DC Motor Application Considerations

Audible Noise: Audible noise is a concern in some types of motor applications. In many medical applications like infusion pumps or prosthetic devices, the patient can be very sensitive to the noise disturbance. Good design practice requires that the noise be limited as much as possible. In large machines, the combination of hundreds of DC motors and gears operating simultaneously can be very loud and distracting to the employees who have to work in close proximity to the machine

Quality Components: Probably the best method of insuring low audible noise in motors is to specify quality components. Motors using cheap or poorly fitted bearings are more likely to be noisy. Poorly designed or loose fitting brush sets can contribute to audibly noisy commutation. Manufacturers of inexpensive, high volume motors cannot reasonably be expected to concern themselves with quiet operation beyond some minimum standard, and the use of such motors in applications where quiet operation is important should be considered carefully. The designer must consider whether low cost takes precedence over quiet operation in the priorities of the customer.

Bearing Choice: The use of ball bearings without preload is a potential source of audible noise. Where the specific application permits, ball bearings should be preloaded. This means that the balls will not be able to move axially in the race and cause the minute intermittent rattling that can sometime be associated with unpreloaded ball bearings. Smaller ball bearings can be sensitive to heavy shaft loads. They are easily damaged during press fitting added components and by short radial or axial overloads. Care should be taken not to exceed the shaft loading ranges specified in the datasheets. A damaged ball bearing can be a significant source of audible noise and can effect motor life.

Sintered sleeve bearings are a very good choice when limiting audible noise if the application does not require the motor to endure significant continuous or intermittent changes in the shaft loading characteristics. The shaft of the motor actually rides on a thermodynamic film of lubrication and the reduced friction can limit audible noise. If the bearing is overloaded radially, however, this film breaks down and the shaft will grind the bearing down causing audible noise and reducing the operational lifetime of the motor.

Vibration: Rotor vibration can be a significant source of audible noise. Vibration and noise increases with speed. Even a slight imbalance in the rotor can cause major vibrations at speeds of 10,000 rpm.

Brush Options: Copper-graphite type brushes tend to be both audibly and electrically noisier than precious metal systems. Graphite based brushes are capable of withstanding considerably higher current densities, however, and they are often required in an application for that reason. Where a choice is available for a specific application and audible noise is important, precious metal brushes are the better choice.

Electromagnetic Interference (EI)

DC motors are a source of electrical as well as audible noise. EMI (electro-magnetic interference) can be radiated by motor terminals and lead wires and may cause problems with other components in the vicinity of the motor. It is also possible for spikes to be coupled onto data lines or output lines from encoders. The result can be false data or encoder information. There are a number of methods that can be used to minimize EMI in motor applications. Like many other considerations in DC motor applications, each has its advantages and disadvantages and must be evaluated within the context of the application.

Motor Commutation: The most common source of EMI problems is the commutation of motors. At each commutation point, when the brush breaks contact with a commutator segment, the energy stored in the motor winding as a magnetic field causes an arc or voltage spike between the brush and the commutator segment. This occurs not only during normal commutation but also in situations where the brushes "bounce" on the rotating commutator. Coreless DC motors are typically less electrically noisy than iron core DC motors because of the lower armature inductance which in turn reduces the level of the arc energy. This arcing can be further mitigated with the addition of a capacitor ring, which serves to dissipate the energy through a capacitor and resistor series back into the motor coil.

Quality Components: The importance of using quality components in any motor design is of a crucial importance. As was the case with audible noise, the use of cheap, poorly constructed motors adds to the electrical noise problem. "Open case" motors do not effectively block EMI radiated from the coil windings. Poorly fitted brush holders and inadequate brush tension contribute to radiated EMI as well.

Coreless motors: Coreless DC motors have much lower armature inductance than iron-core motors of comparable size. Since armature inductance is the primary cause of EMI problems, minimizing it through selection of coreless motors is recommended where EMI is a critical factor.

