

1. Mark your confusion.
2. Show evidence of a close reading.
3. Write a 1+ page reflection.

A 17-Year-Old Designed a Motor That Could Potentially Transform the Electric Car Industry

Robert Sansone's research could pave the way for the sustainable manufacturing of electric vehicles that do not require rare-earth magnets.

Source: Margaret Osborne, SmithsonianMag.com, August 11, 2022

Robert Sansone is a natural born engineer. From animatronic hands to high-speed running boots and a go-kart that can reach speeds of more than 70 miles per hour, the Fort Pierce, Florida-based inventor estimates he's completed at least 60 engineering projects in his spare time. And he's only 17 years old.

A couple years ago, Sansone came across a video about the advantages and disadvantages of electric cars. The video explained that most electric car motors require magnets made from rare-earth elements, which can be costly, both financially and environmentally, to extract. The rare-earth materials needed can cost hundreds of dollars per kilogram. In comparison, copper is worth \$7.83 per kilogram.

"I have a natural interest in electric motors," says Sansone, who had used them in different robotics projects. "With that sustainability issue, I wanted to tackle it, and try and design a different motor."

As a highschooler, he had heard of a type of electric motor—the synchronous reluctance motor—that doesn't use these rare-earth materials. This kind of motor is currently used for pumps and fans, but it isn't powerful enough by itself to be used in an electric vehicle. So, Sansone started brainstorming ways he could improve its performance.

Over the course of a year, Sansone created a prototype of a novel synchronous reluctance motor that had greater rotational force—or torque—and efficiency than existing ones. The prototype was made from 3-D printed plastic, copper wires and a steel rotor and tested using a variety of meters to measure power and a laser tachometer to determine the motor's rotational speed. His work earned him first prize, and \$75,000 in winnings, at 2022's Regeneron International Science and Engineering Fair (ISEF), the largest international high school STEM competition.

The less sustainable permanent magnet motors use materials such as neodymium, samarium and dysprosium, which are in high demand because they're used in many different products, including headphones and earbuds, explains Heath Hofmann, a professor of electrical and computer engineering at the University of Michigan. Hofmann has worked extensively on electric vehicles, including consulting with Tesla to develop the control algorithms for its propulsion drive.

"The number of applications that use magnets just seems to be getting larger and larger," he says. "A lot of the materials are mined in China, and so the price can often depend upon our trade status with China." Hofmann adds that Tesla recently started using permanent magnets in its motors.

Electric motors use rotating electromagnetic fields to spin a rotor. Coils of wire in the stationary outer portion of the motor, called the stator, produce these electromagnetic fields. In permanent magnet motors, magnets attached to the edge of a spinning rotor produce a magnetic field that is attracted to the opposite poles on the spinning field. This attraction spins the rotor.

Synchronous reluctance motors don't use magnets. Instead, a steel rotor with air gaps cut into it aligns itself with the rotating magnetic field. Reluctance, or the magnetism of a material, is key to this process. As the rotor spins along with the rotating magnetic field, torque is produced. More torque is produced when the saliency ratio, or difference in magnetism between materials (in this case, the steel and the non-magnetic air gaps), is greater.

Instead of using air gaps, Sansone thought he could incorporate another magnetic field into a motor. This would increase this saliency ratio and, in turn, produce more torque. His design has other components, but he can't disclose any more details because he hopes to patent the technology in the future.

“Once I had this initial idea, then I had to do some prototyping to try and see if that design would actually work,” Sansone says. “I don’t have tons of resources for making very advanced motors, and so I had to make a smaller version—a scale model—using a 3-D printer.”

It took several prototypes before he could test his design.

“I didn’t have a mentor to help me, really, so each time a motor failed, I had to do tons of research and try and troubleshoot what went wrong,” he says. “But eventually on the 15th motor, I was able to get a working prototype.”

Sansone tested his motor for torque and efficiency, and then reconfigured it to run as a more traditional synchronous reluctance motor for comparison. He found that his novel design exhibited 39 percent greater torque and 31 percent greater efficiency at 300 revolutions per minute (RPM). At 750 RPM, it performed at 37 percent greater efficiency. He couldn’t test his prototype at higher revolutions per minute because the plastic pieces would overheat—a lesson he learned the hard way when one of the prototypes melted on his desk, he tells *Top of the Class*, a podcast produced by Crimson Education.

In comparison, Tesla’s Model S motor can reach up to 18,000 RPM, explained the company’s principal motor designer Konstantinos Laskaris in a 2016 interview with Christian Ruoff of the electric vehicles magazine *Charged*.

Sansone validated his results in a second experiment, in which he “isolated the theoretical principle under which the novel design creates magnetic saliency,” per his project presentation. Essentially, this experiment eliminated all other variables and confirmed that the improvements in torque and efficiency were correlated with the greater saliency ratio of his design.

“He’s definitely looking at things the right way,” Hofmann says of Sansone. “There’s the potential that it could be the next big thing.” Though, he adds that many professors work on research their whole lives, and it’s “fairly rare that they end up taking over the world.”

Hofmann says the materials for synchronous reluctance motors are cheap, but the machines are complex and notoriously difficult to manufacture. High manufacturing costs are, therefore, a barrier to their widespread use—and a major limiting factor to Sansone’s invention.

Sansone agrees, but says “with new technologies like additive manufacturing [such as 3-D printing], it would be easier to construct it in the future.”

Sansone says he hadn’t originally planned to enter into the competition. But when he learned that one of his classes allowed him to complete a year-long research project and paper on a topic of his choice, he decided to take the opportunity to continue working on his motor.

“I was thinking if I’m able to put this much energy into it, I might as well make it a science fair project and compete with it,” he explains. After doing well at the district and state competitions, he advanced to ISEF.

Sansone is waiting until his next phase of testing before he approaches any car companies, but he hopes that one day his motor will be the design of choice for electric vehicles.

“Rare-earth materials in existing electric motors are a major factor undermining the sustainability of electric vehicles,” he says. “Seeing the day when EVs are fully sustainable due to the help of my novel motor design would be a dream come true.”

Possible Response Questions

- What are your thoughts about this young inventor and his invention? Explain.
- Did something in the article surprise you? Discuss.
- Pick a word/line/passage from the article and respond to it.
- Discuss a “move” made by the writer in this piece that you think is good/interesting. Explain.