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PERMANENT MAGNET MOTOR EFFICIENCIES

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The permanent magnet motor as technically advanced and highly efficient transformer of electrical to mechanical energy

New permanent magnet (PM) materials and production technology are making it possible to offer a wide range of motors with horsepower suited to nearly every industrial application. With higher efficiency and flexible rotor design, PM motors are being specified for applications from micro electronics to computers, robotics, industrial automation, heavy industry, military, and marine – nearly everywhere induction motors are currently used.

When we compare synchronous PM and traditional induction motors over a range of shaft speeds, PM motors offer higher efficiency at all speeds. Here, efficiency describes the relationship between electrical energy input and mechanical energy output. Some energy will always be lost to electrical, magnetic, or mechanical forces, but synchronous PM motors typically operate at efficiency levels between 93% and 98%. Some designs even approach 99% efficiency (near their theoretical limit). Since the traditional induction motor typically operates in a range from 80% to 85% efficiency, PM motors offer cooler operating temperatures, smaller standard dimensions, and dramatically lower energy consumption.

Given an input power factor of 1.0, and controlled by an electronic drive, high efficiency is achieved using pure sinusoidal phase voltage. Rotor heat is negligible, and stator heat is easily dissipated.

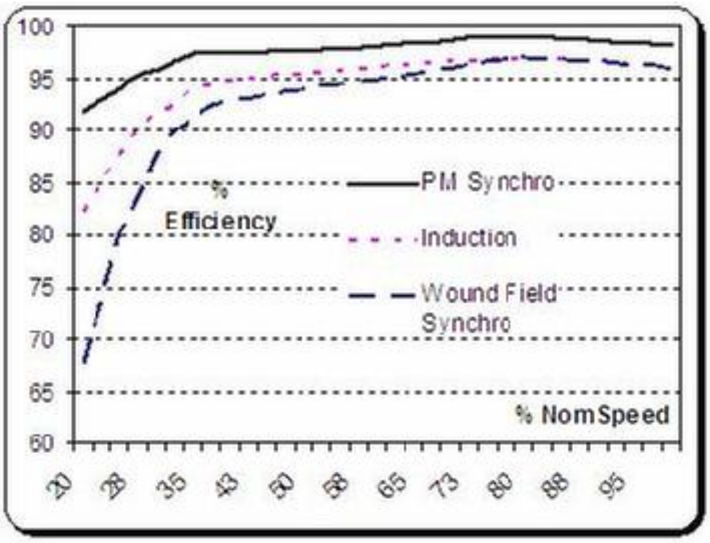
PM motor efficiency unsurpassed at any shaft speed

Induction motors transfer energy for rotor excitation from the stator winding to the rotor cage, producing a magnetic field and generating torque as the magnetic fields of the rotor and stator merge. The transfer of energy to the rotor generates heat, resulting in degradation of the motor's efficiency. Both asynchronous and synchronous induction motors are subject to this form of energy loss.

PM motors do not require the transfer of excitation energy from the stator to the rotor. Neither do they require a separate energy source to produce a magnetic field in the rotor like an induction motor. The rotor's permanent magnetic field generates torque as the magnetic fields of the rotor and stator merge, but without the accompanying electromagnetic losses inherent in an induction motor.

In a PM motor, the motor rated power is dedicated to the maximum motor load, but not only at full power. The PM motor's sophisticated drive keeps efficiency higher at all RPM's through phase alignment and other carefully controlled parameters and related motor design characteristics. In fact, at very low RPM's, where conventional motors are especially inefficient, PM motors demonstrate an even greater efficiency improvement.

