

AC 2008-1742: MATERIAL SCIENCE MEETS ENGINEERING EDUCATION WHILE BUILDING AN INDUCTION PULSE ELECTRIC MOTOR

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Introduction

This is an excellent design and fabrication project that can be used in introductory engineering classes to teach motor principles as well as material selection. The basic concept of this activity was originally developed by Beakman's World, and I have improved it over the past ten years while teaching motor principles at the university level. Standard *Radio Shack* materials can be used. One of the most important improvements is replacing the paperclip based motor cradle for one made from copper wire.

The primary objective of this project is to gain an understanding of electric motor principles; and the materials needed to convert electricity and magnetism into motion. Keywords related to this project include: conductors; insulators; enamel; magnetism; electromagnet; and motor principles. Only a very basic knowledge of electricity and magnetism are needed as a prerequisite.

When being utilized as a "materials" experiment, students can experiment with conductors other than copper (such as aluminum and steel) and detect slower (less efficient) motor operation.

Low Voltage Direct Current Electric Motor Operation

Heavy gauge copper wire is used to fabricate the coil cradle, and the cradle is attached to a standard "D" size battery with elastic bands. After winding the motor coil, we remove insulation from two locations with sandpaper and assemble the device.

When the un-insulated parts of the coil make contact with the cradle, current flows through the coil, making it into an electromagnet. Since magnets attract, the coil attempts to align itself with the magnet. However, when the coil turns to face the magnet, contact is broken, and the magnetic field collapses. Inertia causes the coil to continue around until contact is reestablished and the process repeats itself. In other words, the motor revolves continuously.

Needed Supplies

One 'D' cell alkaline battery
One wide rubber band
Two three inch lengths of 12 gauge copper wire
One rectangular ceramic magnet (.5" x .1" x 2")
22 gauge magnet wire
Fine sandpaper
Needle-nosed pliers

Image



Procedure

1. Start about 3 inches from the end of the magnet wire and wrap it seven times around the battery. Remove the battery and cut the wire, leaving a three-inch tail opposite the original starting point. Wrap the two tails around the coil so that the coil is held together and the two tails extend perpendicular to the coil.
2. On one tail, use fine sandpaper to completely remove the insulation from the wire. On the other tail, lay the coil down flat and lightly sand off the insulation from the top half of the wire only.
3. Using needle-nosed pliers, bend the two heavy copper wires. Form a cradle on one end that will hold the coil, and form a loop on the other end that will contact the battery.
4. Use a rubber band to hold the loop ends to the terminals of the "D" cell battery.

5. Stick the ceramic magnet on the side of the battery between the attached copper wires. It is attracted to the steel battery case.
6. Place the coil in the cradle formed by the 12 gauge copper wire lengths. You may have to give it a gentle push to get it started, but it should begin to spin rapidly.
7. (Optional) Use different materials to make the cradle and evaluate the performance of each material. Using an ohm meter, evaluate the material relationship between cradle electrical resistance and motor performance.

Teacher Comments

Balance is important, so be sure to center the two tails on either side of the coil.

If it doesn't spin, check to make sure that all of the insulation has been removed from the wire ends.

If it spins erratically, make sure that the tails on the coil are centered on the sides of the coil.

Learning Outcomes

Upon completion of this exercise, each participant should be able to:

Identify and describe the components needed to make an electric motor.

Discuss motor principles related to material selection and method of operation.

Discuss the importance of balance related to motor operation.

Discuss the effect that material conductivity has on motor performance.

Conclusion

This activity has been used with “students” from as young as eight years old, all the way through university seniors. One of the distinct advantages is the immediate visual and tactile feedback it provides when adjustments are made or when different forms of conductors are used. It is interesting to note that one of the professional reviewers that evaluated this manuscript for publication indicated that this was a “great little motor” and that she actually used it in her engineering classes!

This activity can serve as a springboard into a deeper discussion of material principles including insulation and conductivity, as well as fatigue and failure. As participants fabricate the motor cradle, overworking the material will result in breakage.

Bibliographic Information

Beakman's Electric Motor <http://fly.hiwaay.net/~palmer/motor.html>

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Biography