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Portland State
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Experiences in research: Electric motor design

By

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My research for Professor Bird

I worked over the quarter as a research assistant for Professor Bird. My duties were to build and test a DC brushless electric motor and include any design difficulties.

Figure 1: Testing the motor as a generator

The electric motor

Briefly, the Electric motor works by using Ampere's Law to our advantage:

$$\nabla XB = \underbrace{\mu_o I +}_{\text{const B field}} \quad \mu_o \epsilon \frac{\partial \Phi_e}{\partial t}$$

By introducing a significant amount of current into the medium, we can create a constant magnetic field rotating in the clockwise or counterclockwise direction.

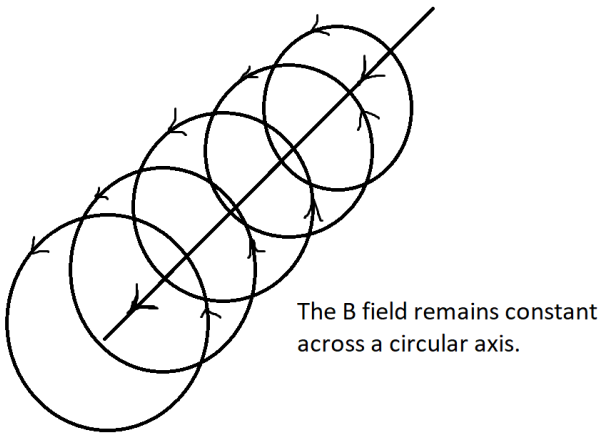

Figure 2 Description of the B field

The electric motor ctd

To exploit this, we wrap the wires in such a way that the B field constructively adds up into a certain direction. This allows a strong magnetic flux propagating into a single direction, which if combined with another magnetic force, creates force into the direction of alignment.

This is done with three separate solenoids and with 12 magnets, separated rotationally by 120 degrees.

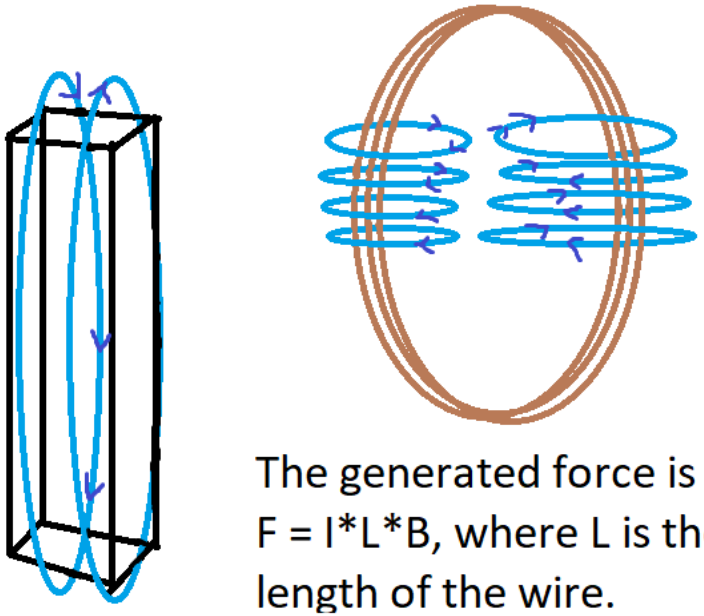

Figure 3: B fields of the Solenoid and the magnet

My experience in research

Research is very much like developing something brand new.

Since no one had done this before, I basically had to create my own methods to measure certain things.
For example, *if we don't have a gauss meter, how can we measure the magnetic field strength of a bar magnet?*

Solution: Measure them relative to the same position using a scale!

Figure 4 Relative field measurement method

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The motor shell was 3d printed using a material using Polyethylene Terephthalate Glycol (PETG). The printing failed 3 times and often gave at least one deformed part every single print. Those that did not fail were covered in a web like residue. Once I had gathered all the parts, I noticed that the majority of the components were too small for their intended use.

Figure 5: Deformed components.

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To solve this, I used a power drill and a buffer attachment to fit the shell into a proper size.

The next obstacle was to implement the magnets into the shell and have the fields be as equal as possible...Then the magnets **broke**. Two of them. It turned out that these magnets are extremely brittle and their dimensions, 30x10x3 are actually very proprietary and uncommon.

Figure 6: Magnet placement inside the rotor

I placed the magnets as best I could, intentionally distributing the lack of fields symmetrically

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After implementing the magnets, I then attempted to wire the motor as per the diagram provided in Figure 7. However, it turns out that the diagram was not accurate and it was mentioned further down in the procedure that the wire needed to be wrapped 4 times the amount listed.

This ended up wasting a significant amount of wire.