Motor efficiency comparison chart

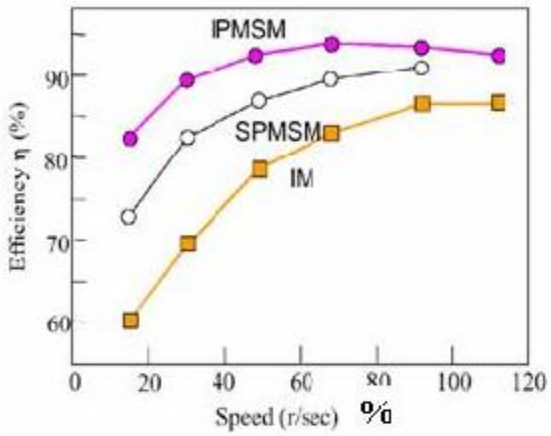


Flexible PM motor design optimized for different applications

There are currently two approaches to rotor design in PM motors: surface mounted (SPMSM) and embedded magnets (IPMSM). There are distinct advantages to PM motors with embedded magnets including:

- Higher torque to volume ratio, enabling smaller, lighter footprint
- Higher efficiency for reduced energy consumption
- Lower rotor moment of inertia, increasing responsiveness
- Low torque ripple, simplifying design and control
- Glueless magnet assembly, increasing reliability at higher operating temperatures
- Robust construction enabling high speed applications
- Higher performance at comparable cost

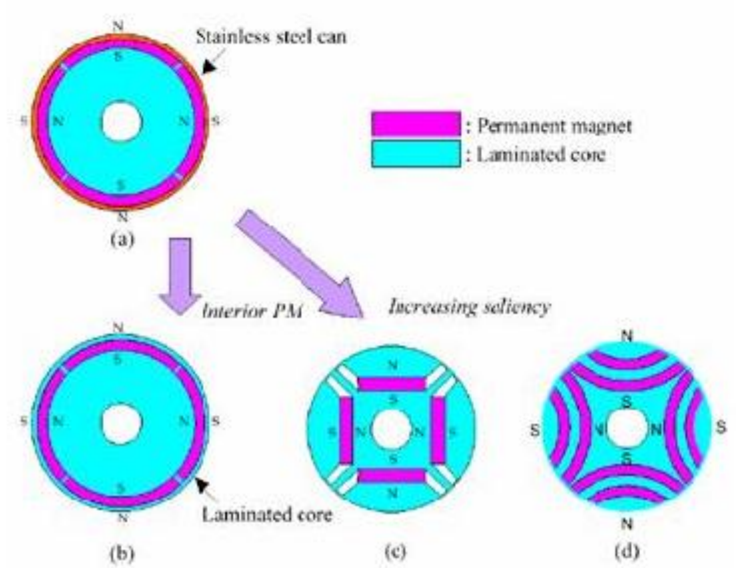
Different rotor design improves motor efficiency



For maximum benefits throughout a variety of applications, **TEMA** makes two kinds of embedded magnet rotors available: radial segment and tangential segment. Whereas radial design requires a stainless steel shaft, tangential embedded segments do not, making them better suited to high kilowatt (horsepower) applications. Tangential design also offers a variety of controlled saliency levels. Our experience in this area insures optimization for applications from relatively level torque to marine, military, and locomotive power.

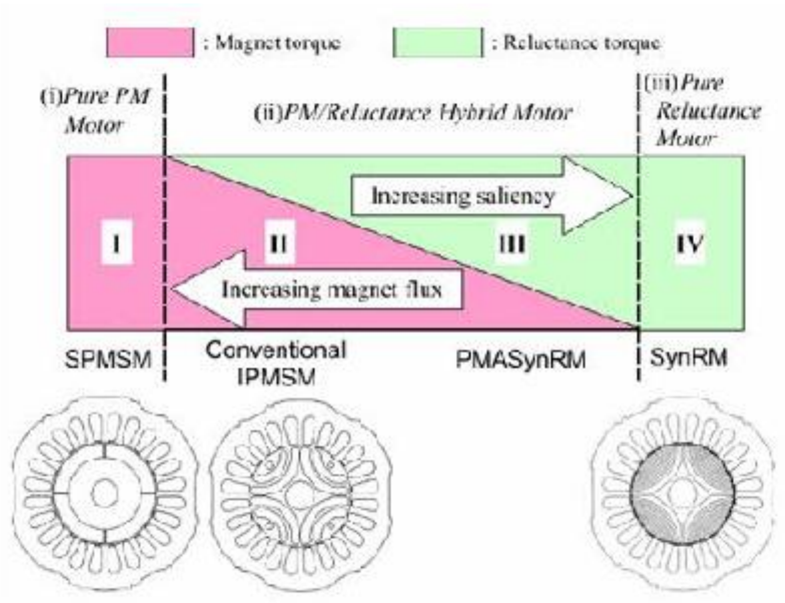
Lamination design achieves final level of operating efficiency

