5 Motor Design Possibilities

This chapter illustrates the features of many different brushless permanent magnet motor structures. Because there are so many possibilities, they cannot all be rigorously analyzed. Only the most common structures are analyzed in later chapters. For most structures, it is simply a matter of modifying the geometric parameters to apply developed expressions to alternative structures.

5.1 Radial Flux Motors

Inner Rotor

In most motors, flux crosses from the rotor to the stator in the radial direction. Of these motors, the vast majority have an inner rotor and outer stator. The motors considered in Chapter 4 were radial flux motors with inner rotors. While the rotors considered up to this point had surface mounted magnets, they are not the only possibility. **Figure 5-1** shows a variety of the most common inner rotor types.

Four of the rotors shown, Figs. 5-1*a-d*, depict variations of surface mounted magnets. The traditional radial arc magnet shape is shown in Fig. 5-1*a*. Figure 5-1*b* is similar, except the sides of the magnet are parallel, rather than radial. Yet another alternative is shown in Fig. 5-1*c*, where the sides are parallel and the bottom is flat. This particular magnet shape is often called bread loaf or simply loaf because of its resemblance to a slice of bread baked in a loaf pan. The magnet shapes in Figs. 5-1*b* and 5-1*c* appear primarily for manufacturing reasons. These shapes are easy to create by starting with a rectangular block of magnet material. When magnet material is bonded rather than sintered, the rotor magnets are often formed from a solid ring of magnet material as shown in Fig. 5-1*d*. In this case the magnet poles are created by magnetizing the rotor after assembling it to the rotor yoke. The remaining two rotor cross sections in Fig. 5-1 show two common interior permanent magnet rotors. The rotor shown in Fig. 5-1*e* is known as the spoke configuration. This configuration promotes flux concentration because the magnet surface area can be greater than the rotor surface area. The spoke configuration is useful for gaining better performance from ferrite magnet material and has the benefit of using rectangular block magnets. The final rotor shown in Fig. 5-1*f*, has buried magnets. This construction is beneficial for high speed operation, since the rectangular magnets are entirely enclosed in a solid rotor structure. While the interior permanent magnet rotors support the use of rectangular magnets, the presence of

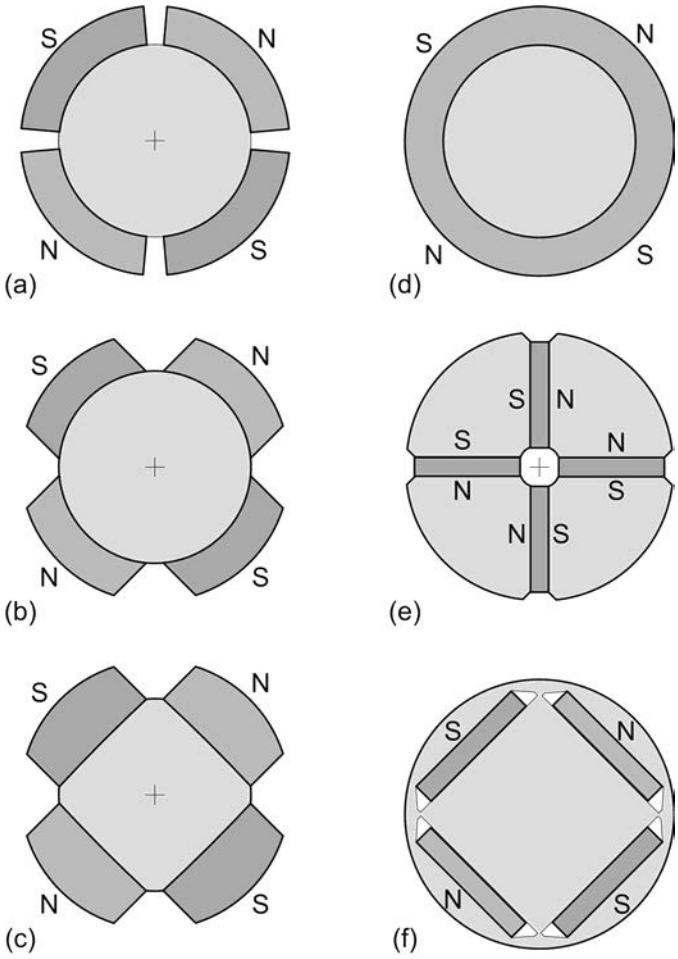

Figure 5-1. Some inner rotor possibilities.

ferromagnetic material at the rotor surface dramatically increases the air gap inductance. Furthermore, it adds a reluctance component to the torque produced.

The surface mounted magnet rotors shown in Fig. 5-1 appear in an overwhelming number of applications. The differences between the magnets shown in Figs. 5-1*a* through 5-1*c* are significant when the number of magnet poles is small but the differences diminish as the number of magnet poles increases.

It is commonly assumed that the shape of a magnet determines the direction of its magnetization. That is, the magnetization is radial for the radial arc magnet shown in Fig. 5-1*a*, and straight through, parallel to the edges of the magnets shown in Figs. 5-1*b* and 5-1*c*. These assumptions may be true in some cases, but magnetization direction is determined by both the material's preferred direction and the fixture used to magnetize the magnets. In any case, the magnetization direction has less impact on motor performance as the magnet pole count increases.