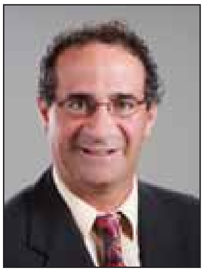
A Column by Tony Morcos, President • ACM Magnetics

MAGNETS FOR CLUNKERS



In my previous article, I discussed how the global push for renewable energy sources, especially wind power, will have positive implications for designers and manufacturers of electrical motors and generators. This is a potential windfall for suppliers of copper wire, steel, power electronics and permanent magnets – these commodities compose the "guts" of the machines that convert mechanical energy to electrical energy and vice versa. I also noted in the push to maximize efficiency and return-on-investment in these large, expensive electro-mechanical machines, one may or may not choose to employ permanent magnets, depending upon ever-fluctuating market conditions and commodity pricing.

Large electrical machines for wind turbines generate (and consume) many kilowatts of power and cost many thousands of dollars. For every such large generator, there are hundreds of thousands of smaller, lower-cost motors, in the 2 watt to 2 kilowatt range. The most common applications for these fractional-horsepower (FHP) industrial motors are fans, pumps and compressors. These smaller motors tend to be commodity items, priced accordingly. Selling price, not efficiency, drives this market, and the most common motor types for these applications are induction motors, which do not employ permanent magnets. With 60 to 75 percent of global industrial electrical consumption being used to drive electrical motors, improvements in the efficiencies of industrial motors will yield great dividends in reducing electrical consumption and in the battle against global warming.

The low hanging fruit in the movement to increase the efficiency of industrial motors would be the simplest single-phase FHP induction motors – for example, shaded pole and capacitor-start motors. Such motors typically do not incorporate speed control, and their operating efficiency is in the 10 to 30 percent range. The simple conversion to a permanent magnet brush DC motor will push the efficiency to 45 to 65 percent. A brush DC motor allows for simple speed control (via the adjustment of input voltage) while also providing increased energy density in motor output. Thus, switching to a DC brush motor allows the use of a physically-smaller motor to generate equivalent motor output power with less input power, compared to a single-phase induction motor. The cost difference between a simple single-phase induction motor and a permanent magnet DC brush motor is primarily due to the cost of the permanent magnets and the brushes and commutator. Low-cost ferrite permanent magnets can be utilized to mitigate the cost differential between an induction motor and a DC brush motor while increasing motor efficiency by up to 50 percent.

Unfortunately, the life of a brush DC motor is limited by the life of the brushes used to commutate the motor, and the application of such motors is often restricted to intermittent-use applications. The next logical step is the permanent magnet brushless DC motor, also called an electronically-commutated motor (ECM). Such motors switch the current in the windings via power electronics controlled by either Hall sensors or by the back-EMF signal of the permanent magnet rotor. The simplest ECM with minimal controls and low-cost rubber-bonded ferrite magnets can achieve 60 to 65 percent efficiency. Efficiencies of up to 90 percent can be achieved by adding a combination of higher-energy magnets (sintered ferrite, bonded and sintered rare earth), lower-loss steel laminations and "smarts" to the control scheme. The life of a brushless DC motor is limited by the life of the bearings, which is orders-of-magnitude longer than the brush life in a brush DC motor. The cost difference between a brush DC and a brushless DC motor is due to the cost of the power electronics and sensors. Using low-cost ferrite permanent magnets and a simple electronic control scheme with a minimum of parts and features can allow for a doubling or tripling of the efficiency in comparison to a single-phase induction motor.

With global warming and energy consumption still in the forefront of issues facing the planet, it is just a matter of time before government regulations begin to dictate the minimum efficiency of electric motors in certain applications. The first regulated applications should be compressor and blower motors for refrigeration systems, because increased motor efficiency in these applications provides a "double-whammy" improvement by reducing the waste-heat input to the target environment as well as requiring lower input power to do the job. Such regulations will begin in the EU countries and drive westward to the Americas and then to Asia. I have the following suggestions:

1. Manufacturers of low-cost induction motors should develop parallel product lines of brush DC and brushless DC motors, if they have not already done so. Ferrite permanent magnets, either rubber-bonded flexible, injection molded or sintered, should be the baseline to mitigate the cost penalty in comparison to induction motors.

2. Magnet manufacturers should develop their lines of permanent magnets suitable for use in brush DC and brushless DC motors. The most important magnet types are sintered-ferrite arcs, flexible ferrite strips, bonded NdFeB rings and sintered NdFeB arcs.

3. Injection-molded magnet materials, both ferrite and NdFeB, allow for the most flexibility in both the manufacturing and design of high-volume electrical motors. Such materials have the added bonus that once the tooling and processes are developed, the compounding, molding and magnetizing of the permanent magnets can be brought in-house to the motor manufacturing facility. The use of injection-molded magnets will be limited to fairly high-volume applications due to the high cost of tooling.

4. Steel manufacturers should develop and market their lower-loss steel formulations, noting that reductions in hysteresis and eddy-current losses (core losses) alone can lead to significant increases in motor efficiency.

5. Power electronics and Hall sensor manufacturers should develop and market their products geared toward the use of FHP brushless motors. Noting the competition from induction motors and brush DC motors, the primary goal should be to reduce the selling prices of these electronic components to further the penetration of brushless DC motors in the various FHP industrial motor markets.

Similar to the current "cash for clunkers" program currently running the USA, I expect the future will bring government incentives for replacing inefficient induction motors with efficient permanent magnet brushless DC motors in FHP commercial and industrial applications. Less desirable, but perhaps equally possible, is a government penalty (tax) for not doing so. Motor manufacturers and suppliers of permanent magnets, steel and power electronics should position themselves accordingly.

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