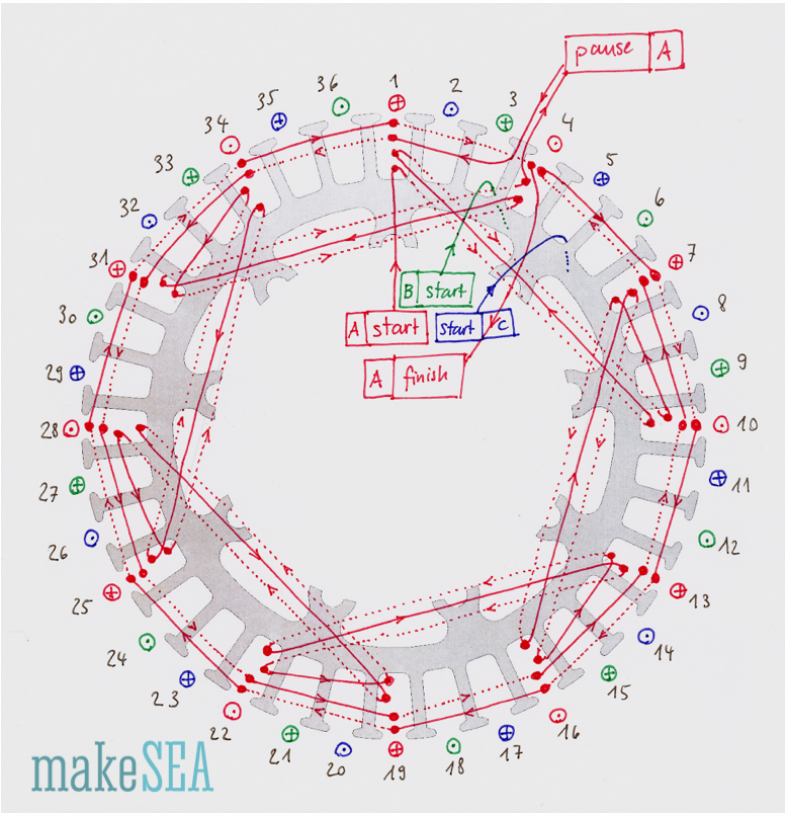

Figure 7: Winding Scheme

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After properly winding the stator (stationary component of a motor), I noticed a significant amount of friction when spinning the rotor around it. It turns out that the wire gauge was fairly low and was impeding the rotation of the motor.

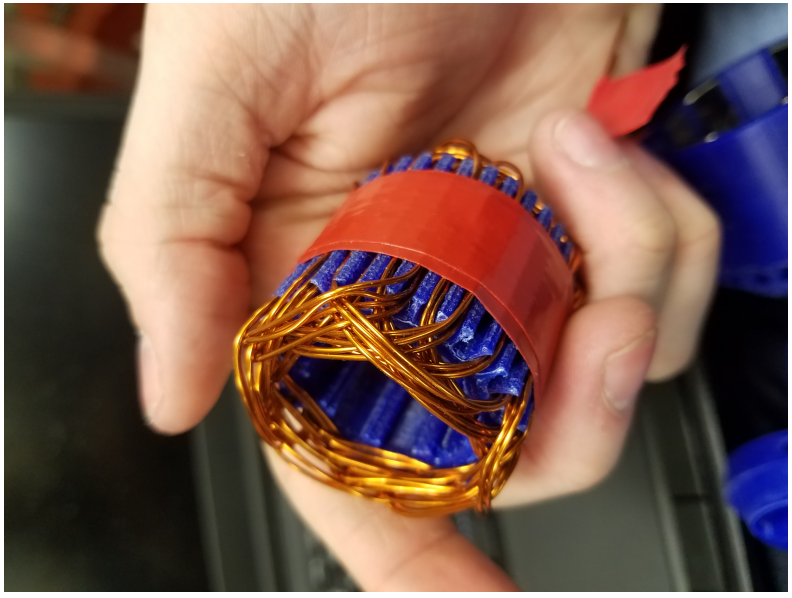

Figure 8: Wound stator for motor

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So I raised the gauge and tried again, successfully winding stator and rotating the rotor around it. It was time to test the motor. Only...it didn't work. The rotor shook but never spun, the casing material heated up and began to deform and the wire oxidized.

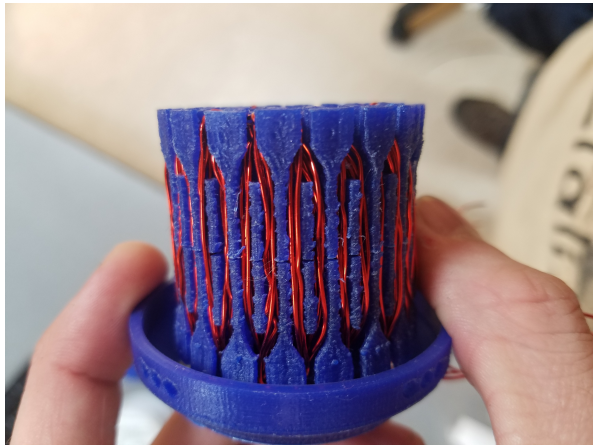

Figure 9: Finished stator

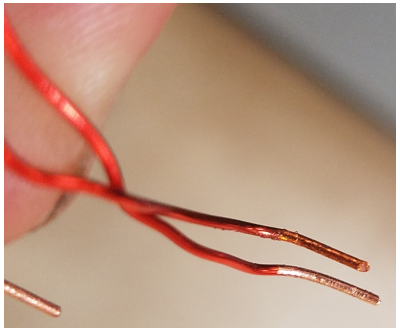

Figure 10: Oxidized wire

What it means to participate in research

So what was the point of all of it? I don't have a working motor!

The point was that everything I've said happened to be a **serious design flaw** that I was able to find a solution to, solutions that I could and did pass on to the students later on when they were assigned this.

By the time I was writing this presentation, I had over **4 pages** written of just problems and solutions that I found during this project in my design log.

Figure 11: My design log

Moral

By participating in this research, I was able to save students time, money and effort by showing them the solutions to problems I had already encountered.