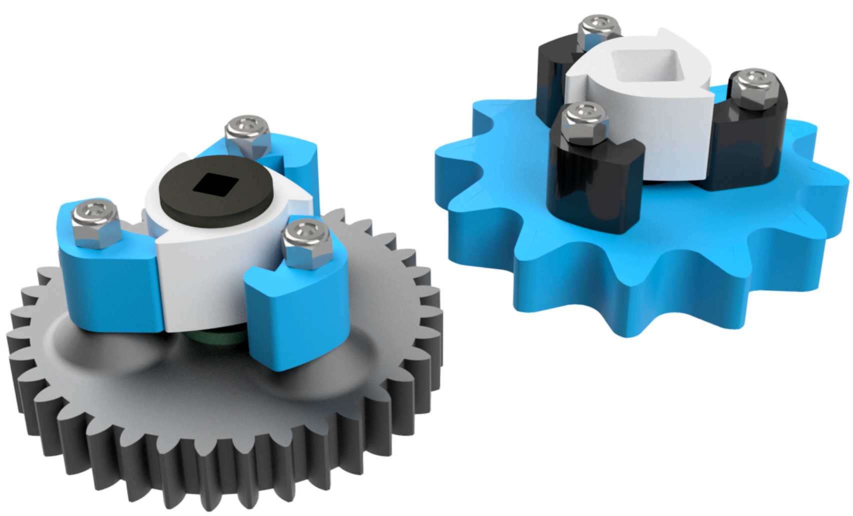
VEX Robotics Competition "Make It Real" CAD Engineering Challenge Sponsored by Autodesk®

Compact Ratcheting System

Presented by Team NXS



Summary

We created an extremely compact and low friction ratcheting mechanism that is compatible with both gears and high strength sprockets. It works by having three pawls that use the ratchet itself to align the pawls with the teeth. We are currently using this mechanism on our 15” VEXU bot and have tested it extensively.

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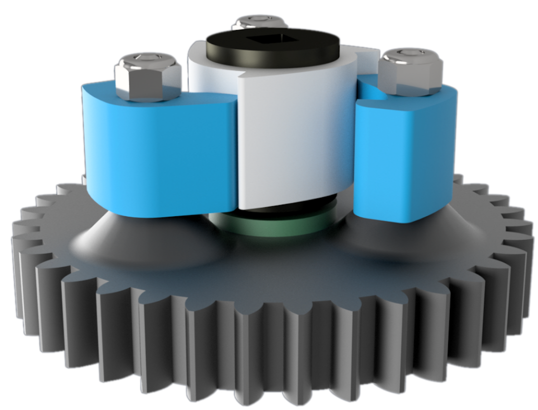


Figure 1. Low Strength 36T Gear Variant

Introduction

Ratchets are not a new concept to VEX Robotics, but they are often either quite bulky or induce plenty of friction. For the current VRC challenge *Change Up* the main scoring object are balls, which can be easily manipulated using rollers and flywheels. Where there are rollers and flywheels, there are ratchets.

VEX does currently sell a ratchet and pawl mechanism, but they require either gravity or an elastic to hold the pawl against the ratchet. Elastics wear down over time, and using gravity to hold down the pawl only works if the pawl's mounting point is stationary and the ratchet is vertical. A solution to this problem is to use flexible materials for the pawl, such as some of the polycarbonates that are legal in both VRC and VEXU. The issue with this solution is that they wear down over time and can cause additional friction if not tuned properly. In our 15" VEXU robot, space is very limited, so we needed to find an extra compact solution for the ratchets on our sorting roller.

