Introduction

The part we created for the Autodesk Make it Real Challenge is an adapter that allows for use of the V5 Motor Gearbox Inserts on mechanisms external to the motor. This allows for large gear ratios to be created in an extremely small space, enabling lighter and more compact mechanisms, as well as simplifying the process of creating geared mechanisms for new teams.

Design Explanation

The inspiration for our cartridge adapter comes from the VersaPlanetary, available in the VEXPro product line. During past seasons, we encountered numerous problems when attempting to fit complex mechanisms into constrained spaces on our robot, especially when it came to making room for compound gear ratios for larger mechanisms. Many times, mechanisms would need to be refactored to fit within the space constraints imposed on the mechanism, often taking away performance of the mechanism to make it usable.

Additionally, when working with VEX teams composed of younger students, they often fail to understand the elaborate structure required to make a robust gear-train, and asking students to implement larger gear ratios will be detrimental in the overall development of their robot. While they may understand how the gear ratio works, teaching all the intricacies of friction, torque, and bracing for the gear train is a longer process and often can't be done "on the fly".

With our product, we are encompassing the complex structure present with larger gear-trains into an already created product - the V5 Gearbox Insert. Functioning similarly to the VersaPlanetary gearbox, teams can now easily create large gear ratios with a tiny footprint. These planetary gearboxes are a fraction of the space of any inline or planetary gear ratios implemented with standard VEX components, allowing for mechanisms to be simplified and reduced significantly.

This new part is useful in many mechanisms, independent of the game used. There are many circumstances and designs that require some amount of external gear ratios, which can be vastly simplified by our V5 Gearbox Insert adapter. For instance, in a game that prioritizes shooting elements, our cartridge adapter could be used to create external gear ratios on top of those provided inside of the motor, to further increase the velocity of a spinning mechanism such as a flywheel. This cartridge adapter can also be used to create gear reductions for high torque use cases. For example, this adapter could have been extremely useful in last year's game, Tower Takeover in the tray tilting mechanisms which were utilized on many robots. For our large 24" robot, we utilized a 35:1 ratio to lift the tray up. The high torque was required due to the low angle of the tray, and the excess weight put on the mechanism while holding a full stack of cubes. We had a lot of trouble trying to package such a high gear ratio inside of that robot due to how little space there was between the tray, the lift, and the drivetrain. This created a mechanism that was hard to maintain and repair, as well as adding lots of excess weight to the end of our lift mechanism. These issues could have been solved with this cartridge adapter, which would allow for gear ratios of 6:1, 18:1, or 36:1 to be created in an exceptionally small space.

Software Used

To design this part, we used Inventor 2021 Professional where we took the base design of the V5 Smart Motor and adapted the pinion for the ratio cartridge to be able to accept standard or high strength shafts. From this, an outer case and cover was constructed to replace what would

normally be the motor housing to retain the cartridge rotationally and provide mounting opportunities for the case on all faces.

Conclusion

During this project, our team learned a lot about the composition of the V5 Gearbox Inserts, and their relative similarity to the VersaPlanetary adapter. Once making this connection, we were able to understand much broader use-cases for our product, and helped us iterate on revisions to the design. For instance, we ended up adding mounting holes to every face of the box, similarly to the VersaPlanetary, to adapt to more mechanism types.

Our usage of 3D design software has been instrumental in the survival of our team, especially outside of this challenge. When our school moved most of our content online, we needed to find a way to keep our team engaged while not being able to meet in person. This led us to dive deep into 3D design software, and teach our students how we can continue our season virtually until we can meet once again. Specifically on a robotics team, we have been able to use 3D software to virtually simulate our robots, and produce functional models of an entire robot without the need to be in person to assemble anything. Additionally, working with 3D design software, we are able to simulate parts of the robot in ways that can't be done physically, such as understanding where our weak points are, how to mechanically optimize custom parts, or even looking at tolerances between our components.

Many of our students can benefit from 3D design in their career path, independent of major. 3D design teaches a broader understanding of system architecture, and allows an individual to understand how something gets put together. For instance, people generating electrical schematics for mechanisms can have a better understanding of component footprints and needed sensors, given an understanding of 3D design. Programmers can understand the capabilities and limitations of a machine, given an understanding of 3D design. Finally, many engineers can develop advanced products and simulations of products given 3D design, helping to create new technology in all fields in an efficient manner.