Brush DC Motor Runs Along

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Everything started in 1800 when Volta developed the first DC battery. Faraday used the DC battery to develop the first electric motor. It used brushes to transfer the battery voltage and current to the rotating disk rotor. This was in mid-1831. Thus was born the brush DC motor.

Construction

The slotted brush DC motor of today comes in two basic configurations: the wound field DC motor and the permanent magnet DC motor. The key parts of a DC motor include the armature (the rotating part), the field (either a copper winding or permanent magnet), and a mechanical commutation system consisting of a slotted commutator, mechanical brushes with copper wires connecting to outside terminals. The commutator is connected to various windings in a sequential pattern. The two brushes ride on the commutator to connect to the battery or outside power source via the terminals as shown in Figure 1. These brush DC motor types are called slotted or iron core types.

Motor Operation

The DC motor is the simplest motor type. Raise the input voltage and the motor speeds up. Lower the voltage and it reduces speed. Increase the motor's shaft load and shaft torque and armature current go up while the speed goes down. The permanent magnet DC motor is the most popular type, replacing the three wound field DC motors in many applications. Today the most popular wound field DC motor has another name—the universal motor—a separate motor type because it can be driven by AC and DC input power. The permanent magnet DC motor version operates linearly as shown in Figure 2. It is a simple motor to control with an outside variable DC power controller.

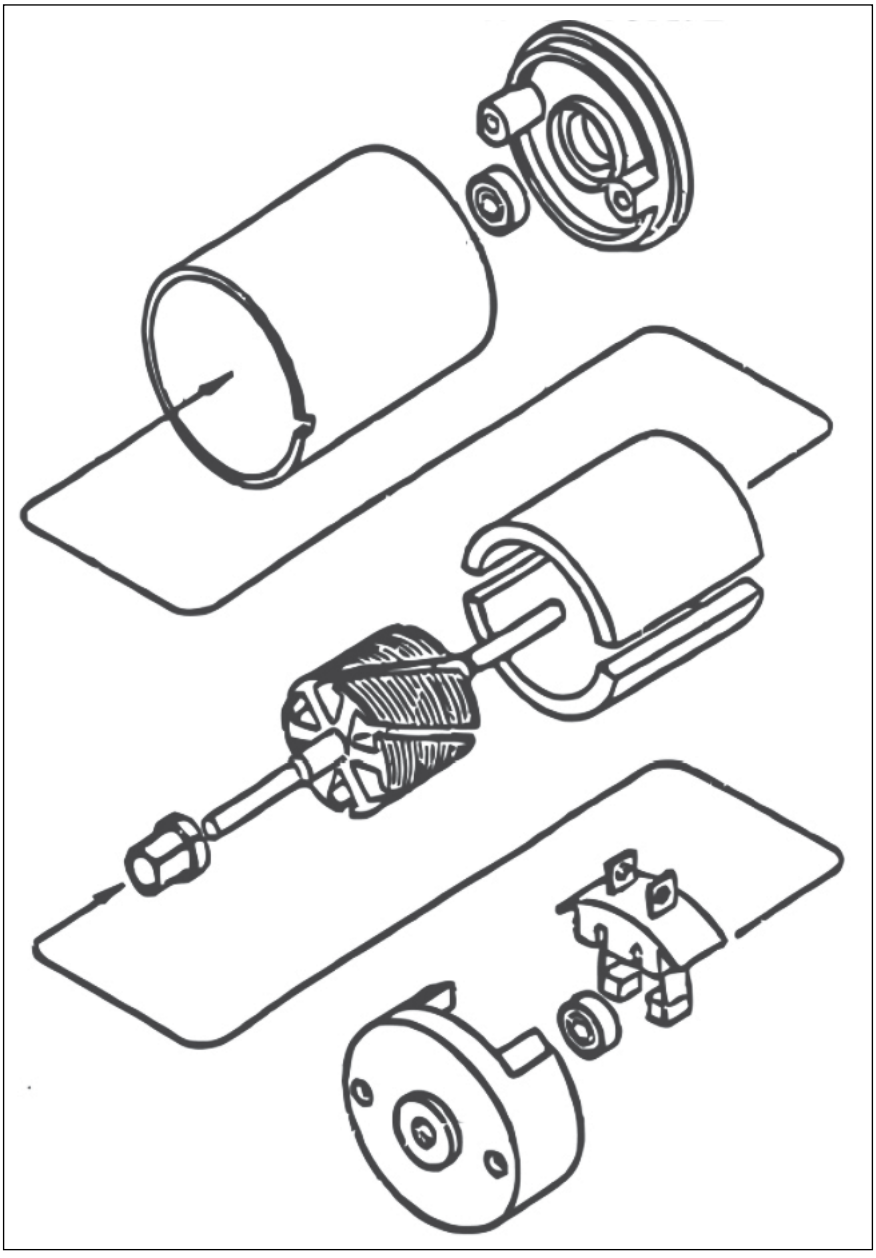

Figure 1 Permanent magnet DC motor structure.

