VEX VRC – 2022 / 2023

CAD ENGINEERING CHALLENGE

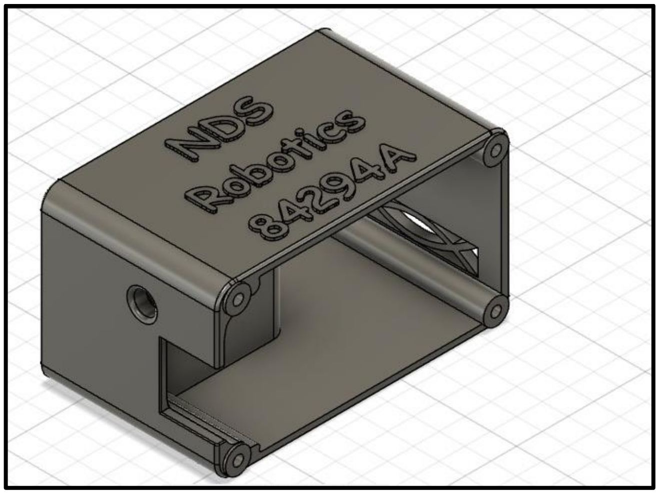
Final Report

Team No. 84294A

Notre Dame du Sault

Sault Ste. Marie, Ontario, Canada

V5 Pneumatic Motor Cooling Jacket



By: Liam, Luke, Gaby, and Sophie

Word count: 812

1) Introduction

We are team **84294A** from Notre Dame du Sault in Sault Ste. Marie Ontario, Canada. This year, we are competing in the VEX VRC High School division. While building our robot, we found that the V5 motors would often overheat during practice. When the motors overheat, they are designed to run at reduced power and in most cases, stop working altogether until the motors cool down. With this problem in mind, we went to the drawing board to design a new motor housing that would incorporate an inlet to connect to the pneumatic system. This will provide air flow with the use of the VEX Pneumatic Pressure Regulator to keep the motors cooler. By introducing cooler air around the internal motor components, the warmer air from inside the motor housing will dissipate through an exhaust grill. Keeping the motors cooler will prolong the driving time of the robot.

We call the new part the **"V5 Pneumatic Motor Cooling Jacket"**.

2) Explanation of the New Part

There were several design criteria for the new part:

- low cost for manufacturing purposes,
- compact, so it does not increase the space requirements for the motor,
- integrate into existing VEX components so it could be used on the V5 platform, and
- robust and reliable, and
- a solution that has no moving parts to minimize wear and maintenance.

The following VEX parts are needed to work with the **V5 Pneumatic Motor Cooling Jacket:**

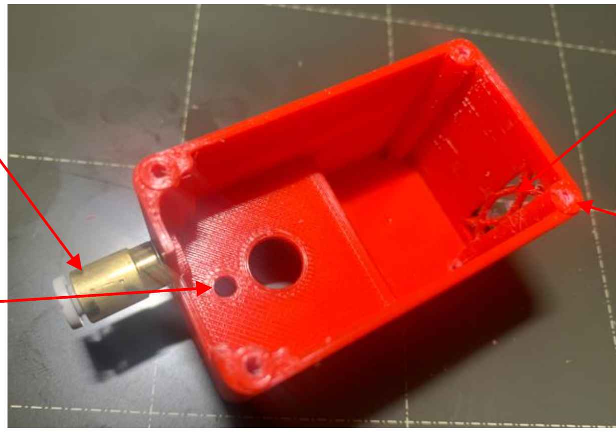
- one (1) VEX Brain with battery,
- one (1) VEX Pneumatic Reservoir,
- one (1) VEX Pneumatic Pressure Regulator,
- one (1) VEX Solenoid Driver, and
- pneumatic tubing.

Below is a picture of the completed **V5 Pneumatic Motor Cooling Jacket.**

Photo 1: V5 Pneumatic Motor Cooling Jacket

Air Inlet: connects to the pneumatic air system on the robot.

Holes: to accommodate the VEX gear cartridges and motor shaft



Exhaust Grill: warm air exhaust through the grill thereby keeping the motor cooler.