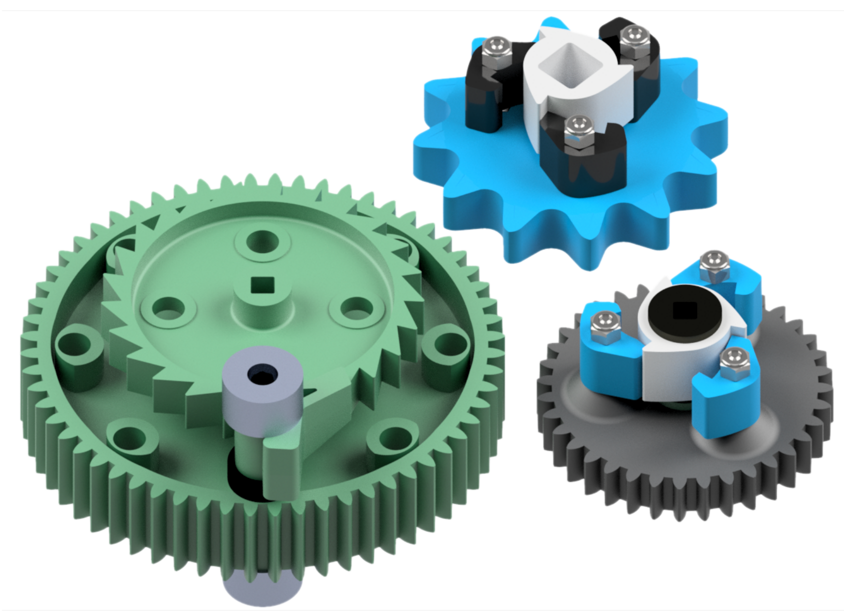


Figure 2. Size comparison of an equivalent system made from VEX parts

How It Works

The ratcheting mechanism consists of the input sprocket/gear, three pawls, and the central ratchet as seen in Figure 3. The pawls are mounted on 16mm long M2 screws and held in place by two nuts so that they can easily rotate. The input gear uses plastic free-spinning inserts and the ratchet uses metal square inserts, which are both VEX products.

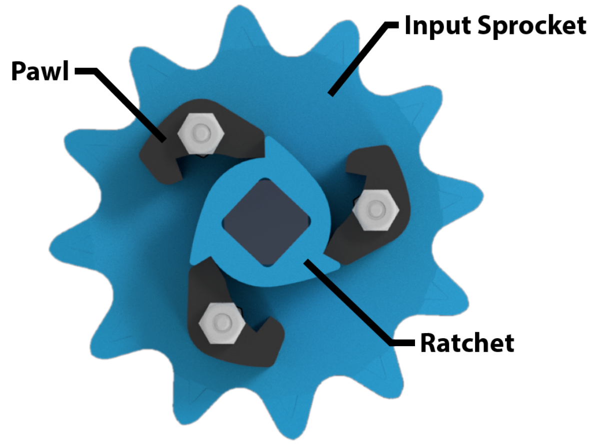


Figure 3. Diagram of Ratcheting System

The key feature of the ratchet is that the pawls do not need an external force to keep them pressed against the ratchet. In the example shown in Figure 4, if the input gear turns clockwise, the pawls will freely rotate out of the way when approaching the highest part of the ratchet. If the input gear turns counter-clockwise, and the pawls are not close enough to the teeth of the ratchet to engage (Step 1), the ratchet teeth 'kick' the protrusion on the other side of the pawls (Step 2), and push the pawls into the correct position (Step 3). This means that the only friction in the system of any significance when the ratchet is not engaged is between the pawls and the screws where they are mounted.