TEMA specifies rotor lamination shapes and construction to insure the best fit between motor design and application requirements, achieving the optimum balance among motor features, operating characteristics, and production costs.



Rotor design is directly related to motor parameters and behavior

Depending upon the specific request we offer optimized design to fulfill possibly the best applications requirements.



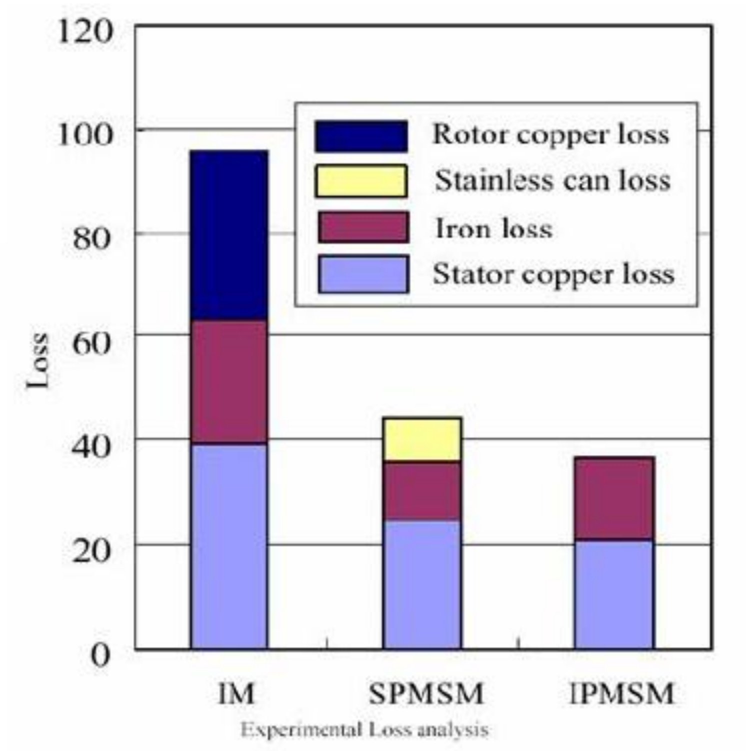
Special rotor design combines permanent magnet and reluctance motor

Power losses in PM motors are confined to the outer surface for more effective cooling

The cooling system is an essential part of every motor, and the more efficient the cooling, the better the motor performance. Every practical machine must be cooled to dissipate heat generated through inescapable efficiency losses. This prevents overheating the machine, and ensures isolation and other critical machine components and features.

Electromagnetic losses can be located in stator and rotor structure. PM motors have nearly no losses in the rotor - no current flow in the rotor circuit, and because of a unity power factor control there is also negligible eddy current flow in the rotor circuit. Almost all electromagnetic losses will be confined to the stator.

The stator is the “outside” component of the machine and easily cooled by natural radiation, ventilation, or liquid cooling. PM motors enjoy the advantage of eliminating additional heat transfer from the rotor (internal) to the “external” stator. This is a crucial advantage in large motor construction, as any percentage of inefficiency generates kilowatts of the heat which must be removed from the machine.



Again, flexible design enables **TEMA** to optimize motor characteristics to meet application requirements, from specialized cooling to frameless design.