Rossum Rumblers Robotics

Custom Mecanum Wheels

Autodesk "Make it Real" CAD Engineering Challenge

Kenneth Hodson and Andrew Ayerh

VEXU Team PYRO
Mesa, Arizona
January 2023

Contents

1 Introduction: Component Functionality and Solved Issues

Figure 1: **Most recent iteration of the PYRO custom 2" mecanum wheels, which use laser-cut metal hubs and molded rubber rollers.**

One of the simplest methods to create a holonomic drivetrain (omni-directional movement) is to use mecanum wheels. Mecanum wheels have small rollers placed around the outside of the wheel whose rotation axes are at a 45 degree angle to the main axis. These are an existing VEX product, and come in various diameters[1]. Of interest to the team are 2" VEXpro mecanum wheels, as they are compact, lightweight, and can be directly driven (no external gearboxes) on a drivetrain to get a suitably fast holonomic robot. However, as shown in Figure 2, VEXpro mecanums have barely any ground clearance (<0.3 mm). This means the plastic hubs will rub against the field if used in a drivetrain, which increases friction and lowers traction. In order to solve this problem, the team developed a custom 2" mecanum wheel in Fusion 360 that uses aluminum hubs, which allows for >470% increase in ground clearance (see Figure 1 and 2).

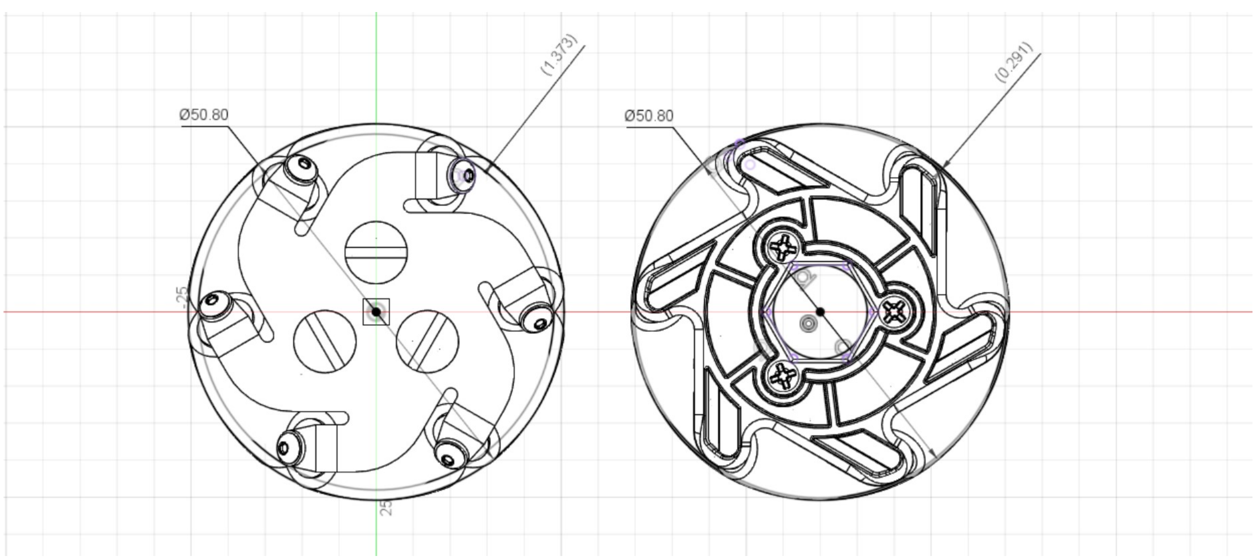


Figure 2: **Left: PYRO Custom 2" Mecanum ($\sim$ 1.4mm clearance), Right: VEXpro 2" Mecanum ($\sim$ 0.3mm clearance).**

[1] VEXpro Mecanum, VRC Wheels

2 Design: How the Part is Used

Given how the PYRO custom mecanum wheels increase ground clearance, they can be used on a drivetrain of a lightweight robot. It is recommended to use eight wheels per robot, as it distributes the weight load. The main advantage of this setup its compactness: the wheels are small and no external gearbox is required. This allows for a versatile, easily reparable, and simple holonomic drivetrain. An example 15" implementation is shown in Figure 3.

Additionally, the lack of an external gearbox means the wheel locations and spacing are arbitrary, so a chassis design not require concessions for specific motor placements. This significantly streamlines design and construction of prototypes.

