THE UNIVERSITY OF UTAH
MECHANICAL ENGINEERING

Vertical Axis Wind Turbine

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Project Introduction

Vertical axis wind turbines are widely used in urban environments where space is limited, and wind direction can change abruptly and frequently. This project aims to improve upon an existing vertical-axis wind turbine prototype built by previous senior design teams. The primary objective is to improve the overall efficiency of the turbine by reducing frictional losses in the rotating components, as well as implement a braking system to slow down or stop the turbine as needed.

Position Sensor/Active Bearing

Originally, we used a Hall Effect Sensor to measure the vertical position and provide feedback to the control system for an active magnetic bearing. We calibrated the sensor by measuring the sensor output at various distances, with 5 trials for each position. The data was averaged, and a curve was fit to the data. We can then use the fit equation to find position based on the output of the sensor. The maximum error in the calculated distance (vs. actual distance) is in the right column. Maximum overall error is less than 1%. Unfortunately, the active bearing did not function as intended, so we decided to use the passive bearings to levitate the turbine instead.

Position (mm)	Max Error (%)
5	.3
5.5	.3
6	.3
6.5	.5
7	.5
7.5	.6
8	.5
9	.6

Table 1: *Max Error from position sensor after 5 trials at each position*

Metrics	Target	Achieved
Active Bearing Force	65 N	5 N
Position Sensor Error	<1%	Max: .6%
Braking System Torque	5 N-m	5.23 N-m
Rotational Torque @ 175 rpm	<0.02 N-m	.0304 N-m