Screw Holes: to secure the cooling jacket to the motor base

Photo 2: V5 Pneumatic Motor Cooling Jacket Features

3) Software

To design our part, our team decided to model the **V5 Pneumatic Motor Cooling Jacket** with Autodesk Fusion 360 version 2.0.15050 (Educational License). Out of our three options (Autodesk® Fusion 360™, Autodesk® Inventor®, or Tinkercad™) our team used Fusion 360 since it is commonly utilized in the robotics and 3D modelling industry. We also have experience with this program as we have worked with Fusion 360 for our robot design process.

Below is the completed model shown in the Fusion 360 program.

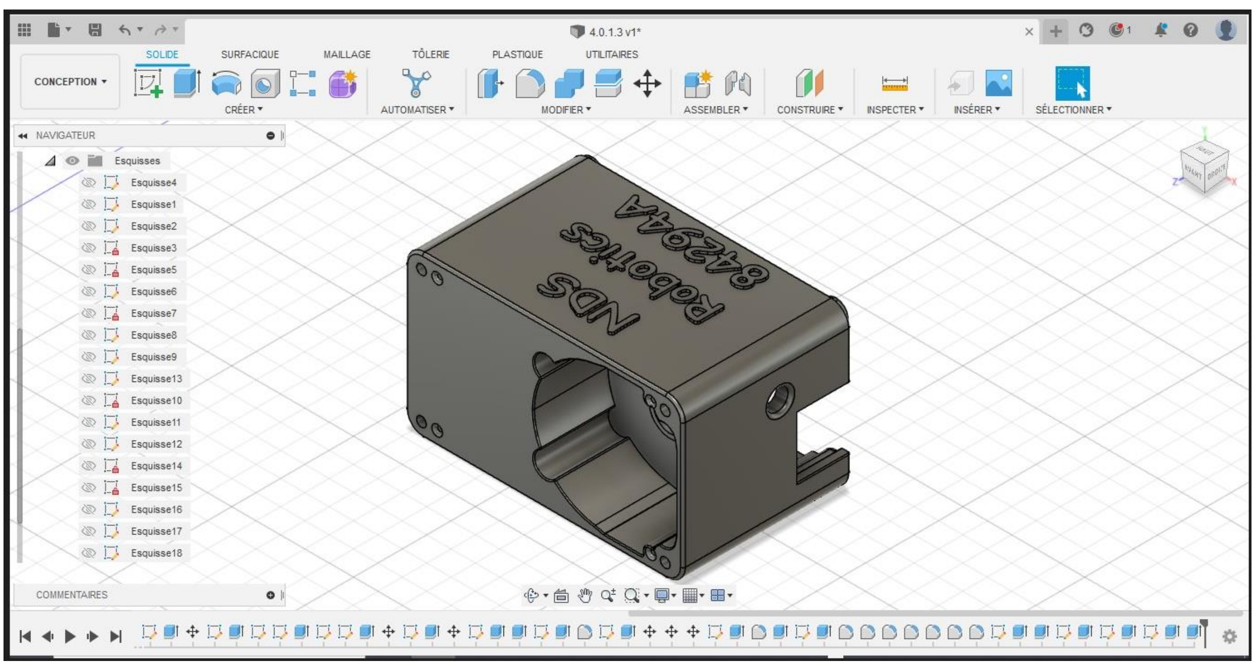


Photo 3: V5 Pneumatic Motor Cooling Jacket using Autodesk Fusion 360

4) Design with Fusion 360

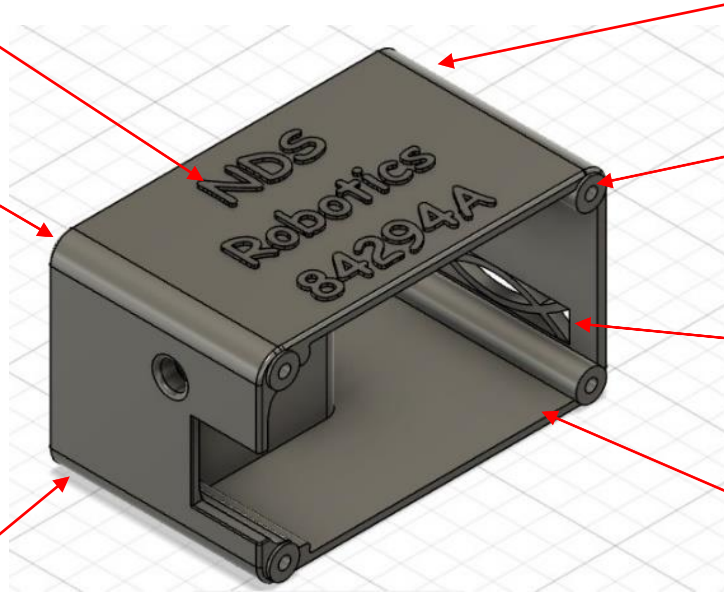
Throughout the design process, there was a lot of prototyping and re-engineering. We created the **V5 Pneumatic Motor Cooling Jacket** using an existing motor casing as a sample. We used a digital caliper to take the measurements, then created the model in Fusion 360. Once the basic geometry was established, other Fusion 360 tools such as ***chamfer***, ***extrude***, ***sketch***, ***fillet***, ***text***, ***scale***, and ***spline*** were used to round-off the corners, make the necessary holes for the screws and air inlet. This produced a professional looking part which is efficient, simple, and elegant.