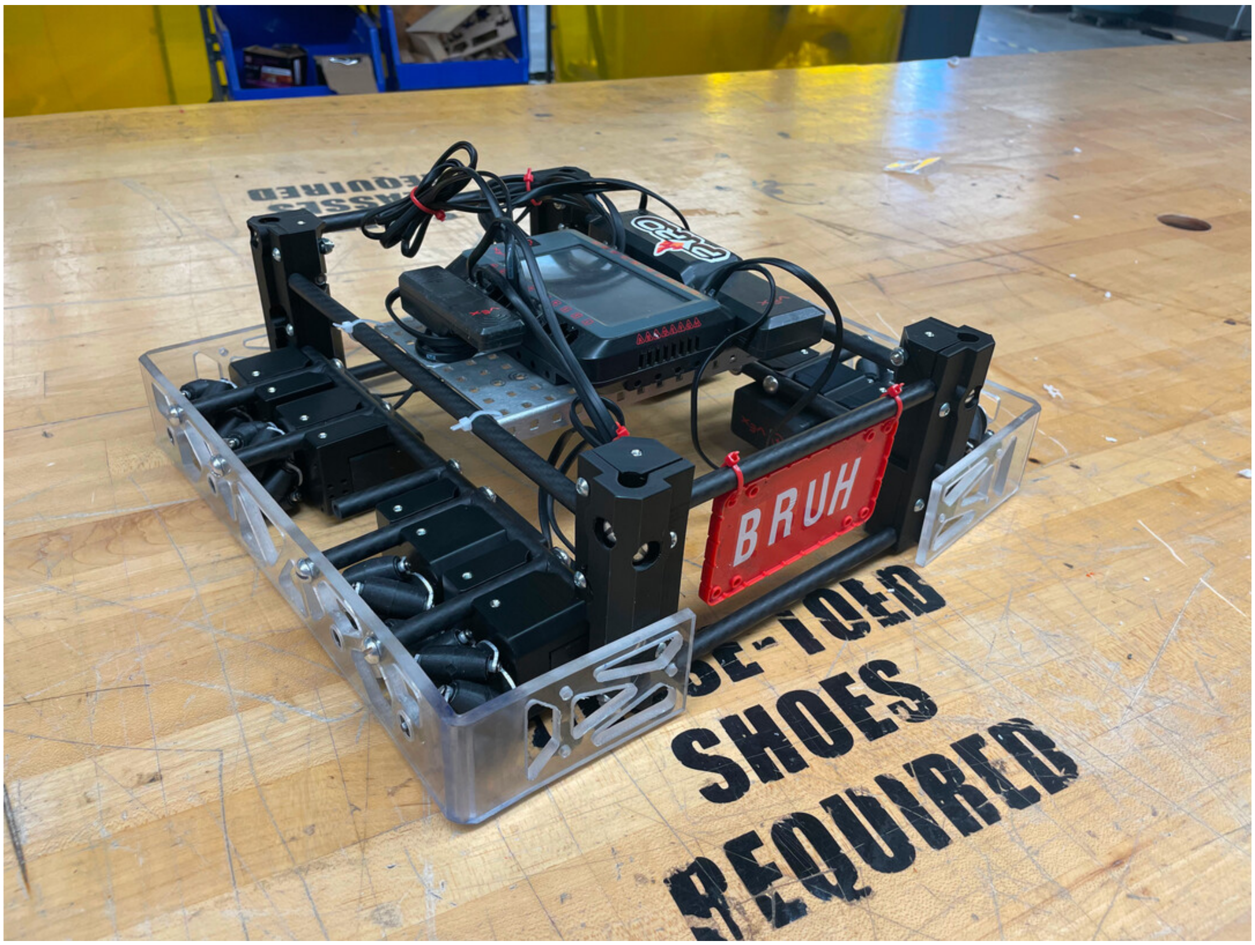


Figure 3: **Programming testbed and proof-of-concept drivetrain. 600 RPM v5 VEX motors directly driving eight PYRO mecanum wheels.**

3 Modeling: Autodesk Software and Features

The version of Fusion 360 used is 2.0.15050. The design process was to first design the roller, then build the metal plate and center hub to match. There were many features used, such as extrude, revolve, hole, modeled threads, and circular pattern, but there were four main aspects of Fusion that accelerated the design process:

