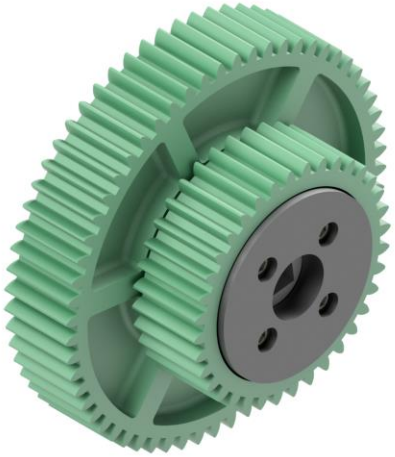
Direction Dependent Gear Selector

Auckland University Robotics Association

Introduction

Frequently in the VEX Robotics Competition, we see a need for a system that has more torque in one direction, and more speed in the other. Such systems might be for a catapult, or a quick robot elevation/hanging mechanism, but the implementation of the concept can be widespread. Typically, these mechanisms end up being bulky, inefficient, or simply not using harnessing their full potential.

To address these issues, the Auckland University Robotics Association (AURA) designed a simple and elegant solution using a pawl and ratchet system within a pair of gears, using the direction of motion to alternate between gears. We call this a Direction Dependent Gear Selector.



Above: Isometric view of Direction Dependent Gear Selector assembly

Implementation

The Direction Dependent Gear Selector is designed to fit right into a gear train. Input power is provided by motors via drive shafts to the core, which transfers the power via a pawl and ratchet system to the gears, to then be further transferred to other gears. The Direction Dependent Gear Selector is designed for use with the VEX High Strength Shafts, although regular VEX drive shafts can be used by inserting square inserts from the High Strength Gears kit.

This component could, for example, be used to power a catapult system. For this, motors could be powering the Direction Dependent Gear Selector, and then further gears meshing with the component could be bolted onto a catapult arm. Typically, in these systems there is some elastic assistance to help with the “launch”. When the motors are driving the catapult down, a high torque ratio would be engaged. When firing, a high-speed ratio would be engaged. This then further harnesses the power of the motor(s) to help with the launch, unlike other common mechanisms (such as “slip gears” or a “choo-choo”). This results in the ability to reduce the provided elastic force, in turn allowing a faster “wind-down” phase - a significant advantage over alternative mechanisms, in a convenient small form factor solution.

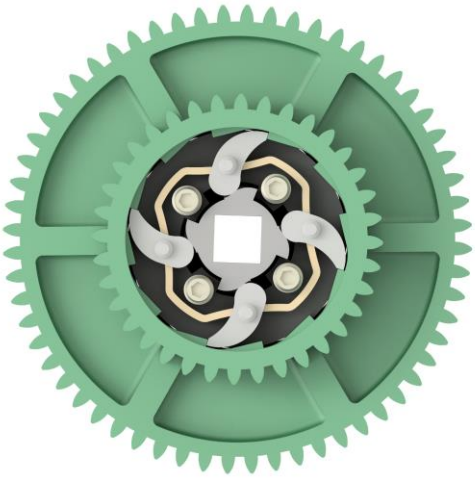
Since this component is compliant with rules <VUR2> and <R5>, it is legal for use in the VEX U competition. All plastic components can be 3D printed, VEX 8-32 1” couplers are used to hold the assembly together, and size 32 rubber bands (sliced in half to reduce thickness and then folded over three times to reduce diameter) work to provide the spring force for the pawls.

Above: Functioning 3D Printed Direction Dependent Gear Selector

Engineering and Design

Several challenges were encountered through the design of the Direction Dependent Gear Selector, observed through rapid prototyping by 3D printing, and then fixed by adjusting the CAD design. **Autodesk Inventor Professional 2017 was used** to design, simulate, render and animate the component.

One problem discovered was through a case of back-driving, where one gear would end up locking against the pawls and inhibiting any movement. We observed this was due to the relative movement due to the different speeds of the gears on the component due to different gear ratios, and only occurred for the smaller gear. To work through this issue, we redesigned the core piece to rotate slightly within the hub (which consisted of two outer plates and one inner plate), and added some curved geometry to allow the core to forcibly disengage the pawls in one direction, thereby eliminating any potential for the issue to arise.



Above: A view of the pawl, ratchet and core interaction within the component

In Autodesk Inventor Professional 2017, various 2D sketch and 3D modelling tools were used. Most notably, the extrusion tool was used extensively, along with pattern features. Fillets and chamfers were used where necessary. Geometry for the gears was projected directly from official VEX gears, to ensure a perfect mesh with other VEX gears and components.

Conclusion

Through this project, the team at the Auckland University Robotics Association learned a lot from the design process behind the development of the Direction Dependent Gear Selector. CAD skills gained from use of Autodesk Inventor Professional 2017 will greatly help us with our competition robot development, but also through our studies as engineering students and further in industry. Almost all of us will frequently use CAD software in our careers – some of us already are in our summer internships daily, to prototype and design components in a virtual space.