Fusion 360 Tools Used for the Part Design

Text: used to write the Team Name and Team Number on the part

Sketch: used to create the 2D shape of the entire part, including openings and holes that would later be extruded or cut to create a 3D shape

Scale: used to ensure the part is at the correct dimensions required within specific tolerances



Chamfer: used to round corners

Extrude: used to model the screw channels, cut the holes, and to emboss the text

Spline: used to design the intricate exhaust grill

Fillet: used to create an edge on the housing to mate with the bottom cover

<u>Fusion 360 Model of the V5 Pneumatic Motor Cooling Jacket</u>

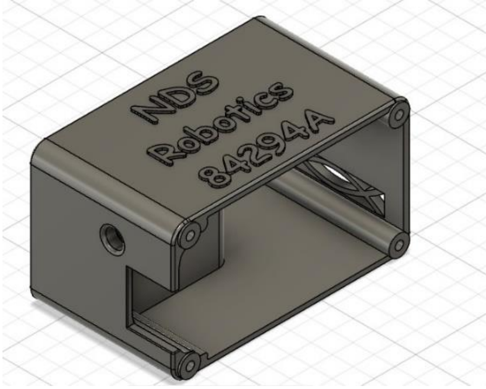


Photo 4: Isometric

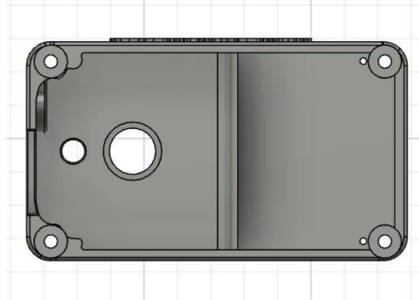


Photo 5: Bottom View

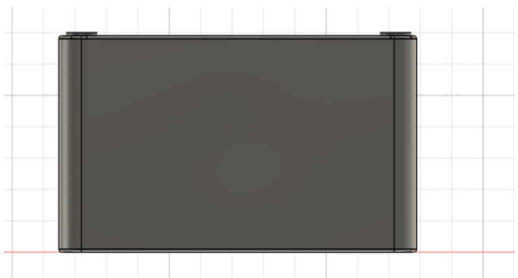


Photo 6: Side View.

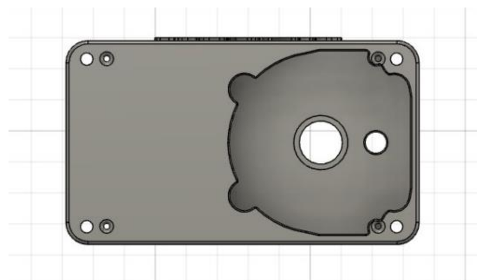


Photo 7: Top View

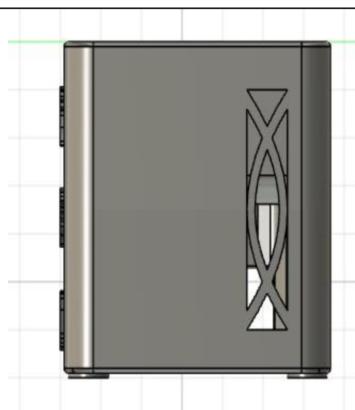


Photo 8:End View

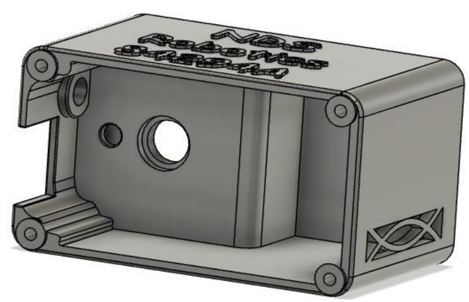


Photo 9: Inside View

5) Fabrication of the Part

In order to test the design, we fabricated the **V5 Pneumatic Motor Cooling Jacket** using a Prusa Mini 3D printer.