If it is so simple to control, why then is it being replaced in a wide range of applications? Well, the answer lies in the motor's life expectancy based on brush wear and the resulting motor life.

Commutation System

It's the wearing away of the carbon or metal graphite brushes that concerns many. The mechanical contact between the brush and the commutation transfers voltage and current to the armature necessary to generate motor torque and speed. Since the brush wear can vary under different current and speed combinations (and it is *supposed* to wear, but not too quickly), it is very difficult to predict motor operating life. Motor design engineers usually have experience with a number of brush grades that they can hopefully rely upon for use in new applications. The brush manufacturers can also assist the motor designer in selecting the "right" brush grade.

Motor Variations

New applications foster new variations for all motor types, and the brush DC motor is no different. The ironless DC motor is also called a coreless or slotless DC motor. Developed just after World War II in Switzerland, the ironless DC motor eliminates the armature teeth. Its armature is constructed as a self-supporting copper wire winding basket supported by an epoxy resin cylinder.

The permanent magnets occupy a central position inside the copper winding basket. This construction reduces the winding inductance into the microhenry range. Silver brushes are used to reduce motor resistance, allowing this motor type to reach rated power efficiencies above 90 percent. Almost all power output performance is below 100 watts for the ironless motor types.

Another form of brush motor is the permanent magnet brush disk DC motor, very popular in the 1960s through the 1990s and still made today. They would be classified today as axial flux DC motors. They produce lots of torque. Their armatures are multi-copper sheets in a thin pancake configuration.

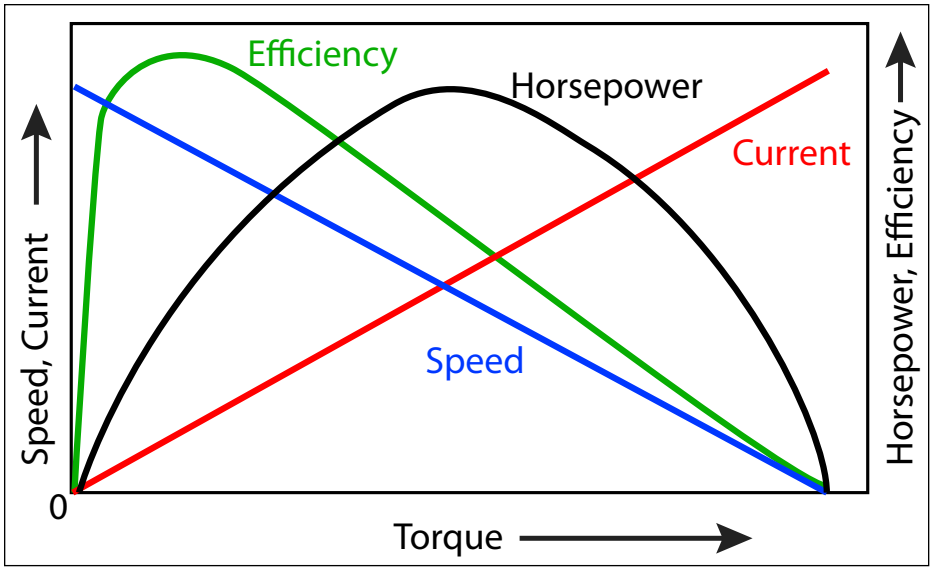

Figure 2 Full speed/torque curve for a permanent magnet DC motor.

Typical Applications

While slotted brush DC motors still have many applications, particularly in automotive auxiliary applications (windshield wipers, window lift motors and seat adjust motors), the brushless DC motor (a competing technology) is slowly gaining market share against the slotted and the ironless brush DC motor.

The ironless DC motor has its market niche in medical pumps, blood pumps, precision scales, small robots, and many other applications. One can expect the brush DC motor to be used in a myriad of applications for many years to come. **PTE**

Dan Jones received his BSEE degree from Hofstra University in 1965 and MS in Mathematics at Adelphi in 1969. He has over 50 years' experience in the design of all types of electric motors and generators from 10 W to 500 kW and has held engineering design, management and marketing management positions at a number of companies. He is recognized as an international authority on electric motors and motion control. He has written 250+ technical articles/papers and held seminars in 10 countries. He is a past member of the board of directors of SMMA and EMERF. He currently is a member of the board of directors of the Motion Control Association (MCA). He is a life member of IEEE and a member of ASME. This article was adapted from his seminar on motor types, which is being presented at Motion Control 2013 (October 15–17 in Los Angeles) and at the Motor, Drives and Automation Systems 2014 Show (January 29–30 in Orlando).