General Motor Knowledge #39

PERMANENT MAGNETS

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Last month we learned how we induce a magnetic field in our rotors. As promised, this month we will look at a simpler way to set up this rotor magnetic field. The obvious answer is to put permanent magnets (PM's) on the rotor. Now we have a rotor magnetic field for free since we don't have to put any current into the stator to set up this field. That's pretty energy efficient!

Before we look at how to make a PM rotor, let's make sure we understand some basics about magnets, magnetic fields, and the terms used to describe them. The flux from a PM can be thought of as the amount of magnetic strength coming from the magnet. The flux density of the magnet is the amount of flux divided by the area of the magnet face the flux is coming from. Flux and flux density not only have values but directions. By traditional definitions the flux from a magnet leaves the north pole face and flows toward and back into the south pole face. Magnet flux travels only in closed loops. In other words, regardless of the path it travels, all the flux that leaves the north pole comes back into the south pole.

In its path from the north pole to the south pole the flux will follow the path of least resistance. Some materials like air have a high resistance to flux while other materials like steel have very low resistance to passing flux. That's why we use steel in the motor - it can carry a lot of flux and lets us make the flux go where we want it. It's also why we make the air gap as small as we can. This resistance to the passage of flux is known as a material's permeability. The higher the permeability, the less the resistance to flux. Another factor that determines how much flux you can get from a magnet is the magnet's thickness, the distance between the north and south pole faces. The thicker the magnet, the greater its ability to force flux to flow between the pole faces.

Permanent magnets are not really permanent; they can be demagnetized under some conditions. As a PM's temperature goes up, it loses flux density or strength. As long as a certain temperature, known as the Curie temperature is not exceeded, the PM will regain its strength as it cools off. Heated above the Curie temperature the PM is demagnetized and will not regain its magnetism when it cools off. PM's can also be demagnetized by external magnetic fields such as those generated by current flowing in the coils of a motor stator. A PM's resistance to this kind of demagnetization is affected both by temperature and the thickness of the magnet.

With these basics in mind, we'll be ready next month to look at a permanent magnet rotor.