Table 2: *Metrics*

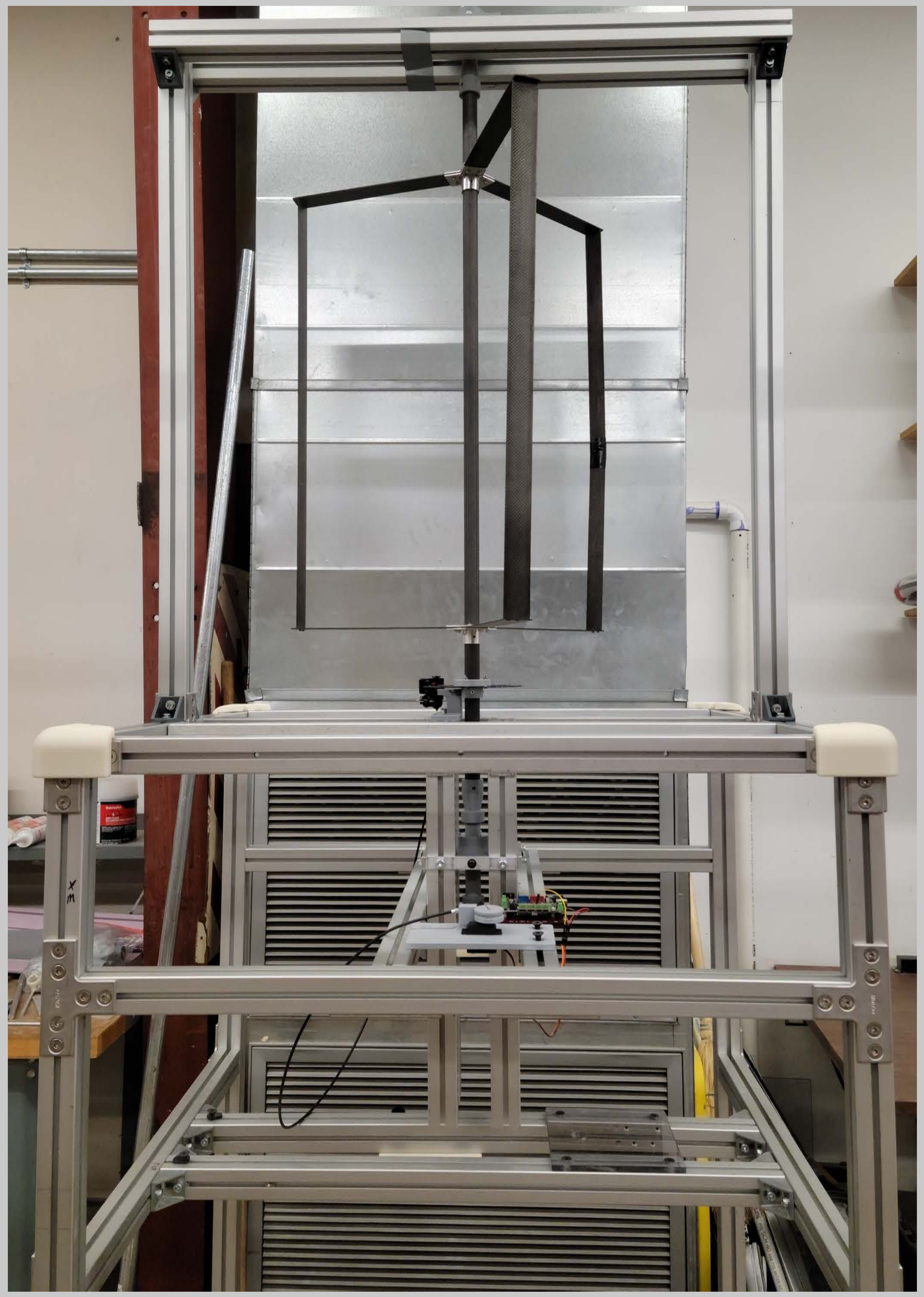

Figure 1: Fully Assembled Turbine

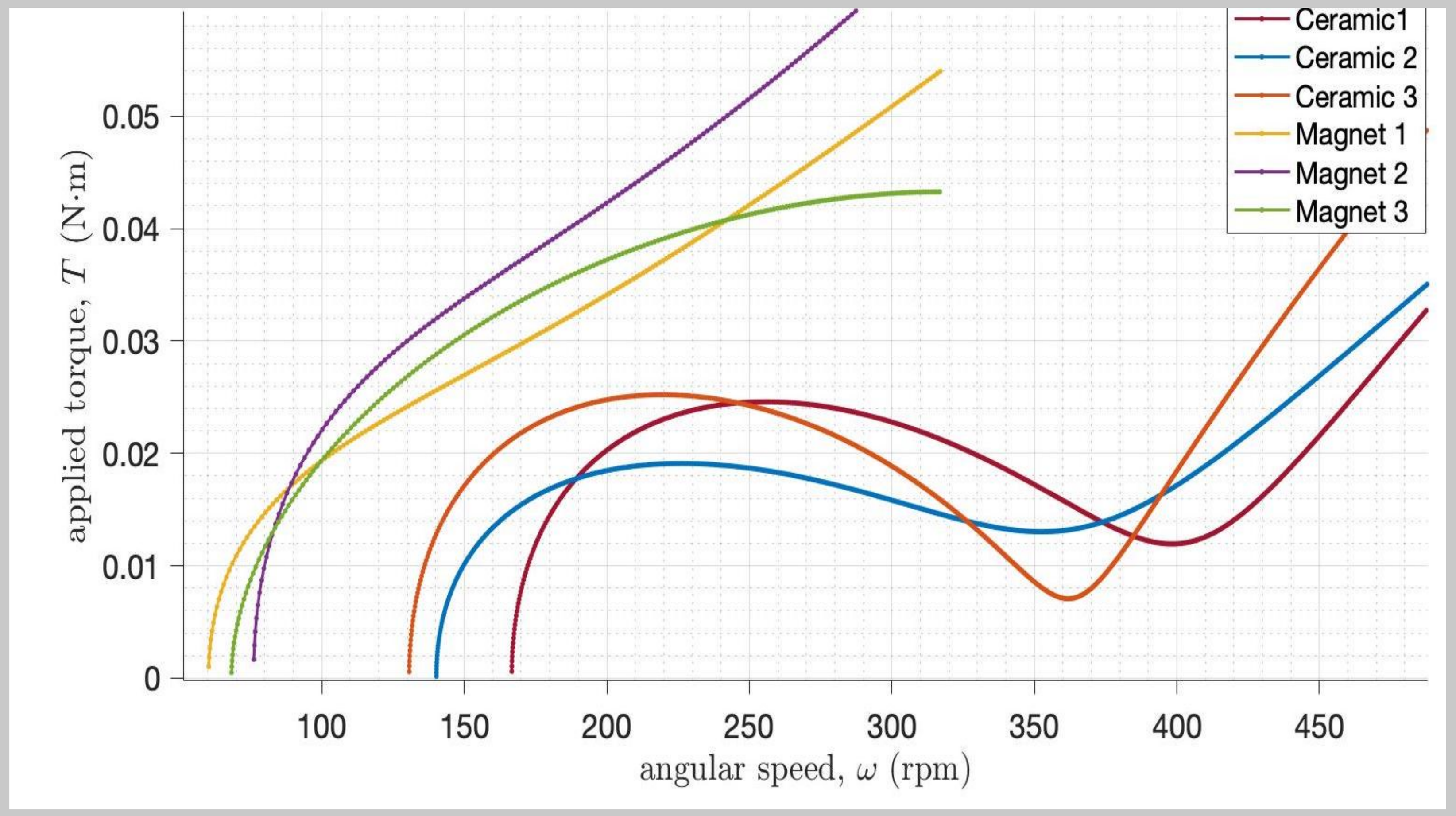

Figure 2: *Torque vs. Rotational Speed*

Passive Magnetic Bearings

The function of the passive magnetic bearings is to maintain the radial alignment of the turbine rotor shaft as well as maintain vertical position. The bearing has two main components: the rotor and the stator. The rotor is housed inside the turbine shaft and consists of disc-shaped neodymium magnets. The stator contains ring-shaped magnets that surround the shaft and the rotor. The interaction of the magnetic forces between the rotor and stator maintain the radial alignment of the shaft, keeping it centered about its axis of rotation and in the desired vertical position.

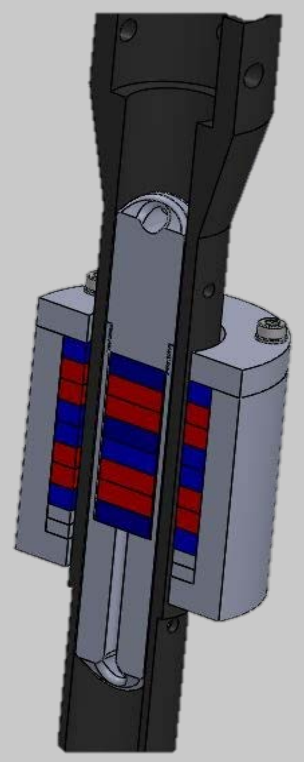

Figure 3: *Magnetic bearing*

Braking System

The turbine uses a mountain bike disc brake kit for the braking system. The caliper is actuated by a servo motor and cable pulley system. This design can provide 5.23 N-m of torque. The aerodynamic torque of the turbine reaches a maximum of 1.75 N-m at speed, resulting a safety factor of ~3. This system is reliable, easy to replace, and cheap. The only downside to this approach is that it requires an active control system. The control system will need to be externally powered, either from the electrical grid or from the turbine itself, which negatively impacts the overall efficiency.

Figure 4: *Brake rotor and caliper*

Results

A spin down test was used to measure the friction in the system. It was then graphed and compared to the ceramic bearings that were installed previously. Each test can be found in Figure 2. The steeper the slope is, the more friction there is in the system. The passive bearings did not perform as well as the ceramic bearings.

Conclusion

Although the passive bearings performed well in the spin down tests, they did not decrease friction when compared to the ceramic bearings we started with. These passive bearings could be improved with better alignment of all components of the frame, as well as adding more magnets to the bearings to increase the radial force on the shaft.