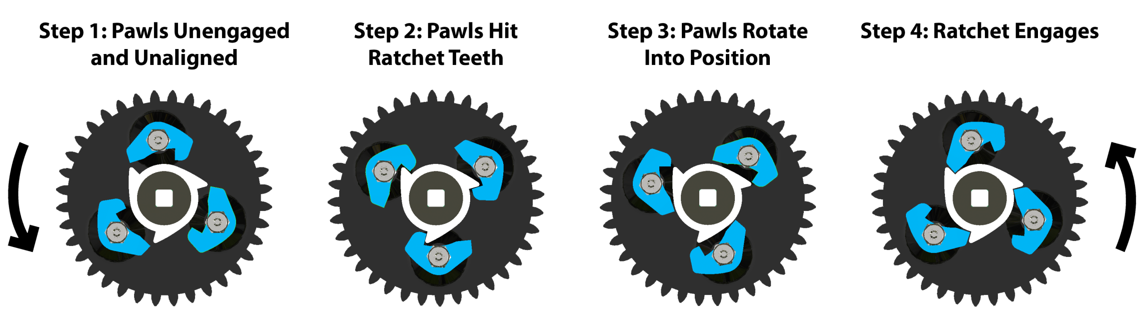


Figure 4. Pawls auto-aligning as the gear turns counter-clockwise

The reason we used three pawls instead of one is so that the system can carry greater loads, and so that if one pawl breaks or fails to engage there are two backups. The latest version has yet to fail and has been on our 15” robot since November 1st, 2020.

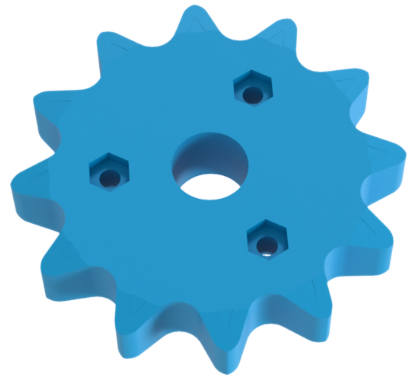
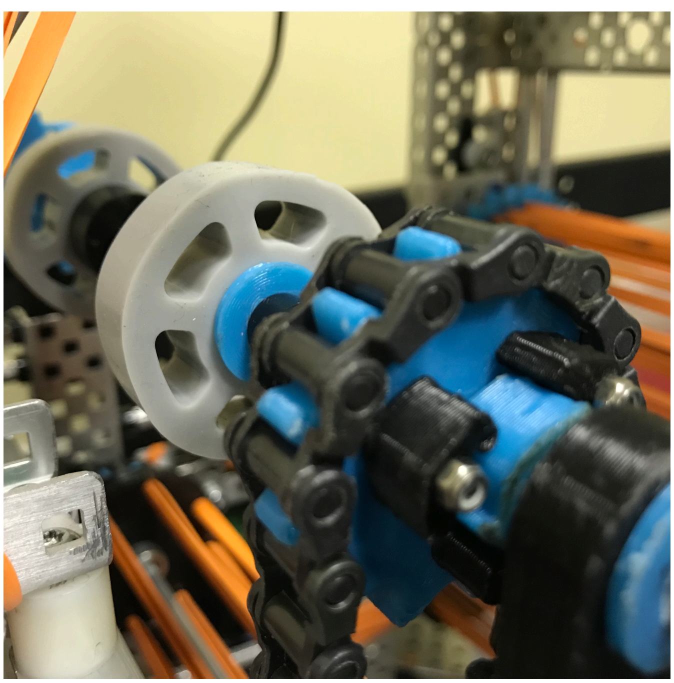


Figure 5. Top View of 12T Sprocket Piece

How We Use It

Currently, this ratchet system is being used on two different rollers in our 15” robot, both of which are involved in sorting balls as they enter the robot. We also use larger versions of the pawls elsewhere on the bot, where the pawl’s rotation point is fixed. The ratchets allow us to utilize the power of the sorting roller to power other rollers that will only turn in one direction. We also plan on using the ratchet to power a flywheel on our robot and created the flywheel tester to test the limits of our design.



