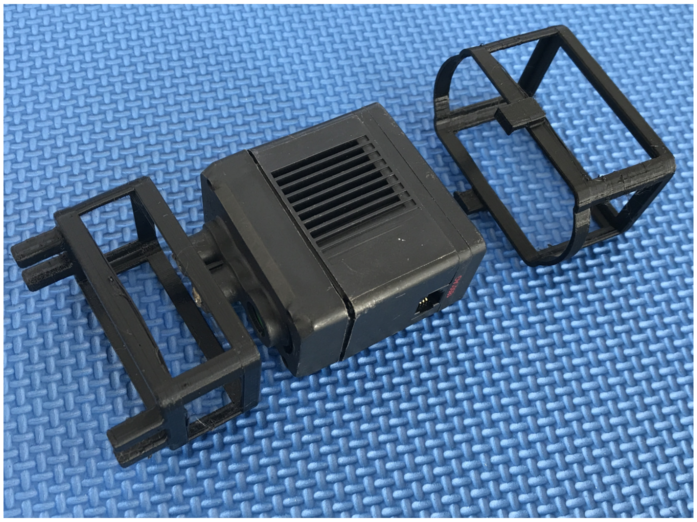
Traditional quickswap is a massive improvement from the usage of motor screws, but it isn't without its flaws. The zip ties could break during matches, along with being easy to lose among parts when maintaining the robot. Zip ties are also hard to install in cramp locations. Reused zip ties require a certain angle to be secured on one side first, then to the second. Some force is also needed so the zip ties could not slide out.



Our Solution

Our design is a structure that encapsulates the V5 motor. The shell attaching to the lid, or the top shell, features 4 prongs to prevent the shell from sliding. The part attached to the body of the motor, named the bottom shell, features a clamping attachment mechanism to the top shell. The bottom shell has two clasps that lock onto the lid cage when you slide both parts together. In order to release, the shell is stretched through applied force on the curved bottoms of the shell.

The quickswap shell is used on motors on our team's robot during testing and programming. As we want to have non-stop practice time, this custom system allows us to swap the motor with ease instead of hassling with three zip ties.



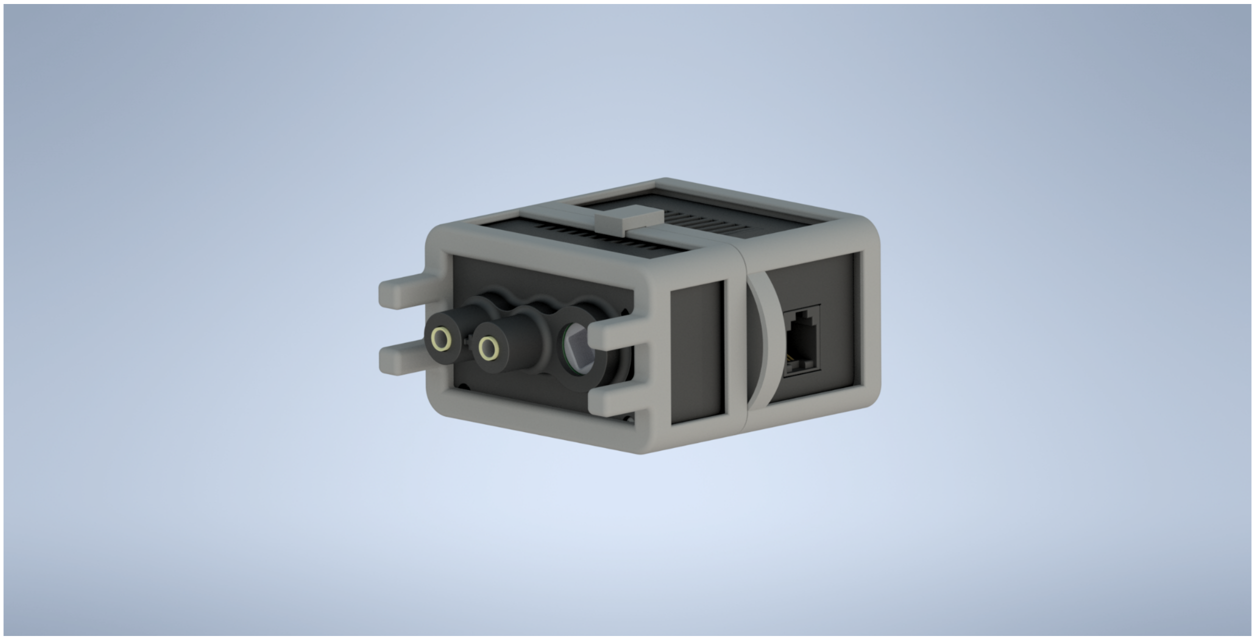

PETG prototype

Final product

Software and Design

The software used was Autodesk Inventor Professional 2022. Keehan learned how to use this program and design through watching online tutorials and asking peers for advice.