The part was printed using 15% infill of PLA plastic material. We found that using an extruder emperature of 210 degrees Celsius provided the optimal printing quality.

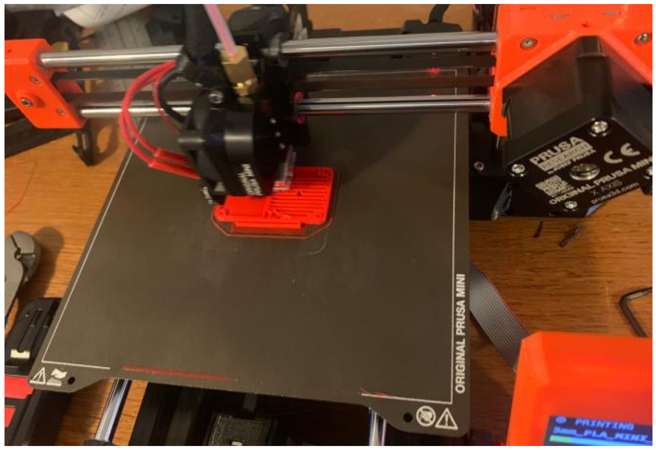


Photo 10: Printing the V5 Pneumatic Motor Cooling Jacket on the 3D Printer.

Feature type	Time	Percentage	Used filament	
Perimeter	49m	28.8%	2.19 m	6.54 g
External perimeter	1h4m	37.2%	2.30 m	6.85 g
Overhang perimeter	13s	0.1%	0.00 m	0.01 g
Internal infill	14m	8.2%	0.27 m	0.81 g
Solid infill	16m	9.4%	0.95 m	2.83 g
Top solid infill	2m	1.2%	0.10 m	0.29 g
Bridge infill	3m	1.5%	0.10 m	0.29 g
Skirt/Brim	20s	0.2%	0.02 m	0.05 g
Support material	20m	11.7%	0.87 m	2.60 g
Support material interface	3m	1.5%	0.10 m	0.30 g
Custom	20s	0.2%	0.02 m	0.05 g

Estimated printing times:

First layer: 5m

Total: 2h52m

Photo 11: Printing Parameters

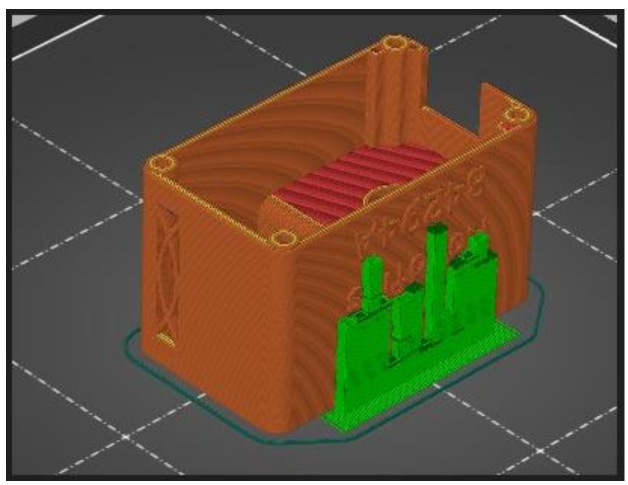


Photo 12: Supports used for printing overhangs and letters.

Photos of the V5 Pneumatic Motor Cooling Jacket

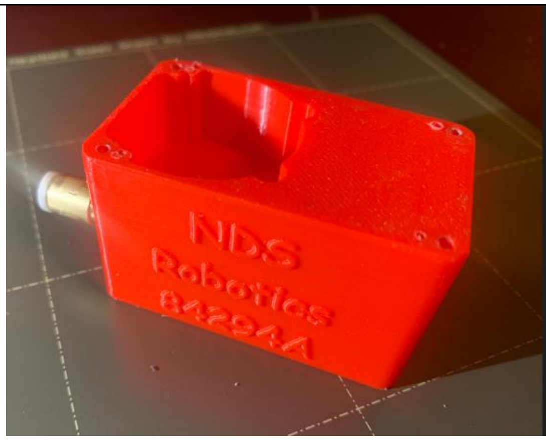


Photo 13: Cooling Jacket with air-inlet.