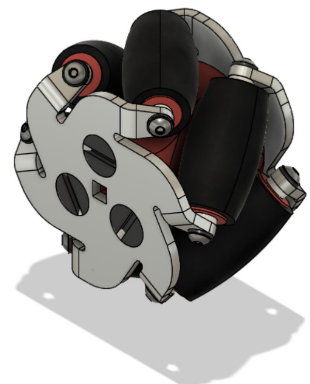


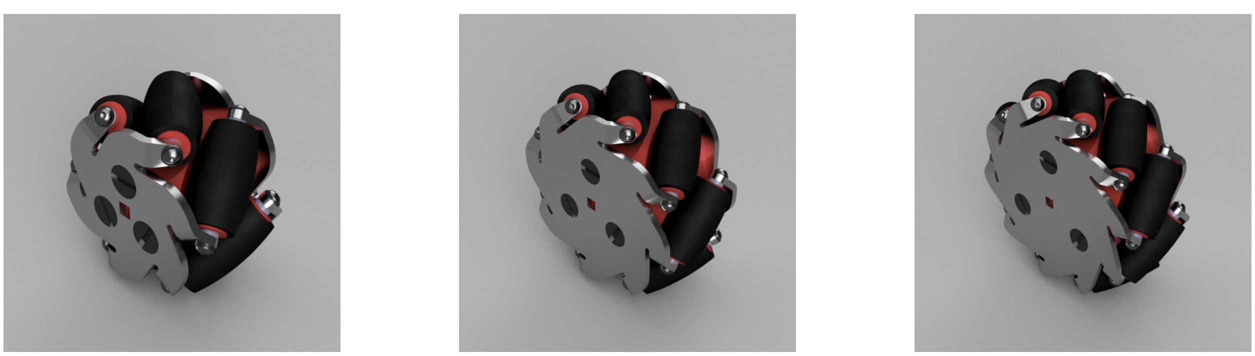
Figure 4: **Fusion 360 Screenshot**

3.1 Sheet Metal Components

Since the main drawback with the existing VEXpro wheels was their bulky hubs, the only way to gain ground clearance is to reduce the roller pin support size. Since plastic lacks enough strength, the team decided to implement a bent sheet metal design. Fusion has the sheet metal component built-in for this exact purpose. It allowed for easy construction which could easily convert into a flat pattern for laser cutting.

3.2 Global Parameters

A serious limitation of many CAD suites is that assemblies require external components, meaning equations and parameters only impact the top-level file. In Fusion, since all components are within one file, a single parameter can impact many different components. For example, a parameter defining the "number of rollers" has to not only change the amount in the roller circular pattern in the top-level assembly, but also alter the metal plate and center hub geometry. Fusion allowed the team to generate many combinations of mecanum wheel to find an optimized design, which would be difficult or impossible in other CAD programs. Examples are shown in Figure 5.



(a) 2" wheel, 6 rollers (b) 2.75" wheel, 8 rollers (c) 3" wheel, 10 rollers

Figure 5: **Renders of various mecanum wheels using Fusion parameters.**

3.3 External Hardware Integration

Because the design uses hardware that is not printed (5 different fasteners), it is useful having an integrated window to browse McMaster-Carr.

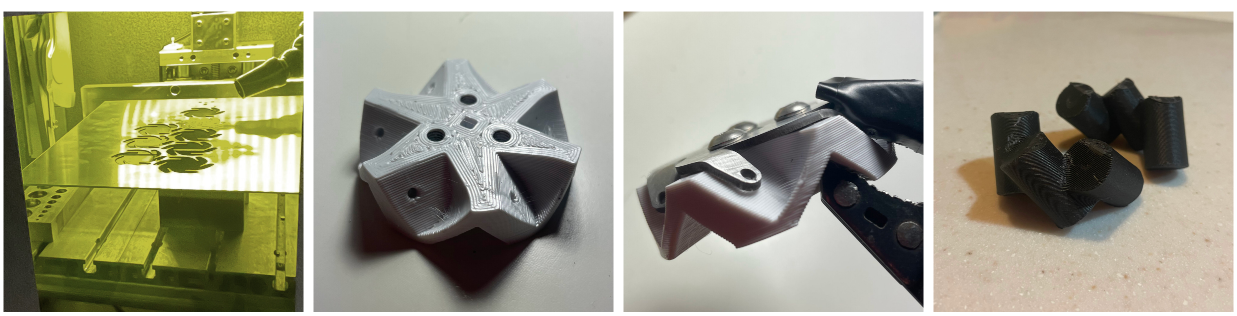
3.4 Collaborative CAD

Having project files stored in the cloud allowed multiple team members to easily access the project to make alterations, check part numbers, or see building instructions.