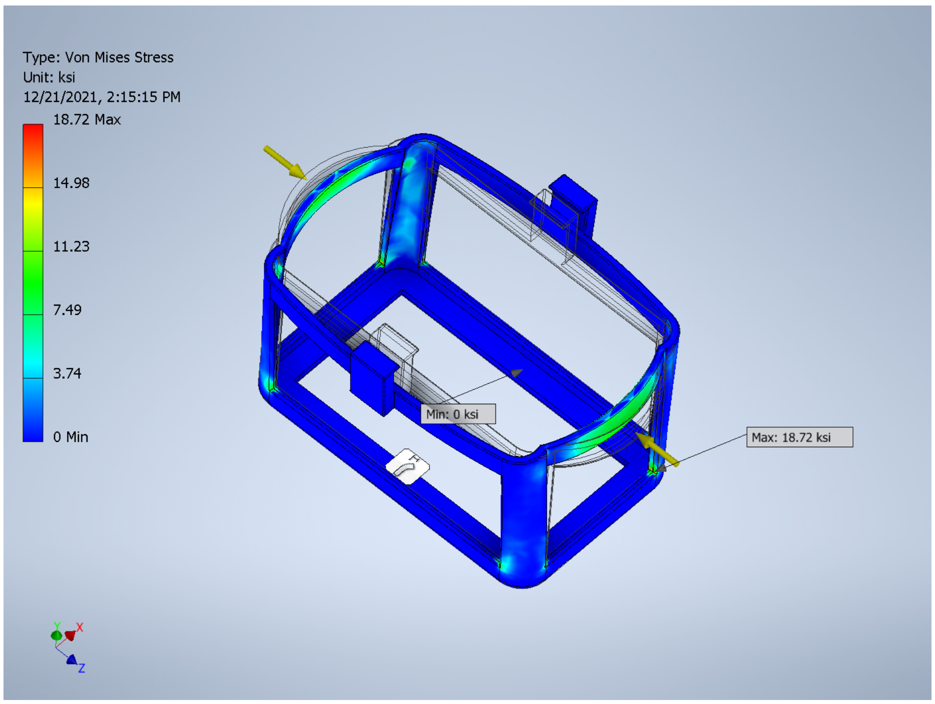
In order for the design to have accurate dimensions, I first imported the model of the motor from the official VEX website. Using the motor as a guide, I created new sketches based on the motor, modified the size for tolerance, and then extruded them to make the three-dimensional shape of the cage. Extrusion was also used to create features such as the prongs and indentations on previous designs for zip tie attachment. For the prongs, I imported a model of a c-channel to simulate the connection between a c-channel and motor, aligning the supports away from the holes while using the dimensions to make sure it is slightly larger in width to make sure all four prongs will touch the c-channel. The mirror feature was used to duplicate it on the opposite side for any symmetrical aspects such as the prongs and clasps. For smoothness, fillets were applied for a safer profile.

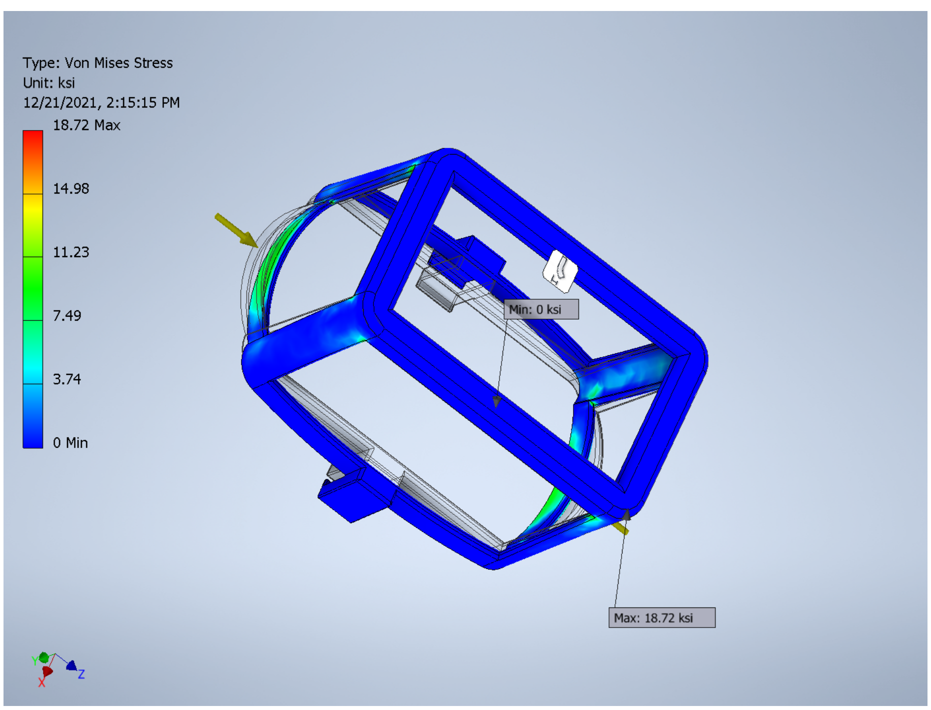


I also printed this design in multiple materials. I used the clamps on the side to test the flexibility of each material. I determined that PETG would be the best for prototyping, and carbon-infused nylon for the final product due to its flexibility/durability.


PETG
TPU

The circular handles initially came with the risk of breaking due to excessive force as a result of both the design and material choice. For the final design, the circular handles were first sketched as arcs before extruding outwards and replacing the original straight side of the rectangular cage. To be time-efficient and not waste material, simulation and stress analysis were used to make sure the arcs would bend just enough when force is applied. I first created custom materials for the simulation. Then, I fixed the bottom half of the shell and added loads to the arcs.





Reflection

Before designing the quickswap shell, we did not know powerful tools such as simulations existed. By participating in this challenge, we learned how to design parts, then used simulation to analyze them before making it in the real world. This would make our design process more eco-friendly and accurate. Next year, we will use simulation when designing other parts of our robot, such as testing custom polycarbonate parts and stress analysis on c-channels. We also hope to use this knowledge in future projects that are not necessarily for robotics.

As our VEX program is sponsored by the school, we would like to give back to the community that made this possible. Helping others has always been an important value of our organization. In FRC, our team helped start over 20 teams in Taiwan. Similarly, we would often help teams in our region. Now, with all our CAD knowledge learned from competing in VEX, we want to spread this powerful tool to everyone, to make Taiwan a better, more experienced region.

Credits

Designer: Keehan Tsai
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Manufacture help: Ryan Liao
Special Thanks: Mr. Matt Fagen, Dr. Allan Bayntun for letting us use the 3D printers