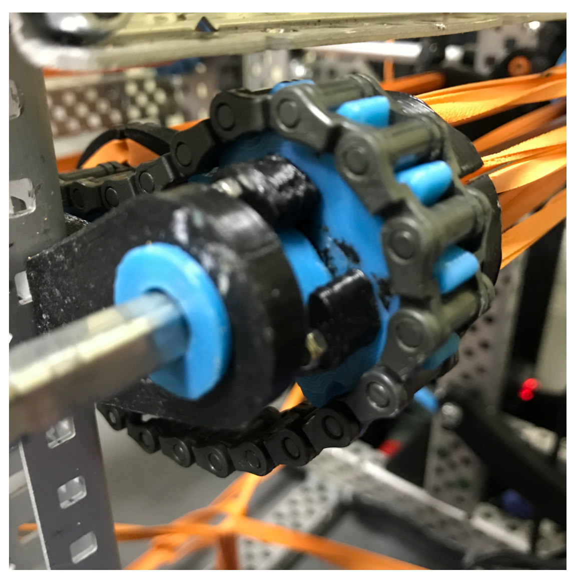


Figure 6 and 7. The 12T sprocket variant in use on our 15” robot

How We Created It

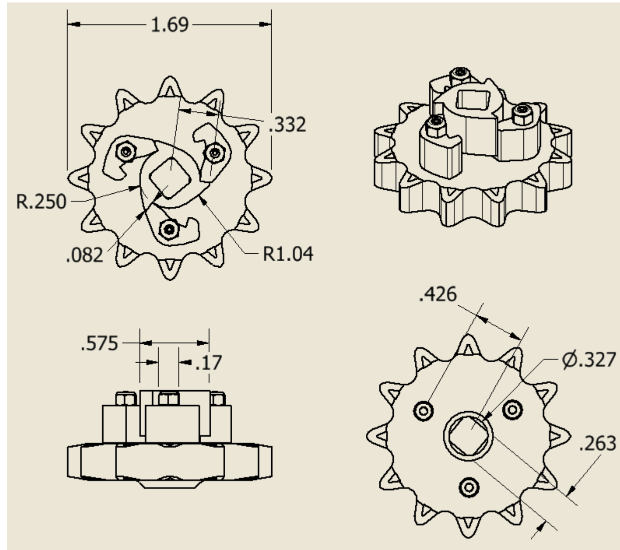


Figure 8. Orthographic view and dimensions of 12T sprocket variant

We used Autodesk Inventor Professional 2021 to create the parts. The input sprocket was based on VEX's High Strength 12 Tooth Sprocket, and the gear is based on the Low Strength 36 Tooth Gear. We then created the central ratchet from scratch and used iterative designing to create the pawls. Both the ratchet and the pawls were designed by extruding 2D drawings. The pawls need to be the correct length to catch properly when the protrusion is kicked by the ratchet, and the correct distance away from the ratchet so that they can rotate out of the way when spinning in the unengaged direction.

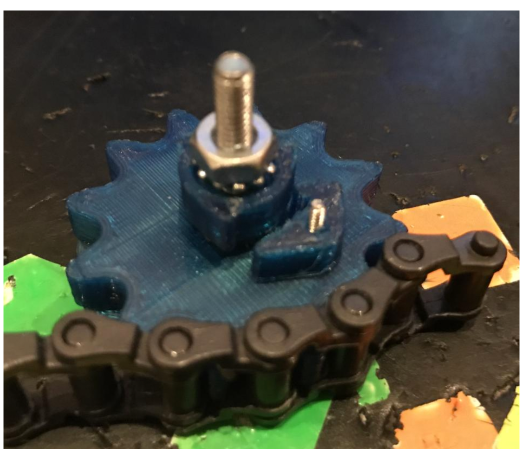


Figure 9. Single Pawl Prototype

Before making the compact triple-pawl version, we started with a larger ratchet and a single pawl allowing us to test various shapes of pawls and verify that the idea worked, and then moved onto the smaller version. Initially, we used motor casing screws with 3D printed 'locknuts', but after they continued to fall, off we invested in the M2 screws and nuts. The change from one pawl to three was simply a precaution, as we predicted that a single pawl system would not endure an entire competition season.

Conclusion

This project has taught us about the viability of ratchets, the importance of understanding the limitations of 3D printing, and the advantages of using CAD in robotics. Our current robot has an incredibly large number of 3D printed parts, and our design would not have been possible without them. Endless possibilities are possible with CAD, and that is why we will continue to use it going forward. The experience we gain using it will be quite beneficial to us as most of our team members are students in various fields of engineering, and a large variety of engineering jobs require the use of computer-aided design.