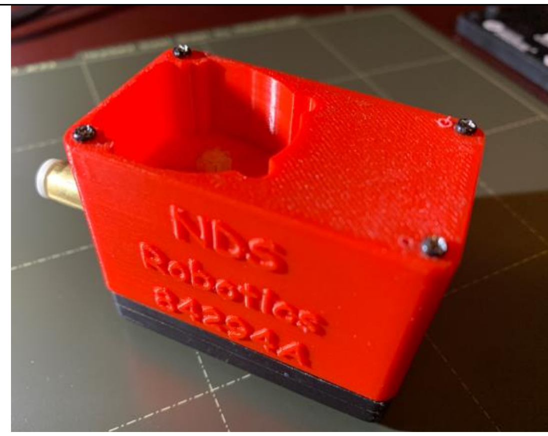


Photo 14: Cooling Jacket mounted to motor base.

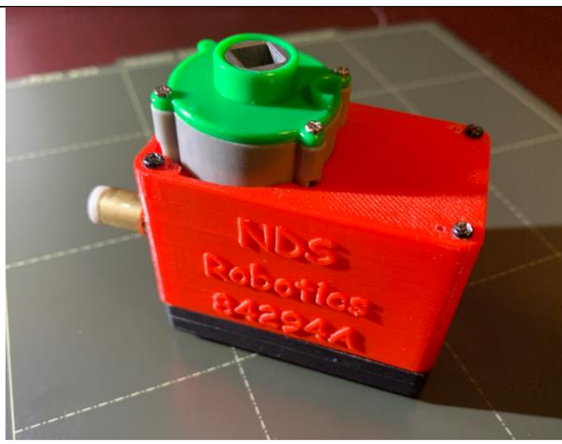


Photo 15: Cooling Jacket with motor base and gear box.

Photo 16: Cooling Jacket fully assembled.

Photo 17: Cooling Jacket – exhaust air port.

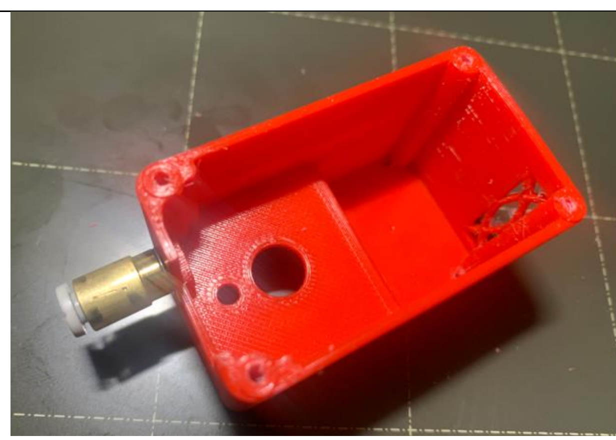


Photo 18: Interior view of Cooling Jacket.

The operation of the **V5 Pneumatic Motor Cooling Jacket** requires the use of the VEX Pneumatic Solenoid Valve which is connected to the 3-wire port on the V5 Brain (shown in photo to the right).

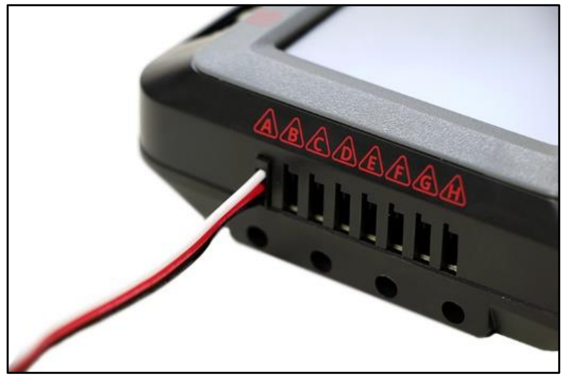


Photo 19: V5 Brain (3-wire inputs)

6) Testing

The **V5 Pneumatic Motor Cooling Jacket** was tested on a fabricated test apparatus shown below. The motor on the left is equipped with our new cooling jacket which is connected to the pneumatic air supply. The motor on the right is a standard V5 motor.

