PRODUCT DESIGN & DEVELOPMENT

A Follow-up On Customizing Dc Motors By Design

Wednesday, March 11, 2009

Cases where challenging operating or performance requirements must be realized, customized motor components hold keys to successful outcomes.

By Mike Lefebvre, Motors Engineering Manager, AMETEK

When designers must evaluate, select, and specify an electric motor for an application, the field usually will narrow to permanent magnet brush-commutated and brushless DC servomotors. In cases where uniquely challenging operating or performance requirements must be realized, customized motor components hold keys to successful outcomes.

Conventional brush-commutated DC motors use brushes (typically graphite with metal content) as part of the commutation process**.**

As an initial guide in selecting a brush or brushless DC motor for an application, designers can benefit from a review of basic motor dynamics and how these two motor types compare. A toolbox of options for motor customization can then empower tailor-made solutions.

Comparing The Technologies

All permanent magnet brush-commutated and brushless DC servomotors operate by converting electrical energy into mechanical energy through the interaction of two magnetic fields. The permanent magnet assembly creates one field and electrical current flowing in the motor windings produces the other.

The relationship between these two fields results in a torque that rotates the rotor. As the rotor turns, the current in the windings is commutated, or switched, to produce a continuous torque output.

Conventional brush-commutated DC motors use brushes (typically graphite with metal content) as part of the commutation process, while brushless DC motors handle commutation electronically with a permanent-magnet rotor, wound stator, and rotor-position sensing scheme.

These motor technologies invite comparisons to help designers choose among the appropriate motor type for an application.

Load – Brush and brushless DC servomotors can accommodate a wide range of loads, whether loads are constant, variable, high intermittent peak, or unpredictable.

Relative Physical Size and Power Density – High thermal impedance in brush DC motors (due to windings located on the armature, or rotor) creates a less efficient thermal path and diminished rate of heat dissipation, which may necessitate a larger (brush) motor to achieve a given continuous output torque.

Lower thermal impedance in brushless DC motors (windings in the stator) delivers a more efficient thermal path and higher rate of heat dissipation, which allows specification of a smaller (brushless) motor to achieve a given continuous output torque.

Speed – Brush-commutated DC motors should generally be operated in excess of 1,000 rpm to prevent brush particle accumulation in the slots between commutator segments, which could result in shorting. Recommended operating speeds above 10,000 rpm are atypical, due to limitations inherent in brush-commutator systems (Speeds below 1,000 rpm can be realized with a gearbox).

High rotational speeds for brushless DC motors often will be limited only by the mechanical integrity of the rotor construction, speed-related internal losses, and bearing selection. Speeds in excess of 10,000 rpm (and even much higher) are possible (with appropriate designs) and speeds below 1,000 rpm can be handled with a gearbox or directly, depending on drive capabilities.

Brushless DC motors handle commutation electronically with a permanent-magnet rotor, wound stator, and rotor-position sensing scheme.

Audible Noise – Primary sources of audible noise in brush DC motors can include armature imbalance, bearings, and brushes yielding moderate overall noise levels. Primary sources in brushless DC motors include rotor imbalance and bearings for lower overall noise levels. Techniques such as rotor balancing and appropriate bearing and brush material selection can be employed to reduce noise.

Electrical Noise – Brushless DC motors generate relatively less electrical noise compared with brush types, due to the nature of the mechanical commutation system in brush motors (Noise can be mitigated in brush types by adding suppression devices and filters and appropriately selecting brush materials).

Service Life – In general, brushless DC motors will serve significantly longer than brush-commutated DC motor counterparts. Life expectancy for brush-commutated DC motors is limited primarily by the life of the brushes, bearings, and gearbox and will be in the range of 2,000 to 5,000 hours of operation (although actual service life can vary greatly, depending on the motor design and operating current, voltage, speed, and other conditions).

For brushless DC motors life expectancies rise much higher (well in excess of 10,000 hours) and will be limited essentially by bearing life and related radial and axial loads, temperature, and environment.

Ease of Integration – Brush DC motors are relatively simple to engineer into an application, in part because commutation is performed mechanically without requiring additional components. These motor types can be driven directly by a DC power supply, including a battery, and more advanced drive and control schemes can be employed for expanded functionality.

Integrating brushless DC motors will involve drive electronics for electronic commutation, but advances in "onboard" technologies help simplify the job and suit applications involving smaller design envelopes.

Customized Solutions

Motor manufacturers offer a variety of ways to customize their products with options such as gearboxes, brakes, encoders, and modified shafts, among many others. Each option carries its own set of variables and design/performance considerations.

Gearboxes – These increase output torque and decrease speed. For most applications a spur gearhead will be flexible enough to satisfy torque, noise, and cost requirements. As an alternative, planetary gearheads will exhibit lower backlash and much higher torque.

Brakes – Developed as a safety and energy-saving feature, rear-mounted power-off and power-on electromagnetic brakes prevent a motor or gearmotor from rotating freely. Brakes also can contribute superior holding capacity.

A power-off brake stops a motor when power is removed and releases the motor when power is reapplied. In low-duty applications, the brake saves energy by maintaining a known motor position without power. An added safety feature is that should power be lost while the motor is lifting an object by pulley or lead screw, the brake will lock the motor and prevent the object from falling.

A power-on brake holds the motor in place upon application of power and releases the motor when power is removed.

Encoders – Incremental optical encoders for precision motion control applications supply accurate feedback on position, velocity, acceleration, and direction. Encoders can be added to any motor or gearmotor with wires or side-exiting power terminals and can be metal-housed or open air. They can be factory-mounted or prepared for mounting in the final stages of end-product assembly. Some manufacturers can supply complete encoder kits.

Shafts – Even a motor's physical shaft can be modified for a design as necessary with a flat, journal, cross hole, keyway, slot, groove, gear, or pulley, or any combination. Shaft materials, diameters, and lengths also can be specially configured.

Footnote: While generalizations about motor characteristics may be typical, useful, and preliminarily necessary, they should never be considered absolute. Ultimately, the application will be the primary driver in motor selection. Partnering with an experienced motor engineering resource can help turn designers in the right direction.

Mike Lefebvre is a Motors Engineering Manager at AMETEK Technical & Industrial Products. Send comments to mike.lefebvre@ametek.com

BROUGHT TO YOU BY
Ametek Technical & Industrial Products
627 Lake St., Kent, OH 44240