Lead Wires and Shielding: Motor lead wires should be placed as close together as possible so that EMI radiated from the two leads can cancel each other. This canceling effect can be improved by using so-called "twisted pairs" where the positive and negative lead wires are twisted together. Motor leads should be physically separated from data lines or encoder outputs to reduce the possibility of coupling motor noise onto them. This means that when using shielded pigtails, the feedback lines should be shielded separately from the motor leads. If noise is still causing problems with the encoder signals than it may be time to consider using a differential encoder to eliminate the effect of interference on the encoder. PWM switching noise is another source of EMI problems. Most commonly, PWM switching results in radiated noise from motor lead wires. Shielding and lead wire placement can also help mitigate the effect of PWM generated EMI.

Passive components: EMI problems can often be significantly reduced by the simple act of installing a capacitor across the motor terminals. In some types of applications, this method may not be suitable since a resonant circuit is created which can cause "ringing" problems near resonant frequencies. In these instances, an RC snubber network across the motor terminals may be more effective. Component values are not critical for motors driven with DC, but care must be taken in selecting components for PWM driven systems.

Motor Service Life

Operating Point: In most applications, the torque and speed demands placed upon a DC motor determine its overall operational lifetime. As the torque requirements on the motor increase, the current through the armature increases proportionally, thus increasing the current density at the brush-commutator interface. High current densities promote electro-erosion of brush and commutator materials, a limiting factor in motor service life. In addition, high rotational speeds shorten motor service life by accelerating mechanical wear.

Although each application has its own specific requirements to be addressed, it is usually advisable to operate a DC motor with precious metal brushes and commutator continuously at no more than 1/3 of its rated stall torque. Motors with graphite on copper commutation systems should be run continuously at no more than 1/2 of the motor's rated stall torque. These recommendations attempt to maximize motor service life. Some applications may not require the maximum lifetime that the motor has to offer.

Rotor Inductance: One of the factors limiting brush and commutator life is the inductance of the motor armature. During commutation, when current flows through a particular coil winding there is storage of energy in the form of a magnetic field. When the motor commutates and the current flow is switched to another winding, the magnetic field collapses and the resulting discharge of energy causes an arc between the commutator and brush. This arcing accelerates electro-erosion and decreases motor life. One could, theoretically, reduce the armature inductance of the motor windings by decreasing the number of turns in each armature segment. This lowers the torque constant of the motor, however, which increases the motor current for a given torque and, therefore, increases the current density at the brush-commutator interface. This is not recommended. To reduce the affect of inductance and arcing on motor lifetime a capacitor ring is being mounted to the commutator. The ring provides the equivalent effect of each winding connected in parallel with a small capacitor and resistor. The collapse of the magnetic field during commutation then serves to charge the capacitor rather than creating an arc between brush and commutator. The stored energy is released and dissipated back into the next coil phase in the commutation sequence. This technique, while slightly increasing the electrical time constant of the motor, dramatically increases motor service life.

Drive Profiles: Operating conditions other than torque and speed also affect service life. The application may require frequent starting and stopping or reversals of direction. Both situations result in periods of high current density and a resulting shortening of service life. A similar effect is seen in applications where pulse width modulated (PWM) drives are used. If the PWM frequency is too low, the motor is constantly accelerating and decelerating with an accompanying increase in current density. As a general rule, PWM frequencies of 20 kHz or higher are recommended for ironless core motors.

Environmental Considerations: Environmental conditions can have a profound effect on motor service life. One good example is the rapid drying and wear of graphite-based brushes in a vacuum or very dry environment. Very warm and dry conditions also hasten the breakdown of bearing and commutator lubricants. The ambient temperature has a cumulative effect on the motor's operational temperature and can lower performance by limiting the operational temperature range of the motor. External cooling by contact, air or forced air can produce significant gains in motor performance. At the opposite extreme, very cold conditions increase the viscosity of lubricants and cause the motor to run at a higher current.

Shaft Loading: Shock loads and vibration contribute to the tendency of the brushes to "bounce" on the commutator, thus causing arcing and accelerated electro-erosion. Shock loads and vibration also accelerate bearing wear. Excessive axial or radial shaft loads decrease the life of bearings, sometimes significantly. In continuous duty applications with low radial shaft loads, sintered bearings are the inexpensive choice. For increased radial loads, ceramic bearings are available. Ball bearings are typically specified when the application calls for higher radial and axial shaft loads.

Reference

MICROMO - rotary and linear custom motion solutions

Source:

http://www.openelectrical.org/wiki/index.php?title=DC_Motors