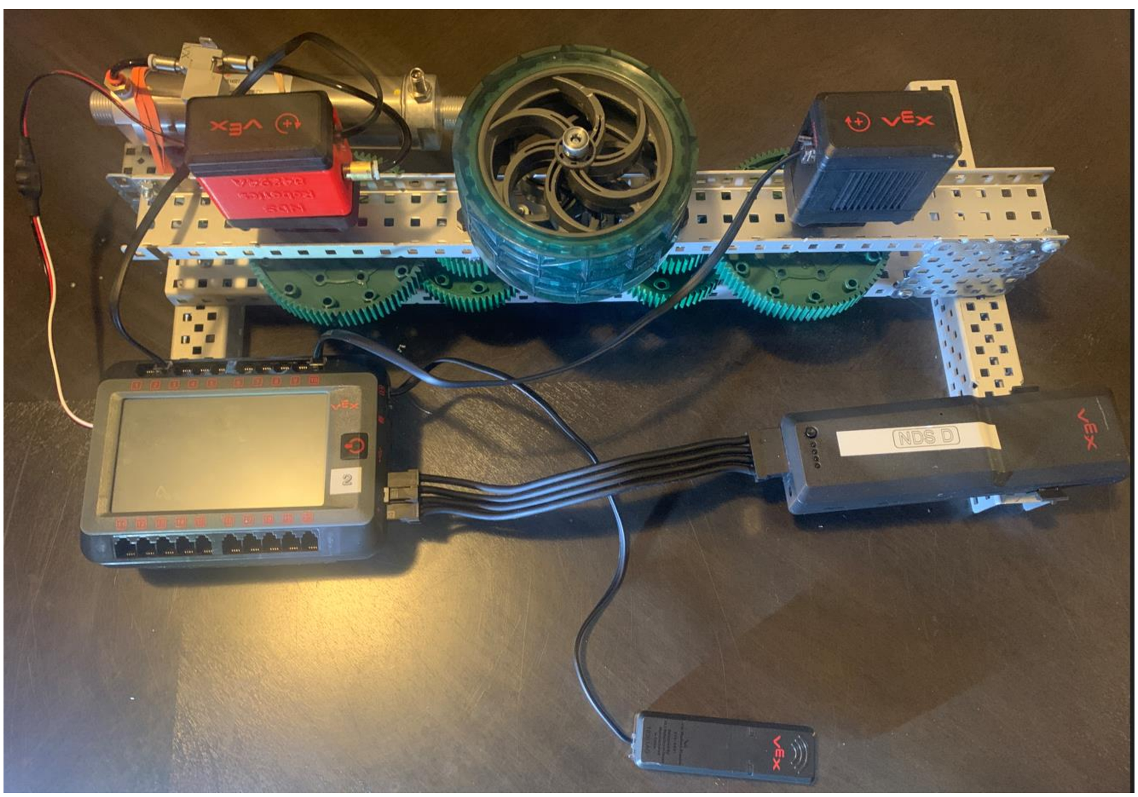


Photo 20: Test apparatus

In order to run the test, a program was written to run the motors, activate the pneumatic air system, as well as display the motor temperatures on the V5 Brain. The results showed a proof of concept that the motor worked with the **V5 Pneumatic Motor Cooling Jacket**. The recorded temperatures demonstrated positive change but more testing would need to be done to optimize the design and improve efficiencies.