4 Prototyping: Image Documentation

Figure 6: **v2 (left) & v1 (right)**

This section shows images from PYRO's engineering notebook to explain the construction and iterative design process. There were two versions of the wheel: one was entirely printed (excluding metal plates and hardware), while the next version uses two-part rubber molded rollers. The printed TPU rollers had little traction compared to rubber ones. Exploded views were generated for both versions[2]. The molded version uses nylon flathead screws instead of stainless steel button screws, which shrunk the wheel profile and offset the weight increase from the rubber rollers. Both versions, shown in Figure 6, weigh 45 grams.



(a) Laser cutting (b) Bending jig 1 (c) Bending (d) Bending jig 2

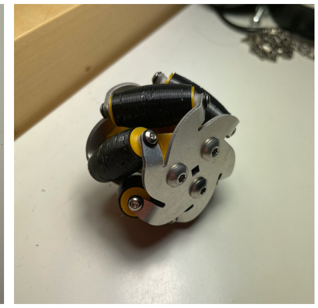
Figure 7: **Plate manufacturing. A better bending jig was developed later (d), which allowed for more consistent alignment. Bending the same aluminum profile in the opposite direction created the mirror version of the wheel.**

[2]Printed version & Molded version, plus demonstration

(a)

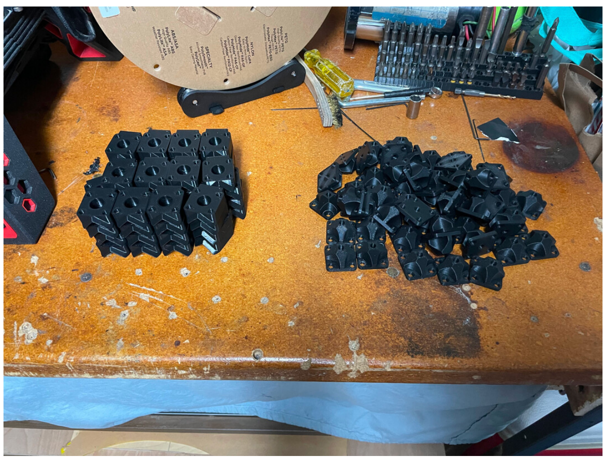
(b)

(c)

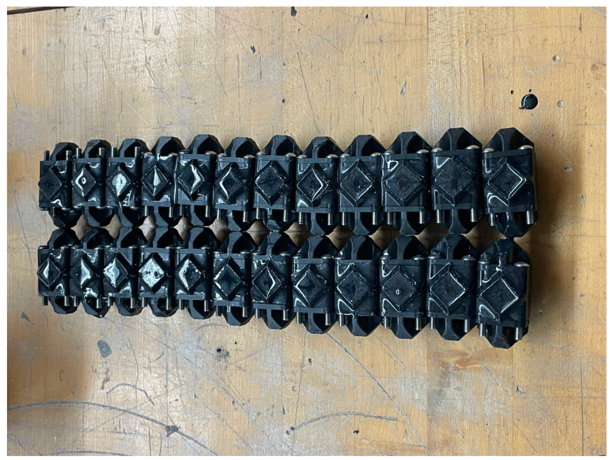


(d)

Figure 8: **Assembly process for the first version of the wheel.**



(a) Printing the roller molds



(b) Filling the molds with rubber

(c) Breaking the molds open

(d) Rollers and Assembled Wheels

Figure 9: **Mold process for the rollers of the second version of the wheel.**

5 Conclusion: Things We Learned

The design process for the wheel taught the team many things about CAD and robotics. For one, the team now has a better understanding about designing and manufacturing sheet metal parts. Additionally, we took a deep dive into existing designs for mecanum wheels, as we investigated the different ways of mounting rollers. For instance, cantilevered rollers, screw joints, or dowel pin joints. The programming team also learned how to program a mecanum drive, which was a first for our team. This was also the first time we experimented with two-part rubber, which we plan to implement on custom flywheels this season.

The model offered a good starting point for new team members, as many did not have CAD experience, so interacting with the relatively simple wheel model assembly is a great entrance to the world of CAD and Fusion. It is now easier for them to help with the CAD model of our robots for this season. In the near future, the CAD skills learned will be key to success in our university classes. Beyond that, knowing Fusion is a valuable resume skill that will be critical for our careers as mechanical, electrical, or robotics engineers.