Below is the code that was written test the new **V5 Pneumatic Motor Cooling Jacket**.

```
// THE FOLLOWING PROGRAM WILL RUN THE TWO MOTORS AND DISPLAY THE MOTOR TEMPERATURE
//  RESULTS ON THE V5 BRAIN.
//  MOTOR A:  MOTOR WITH THE V5 PNEUMATIC COOLING JACKET
//  MOTOR B:  STANDARD V5 MOTOR

PN1.open();  // INITIATE MOTOR COOLING SYSTEM ON MOTOR_A

while(true) {
  double motor_temperature_A = MOTOR_A.temperature(percentUnits::pct);
  double motor_temperature_B = MOTOR_B.temperature(percentUnits::pct);

  double temp_in_percent_A = (motor_temperature_A - 20) / 50 * 100;
  double temp_in_percent_B = (motor_temperature_B - 20) / 50 * 100;

 // Print MOTOR TEMPERATURE values to the V5 Brain
  Brain.Screen.clearScreen();
  Brain.Screen.print("MOTOR_A: %.2f", temp_in_percent_A);
  Brain.Screen.print("  MOTOR_B: %.2f", temp_in_percent_B);
  Brain.Screen.newLine();

 // Spin both motors at 75% speed
  MOTOR_A.spin(forward, 75, velocityUnits::pct);
  MOTOR_B.spin(forward, 75, velocityUnits::pct);

 // Wait 5 seconds, then display again
  wait (5, seconds);
}
```

Photo 21: Code for Testing

6) Conclusion

In designing the **V5 Pneumatic Motor Cooling Jacket** we learned a great deal about the systematic realization from identifying a problem, coming up with a concept, and producing a final product. It starts with conceptualization and is refined through trial and error, prototyping, analysis, and problem solving. We also learned that the design of a single component is only part of the design process. The new component design must fully integrate into the surrounding parts to make a fully functional and efficient system. In working on this project, we became more proficient using the Autodesk Fusion 360 software. Now that we are more comfortable with the program, we will use it for future design development projects.

Our team members have an interest in pursuing engineering careers where this process will be used.

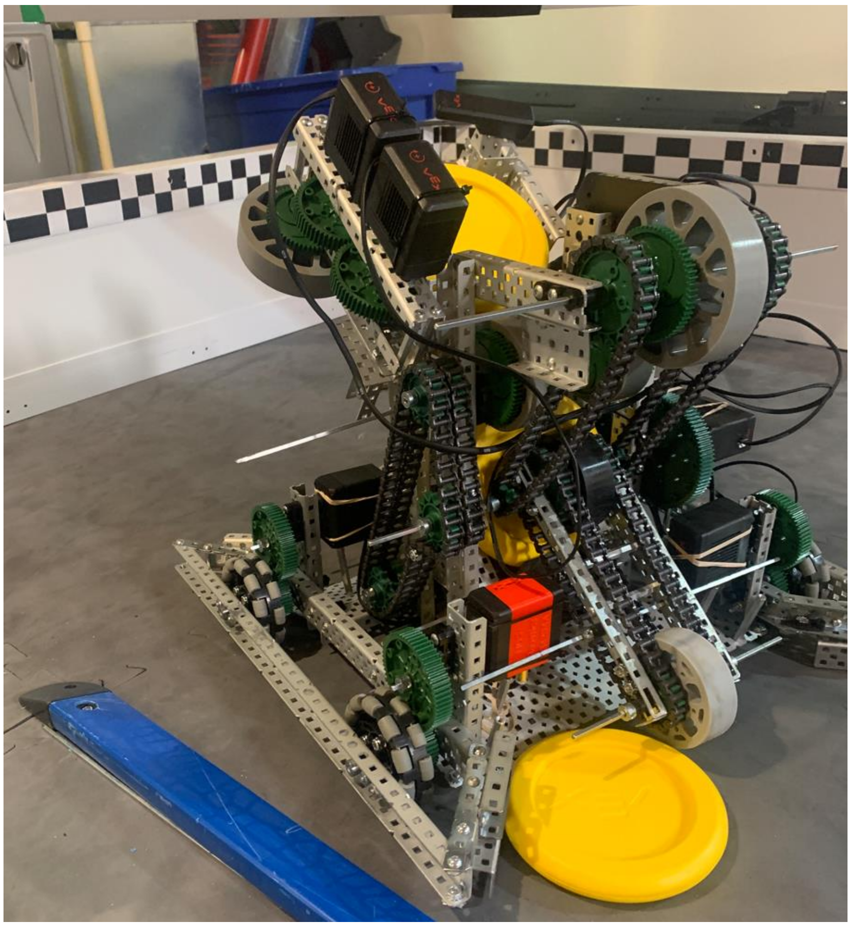


Photo 22: V5 Pneumatic Motor Cooling Jacket Incorporated into the Competition Robot.

V5 Pneumatic Motor Cooling Jacket coming soon to a robot near you…

Thank you.